

# Science Club Activities Guide

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This is a guide is meant to suggest ideas for an after-school science club. Obviously, after-school programs are voluntary, so our primary objective is to get the students there and keep them excited about science. Activities are designed primarily to introduce students to interesting/exciting science ideas, like motors, circuits, rockets, goofy putty, and squid. A secondary goal is to relate these ideas to science concepts from the classroom, as well as explain science topics. All activities are designed to take between one and one and a half hours. (Our science club meetings lasted an hour and a half; leftover time was used for organizational things or for snack time.) Also, consumable supplies are necessary for almost every activity – These range in cost from \$5 to \$50 for supplying 20 students. With the exception of liquid nitrogen, all supplies are readily available from grocery and drug stores.

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## Liquid Nitrogen Demonstration

*This is an excellent first-day demo because it grabs the students' attention and introduces many science concepts in an appealing way. It includes creating ice cream on the spot, eating freeze dried marshmallows, shattering a carnation, seeing a balloon deflate, and breaking racquetballs.*

**Science Topics covered:** phases of matter, density, and elasticity

### Materials

Liquid Nitrogen (available at colleges, universities, or anyplace where there is a chemistry or physics laboratory. **Caution:** Liquid nitrogen is very cold and poses a severe frostbite risk. Make sure you keep it a safe distance from students and take necessary safety precautions. You also need a dewar to hold the liquid nitrogen and keep it cold, as well as insulated gloves for the person handling the liquid nitrogen. )

**VERY IMPORTANT:** See the following web page for safety details and possible trouble spots: <http://webs.wichita.edu/facsme/nitro/safe.htm>

Metal tongs  
Several Metal pie plates (or other shallow containers for holding liquid nitrogen)  
Plastic Bucket (or other deep container for holding liquid nitrogen)  
Marshmallows  
Carnations  
Balloon  
Test tube or clear plastic soda bottle  
2 Racquetballs

*Ice Cream Supplies (1/2 gallon, serves about 20 people):*

Large metal mixing bowl  
Measuring cups  
Large Wooden spoon  
Paper towels  
Plastic cups with spoons/ice cream cones

**cream base:**

4 cups heavy cream 1 ½ cups half and half  
1 ¾ cups sugar

**berry mixture:**

1 quart frozen strawberries that have been allowed to thaw or fresh strawberries, mashed  
½ cup sugar

Total cost: About \$25 for ice cream supplies, \$5/liter for liquid nitrogen

### Supervisor Activity guide

1. Tell the students that you will be working with liquid nitrogen. Perhaps ask them if they have seen a liquid nitrogen demonstration before, or if they know what nitrogen is. Caution them that liquid nitrogen is so very cold that it will give them frostbite immediately, so not to touch it, and to be very cautious.
2. Pour liquid nitrogen into bucket about 2-3 inches deep. Place one racquetball in the nitrogen. Leave it there while you perform other demonstrations, turning it occasionally to ensure the ball gets cold everywhere.
3. Place marshmallows one layer deep on a pie plate. Pour liquid nitrogen slowly over the marshmallows and stir with a wooden spoon until the marshmallows no longer yield under pressure.
4. Allow the students to eat a marshmallow. The 'mallows will be quite cold and crunchy, similar to the marshmallows in Lucky Charms cereal. Ask the students to describe how the taste and the texture. Ask them why they think the 'mallow is cold. Why it is crunchy?
5. Next, pour some more nitrogen into a pie pan, and place the top of a carnation into the nitrogen. Stir the flower around by the stem until the petals harden or freeze.
6. Ask a student to touch the carnation petals (it's safe). The petals will be rock hard. Ask a student to grasp the top of the flower, or hit the top of the flower on the desk. The petals will shatter. Why does the flower get hard? What words could you use to describe it? (Brittle, frozen)
7. Pour some more liquid nitrogen into the pie pan. Blow up the balloon, but make sure the balloon is small enough to fit inside the pie pan. **DO NOT TIE THE BALLOON**. Instead, stretch the mouth of the balloon over the mouth of the test tube so it forms an airtight seal.
8. Place the balloon inside the pie pan and using the wooden spoon press on the balloon. Turn the balloon over a few times to ensure the entire balloon gets cold. The balloon will deflate. In the bottom of the test tube, there will be 'liquid air'. As the balloon warms up it will re-inflate. Why does the balloon deflate if there is no hole in the balloon? Where does the liquid (not water) in the test tube come from? Why does the balloon re-inflate when it gets warm again?
9. Keep all ingredients cold! Make sure the sugar is dissolved in the cream base. Pour the cream base into a large metal bowl. Add one to two liters of liquid nitrogen and stir vigorously. When the cream has thickened, add the berry mixture and more nitrogen, if necessary. Continue to stir until the nitrogen has evaporated (the fog has disappeared). The recipe does not keep well and is best if consumed immediately. If it begins to melt before everyone is served, simply add more liquid nitrogen.
10. Dispense into cups/cones. What makes the ice cream cold? What is the fog that you see?
11. Use tongs to retrieve racquetball that has been chilling in liquid nitrogen. Ask students to predict what might happen to the ball when you drop it. Drop a normal racquetball at room temperature. (It bounces) Drop the normal racquetball and the 'frozen' racquetball



- side by side. (the cold racquetball will shatter.) Why does the cold ball shatter? What has changed about the ball? How is this similar to the carnation petals? To the marshmallow?
12. Being careful to avoid students, you can carefully pour the remaining liquid nitrogen on the floor, to create a 'fog'. This is safe as long as liquid nitrogen is not poured directly on people's feet.

### Science behind the demo:

#### Physical properties of Nitrogen

Boiling Point at 1atm	-195.8°
Freezing Point at 1atm	-209.9°
Density of the gas at 21.1° and 1atm	1.153 kg/m <sup>3</sup>

Nitrogen is about 78% of the volume of the atmosphere. By decreasing the temperature/increasing the pressure, nitrogen can be changed from its gaseous phase (at room temperature/pressure) to liquid phase. Liquid nitrogen is very cold; at normal atmospheric pressure it is -196 degrees Celsius. We breathe nitrogen everyday in our air, and liquid nitrogen only becomes dangerous if it splashes on your skin and causes frostbite or too much of it evaporates into a closed environment and there is not enough oxygen to breathe.

An important concept for students to realize is that just like water boils when heated to 100 degrees Celsius and changes phase into water vapor, liquid nitrogen boils when heated to -196 degrees Celsius and turns into gaseous nitrogen. But since room temperature is ALWAYS above -196 degrees, liquid nitrogen is always boiling at atmospheric pressure. Of course, by increasing the pressure we can increase the temperature at which the liquid will boil. So liquid nitrogen can be stored by keeping it at a very high pressure where it won't boil at room temperature. That is why liquid nitrogen and other gases are stored in high-pressure tanks. This concept is closely related to density, as well. When matter is heated, kinetic energy is added to the atoms/molecules that make up the material. In a solid, the matter vibrates but doesn't change shape. In a liquid, the molecules squirm around each other, slipping and sliding around in close contact. In a gas, the molecules are separated from each other and go whizzing about, bouncing off the walls. In general, solids have the highest density, while gases have the lowest.

#### Explaining the demos:

When liquid nitrogen is poured over the marshmallows, all of the water in the 'mallows instantly freezes. The normally spongy texture becomes hard, which leads to the crunchy texture. If the marshmallow is allowed to warm up again, it will taste and feel like a normal marshmallow again. Also, the extreme cold changes the elasticity of the marshmallow. Normally, elastic materials bend and store the energy from an impact and release it by exerting a 'restoring force' in the opposite direction. When these materials get very cold they no longer bend, but instead they break or shatter, and no longer store elastic energy. They become brittle or inelastic.

Similarly, the nitrogen freezes all of the water in the carnation petals, which makes the petals brittle and easily shattered. This is the same reason why the racquetball shatters, too.

The balloon shrinks when you put it in liquid nitrogen because as the gaseous air (80% nitrogen) in the balloon cools, the molecules slow down and take up less volume. The air

becomes more and more dense until the molecules are all very close to each other and the gas turns into a liquid. Liquid air is what you see in the bottom of the test tube. It is important for the students to realize that no air has left the balloon/test tube. It has simply changed phase. To prove this, when the balloon warms back up, the liquid will boil and turn into gaseous air again and re-inflate the balloon.

Liquid Nitrogen makes good ice cream for two reasons:

- 1) The mix freezes very quickly, so you get small crystals and a very creamy texture.
- 2) The evaporating Liquid N<sub>2</sub> aerates (nitrogenates?) the mixture, so it doesn't end up as a frozen lump.

When you add the liquid nitrogen to the cream base (which is mostly water) it cools the water until it freezes. Conversely, the water warms the liquid nitrogen and makes it boil, creating liquid nitrogen. The fog that you see is water particles in the air that are condensed into water by the very cold liquid nitrogen (The fog is not liquid nitrogen itself).

### Uses of Nitrogen:

Nitrogen finds use in diverse commercial applications, including:

- **Chemical** Processing ... to inert vessels and oxygen-sensitive chemicals, creating an oxygen-deficient environment that reduces safety hazards; to propel liquids through pipelines; and to manufacture ammonia.
- **Food** ... to extend shelf-life in packaged foods by preventing spoilage from oxidation, mold growth, moisture migration and insect infestation; to rapidly freeze; and to refrigerate perishables during transport.
- **Petroleum** Recovery and Refining ... to improve recovery and maintain pressure in oil and gas reservoirs; to blanket storage tanks and product loading/unloading; to purge pipelines; and to strip volatile organic compounds (VOCs) from waste streams or to cool vent streams. Controlling VOC emissions helps refiners comply with U.S. Clean Air Act requirements.
- **Metal Production** and **Fabrication** ... to protect metals such as steel, copper and aluminum during annealing, carburizing and sintering operations in high temperature furnaces; to cool extrusion dies; and to shrink fit metal parts; utilized as a purge gas with stainless steel tube welding. Also used to support plasma cutting.
- **Electronics** ... to prevent oxidation in the manufacture of semiconductors and printed circuits; and to enhance solvent recovery systems by eliminating the use of chlorofluorocarbons for cleanup.
- **Glass** Manufacturing ... to cool furnace electrodes and prevent oxidation during manufacturing; and to lower air temperatures for optimum cooling rates.
- **Research and Health Services** ... to freeze and preserve blood, tissue, semen and other biological specimens; to freeze and destroy diseased tissue in cryosurgery and dermatology; and to pre-cool or insulate Magnetic Resonance Imaging (MRI), conserving the more costly helium.
- **Construction** ... to suppress the pour temperature of concrete mixtures, inhibiting the formation of cracks; and to stabilize the ground as in the restoration of the Leaning Tower of Pisa.

### References:

- [webs.wichita.edu/facsme/nitro/cream.htm](http://webs.wichita.edu/facsme/nitro/cream.htm)
- [www.chem.northwestern.edu/~ucc/ScopeDemoBook.pdf](http://www.chem.northwestern.edu/~ucc/ScopeDemoBook.pdf)
- <http://www.praxair.com/praxair.nsf/0/cdda20a87d5647a485256afc002c46b8?OpenDocument>

## **Shoestring Electric Motor**

*Students may have seen this before on Beakman's World, or at the Exploratorium. It is a nifty little motor that students can build out of ordinary everyday stuff. A lot of the instructions must be followed precisely to get this motor to work, and students usually need a fair amount of one-on-one help to troubleshoot. It is nice to have extra helpers around for this activity.*

**Science Topics covered:** Electricity, Magnetism

### **Materials for EACH electromagnet**

'D' Cell Alkaline Battery

1-2 meters of Heavy Gauge Magnet Wire (the kind with red enamel insulation, not plastic coated) (available at Radio Shack)

One **iron** nail (2-5 inches long)

Fine Sandpaper

Rubber Band

Clear Tape

Small paper clips

### **Materials Required for EACH motor:**

'D' Cell Alkaline Battery

Paper Cup

Rubber Band

Clear Tape

Two Large Metal Paper Clips

1 meter Heavy Gauge Magnet Wire

One or Two Rectangular Ceramic Magnets (available at Radio Shack)

Toilet Paper Tube, Test tube, or other cylindrical object

Fine Sandpaper

Optional: Glue, Small Block of Wood for Base

### **Supervisor Activity guide:**

*To prepare students for this activity, ask them about electricity – where do they use electricity? What does it do? Ask them what a motor does (converts electrical energy into mechanical energy). Can they give an example of a motor? What are magnets? What properties do they have?*

*This is also a good time to discuss positive and negative charges, and north and south poles on a magnet. Do positive and negative charges attract or repel? What about north and south poles?*

*To help the students understand electromagnets, it may be helpful to have them construct an electromagnet. This shows them that electricity makes a magnetic field.*

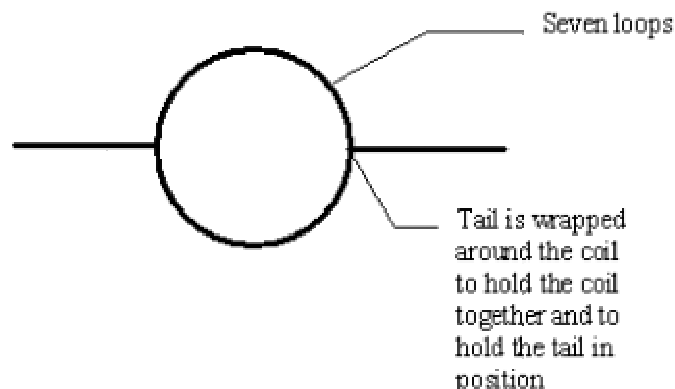
- The ends of the copper wire need to be exposed so that the battery can make a good electrical connection. Use sandpaper to sand off the insulation all the way around the wire.
- Neatly wrap the wire around the nail. The more wire you wrap around the nail, the stronger your electromagnet will be. Make certain that you leave enough of the wire unwound so that you can attach the battery.

- When you wrap the wire around the nail, make certain that you wrap the wire all in one direction. You need to do this because the direction of a magnet field depends on the direction of the electric current creating it.
- Use a rubber band to hold the ends of the wire next to the battery terminals. Secure in place using clear tape.
- Use you electromagnet to pick up small paper clips. See how many you can string together.



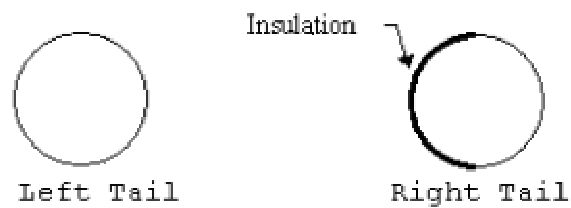
*It is a good idea to have one working electric motor to show the kids before they begin. As they are building the motor, ask them how the different parts of the motor work. Be sure to stress that the loop of wire in the motor turns into a magnet just like the electromagnet they just made.*

- Starting about 3 inches from the end of the wire, wrap it 7 times around the toilet paper tube. Remove the tube (you don't need it any more). Cut the wire, leaving a 3-inch tail opposite the original starting point. Wrap the two tails around the coil so that the coil is held together and the two tails extend perpendicular to the coil. See illustration below:

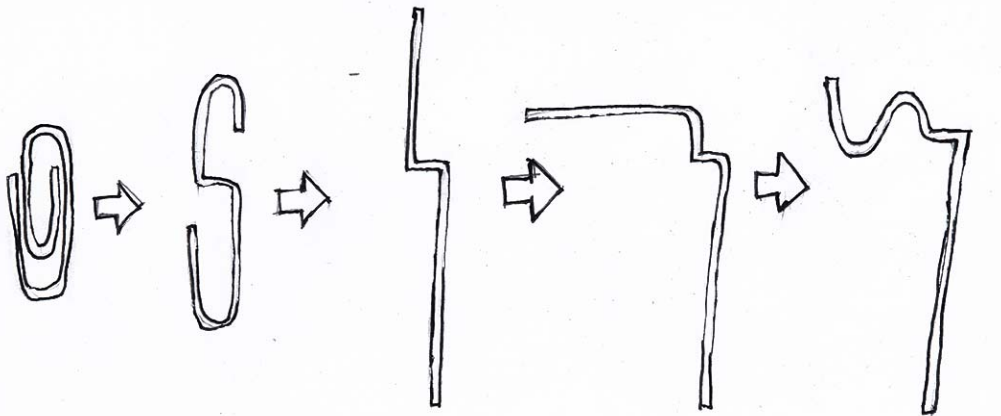


**Note:** Be sure to center the two tails on either side of the coil. **Balance is important.** You might need to put a drop of glue where the tail meets the coil to prevent slipping.

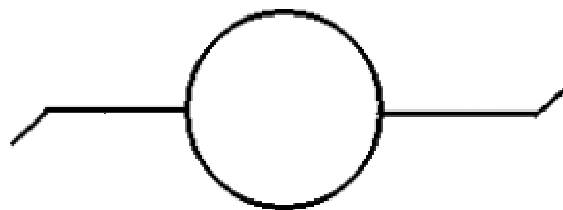
- On one tail, use fine sandpaper to completely remove the insulation from the wire. Leave about 1/4" of insulation on the end and where the wire meets to coil. On the other tail, lay the coil down flat and lightly sand off the insulation from the top half of the wire only. Again, leave 1/4" of full insulation on the end and where the wire meets the coil.



- Bend the two paper clips into the following shape (needle-nosed pliers may be useful here):

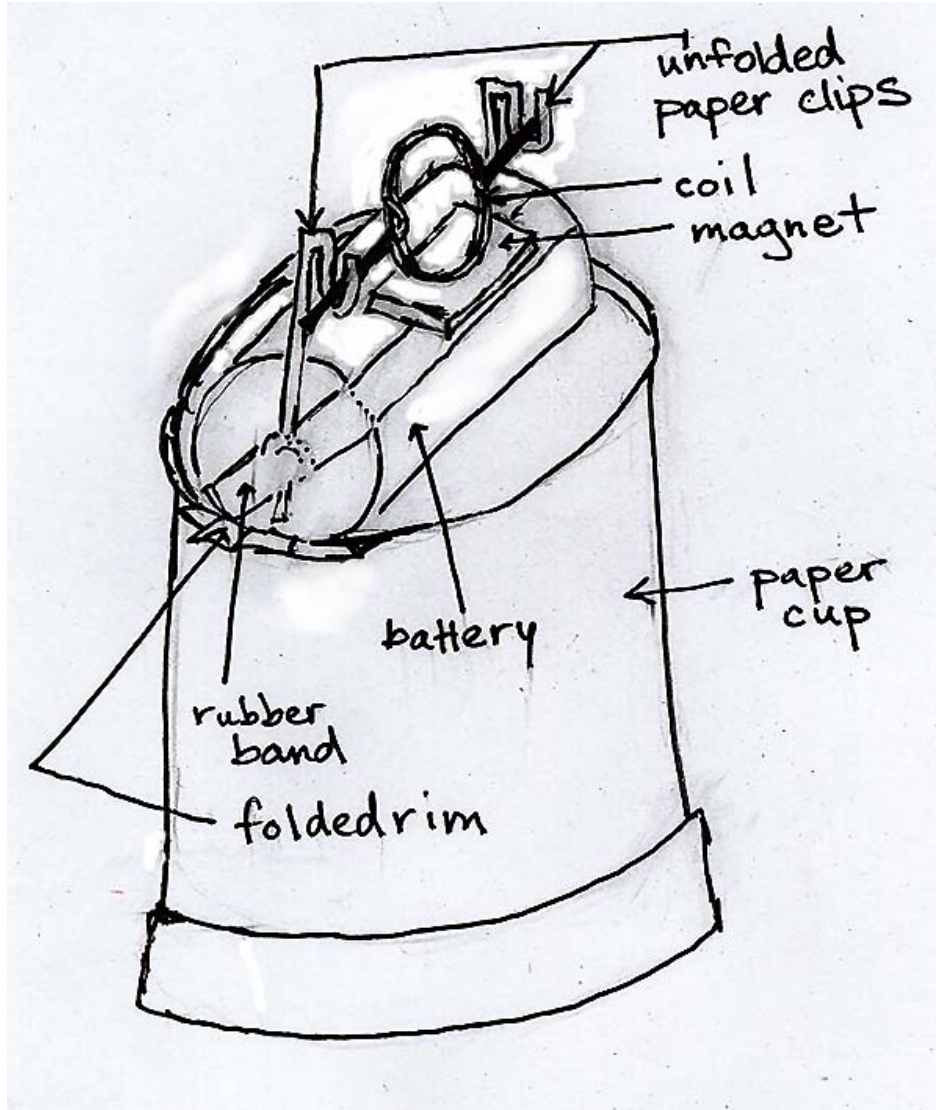


- Turn the paper cup upside down. Place the battery on top of the cup and tape into place. (You may need to break the rim on the bottom of the cup a little to fit the battery into place)
- Use the rubber band to hold the paperclips to the terminals of the "D" Cell battery. See finished motor diagram.
- Stick the ceramic magnet on top of the battery
- Place the coil in the cradle formed by the right ends of the paper clips. You may have to give it a gentle push to get it started, but it should begin to spin rapidly. If it doesn't spin, check to make sure that all of the insulation has been removed from the wire ends. If it spins erratically, make sure that the tails on the coil are centered on the sides of the coil. Note that the motor is "in phase" only when it is held horizontally (as shown in the drawing).
- It also helps to bend the ends of the coil a bit so that as it slips right or left, the bends keep it in the proper position:





Here is a diagram of the finished motor:



#### Troubleshooting Guide:

- The wire should be enamel coated magnet wire. This is solid copper wire with a baked on insulation, usually red, although it can be clear. Un-insulated wire will not work. Wire with rubber or plastic insulation will not work without some extra work.
- Small refrigerator magnets or those rubbery sheet magnets probably won't work. If all you have is small magnets, try stacking them together. The large rectangular magnets from Radio Shack work very well. If your Radio Shack doesn't carry them (or you don't have a Radio Shack nearby), try your local hardware store (such as Lowe's or Home Depot), they usually have a large selection of magnets for doing things like magnetizing tools or hanging tools on walls.
- The sanding of the coils is probably the trickiest part. Reread these directions and see if

they correspond with your understanding of these instructions. Take your sandpaper and sand all of the insulation off of one tail of the coil (the wire sticking out from the coil). It should be bright and shiny copper all the way around. Now, lay the coil down on something that is safe to sand on. On the other tail, sand off all of the insulation on the top half of the wire. When you get through, the wire should be red on one side and copper colored on the other.

- Make the coil per the directions. If the coil is lopsided or the leads coming out either side are not exactly parallel or don't come off exactly halfway up the circle, then the coil will not turn as it should.
- Make sure your paper clips are good quality metal and are not covered with plastic or rubber. Sand them lightly on the surfaces that contact the battery and on the surfaces that the coil lays on.
- If all else fails, make sure you have a fresh battery -- previous errors in sanding the coils may have created a short circuit that drained your battery.
- Have someone else read the instructions without looking at your construction -- sometimes a fresh viewpoint can point out problems and misconceptions.

### **Science Behind the Motor:**

Wires are made of metals, which are good conductors. This means they carry electricity, or electric currents. A current is moving electric charges. Metals are good conductors because they are filled with electrons that are free to move around. (Plastics and other insulators have electrons that are stuck to atoms and molecules and can't move around to carry electric currents.) When you attach a wire to a battery, it causes the electrons (electric charges) to start moving inside the metal, or generating a current.

One of the coolest things in science is the fact that electricity and magnetism are very closely related to each other. The movement of electric charges creates a magnetic field. If you could see the magnetic field around a wire that has electricity flowing through it, it would look like a series of circles around the wire. If an electric current is flowing directly towards you, the magnetic field created by it circles around the wire in a counter-clockwise direction. If the direction of the electric current is reversed, the magnetic field reverses also and circles the wire in a clockwise direction. A quick trick for figuring out the direction of the magnetic field is the right-hand rule: Stick your right thumb in the direction the current is traveling, and the magnetic field goes in the direction your fingers are curled. This is why you have to wrap your electromagnet so it always goes in the same direction. If you wrap some of the wire around the nail in one direction and some of the wire in the other direction, the magnetic fields from the different sections fight each other and cancel out, reducing the strength of your magnet.

Besides electromagnets, which only work when electricity is flowing through them, there are permanent magnets. This is what you use to hang stuff on your fridge. Permanent magnets are ALWAYS magnetic – they don't need electricity to work. They are made of *ferromagnetic*

*materials* like iron, that have the magnetism ‘frozen in’. Usually this is done by heating up the materials until they are very hot, using an electromagnet to magnetize them, and then cooling them down very fast so that they don’t have a chance to go back to normal. Even if one magnet is a permanent magnet and the other is an electromagnet, they still have the same property: The north and south poles of a magnet attract, while two north poles or two south poles repel each other.

Now it becomes clear how the electric motor works: When the un-insulated parts of the coil make contact with the paper clips, current flows through the coil, making it into an electromagnet. Since magnets attract, the coil attempts to align itself with the ceramic magnet. However, when the coil turns to face the magnet, contact is broken (because the insulation on one tail is now preventing current flow). Inertia (the principle that an object in motion tends to stay in motion) causes the coil to continue around. When the coil makes a nearly complete spin, contact is re-established and the process repeats.

Technically (if you look up references on more complex motors), this motor is a single-pole pulse motor. More complex motors are created by using more than one coil and more complex set of brushes (the things that connect the coils to the current) so that no matter where the coil is in the spin pattern, at least one coil is always energized and trying to turn the coil assembly to align with the next magnet.

References:

<http://fly.hiwaay.net/~palmer/motor.html>

<http://education.jlab.org/qa/electromagnet.html>

## Speaker Activity

*This is a 'discovery' activity, where students are not given exact directions. Instead, they are given supplies and attempt many different configurations until they find one that suits their purposes. Getting started is the hardest part of this lab: students may need several hints. Be sure to highlight students who are headed in the right direction. This activity works well right after the electric motor activity, and uses the same magnets.*

**Science Topics Covered:** Electricity, Magnetism, Sound

### **Materials:**

Plastic food containers

Paper plates

Paper/plastic cups

Aluminum foil

Other miscellaneous paper/plastic materials to act as speaker base

Heavy gauge wire ( 1 meter per group)

Ceramic magnets (2 – 5 per group)

Clear Tape

Boom box or radio with external speakers (you need the kind with exposed, ordinary wires connecting the speakers to the source)

Optional: cow magnet

### **Supervisor Activity Guide**

The most difficult part of this activity is encouraging students to figure out what to do for themselves. When you give them some random supplies and tell them to make a speaker, they are CONVINCED that they will not be able to do it without your instructions. The key is to give them information and hints without telling them exactly how to do it.

If your group worked on the electric motor recently, it is easier to get started. Ask students, moving charges create what? (a magnet) How did you create an electromagnet in when you made your electric motor? (Made a coil of wire with batteries at the end) Which way does the magnet point? (This is a tricky point... Help students use the right-hand rule to figure out their magnets point through the coil. Which way is north and south depends on how they hooked up their battery.)

Ask them how they got the electric motor to move. With a little coaching, they will figure out that it was the two magnets (one electromagnet, one permanent magnet) repelling each other that caused the motor to turn. Tell them that to make a speaker they need to once again have two magnets repel each other to make movement.

The last concept they need is sound. Ask, What is sound? In physics, sound is simply a vibration of air. To make sound, all you need is something that is vibrating. That is why a guitar string makes noise when you pluck it; the string is vibrating. (Of course, if something is vibrating too slowly or the amount of vibration is small, then you won't be able to hear it.) How slow or fast something vibrates is called the frequency of the vibration, and corresponds to the pitch (how

low or high the sound is.) How small or large the vibration is determines the amplitude of the vibration, and corresponds to the volume (how soft or loud the sound is.) So if they want to make a sound, they must get SOMETHING to vibrate(or move) using electricity.

Show the students the boom box. Demonstrate that the radio works by turning on the speakers. Show the students the exposed wires on the back of the boom box. Explain that the wires carry electricity from the radio to the speakers. In some sense, the wires are carrying the sound in the form of electricity. The job of the speakers is to transform electricity into movement (vibrations), which makes sound. This is almost the same as the job of a motor, to transform electricity into movement.

One important concept for the students to grasp is that the wires from the back of the radio will supply electricity that is already flowing in a special pattern. (This special pattern is *alternating current*, but this concept is too difficult to explain unless the students are already familiar with the subject.) All the speakers have to do is make small movement based on that electricity. The radio has already done the hard part.

Now, let the students get started! They can use up to 1 meter of wire, 4 magnets, and any of the other supplies they want, and they can test their speaker as many times as they want. (You probably want to limit the wire and number of magnets to make it fair – students will soon discover that more wire and more magnets make it louder...) At the end of the hour (or designated time span) the person or group with the loudest speaker wins.

Troubleshooting:

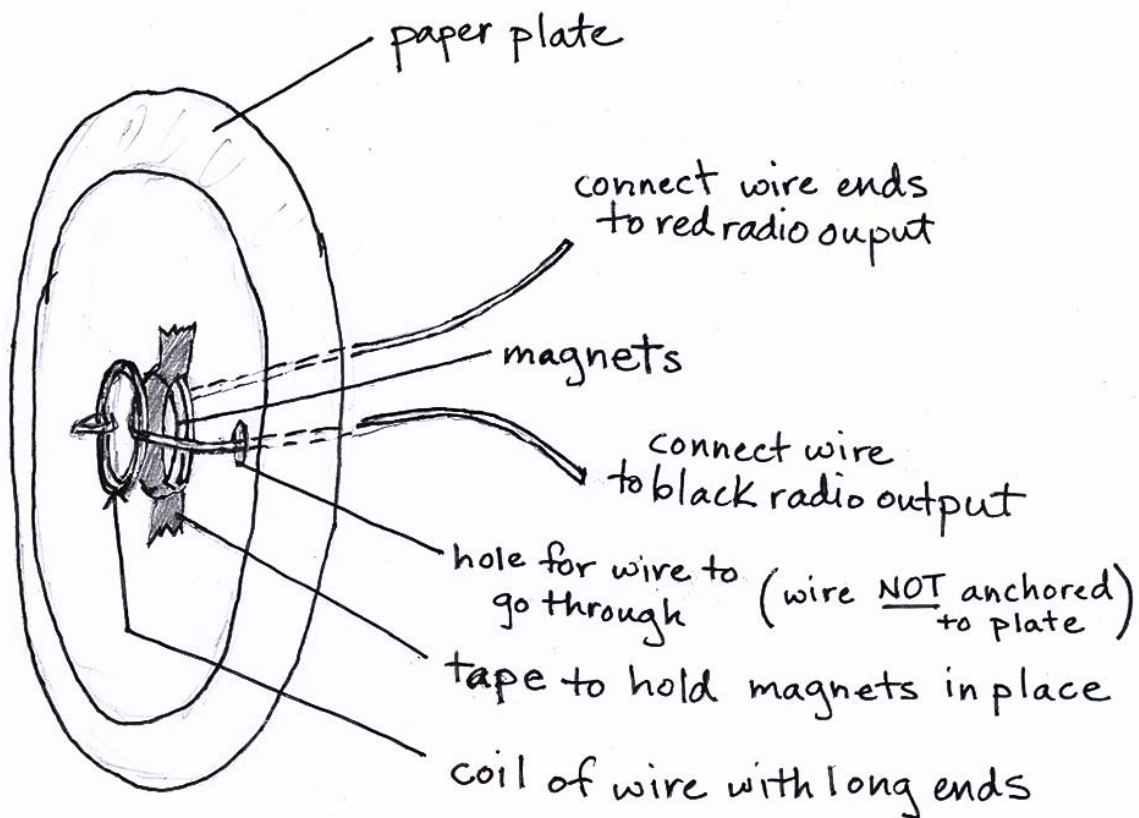
Keep the volume of the radio in a moderate range – too much volume and your ‘speakers’ could blow a fuse in the radio.

### **Good Speaker Design/ Things to Suggest/ Science behind speakers**

In general, these are the components of a good speaker design:

1. Must have a coil of wire (The longer, the better), with the ends of the coil attached to the outputs from the radio
2. The coil of wire should sit right above (or below) the permanent magnets. This causes the two magnetic fields to be parallel to each other. Electricity from the radio is alternating current, which means it rapidly switches direction. When electricity flows in one direction through the coil, the magnetic field of the electromagnet will be in the SAME direction as the permanent magnet, and the two will repel. When the current flows in the opposite direction, the two magnetic fields will be opposite of each other and the two will attract. Thus, the coil and the magnet will vibrate. If the students speakers are not very loud, one thing to check is how close together their magnet and coil are. The best design is to have the coil ring the permanent magnet without touching it.
3. The coil and the magnet should be independently anchored. This means that either the coil or the magnet should be held still, while the other vibrates against it. This is almost always a problem for students. Keep reminding them that they want to have something vibrate, which means that the two ‘magnets’ must be independent of each other. They should not be taped together.

4. To **amplify** the sound, attach a plate or cup or something to the vibrating object (either the coil or the permanent magnet, whichever is not being held still) If the thing you attach is thin and flexible, but not malleable, that will work best. (i.e. a paper plate works better than a rock or jello.)
5. To **direct** the sound, make a cone, and attach it to the vibrating object. This funnels the noise in one direction and makes it easier to hear along that direction.
6. Of course, the speaker will get louder if there is longer wire or stronger magnets. A good demonstration is to place a cow magnet near the ceramic magnets in the speakers and hear the speakers get louder.



## Human Arch and Paper Bridge Building Contest

*This is a relatively simple, yet fun activity. Students love the competition, and are amazed at how much weight a few pieces of paper can hold...*

**Science concepts:** Force, Compression, Load: Live and Dead, Effective use of materials

### **Materials**

Several sheets of plain paper such as photocopier paper

Scissors

Ruler

Five paper clips or one meter of tape

Small weights, such as metal washers, pennies, or film canisters filled with sand

Several books to support the sides of the bridge above the ground

### **Supervisor Activity Guide**

*The first activity is a simple icebreaker designed to give the students some intuition about what makes a strong bridge. The goal is to build a human arch that doesn't break when someone pulls on it.*

- Select three kids. Ask two students to form an arch by extending their arms towards one another and pressing their palms against each other.
- Direct the kids to backup until they are as far apart as possible, without breaking the arch.
- Ask a third student to GENTLY pull down on the arch. (Keep the pressure on until the arch collapses.)
- Ask the "arch" what happened. Have them describe what happened to the rest of the group.
- Introduce the kids to force (a push or pull acting on an object), compression (a squeezing force pushing a material together), live load ( the weight of whatever sits on, travels over, or hangs from a structure), and dead load ( the weight of the structure itself). Ask them how this affects their bridge.
- Select two more kids. Ask the group how they could use these two kids to strengthen the arch.
- Rebuild the arch and try out their ideas.

*The kids may need help getting to the idea of creating a buttress-having the two new kids sit on the floor with their backs leaning against the calves of the students forming the arch. If they are having difficulty ask leading questions, like "how did your legs feel when 'Sally' was pulling on your arms?" or "where would you place 'Johnny and Sarah' to help strengthen the arch?"*

- Once the kids have buttressed their arch, have the third child repeat pulling gently on the arch. What happens?

*If there is time, regroup the kids and ask them how hard was it to withstand the pulling in each situation? Which arch design was harder to collapse? What did you feel during the activity? How did the people sitting on the floor affect the strength of the arch? Can you identify the forces acting on the arch?*

*To give everyone an opportunity to experience compression, load, and butressing break the kids into groups of five. Ask them to repeat the entire activity, switching the roles within the group of five students so everyone has a chance to play each role.*

*Now they can start the paper bridge building contest. The goal is to have students build the strongest bridge they can out of one piece of paper and up to five paperclips that spans 20 cm (8 inches).*

- Lead a short discussion by asking the children to describe bridges they have seen around the area. Why do we need bridges? What do the bridges look like? What are qualities a bridge should have?
- Explain that the city has asked us to make a bridge that can span a river 8 inches wide. The bridge must be made out of one sheet of paper and up to five paperclips, and cannot be attached to the table or desk.
- Holding a piece of paper and one of the weights ask how many weights they think a piece of paper can hold. Explain that their bridge must be able to support the weight of the bridge, the dead load, but also the additional weight of the washers, pennies or canisters, the live load.
- Divide the children into groups of two and have one child from each group collect the needed materials.
- Each group should think out and sketch their design before building. Once a group has completed a bridge, have them set it up across the book supports placed 20 cm (8 inches) apart. Have one of the group members place weights, one at a time, in the middle of the span until the bridge collapses. The group should record how many weights the bridge supported.
- Ask the group what influenced the design for their bridge? Where did their bridge first break when it collapsed? How could they redesign that part of the bridge to be stronger? Have the group redesign and test their bridge again. Are there similarities in the design of each group's strongest bridge?

**Additional questions to investigate:**

If you could add one thing to make your bridge stronger what would it be? Try it and note the difference.

How could you make a bridge that would span 30 cm (12 inches)?

How could you design and build a structure out of paper and paper clips that will support a book at least 5 cm (2 inches) off the ground?

References:

American Society of Civil Engineers

<http://www.asce.org/public/handson.cfm>



## Squid Dissection

*The students in the science club REQUESTED a dissection. Surprisingly, most of the kids were not grossed out by the squishy squid. Through squid dissection, students will examine some of the unique features which have allowed squid to adapt and thrive in Southern California waters and throughout the world. This beginning dissection lesson will allow students to identify internal and external anatomy of the squid and the various functions of its organs. I didn't include cooking calamari when I did this activity, but the dissection itself took less than 45 minutes, so I am including the instructions for cooking calamari here to lengthen the activity.*

### Materials for dissection:

fresh or frozen whole squid (*Loligo opalescens*) (These can usually be purchased in 1lb frozen boxes in the seafood freezer section of a large grocery store.)

clean dissection scissors or basic student scissors

paper plates

paper towels

newspapers

student worksheets

### Materials for food preparation:

portable fryer and oil

2 containers for milk and flour

mallet (for tenderizing)

seasoned flour (such as *Dixie Fry*)

buttermilk

cocktail sauce (optional)

## Supervisor Activity Guide

1. Begin the activity by asking students what they know about squid. (You may wish to refer to the background discussion "Science Behind Squid".) Encourage questions, possibly making a list on the board that you may be able to answer as you continue through the dissections. Possible questions (relating to anatomy) might include:

How does it eat? What does it eat?

How does it swim? How does it "steer"?

How does it protect itself?

Is it male or female? How can you tell?

2. Using one squid for demonstration, and the diagram of external anatomy (attached), begin to discuss the external anatomy and relate the features to the way the squid functions in its marine environment. Important features include the **arms** and **tentacles**, for hunting and mobility, the **fins**, for stabilizing and turning the squid while swimming, and the **chromatophores**, which can change color to aid in finding a mate, or in warning other squid. You may choose to have the students use the student worksheets in addition to your discussion.

3. Once the students are prepared for the dissection, equip each student, or pairs of students, with a squid on a paper plate. Use newspapers to cover the area where they are working.

4. Ask students identify the external anatomy of the squid. Make sure they count the number of arms and tentacles. Have the students pull back the arms to locate the beak. As they identify the features, they can fill in the spaces on their anatomy handout.

5. After the students have had the opportunity to explore the external anatomy they are ready to begin the dissection. Instruct the students to position the squid on the plate with the siphon facing up.

6. Distribute scissors. (These are the easiest tools to work with; scalpels are not necessary and can be dangerous.) Ask students to make one long incision from the bottom of the mantle, above the siphon, to the tip of the mantle next to the fins. Be sure to instruct the students to lift up with their scissors when cutting so as not to cut into the internal organs of the squid.

7. Spread the mantle open and have the students identify the internal anatomy. Begin with locating the feathery gills and following those to their base to locate the hearts. Next have the students locate the gonads and explain the difference between the male and female gonads. Have the students view both sexes to see the difference.

8. When the students have located all of the internal organs, they can remove the arms and internal organs from the mantle. Have the students pick up their squid by the arms and while holding the mantle in the other hand, pull to separate the arms from the mantle. If done properly, the arms and internal organs will all come off in one piece. Students may notice a thin shell-like pen inside the mantle. They can pull the pen out of the mantle. (They may need to snip it out using scissors.)

**TEACHING TIP:**

*Depending on the class, you may wish to demonstrate the entire dissection for the class before asking them to do it. A video camera or flexcam could make this even more effective*

**NOW GET READY TO EAT THE SQUID!**

9. Have the students remove the fins by grasping the mantle in one hand and the fins in the other and pulling to remove the fins. Then have the students clean the mantle by removing any of the excess skin.

10. When the mantle is clean, have the students cut the mantle into strips, starting from the bottom of the mantle to the tip. Once the strips are cut have the students tenderize the squid by pounding it a few times with a block or meat hammer.

11. The students should first coat the squid strips with buttermilk, and then roll them in the seasoned flour mix. The teacher can then drop them carefully into the pre-heated deep-fryer, and let them cook until they curl up and float to the top of the oil, approximately 1 minute. The cooking should be done by an adult to prevent burns or other injuries.

12. Garnish with cocktail sauce and enjoy!

While the students are dissecting the squid, consider asking some questions to encourage discussion about the squid.

1. Where does the squid fit into the marine food web?
2. What role does the squid play in the ocean ecosystem?
3. What adaptations does the squid have that allow it to play this role?
4. Can you think of other animals that play a similar role in other ecosystems?
5. Have you ever used a squid for food or as fish bait?

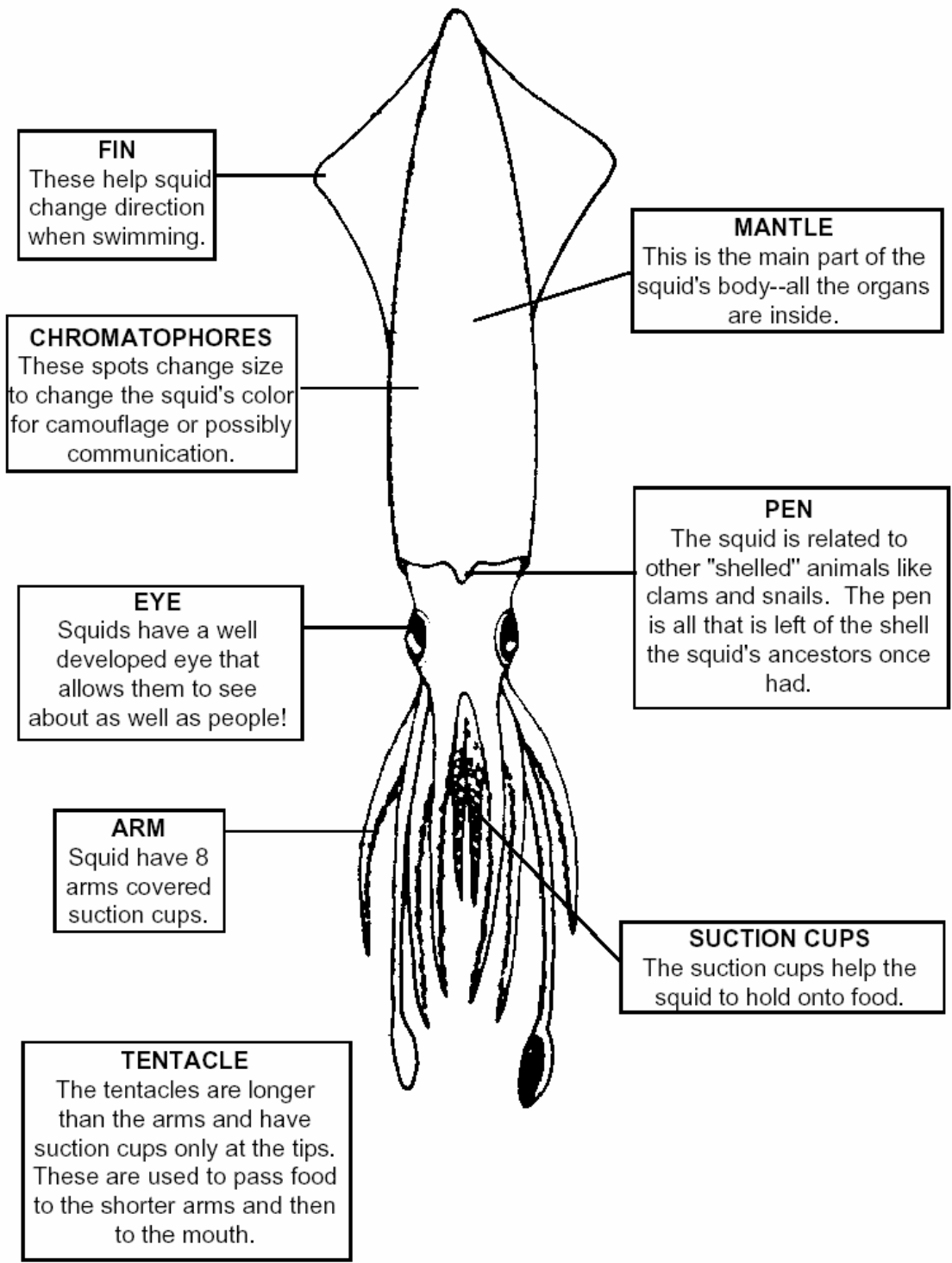
### Science Behind Squid

- The squid is one of the most highly developed **invertebrates**. Some of the animal's structures explored in this lesson illustrate the ways in which the squid has adapted to life in the ocean. Its streamlined body and "jet propulsion" which occurs as the squid squeezes water out of its body through its **siphon**, make the squid a fast, active predator. This animal also has a very good defense mechanism.
- All mollusks have a soft body with a special covering called the mantle, which encloses all of the body organs such as heart, stomach and gills.
- Squid can be as small as a thumbnail, or as large as a house. The giant squid, *Architeuthis*, can measure 60 ft. in length and weigh three tons!
- Squid have ten arms, which are wrapped around the head. Eight are short and heavy, and lined with suction cups. The ninth and tenth are twice the length of the others, and are called tentacles. Suction cups are only on the flat pads at the end of the tentacles.
- Squid feed on small crustaceans, fish, marine worms, and even their own kind! They use their tentacles to quickly catch their prey, which is pulled in by the arms and down to the radula, or beak, which uses a tongue-like action to get food to the mouth so it can be swallowed whole.
- Squid are a major food source for many fishes, birds and marine mammals.
- Squid produce a dark ink that they use to escape from predators. When a squid is startled, the ink is released through the anus, and the cloud of inky water confuses the predator while the squid swims away.
- After mating, a female squid will produce 10-50 elongated egg strings, which contain hundreds of eggs each. In many species, the parents will soon die after leaving the spawning ground. The egg strings are attached to the ocean floor, are left to develop on their own, and hatch approximately ten days later.
- Squid are an important part of the ocean food web. Squid are gaining popularity as a food source for humans around the world. Overfishing is a growing concern because there are no regulations on squid harvesting.
- Southern California squid populations spawn mainly in the winter (December to March). Squid are seined commercially at their spawning grounds. About 6,000 metric tons are taken yearly for human food and bait.

### References

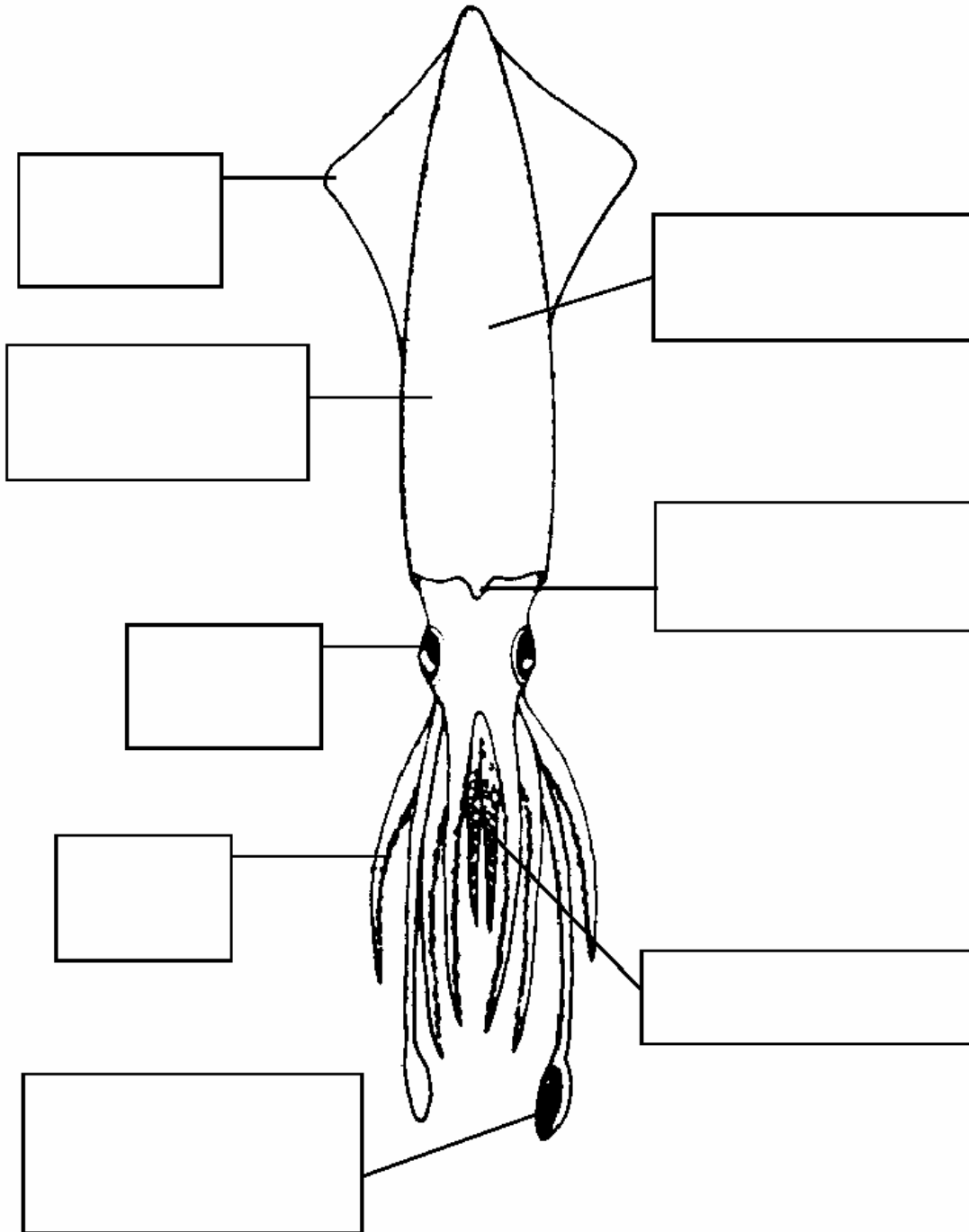
- <http://www.nhm.org/seamobile/PDF/clasacts/sqd%20i.pdf>  
<http://giantsquid.msstate.edu/LessonList/dissection.html>

From Pen to Ink  
**Squid: External Anatomy**

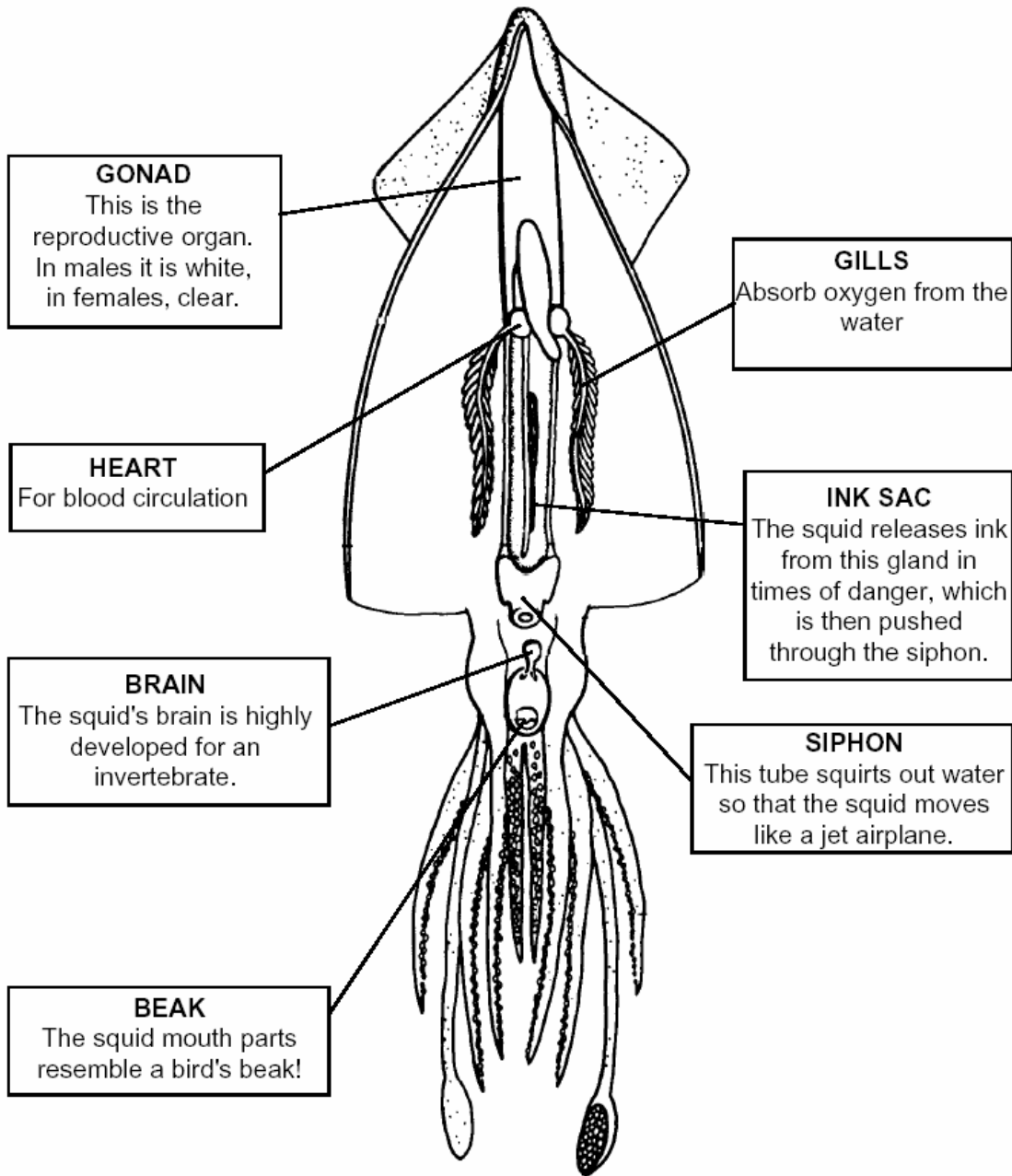


From Pen to Ink

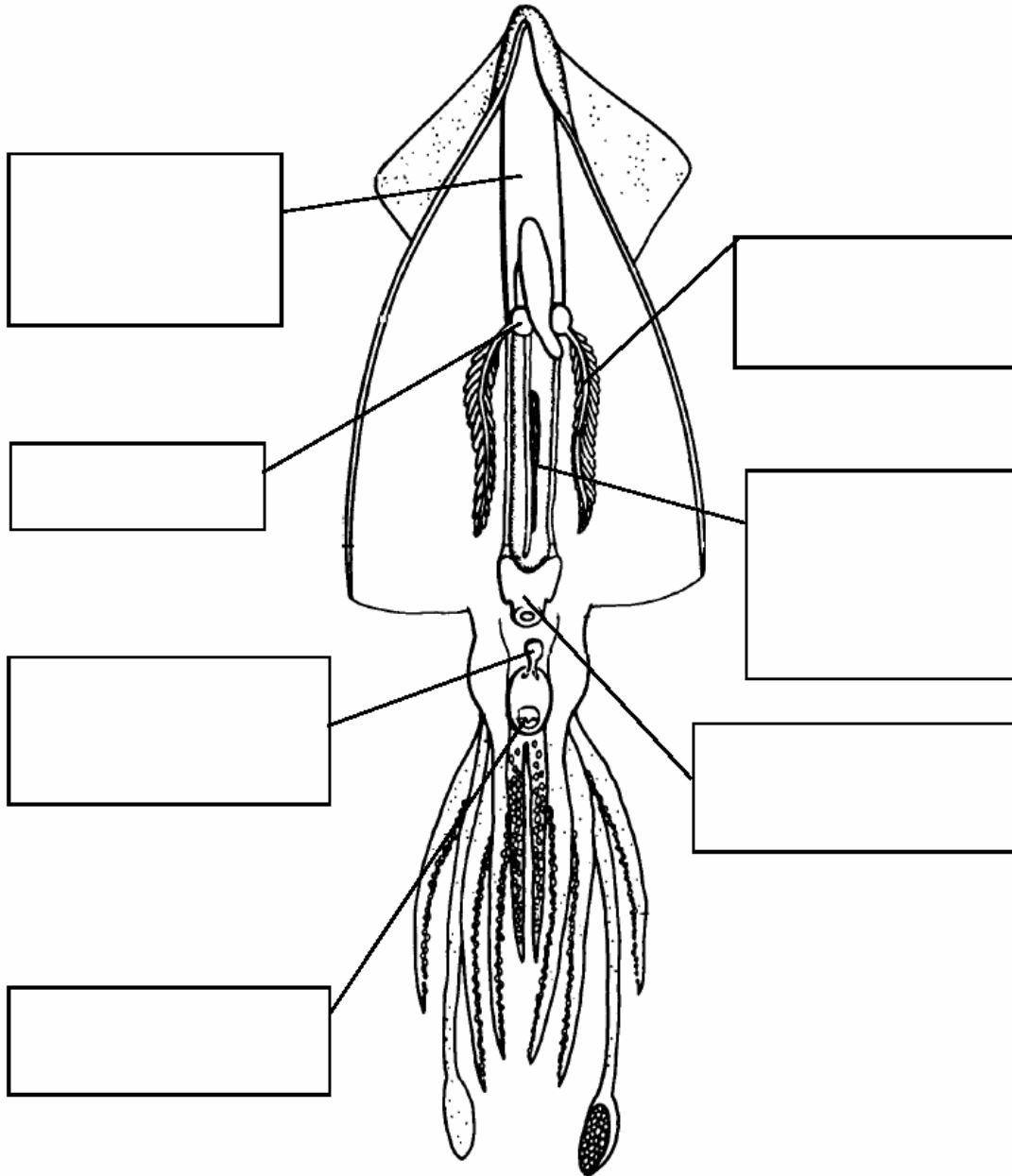
# Squid: External Anatomy (student worksheet)



From Pen to Ink  
**Squid: Internal Anatomy**



From Pen to Ink  
**Squid: Internal Anatomy** (student worksheet)



## Shrinky Dinks, Goofy Putty and Ooze

(3+ hours total activity time)

*This was the favorite activity for the students in my club, and it took two weeks to complete. We completed creating Putty and Ooze right before Halloween. We worked on the Shrinky Dinks together first, then split into two separate groups, one working on Goofy Putty and one on Ooze. The following week we swapped groups. These activities could be run consecutively, as well.*

**Science Topics covered:** Chemistry of plastics, polymers. Viscosity of Liquids, flow. Recycling.

### **Materials:**

#### *Shrinky Dinks*

- Shrinkable Polystyrene Plastic ( PS - Recycle Code 6 )
  1. Clear plastic salad or bakery boxes.
  2. The top of Dannon yogurt containers.
  3. Allene's Shrinkable Plastic ( available at Michael's or Hobby Lobby, but expensive
  4. Clear polystyrene drinking cups ( SAM's Wholesale Club )
  5. Disposable Petri dishes ( not really recommended ).
  6. Other types of plastics with a #6 Recycle Code ( clear, opaque, and foamed )
  
- Permanent markers -- Fine and/or Regular-tipped.
- Toaster oven with dial control ( a regular oven can also be used ).
- Scissors and Paper punches.
- Aluminum foil or Cookie sheet.
- Brown Jersey Gloves or Insulated gloves.
- Rulers/Meter sticks ( for linear measuring ).
- Electronic or Pan-type Scales ( for measuring mass ).
- Calipers ( optional -- for measuring thickness ).

#### *Ooze*

- One box of corn starch (16 oz.)
- Large mixing bowl
- Cookie sheet, square cake pan, or something similar
- Pitcher of water
- Spoon
- Gallon size zipper-lock bag
- Newspaper or a plastic drip cloth to cover the floor
- Water
- Food Coloring

#### *Goofy Putty*

- Elmer's Glue® (glue-all or school glue)
- Borax (Borax brand powdered soap, readily available in most grocery stores.)
- Zipper-lock bag (quart size)



- Empty plastic soda bottle with cap
- Water
- Newspaper to cover the work area
- Optional: food coloring

### **Shrinky Dink Supervisor Guide:**

by Wayne Goates, Kansas Polymer Ambassador .Copyright 1997 Wayne Goates.

- Turn on the toaster oven ( or regular oven ) and preheat it to 165-170 C or 325-350 F.
- You will have a plastic salad lid in which to work with. Some prefer to cut the fluted edges from the lid while others choose to leave the edges on. The fluted edges will actually "shrink" flat, but they sometimes cause curling problems when heat is applied. I recommend you cut and discard the fluted edges.
- Using permanent markers, you should decorate your lid at this time. If you have a traceable pattern you may use that as a guide or make a freehand drawing. Paper punch holes and any cut-outs you wish should be made at this time. Once the plastic is heated, it will be impossible to add punch-outs as the plastic will be too brittle.
- After you have decorated your lid, punched it, and made all of the cut-outs you need, you should record your initial measurements using the ruler/meter sticks, scales, and by using calipers:
  1. Use ruler/meter sticks to record Length and Width.
  2. Use calipers to record the Height.
  3. Use electronic scale to record the Mass.
- Place the samples on an aluminum foil or cookie sheet and heat in the toaster oven. It is recommended that you heat the sample with the decorated side "up" so that the ink will not stick to the aluminum foil or cookie sheet. It is recommended that the teacher do the heating to minimize any chance of burns and to control the heating apparatus.
- Generally the heating process is less than one minute. Trying to speed up the process by increasing the heat may tend to distort the plastic or make it curl up. In addition, the melted plastic is harder to handle and off-gassing of the polystyrene may occur.
- After you have visually seen that the plastic has "shrunk," remove the foil or sheet from the toaster oven so the plastic may cool. I like to invert the foil and set the plastic by patting the inverted foil with my gloved hand. This tends to flatten the shrinky dink.
- Cooling is very fast ( less than one minute ). Be careful as the plastic is extremely brittle at this stage. If waves occur in the finished product, it is usually due to the waves in the aluminum foil and the setting process in "G" above.
- Measure and record the Length, Width, Height, and Mass of the "Shrinky Dink" using the ruler/meter sticks, calipers, and electronic scales. This may be a good time to talk about the Law of Conservation of Mass. While the polystyrene may change its shape and appearance nothing has been lost or gained. The mass should still be the same.

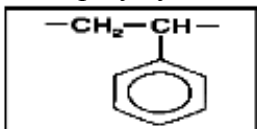
### **Safety Considerations**

As you will be working with a toaster oven at high temperatures, care should be taken to avoid unnecessary contact with the heating elements. You may wish to use either Brown Jersey gloves, Insulated oven gloves, or similar protective handwear. It should also be noted that the

polystyrene used in this activity when subjected to heat will melt. Contact with the skin or clothing should be avoided. When operating the toaster oven, please follow the recommended temperature settings so as to avoid potential toxic off-gassing that may occur as a result of heating the polystyrene. It is recommended that the teacher or an adult do the heating.

### Science Behind Shrinky Dinks

Plastics are polymers that are made of long chains of repeating molecules. The plastic in a milk carton is a synthetic polymer containing the molecule  $\text{CH}_2=\text{CH}_2$ . This is a monomer. If several of these molecules are linked together you create a polymer chain. In this activity, the plastic we will use is polystyrene which is very easy to work with when heated.



**Structure of Polystyrene**

Polystyrene cups that are clear and brittle will demonstrate the order of the polymer chains when you crack the cup to break it. It cracks the direction of the chains that are parallel to the length of the cup. The cup is extruded in the lengthwise direction during manufacturing so the chains are parallel in that direction. The term thermoplastic refers to thermo (heat) and plastic (formable). Certain polymer plastics have the ability to shrink when heated due to the way in which they are made. In the production of the plastic salad lids we are using, the polystyrene is heated, stretched out into a film, and then quickly cooled. This sudden cooling "freezes" the molecular arrangement of the polystyrene



This stretching can occur in one direction ( called **axially oriented** ) or in two directions perpendicular to one another ( called **biaxially oriented** ). While polymers that are oriented in two directions shrink proportionally in two perpendicular directions, other polymers that are oriented in only one direction shrink more in one direction than the other. The plastic may be reheated again and again to correct curling, but once a piece is dropped and broken, the broken piece will not mend.

The ability of polystyrene ( i.e. -- "Shrinky Dinks" ) is somewhat unusual. Most solids, when heated, either expand before they melt into liquids ( i.e. -- metals ) or decompose ( i.e. -- wood ). When polystyrene is heated at low temperatures ( 250-300 F ), it softens, but does not decompose and there is no shrinking or change in mass. One of the fundamental laws of physics is the Law of Conservation of Matter which essentially states that **Matter cannot be created or destroyed, but it may be changed**. Heating the polystyrene does not cause a loss of mass, but there is an obvious change and this helps to prove this law.

When we heat the "Shrinky Dink" material at 300-350 F, these "frozen" molecules are released from their stretched-out configuration returning to their original dimensions and appearing to "shrink." It is for this reason that many refer to polystyrene as memory plastic as it remembers its original configuration prior to it being stretched-out. See the figure below that illustrates the heated polymer returning to this original "shrunken" state.

And what about higher temperatures such as 400 F? Well, I for one do **NOT** recommend higher temperatures for obvious safety considerations, but the shrink rate would definitely be faster. It may also produce toxic off-gassing of the polystyrene.

Shrinky Dinks are manufactured by Colorforms; Ramsey, New Jersey 07446 or Milton Bradley; Springfield, Massachusetts 01101.

### **Ooze Supervisor Guide:**

*This amazing mixture behaves like a solid and a liquid at the same time. By the end of the activity, you will have your hands on, in and all over this wonderful solid-liquid-like mess.*

1. Pour approximately  $\frac{1}{4}$  of the box of cornstarch into the mixing bowl and slowly add about  $\frac{1}{2}$  cup of water. Stir. Sometimes it is easier to mix the cornstarch and water with your bare hands -- of course, this only adds to the fun. Continue adding cornstarch and water in small amounts until you get a mixture that has the consistency of honey. It may take a little work to get the consistency just right, but you will eventually end up mixing one box of cornstarch with roughly 1 to 2 cups of water. Notice that the mixture gets thicker or more viscous as you add more cornstarch.

2. Pour the mixture onto the cookie sheet or cake pan. Notice its unusual consistency when you are pouring it into the pan. Stir it around with your finger, first slowly and then as fast as you can. Skim your finger across the top of the ooze. What do you notice? Sink your entire hand into the ooze and try to grab the fluid and pull it up. Try to roll the fluid between your palms to make a ball. You can even hold your hand flat over the top of the pan and slap the liquid ooze as hard as you can. Most students will run for cover, as you get ready to slap the liquid, fearing that it will splash everywhere. Fear not, all of the ooze stays in the pan...hopefully. If your mixture inadvertently splatters everywhere, you will know to add more cornstarch. As your students play with the ooze, ask them to speculate why the liquid behaves in this manner. What causes it to feel like something solid when you squeeze it, yet it flows like syrup as it drips off your finger? When you are finished, pour the ooze into a large zipper-lock plastic bag for later use.

### **Science behind Ooze:**

How does ooze act like a solid sometimes, and a liquid at other times? Actually, "ooze" is an example of what is called a Non-Newtonian fluid - a fluid that defies Isaac Newton's law of viscosity. All fluids have a property known as viscosity. It is the measurable thickness or resistance to flow in a fluid. Honey and ketchup are liquids that have a high resistance to flow. When I think of viscosity, I always remember the television commercial of the child who is patiently waiting for the ketchup to flow out of the bottle and onto the hamburger bun. Be thankful that the viscosity of ketchup is greater than that of water the next time you are sitting across the table from somebody who is pounding on the bottom of the ketchup bottle.

Newton stated that the viscosity of a fluid can be changed only by altering the fluid's temperature. For example, motor oil or honey flows more easily when you warm it up and becomes very thick when it gets cold. So, a Non-Newtonian fluid has the same dependence on

temperature, but its viscosity can be changed by applying pressure. When you squeeze a handful of ooze, its viscosity increases so it acts like a solid for a split second. When you release pressure, the ooze behaves just like a liquid.

Ironically, the cornstarch will not stay mixed with the water indefinitely. Over time, the grains of cornstarch will separate from the water and form a solid clump at the bottom of the plastic storage bag. It is for this reason that you must not pour this mixture down the drain. It will clog the pipes and stop up the drain. Pour the mixture into a zipper-lock bag and dispose of it in the garbage.

### **Goofy Putty Supervisor Guide**

1. Make the Borax water: Add 1 tablespoon of Borax powder to 1 cup of water. Remember that one cup of Borax water will make many batches of Goofy Putty.
2. Preparing the Glue: Measure 2 tablespoons of Elmer's Glue into a zipper-lock style bag. Add 1 tablespoon of plain water to the bag and mix. The additional water makes the glue very runny. If you have food coloring, add 4 or 5 drops now.
3. Making Goofy Putty: Add 1 tablespoon of the Borax water to the bag of watered-down glue. Seal the bag and squeeze for 2 minutes in order to thoroughly mix the liquids. What is happening to the runny glue? What changes are taking place?

### **Science behind Goofy Putty:**

The mixture of Elmer's Glue with Borax and water produces a putty-like material called a polymer. In simplest terms, a polymer is a long chain of molecules. You can use the example of cooking spaghetti to better understand why this polymer behaves in the way it does. When a pile of freshly cooked spaghetti comes out of the hot water and into the bowl, the strands flow like a liquid from the pan to the bowl. This is because the spaghetti strands are slippery and slide over one another. After awhile, the water drains off of the pasta, the strands start to stick together. The spaghetti takes on a rubbery texture. Wait a little while longer for all of the water to evaporate, and the pile of spaghetti turns into a solid mass -- drop it on the floor and watch it bounce. Many natural and synthetic polymers behave in a similar manner.

Polymers are made out of long strands of molecules like spaghetti. If the long molecules slide past each other easily, then the substance acts like a liquid because the molecules flow. If the molecules stick together at a few places along the strand, then the substance behaves like a rubbery solid called an elastomer. Borax is the compound that is responsible for hooking the glue's molecules together to form the putty-like material.

There are several different methods for making this putty-like material. Some recipes call for liquid starch instead of Borax soap. Either way, when you make Goofy Putty you are learning about some of the properties of polymers.

**Additional Information:**

The Elmer's Glue version of slime is very easy to make, but it's not exactly what you'll find at the toy store. So, what's the "real" slime secret. It's an ingredient called polyvinyl alcohol (PVA) which produces a superior slime. Longer lasting, more transparent... it's the real deal.

## References:

<http://www.geocities.com/CapeCanaveral/Cockpit/8107/polystyrene.html>

<http://www.stevespanglerscience.com/experiment/00000039>

<http://www.stevespanglerscience.com/experiment/00000047>

## Stomp Rockets

*This is an activity for a day when it is sunny outside. Ask students to collect 2 liter bottles so they can each take their rocket launcher home with them.*

**Science Topics:** Pressure, Force, Aerodynamics, Air Pressure

### **Materials:**

#### *Launcher:*

- Empty 2-liter bottle
- Duct Tape
- About 60 centimeters (2 ft) of PVC pipe with ½-inch inner diameter. (Can be found in the Plumbing section of hardware store)

*Ask the hardware store to saw your PVC pipe into the lengths you need.  
If they won't you'll also need a hacksaw blade; wrap one end of the blade with duct tape to make a "handle" and cut the pipe yourself.*

- About 1 meter (3 feet) of clear flexible vinyl tubing with ½-inch inner diameter and 5/8 - inch outer diameter (the type of tubing doesn't matter, as long as you can tape one end to the neck of the soda bottle and the other end to the PVC pipe)
- Meter stick

#### *For each Rocket:*

- 2 pieces 8.5 by 11-inch Scrap Paper
- 30 cm (1 foot) of same PVC pipe used for launcher (for every five students)
- Index cards
- Markers
- Paper clips
- Small Washers
- Scissors
- Clear tape
- 

PRIZES (candy?) for best rockets

## **Supervisor Activity Guide:**

### *To Begin the Activity:*

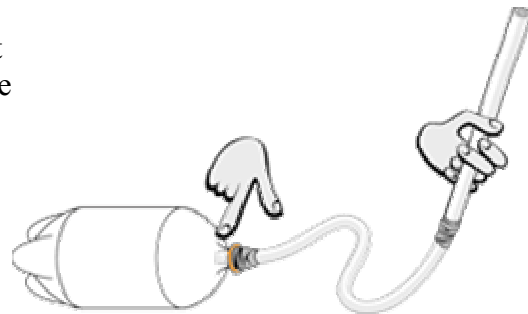
At the Exploratorium, we introduce this activity by launching a rocket once, inside the room, just to show the group how cool it is. If you do this, be sure to point the launcher away from the group, in a direction where the flying rocket won't hurt anyone or anything.

After launching the rocket, blow into the PVC pipe to re-inflate the soda bottle so you are ready to launch again. We suggest that you put your hand around the end of the pipe to make a mouthpiece and put your lips against your hand

*After students stomp on the rocket launchers more than 10 or so times, the launchers will lose effectiveness and may not even re-inflate. It is best to have one launcher per student, or several extras on hand. It takes about 10 minutes to make a launcher, so you can do this before hand or have the students make them themselves.*

### *To Make Rocket Launcher:*

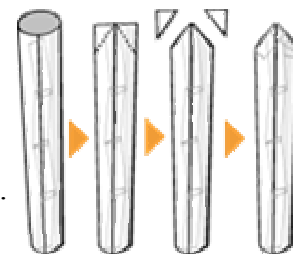
- Remove cap from bottle.
- Insert about an inch of flexible tubing into the bottle opening. Tape it in place with duct tape. Try to make the connection between the tubing and the bottle airtight.
- Push the PVC pipe against the other end of the flexible tubing. (Don't try to insert the tubing into the PVC pipe.) Tape the tubing and the PVC pipe together. Again, try to make the connection airtight.



*There are many ways to proceed with the rocket activity. One fun way is to have the students make a very basic rocket, go outside and launch, measure how far they go, then come inside and make adjustments (add nose, fins, etc.) and then go out to launch again. This helps the students understand how aerodynamic design improves the rockets.*

### *To make the basic rocket:*

- Roll a sheet of 8 1/2" x 11" paper into a cylinder that will fit over the tube. The paper should not be tight around the PVC pipe, but should be able to slide off easily. Tape your paper tube so it stays rolled up, and slip it off the PVC pipe. Put the PVC pipe aside.
- You can roll your sheet of paper the long way or the short way.
- With scissors, clip the end of the tube to make it pointed. Use tape to seal the point so it's airtight. This will be the "nose" of



the rocket.

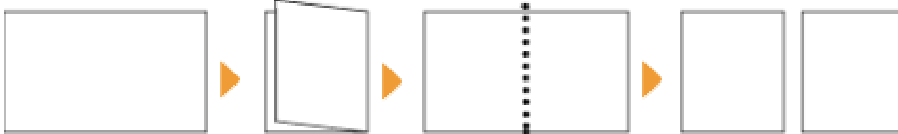
- If desired, have students tape a few washers/pennies to the back of a folded index card, and write their name on the front. This will act as a marker for where their rocket landed.
- As the students finish creating the basic rocket, have them sign up for a launch position: If they launch in a set order they won't go crazy when they get outside.

*Launch procedure:*

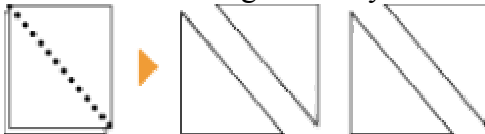
- Go outside. Have students take turns volunteering to be 'aimers'. Place the rocket on the end of the launcher and have the 'aimer' aim the PVC pipe in a way so that they think the rocket will travel the farthest distance measured on the GROUND. (They should aim at around a 45 degree angle from parallel to the ground.) Ask the students how far away the rocket would go if the 'aimer' aimed straight up. Would it go further if the 'aimer' aimed parallel to the ground, or slightly up in the air?
- Have the student who made the rocket stomp on the 2-liter bottle. Then either 1) place a weighted marker on the ground where their rocket landed or 2) measure with the meter stick how far their rocket traveled and record it.
- Tell the students they get another chance to make their rocket better, and go back inside the work tables.

*Now ask the students what they could do to make their rockets better. Ask them about paper airplanes they may have made in the past. How can they make their rockets more **stable** in flight? Rocket fins, of course:*

- Rocket fins will help your rocket fly straight. Fins are usually triangular shapes. Cut fins from a 3" x 5" card or some other stiff paper. Here's one way to cut them from a 3" x 5" card.
- Fold the card in half to make a short rectangle. Unfold it and cut along the fold line.

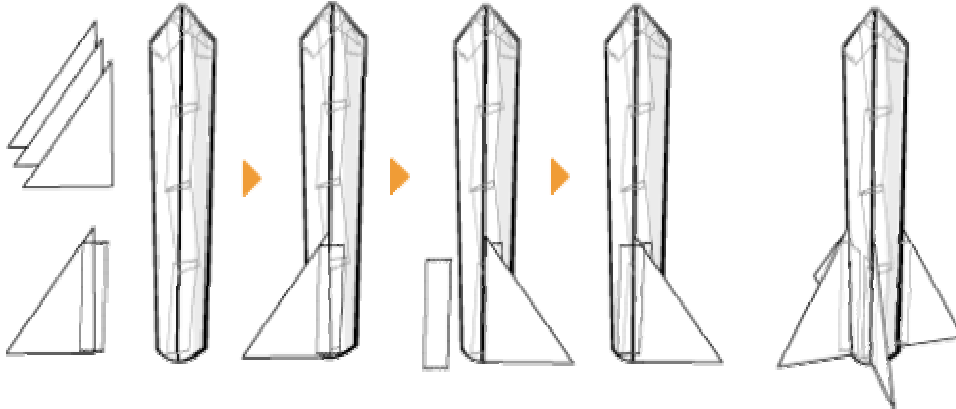


- Stack the two halves of the card. Draw a line from one corner of the folded rectangle to the other. Cut along the line you've drawn and you'll have four fins.





- Tape the fins to the sides of the rocket at the base. Be sure to tape both sides of the fin to the rocket.



- Have students make another weighted marker. Go back outside and repeat the Launch procedure.

*Now ask the students what else might improve the distance of their rocket. With some propting, they will come up with the idea of a nose cone. You can weight the nose cone to make it even better:*

- Cut out a half circle from a 3 by 5 index card. Tape one or two washers/paperclips near the center at the top of the half circle. Overlap the two sides of the half circle to form a cone (with the weights at the apex) and tape the cone together.
- Taping the nose cone to the rocket is tricky. One way to do it is to fold a piece of tape in half with the sticky side out. Attach one half to the rocket body and one half to the inside of the nose cone. Repeat 3 times around the rocket.
- Make another weighted marker, and repeat the launch procedure

*You can try other variables as well – angle of aim for the rocket, weighting the body of the rocket with washers, shortening or lengthening the rocket, making the rocket tighter or looser on the PVC pipe. Let the students be creative. Also, let the students use colored pencils and markers to decorate their rockets.*

*Sometimes the rockets themselves will be too tight or too loose on the PVC pipe. The rocket will have to be disassembled and rolled tighter/less tight before continuing. Tell students to be careful not to jam their rockets onto the end of the PVC pipe, as that will rip the inside of the rocket and make it impossible for them to launch again.*

### **Science Behind Stomp Rockets**

Rockets move when a force acts on them. There are many similarities and differences between stomp rockets and space shuttles used by NASA. Our stomp rockets are propelled by air pressure. Stomping on the bottle causes a rapid increase in the air pressure in the bottle. Because air always moves from a region of high pressure to low pressure, the air rapidly exits from the

high pressure area inside the bottle to the low pressure outside air through the PVC opening. This quickly moving air provides a force that propels the rocket upward. Once the rocket is aloft, gravity and the effects of air resistance are what determine its flight. Gravity is a force that always pulls objects towards the ground. Air resistance is a force that acts when air (which is everywhere in the sky) pushes against the rocket as it tries to fly in a straight line. It slows the rocket down. (Just like water slows you down when you try to walk through it, air slows you down as well.) To help your rocket cut through air, you try to do two things. *Stabilize* your rocket, and make it more *aerodynamic*. You stabilize your rocket by adding fins. This prevents it from wobbling in the air and losing energy. You want your rocket to use all of its energy going forward, not side-to-side. You make your rocket more aerodynamic by adding a nose cone. This helps the air to travel smoothly around the sides of your rocket. Think of very fast airplanes and cars. They are all very smooth and pointy in the front, which helps them ‘cut’ through the air. This makes them faster and more aerodynamic.

NASA space shuttles are made with nose cones and fins to make them aerodynamic and stable, too. However, they use a different type of force to make them go. It is called solid-fuel propulsion. NASA rockets throw fuel out of the back of the rocket. By Newton’s law, every action (force) has an equal and opposite reaction. So when the rocket engine throws stuff out the back, the rocket itself has to move forward. Think of wielding a giant fire hose – the water shoots out one way, causing the person holding the hose to be pushed the other way. If you are interested in how space rockets work, here is a good article:

<http://science.howstuffworks.com/rocket1.htm>

References:

[http://www.exploratorium.edu/math\\_explorer/tfl\\_stompRockets.html](http://www.exploratorium.edu/math_explorer/tfl_stompRockets.html)

<http://www.raft.net/resources/ideas/stomp%20rocket.pdf>

## **Holiday/Christmas Lights**

*This is a great activity close to the Holidays. It is an excellent 'discovery' activity, where you give the students few directions, but instead let them try different possibilities until they come up with one that works. They can take their 'strands of light' home with them.*

**Topics covered:** Electricity, Circuits, Light bulbs, bimetallic strips

### **Materials for each child:**

Scrap paper

One 9 Volt battery (Typical 'C' and 'D' batteries do not have enough voltage to light Christmas lights. CAUTION: If a 9 volt battery is short-circuited it will get hot very quickly, and left for several minutes it could get hot enough to cause burns.)

Aluminum foil

Rubber band

Scissors

Transparent tape

2.5 V Miniature Christmas lights (you can either buy packs of replacement bulbs or buy entire strands and scavenge the bulbs from the strand. Also, replacement 'blinker' lights are really cool.)

One extra Christmas light strand for demonstrations (50 lights, 2.5 V)

### **Supervisor Activity Guide/ Science Behind the Activity**

You can approach this as either a 'discovery' activity or a 'planned' activity. The discovery method takes longer and requires a little more one-on-one attention, but ultimately leaves the kids feeling like inventors.

First, caution the students not to short-circuit their batteries. Explain that this is when there is a direct metal path from the positive terminal to the negative terminal of the battery. Show them what a short circuit would look like. If a battery starts to get hot, it is almost certainly short-circuited. Tell students that if their battery starts to get hot, they should IMMEDIATELY disconnect the circuit.

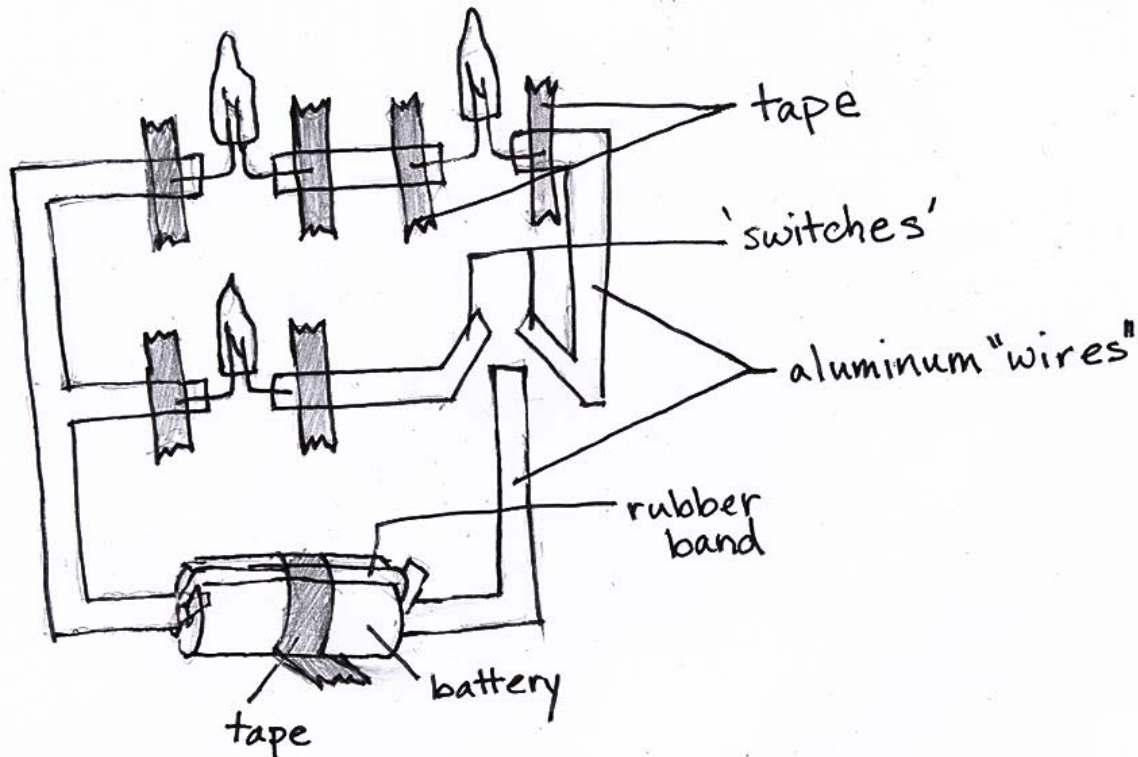
Next, explain that aluminum foil is a conductor and will be used as the 'wires' in their holiday lights. Show how the rubber band can be used to ensure good connections between the foil and the battery terminals.

Show them the two wires leading out of the miniature light bulb. If the two wires touch each other, the light will be short circuited, so it is very important to keep the wires separate. Tell them that a light bulb lights up when electricity flows in one wire and out the other. Connecting the two wires inside the bulb is a special wire called a filament, which glows white hot when electricity goes through it. That's what lights up a light bulb.

Ask them to make a circuit that lights up a single Christmas light. Challenge them to make a circuit that stays on when they aren't touching it. (Suggest anchoring the battery on a piece of scrap paper and taping down the aluminum foil connections.)

Tell the students there are two different ways of connecting two lights together and making them both light up – Called ‘in series’ and ‘in parallel’. When in series, the lights will shine half as bright as a single light alone. In parallel, the lights will both shine just as bright as a single light alone. Challenge the students to connect their two lights in two different ways: Once where the lights are just as bright as a single light, and a different way where the two lights are noticeably dimmer. Give the first student to demonstrate both a prize.

Here is one suggested set-up for the Christmas lights (the entire thing is mounted on scrap paper):



If the top ‘switch’ is closed, (the right-hand piece of aluminum wire is connected to the middle wire in the diagram) then the top two bulbs will light up. They are in series. If the bottom switch is closed (and the top switch is also closed), the bottom bulb will also light up. It is in parallel with the top two bulbs. It will be twice as bright as the top two bulbs.

If the students are interested or start asking questions, you can tell them about current and voltage. When two lights are in series, they get the same amount of current, but each gets half as much voltage. When the lights are in parallel, they get the same amount of voltage, but half as much current. So it is the voltage that causes the lights to get brighter or become dimmer. Compare how bright a light is in a 9-Volt battery circuit to how bright the lights are in a normal strand of Christmas lights. How many lights are there in the strand? (50) On the box for the lights it should say how many volts each light requires (2.5 V). How many volts does the strand need? (2.5\*50) How many volts are supplied through an outlet? (120 V  $\approx$  2.5\*50)

The students can then make their own designs/Christmas light strands. If the lights do not light up, this either means that the light is short circuited (i.e., there is a metal path from the positive to the negative terminal of the battery that by-passes the light) or that the connection between the wires(of the light) and the aluminum foil is bad. Also remind them that too many lights in series will not glow very brightly at all.

Ask the students to make a switch for their light strand. They can turn their lights on and off by closing and opening their circuit. This is how real light switches work, too.

Ask the students if they have ever had a strand of lights where the whole strand would go dark if one bulb was dead. Have they ever had light strands that would keep glowing even if one bulb was dead? Most newer strands stay lit. If you look closely at a bulbs in these newer sets, you can see the shunt wire wrapped around the two posts inside the bulb. The shunt wire contains a **coating** that gives it fairly high resistance until the filament fails. At that point, heat caused by current flowing through the shunt burns off the coating and reduces the shunt's resistance. (A typical bulb has a resistance of 7 to 8 ohms through the filament and 2 to 3 ohms through the shunt once the coating burns off.) In the photo below, the filament is the very thin wavy wire between the two posts, and the red arrow points to the shunt.



Another cool thing to look at is an old-fashioned blinker light, the kind with a red tip. (You can buy replacement packs of 3 at drug stores.) Tell the students that if they want their lights to blink, they can replace one of their lights with a blinker light. In a minute or two (once the light starts to get hot), their circuit will begin blinking.



How does the blinker light work? It has an extra piece of metal inside called a **bi-metallic strip**. The current runs from the strip to the post to light the filament. When the filament gets hot, it

causes the strip to bend, breaking the current and extinguishing the bulb. As the strip cools, it bends back, reconnects the post and re-lights the filament so the cycle repeats. Whenever this blinker bulb is not lit, the rest of the strand is not getting power, so the entire strand blinks in unison. Obviously, these bulbs don't have a shunt (if they did, the rest of the strand would not blink), so when the blinker bulb burns out, the rest of the strand will not light until the blinker bulb is replaced.

References:

<http://home.howstuffworks.com/christmas-lights2.htm>

Ideas for next quarter  
1/4/04

tie-dye T-shirts  
science concepts:  
solubility, capillary action  
<http://www.stevespanglerscience.com/experiment/00000032>

Iron in your breakfast cereal  
<http://www.stevespanglerscience.com/experiment/00000034>

Imploding soda can  
<http://www.stevespanglerscience.com/experiment/00000043>

Vegetable Acid/Base indicators  
'Cup and Saucer Science' book from Wendy

hot air balloon p. 64 bill nye the science guy book

Lemon batteries p.102 bill nye the science guy book.

Building a barometer p.137 Bill nye the science guy

Electrolysis p. 19 bill nye the science guy book

Marine Touch tank field trip

Robotics

Salt Volcano separate worksheet from science explorer  
(not enough time for an entire club meeting)

Optical Illusions day – spot pictures, moiré patterns (pg. 60-3 in the exploratorium book)

Mealworms (p 123 in Science on a shoestring book)

Starfish dissections

Acid Rain experiment p 80 shoestring book

Design a traveling seed

Foam Towers (hand out inside the exploratorium book)

Black marker filter p 22 exploratorium book

Cups of mystery – exploratorium p. 98