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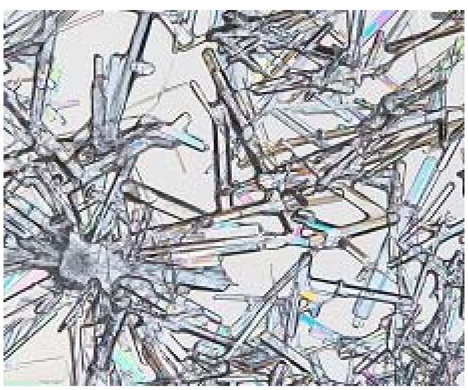
Hot Crystals Cool Outcomes

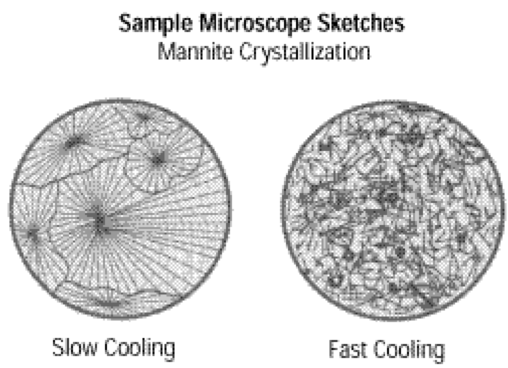
Geology with Hot Crystals and Cool Outcomes

Using phenyl salicylate/Salol crystals to promote an understanding of the role of Earth's heat in crystal formation.

The square in the crystal falls back in its symmetry;
those who open the doors of the earth will find in the darkness, intact and complete, the light of that system's transparency.

The salt cube, the triangular fingers of quartz: the diamond's linear water: the maze in the sapphire and its gothic magnificence;
the multiplication of rectangles in the nut of the amethyst:
all wait for us under the ground: a whole buried geometry:
the salt's school: the decorum of fire.   Pablo Neruda





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Objectives

After the completion of the activities listed in this booklet, based upon content and Florida State Standards, the student will be able to:

SC.7.E.6.1 Describe the layers of the solid Earth, including the lithosphere, the hot convecting mantle, and the dense metallic liquid and solid cores.

SC.7.E.6.2
Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building).

Big Idea: Earth Structures - Over geologic time, internal and external sources of energy have continuously altered the features of Earth by means of both constructive and destructive forces. All life, including human civilization, is dependent on Earth's internal and external energy and material resources.

SC.7.E.6.4 Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes

SC.7.E.6.5 Explore the scientific theory of plate tectonics by describing how the movement of Earth's crustal plates causes both slow and rapid changes in Earth's surface, including volcanic eruptions, earthquakes, and mountain building.

SC.7.E.6.7 Recognize that heat flow and movement of material within Earth causes earthquakes and volcanic eruptions, and creates mountains and ocean basins.

Activity Overview

INCEPTION: As an inquisitive learner, I like to touch, feel and see the things I am learning about. It helps me understand and when I understand, I can apply the information to other situations later in life.

Many of us are in awe of nature's creations. Rocks and crystals are no exception. Although one can hold and admire a variety of rock formations, it is not common to be able to witness the way they or their crystals form. From the hardness of diamonds and the sheen of obsidian to the birefringence of calcite, I sought to find a way to closely simulate, rather than passively peruse a textbook passage, the role of Earth's heat on crystal formation - as we journeyed through the rock portion of the Earth Science section.

As educators know, *Claim-Evidence-Reasoning* in any inquiry activity remains the students' weakest area. If we are to truly educate students, we need to ensure that they leave the activity with an understanding of the material presented. Comprehension can be validated when they are able to submit acceptable evidence supported by effective reasoning and measurement. It is for this reason that I pursued this activity.

APPLICATION: When we review the rock cycle, the discussion inevitably leads to the two types of igneous rocks - extrusive and intrusive - defined by where and how they cool after being melted. Rapid cooling, as with ejected magma (lava) allows little to no crystals to be formed. Conversely, slow cooling, as with magma pushed upward (but remains under the Earth's s surface) allows larger and more complex crystal formation. After review of the Earth layers, their relative depths, temperature, and density, students compare areas of relative heat and hypothesize where cooling might be slowest, and fastest.

Being able to grasp a basic understanding of how crystals form and the role of heat in their formation, is paramount to the application and reasoning of where these crystals are found and why; and why rocks look the way they do. Most facets of Earth science are difficult to simulate due to the forces of Earth that cannot be duplicated. But close simulation brings about a better understanding and relevance of the process.

Students are intrigued by crystals like all things that shine and shimmer. They also have a natural curiosity and need to become the investigator rather than technician. Allowing students to come upon the answer to their own question is critical.

There are several substances that can be used to grow crystals and some that can be used to test crystal growth against certain variables. Some substances simply take too long to form and some are regarded as harmful or toxic for middle school. I began searching for a substance that was safe to use in middle school and one that would lend itself to an investigation on crystal formation within a given timeframe. Using Salol crystals, I was able to provide the students with a manageable inquiry activity where they could realize how the rate of cooling (as found within - and outside of Earth's surface) might impact crystal formation.

Salol crystals - after being heated, liquefied and cooled, can be returned to the bottle for reuse. As you can see in the Featured lesson, Salol crystals can be used on a spoon with a magnifier or between slides and a microscope.

The lab begins when student groups examine and discuss the problem at hand - is there a relationship between how igneous rocks cool and the crystals that form within them. When a plan (Claim, Evidence, Reasoning) is devised and approved, students are provided with a number of crystals in addition to any of the materials made available to them.

Introductory Lessons

Rock Cycle Vocabulary

Weathering	
Erosion	
Deposition	
Igneous Rock	
Sedimentary Rock	
Metamorphic Rock	

formed by cooling & hardening of hot liquid rock

formed by cooling & hardening of hot liquid rock

when rocks are broken down into smaller fragments

when rocks are broken down into smaller fragments

formed when sediments are pressed & cemented together

formed when sediments are pressed & cemented together

when rock fragments are moved by some force of nature

when rock fragments are moved by some force of nature

when rock fragments are laid down in a new location

when rock fragments are laid down in a new location

formed when rocks are changed by heat and pressure

formed when rocks are changed by heat and pressure

Rock Cycle Sample Lab

Provide students a tray with 12 rocks, four from each rock type. Give each student groups a geology identification kit (hardness tools, streak plate, magnet, magnifier, and a key without names.

By using a Rock Cycle Key and what they already know about rock characteristics produced by the different formation processes, allow them to come up with their best proposals. Place emphasis on the rock type characteristics and formation processes rather than coming up with the rock names.

Interactive Rock Cycle Activity

http://www.learner.org/interactives/rockcycle/types.html

Rocks and Minerals Scavenger Hunt

Directions: Look up the answers for the following questions, using the website listed. You may have to read parts of the website to find answers!

1. What is a mineral? Find answer at http://www.windows.ucar.edu/tour/link=/earth/geology/min_intro.html
2. Name four physical properties of minerals. Find answer at http://facweb.bhc.edu/academics/science/harwoodr/Geol101/Labs/Minerals/
3. According to Mohs Hardness Scale, what is the hardest mineral? Find answer at http://www.amfed.org/t_mohs.htm
4. What are the uses of the following minerals; copper, graphite, and talc? Find answer at http://www.mii.org/commonminerals.html
5. What are the three basic rock types? Find answer at http://www.zephyrus.co.uk/rocktypes.html
6. What could an igneous rock turn into during the rock cycle? Find answer at http://www.cotf.edu/ete/modules/msese/earthsysflr/rock.html

7. How does each of the three rock types form? Find answer at http://library.thinkquest.org/20035/newpage8.htm

8. What are the different textures of igneous rocks? Find answer at http://flexiblelearning.auckland.ac.nz/rocks_minerals/rocks/igneous.html

9. What's the difference between intrusive and extrusive igneous rocks? Find answer at http://geomaps.wr.usgs.gov/parks/rxmin/rock.html

10. How are sedimentary rocks formed? Find answer at http://www.fi.edu/fellows/fellow1/oct98/create/sediment.htm

11. What are the three types of sedimentary rocks? Find answer at http://geology.com/rocks/sedimentary-rocks.shtml

12. Give one example of each of the three types of sedimentary rocks. Find answer at http://geology.about.com/cs/basics_roxmin/a/aa011804b.htm

13. How do metamorphic rocks form? Find answer at http://www.rocksforkids.com/RFK/howrocks.html

14. What are the two types of metamorphic rocks? Find answer at http://geology.com/rocks/metamorphic-rocks.shtml

15. Give me an example of each type of metamorphic rocks. Find answer at http://library.thinkquest.org/J002289/meta.html

16. Classify the following rocks as igneous, sedimentary, or metamorphic. Marble, Coal, Granite, and Slate Find answer at http://en.wikipedia.org/wiki/List_of_rocks

Featured Lesson Plan

Leading Question

Igneous rocks are formed when magma cools and crystallizes. The aim of this experiment is to investigate why *intrusive* igneous rocks like ***granite*** contain large crystals, while *extrusive* (volcanic) rocks like ***basalt*** are made up of tiny crystals.

What is the effect of various cooling rates on the formation of crystals?

Materials

rock and mineral samples (granite, obsidian, basalt), salol (**phenyl salicylate), metal spoons, trays, ice cube, candles, cup, clay, goggles, magnifiers

Procedure A: observing crystal formation at room temperature cooling

1. Work in pairs. Each pair MUST have all materials before starting (metal spoon, tray, candle, salol crystals, flashlight, cup, clay, timer, goggles – and later, ice cubes). **CHECK.**
2. Pour LESS THAN ¼ tsp of your salol crystals from the cup into the spoon
3. Place spoon in the middle of a heated hot plate.
4. Remove the spoon from the hot plate once the salol crystals have melted
5. Add a few grains of salol as "seed crystals"
6. Prop up the spoon handle with a small ball of clay to keep the spoon level. Begin timer and let cool
7. Note time when first crystals begin to form
8. Look at the crystals with a magnifier. Note observations.
9. Remove one or two crystals and view under microscope. Not observations in data table.

Procedure B: observing crystal formation at low temperature cooling

1. Replace spoon with hardened salol crystals back onto hot plate to re-melt the crystals.
2. Once crystals are melted, rest the bowl of the spoon on a bowl of ice cubes. Begin timer and let cool.
3. Note time when first crystals begin to form
4. Use magnifier to draw and describe the shapes of the crystals that resulted when the salol cooled on ice.
5. Use microscope to make further observations.
6. Compare the characteristics of the crystals that cooled at the different temperatures.

Data Table

	Salol crystals formed at room temperature	**Salol crystals formed at lower temperature**
DRAW		
TIME/ DESCRIBE	**Time to form crystals:** **Describe:**	**Time to form crystals:** **Describe:**
COMPARE/CONTRAST		

Results:

Did the salol form one big crystal or several smaller crystals?

Did the crystals seem to have sharp edges or smooth ones?

How would you describe **the shape** of each crystal?

Did the crystals form all at once or a few at a time?

Were there a difference in shape between the room temp and low temp crystals? If so, describe.

Concluding Questions

1. Of the igneous rocks you have seen - granite, basalt and obsidian, which one do you think cooled the fastest?

2. What impact did rapid cooling have on the crystals?

   What impact did slow cooling have on the crystals?

3. Like most experiments in Earth Science, this is actually a modeling exercise. In what ways is Salol a good (or not so good) model for molten magma?

Answer….It is a single-component melt (as compared to magmas which contain several different mineral components), the “crystals” that form from Salol are actually bunches of radiating crystals formed from a single nucleus but, in most respects, the model works well.

Additional Activities

Rock Cycle Research:
Use a foldable to creatively enter data into your Interactive Science Notebook

What is a rock?

What is a mineral?

What are the three types of rocks? How are they determined?

What is meant by intrusive and extrusive rock?

What is a crystal?

In what type of rock do you find crystals?

Do crystals differ in intrusive and extrusive rocks? Explain

Alternate lab options:

A. Grain size and cooling rate: an experiment with Salol
http://www.geolsoc.org.uk/ks3/webdav/site/GSL/shared/pdfs/education%20and%20careers/RockCycle/Salol%20Experiment.pdf

Materials:
Test tube containing molten Salol, glass rod, test tube rack.
Two *cool* glass microscope slides (eg. from a ice chest or refrigerator) and two *warm* slides. *Do not collect the slides until you are ready to use them.*
A hand lens or low-power microscope and a piece of colored paper

Procedure:
This experiment works well only if it is carried out quickly but carefully.
Take a drop of molten Salol from the test tube and place it on one of the warm microscope slides using the glass rod. Then quickly, but carefully, place the other warm slide on top, to make a "sandwich" as shown below.
Repeat the process using the two cool slides.
It is important that you do this quite quickly so that the warm slides don't have time to cool down and the cool slides don't have time to warm up!
Place the two pairs of slides on top of the paper and look carefully using your lens to watch the crystals forming.

Questions
On which slides do you observe crystal formations first?

Explain

On which pair of slides do the crystals grow largest?

Explain

B. Crystal Growing Lab

Grade level: Although designed for 4th through 9th graders working in groups, this activity works well as a whole-class demonstration for younger children. High school students can use the extensions to explore different types of crystal structures.

Background

Crystals are solids that form when molecules join together in a regular repeating pattern. In this activity, you dissolve crystallizing molecules in water and your students create a setup to observe the ordered structure of these crystallizing molecules as they solidify.

Materials needed

- 250-mL beaker or 9-oz plastic cup (2 for each group)
- 500-mL beaker
- Coffee stirrer or pencil (2 for each group)
- Hand lens (for each group)
- Hotplate
- Lab apron
- Lab marker (for each group)
- Pair of forceps
- Piece of nylon or cotton string 15 to 20 cm long (2 for each group)
- Shallow container or petri dish
- Small piece of masking tape (2 for each group)
- Rubber gloves
- Safety goggles
- Salt (at least 200 mL)
- Water

Caution: *Review lab safety with your students before they begin work. Use caution around hotplates and hot water.*

1. Put on the gloves, apron, and goggles.
2. Add about 300 mL water to the 500-mL beaker.
3. Place the beaker on the hotplate. Adjust the heat to medium and heat the water until it is very hot, but do not let it boil.
4. Gradually add salt to the beaker and stir to ensure it all dissolves in the water. Add at least 100 mL salt to the water or as much as will go into solution.
5. Use the forceps to remove the beaker from the hotplate, and then pour a small amount of saltwater solution into the shallow container or petri dish. Allow the solution to sit undisturbed for about one hour. Small salt crystals will form in the container. These small crystals will be used as the "seed" crystals for each group.
6. Divide your class into groups of 3 to 4 students each.
7. Make sure each group has TWO of the following materials: a 250-mL beaker or 9-oz plastic cup, a coffee stirrer or pencil, a piece of nylon or cotton string 15 to 20 cm long, and a hand lens.

Procedure (students)

1. Obtain a "seed" crystal from your instructor and tie it to one end of the piece of string.
2. Tie the other end of the string to the coffee stirrer or pencil.
3. Label the beaker or cup with your group's name using the piece of masking tape and lab marker.
4. Place the end of the string with the seed crystal into the salt solution and lay the coffee stirrer or pencil across the mouth of the beaker or cup.
5. Place one crystal growing container in a refrigerator or container of ice and leave the other exposed to room temperature air. Let them remain undisturbed for 24 hours, and then observe and compare the crystals grown at different temperatures.
6. After the 24 hours have passed, remove the string from the solution. Use the hand lens to examine the crystalline structures that have formed on the string.

Discussion

Heating the water allows it to hold much more salt in solution than it could at room temperature. As the water cools, its ability to hold the salt in solution diminishes. This causes the excess salt in the solution to precipitate (form a solid) in crystal form on the string.

Extensions

1. Using the same procedure, prepare 2 different crystal-growing solutions using 2 of the chemicals listed below. Observe and compare the different types of crystals grown.

Caution: *Some of the chemicals listed below may be harmful if swallowed or inhaled. Do not eat or inhale any of the chemicals used in this activity. Do not lick the crystals or put them in your mouth. Wash your hands after handling chemicals and crystals.*

- Copper sulfate
- Magnesium sulfate heptahydrate (Epsom salt)
- Potassium aluminum sulfate dodecahydrate (alum)
- Potassium sodium tartrate tetrahydrate (Rochelle salt)
- Sucrose (sugar) (Procedure note: Make sure the water is boiling when you add the sugar.)

Literary Companions

Reading the Rocks: The Autobiography of the Earth – Marcia Bjornerud

Journey to the Center of the Earth - Jules Verne

Resource List

- **Interactive Internet sites:**

https://www.brainpop.com/science/earthsystem/crystals/preview.weml
http://www.learner.org/interactives/rockcycle/
http://www.mineralogy4kids.org/rock-cycle
http://www.cotf.edu/ete/modules/msese/earthsysFlr/rock.html
http://www.kidsgeo.com/geology-for-kids/0025A-gems.php
http://www.geolsoc.org.uk/ks3/webdav/site/GSL/shared/pdfs/education%20and%20careers/RockCycle/Salol%20Experiment.pdf

- **Supply Source/Price List**

http://www.sciencestuff.com/prod/Chem-Rgnts/C2247 **Salol crystals/ Phenyl Salicylate**

125 grams	$30.72 each
500 grams	$97.64 each

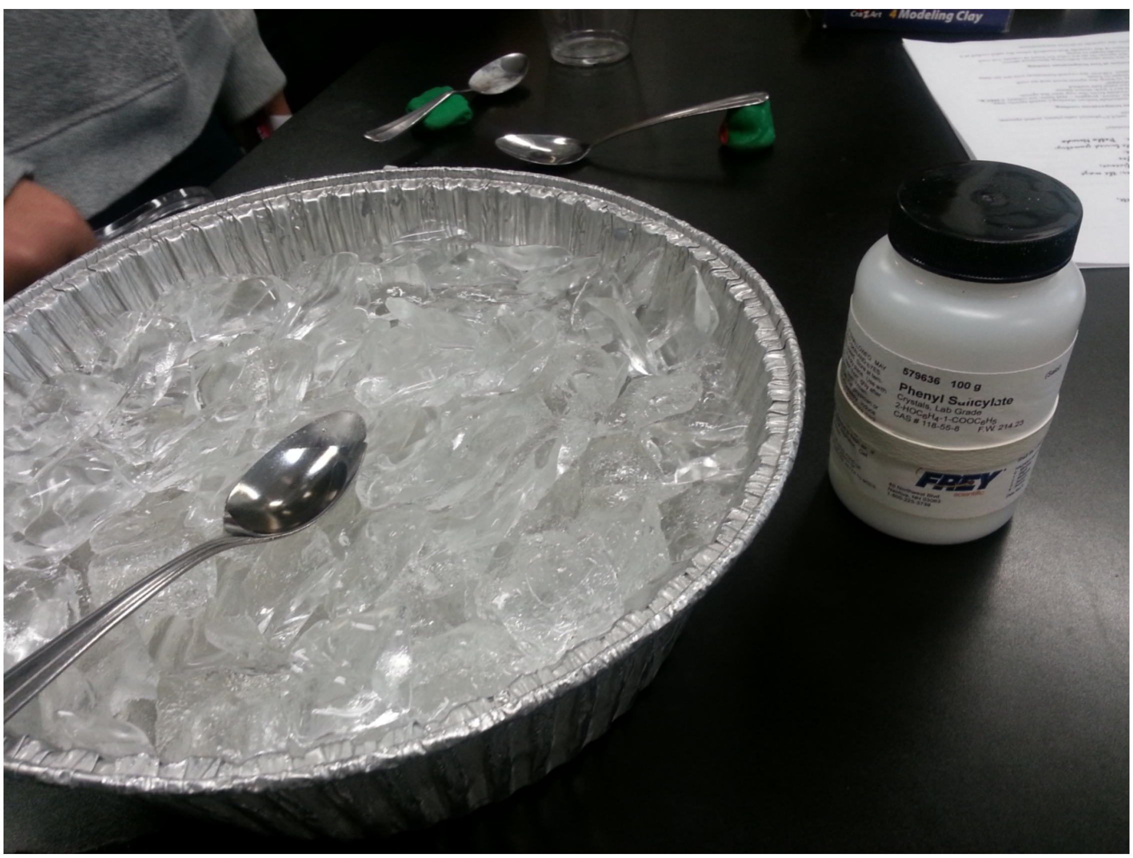
10 metal spoons target/dollar store $6.99

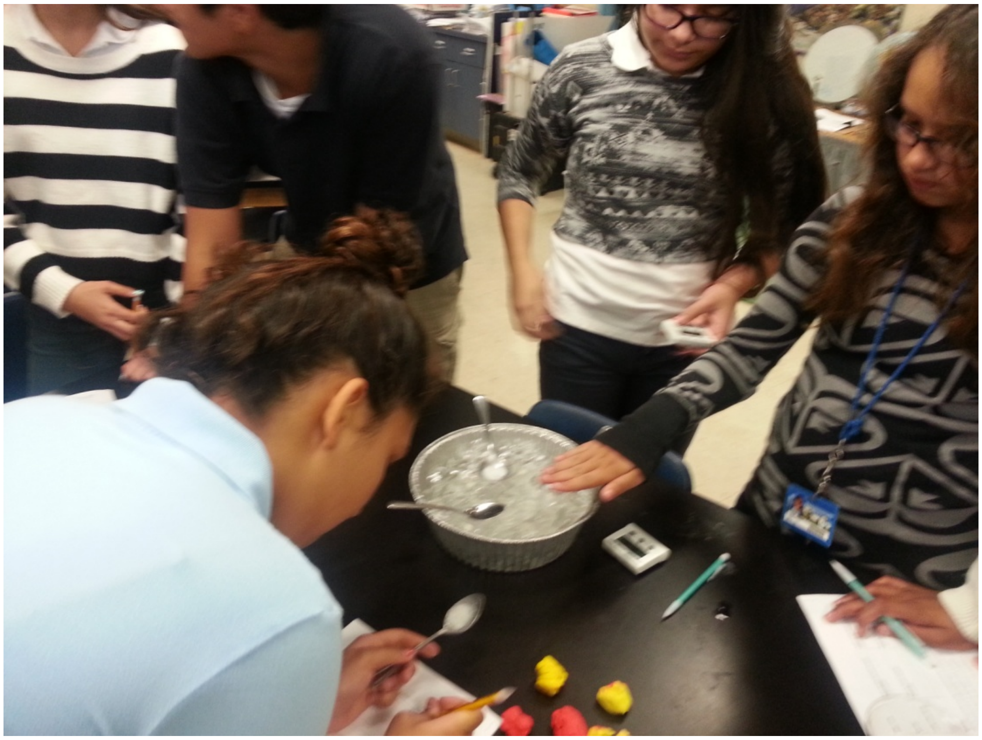
5 aluminum pans Publix/Walgreens $4.99

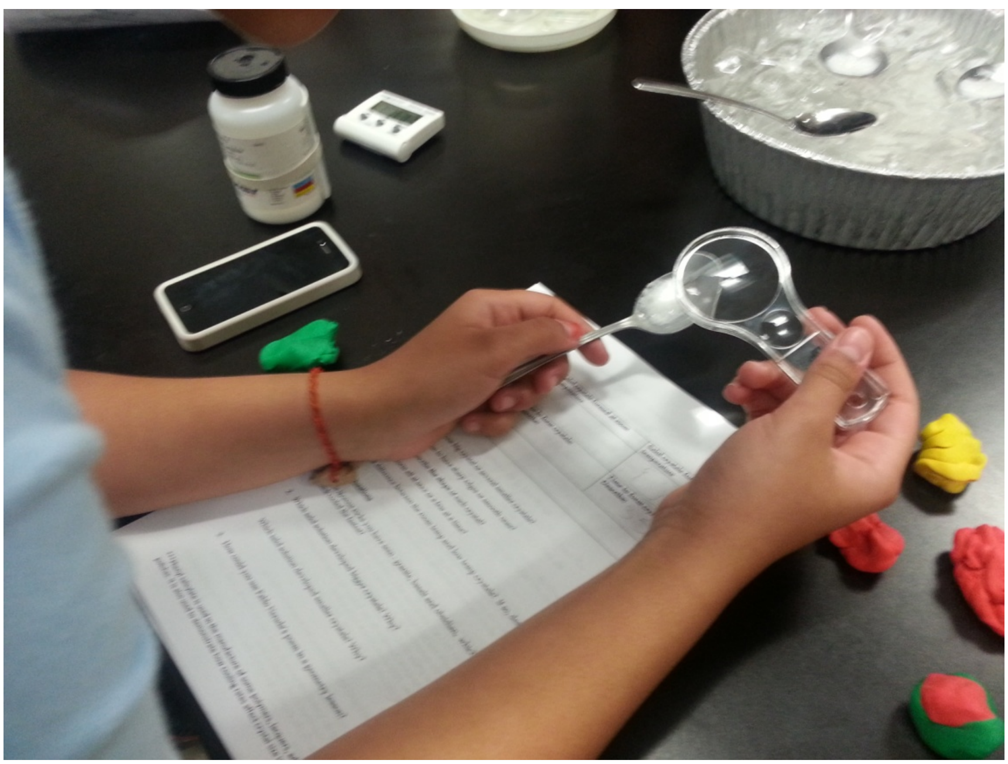
20 magnifiers $26.95 (10 pack)
http://www.amazon.com/Plastic-Handheld-Lens-Magnifying-Magnifier/dp/B008DI82JM/ref=sr_1_26?ie=UTF8&qid=1435273657&sr=8-26&keywords=hand+held+magnifiers

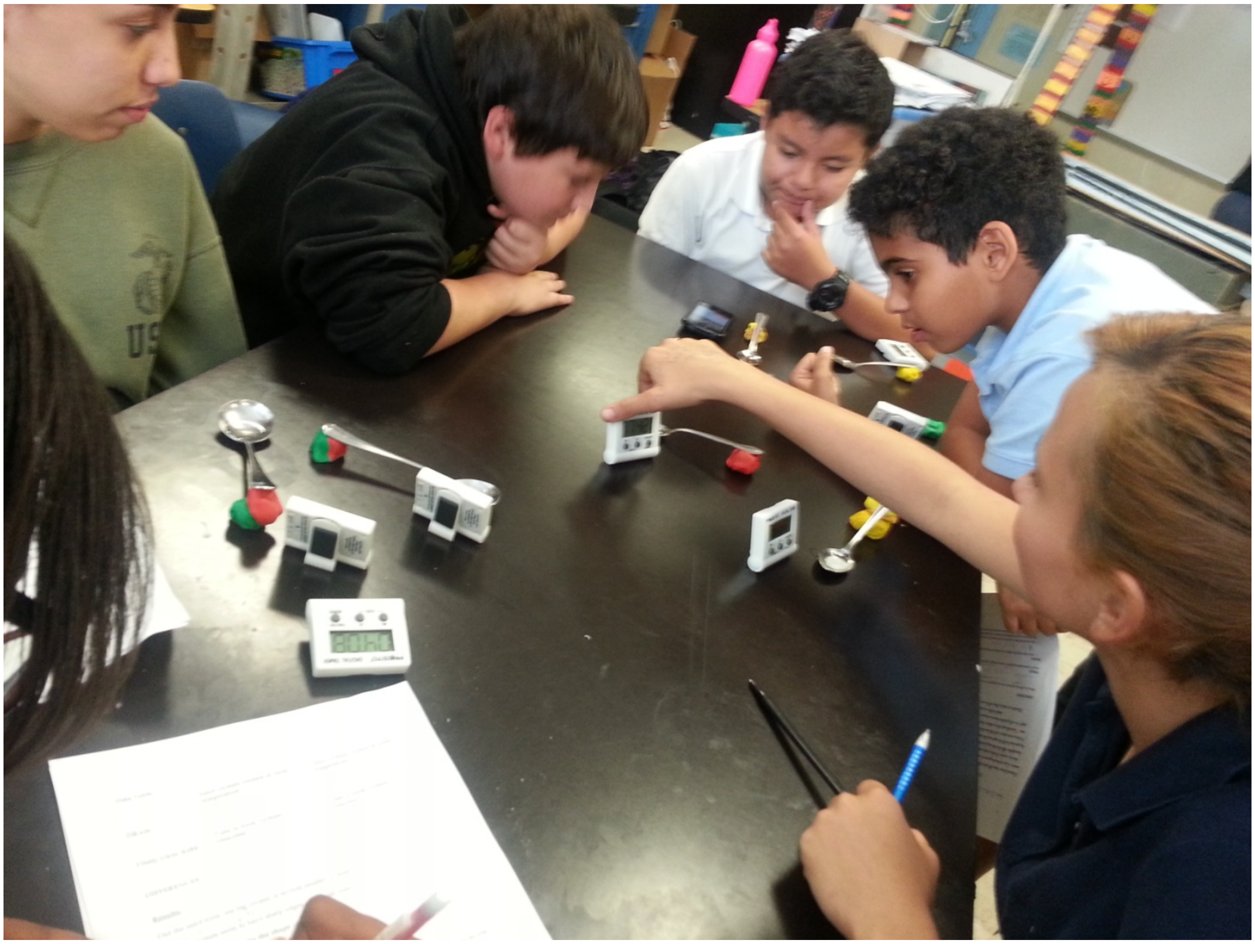
2 boxes modeling clay $6.46/pack
http://www.amazon.com/ALEX-Toys-24-Piece-Rainbow-Modeling/dp/B00LV0ZQLG/ref=sr_1_7?ie=UTF8&qid=1435273724&sr=8-7&keywords=modeling+clay

3 hot plates $59.95
http://www.amazon.com/Waring-SB30-1300-Watt-Portable-Single/dp/B000I14C7I/ref=sr_1_2?s=kitchen&ie=UTF8&qid=1435273428&sr=1-2&keywords=Hot+Plates









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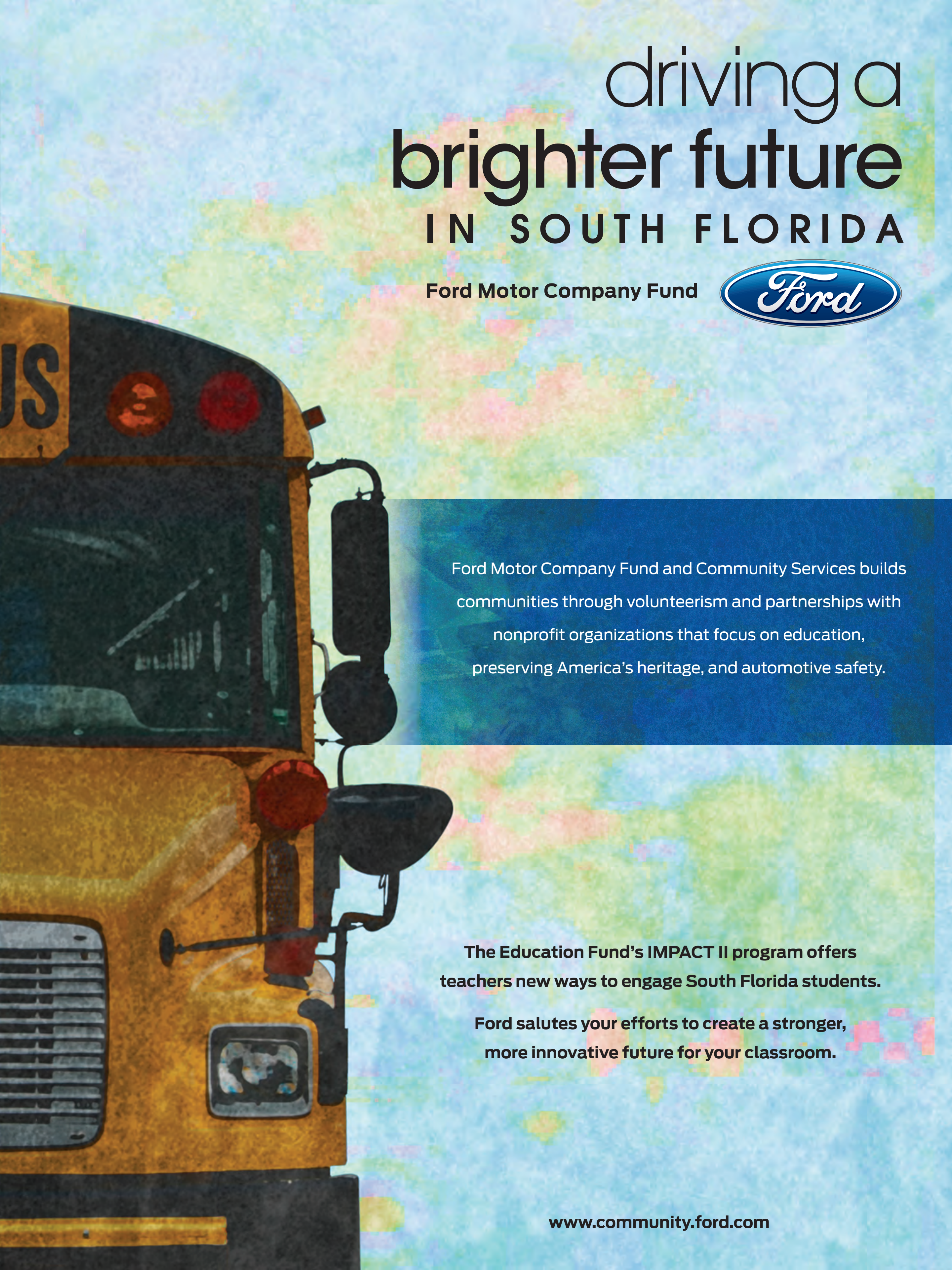
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