



Exploring Crystals Or “What Is That Stuff?”

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Suggestions for Teachers

Purpose:

The purpose of this activity is to acquaint students with basic properties of crystals using an inquiry-based format that will include brainstorming/questioning, observations, and drawings by the students in the initial section. The second part of the inquiry will lead the students to activities that will include the growing of crystals while exploring the supersaturating of liquids and further exploration of crystals using assorted hands-on activities. This activity can be adapted for students from third grade up through middle school.

Objectives:

The student will be able to:

- draw and record visual observations of various crystals;
- communicate ideas and observations concerning crystals;
- test hypothesis about the growing of crystals;
- grow crystals;
- recognize the structure and properties of crystals,
- demonstrate new laboratory techniques and safety skills (appropriate to age level);
- report on observations and growth of crystals over a period of time.

Materials:

Students will work in groups of three or four. Materials listed are per group.

Procedure # 1 (per group):

- Table salt, Epson salt,
- Borax &/or sugar - 1 cup of one of the substances per group\
- Construction paper (black) - 1 sheet/group
- Pencil
- Small metric ruler
- Magnifying glass - hand held
- Microscope
- Notebook paper

Procedure #2 (per group):

- Clear plastic cup - 8 ounce size
- Plastic spoon
- Borax, table salt
- Epson salt &/or sugar - 1 to 3 cups of one substance per group
- Small metric ruler
- Popsicle stick
- Scissors
- Cotton string
- Pencil

Notebook paper
Safety glasses
Hot water - distilled preferred
Heat source such as a hot plate
Hot pad or heat-safe gloves
Measuring cup

Description:

Procedure #1:

The teacher will begin the laboratory inquiry by displaying a rock crystal (if available--picture if not) and asking students questions as to its identity and properties. After leading a brainstorming session and listing the generated possibilities on a writing surface, the teacher will lead the students towards areas of possible explorations. After ideas have been generated, replace the rock crystal with unidentified samples of table salt, Epson salt, and sugar and repeat the brainstorming session to generate further activities. Students will be asked to formulate questions concerning the identity and then the possible properties and behaviors of the substance(s). At this point, the teacher will introduce the materials as listed for procedure #1 and group the class while directing the groups to explore the identity of one or more of the unknown substances using skills of observation (including eyes, magnifying glass, and/or microscope). The students will be directed to answer the questions raised during the brain storming session using the materials and equipment supplied. At the end of a given time, the students will prepare a presentation for the entire class that will include a visual aide as well as any other materials that the students might choose to use.

Procedure #1 can be as short or long as the age of the students will allow. A younger group of students (grades 3-5) will be able to conclude the procedure over 1-2 class periods while an older group (grades 6-9) should be able to use 2-3 class periods to do a complete observation and preparation of the presentation. Depending on the ages of the student, the teacher can make the decision on how much background information and fun facts should be supplied to the students prior to the beginning of either procedure or given at the conclusion of the presentations.

Procedure #2:

To continue the first inquiry, the teacher can begin the next activity by asking the students about possible uses of crystals and questions about how crystals are formed or grown or where crystals are found in nature (see enclosed material for information to lead discussion). The teacher will guide the students into an inquiry-based discussion which is to lead to a generation of questions concerning uses and formation of crystals.

A similar beginning can be used with the second procedure if the activity begins at this point. The presentation of a crystal and then unknown substances can lead to brainstorming and the formation of possible avenues of exploration by older students. If procedure #2 follows procedure #1, the teacher will direct the students into further methods of explorations of crystals such as the growing of crystals starting with a variety of substances to explore the similarities and differences in various crystals. The teacher can then present the materials listed for procedure #2 and direct the student groups (2 to 3 students) towards experimentation in crystal growth. If needed, the teacher can lead the groups towards an acceptable procedure. See Crystal Growing Procedures for additional information for guidance of student groups for this procedure.

Student groups must get their planned exploration approved before proceeding to insure that the exploration will follow the general outlines of the procedure.

Crystal Growing Procedures:

Table salt, Epsom salt, and sugar are the most common substances used to grow crystals. Other substances that may be used include borax and/or alum.

The KEY to growing crystals is to supersaturate the water with the substance that has been selected. Boiling water allows saturation to occur easiest but HOT tap water can be used if there is no source of heat. Begin by adding the substance to the liquid while stirring--an amount 2 to 3 times of substance to the volume of water is suggested. If no measurement is used, the substance must be stirred into the hot water until no more of it will dissolve. After the water is "clear", pour the liquid into a container. Tie the string around the popsicle stick and immerse the string into the liquid. Place the container in a location so that it will not be disturbed and allow the crystals to grow. The LEAST amount of movement possible will insure better growth and allow the solvent to evaporate slowly.

Various "recipes" exist to make the crystal growing procedure more cookbook and those can be found by accessing the several of the web sites listed in References Cited. These recipes might be used for younger students because they simplify the procedure, however, using a "recipe" will not allow the students to explore new ideas and concepts.

Crystal Making Tips:

If heating the liquid, use a glass or enamel container as a metal container may react with your chemicals.

Try to keep the crystal growing experiment in an area with constant humidity and temperature as much as possible.

It is important to place the solutions where they will not be disturbed.

Troubleshooting:

If crystals do not form, there may be too much water or not enough of the chemical, or the temperature or humidity may be unfavorable.

If crystals form but are tiny, there may be too much of the chemical in proportion to the water, or evaporation is happening too quickly.

If crystals grow but then disappear, add more chemical to the solution.

If the crystals begins to shrink, the solution is too weak. Rehear the solution and add more substance to make it stronger.

If crystals are cloudy, there may be impurities in the water or in the chemical. Distilled water is recommended.

The initial work for procedure #2 should be completed during one period with continuing observations of the growing crystals over of period of up to 2-3 weeks. After a given period of time for growth of the crystals, an additional 1-2 periods should be set aside for the completion of a presentation of each group's results and the presentations. The presentation for the second procedure will describe all aspects of the experiment including an introduction, hypothesis, procedures, data, and results, conclusions and sources of error and/or improvements.

Safety Measures:

Before and during this procedure, lab safety must be continually re-emphasized to insure the safety of all those involved.

Procedure #1 will need the teacher to talk about the dangers of putting unidentified objects in the mouth and to emphasize that hands need to be washed before and after handling any of the substances. Care needs to be taken to insure that the substances are not spilled or otherwise mishandled.

Procedure #2 will need close supervision by the teacher when the students are working with the hot water. The appropriate handling of hot liquids will need to be explained and demonstrated by the teacher with emphasis on the use of safety glasses and a hot pad or heat-safe gloves when dealing with hot liquids, making sure that the students know to pour away from the body, to pour over a sink, if available, to tie long hair back and to check for loose clothing when dealing with a heat source and hot liquids. The chemical make-up and properties of each of the substances to be used in each procedure also needs to be explored by the students prior to either procedure to insure that the substances are not taken internally by the students or otherwise mistreated during the procedures. All regular established safety polices should be followed including the washing of hands before and after handling the substances.

Assessment:

A sheet with suggestions for assessment or evaluation of the students is included with three possible forms. The teacher is encouraged to use more than the assessments included in this lesson. During each of the procedures, the teacher will make observations and assessments based on the participation of the members of each group individually as well as a group. Also the teacher will use student self-evaluation, in group evaluation, and class evaluation of the student's as well as her (his) observations, for a broader basis in the assigning of credit for each student's work instead of relying only on one type of assessment.

Relevant National Science Education Standards:

Science as Inquiry--abilities necessary to do scientific inquiry.

Physical Science--properties and changes of properties in matter; transfer of energy

Background Information:

Could be presented before, during, and/or as follow-up to either procedure.

Crystal systems include 7 shapes - Cubic, Tetragonal, Orthorhombic, Monoclinic, Hexagonal, Trogonal, or Rhombohedral, and Triclinic. Each crystal system has a basic block of particles with a particular shape. These are defined by imaginary "axes of symmetry" which give the lengths of any three edges that meet at a comer and the angles at which they meet. As a crystal grows, particles join onto the basic shape so that it gets larger and larger. The maximum number of identical faces varies from six (cubic) to two (triclinic) (see enclosed picture).

Possible discussion questions:

What do you think a crystal is? Scientifically what do you think a crystal is?

A crystal is a solid mineral body. It has a definite shape and volume and the atoms are arranged in fixed, regularly repeating patterns.

How do crystals form?

Crystals usually form from molten rock as the molten rock gradually cools. If the molten rock cools very rapidly, then either small crystals form or no crystals form. If molten rock cools slowly, the large crystals can form. Crystals can also form when water evaporates.

Of what is all matter made?

Small particles.

What happens to particles when they are heated?

They move faster.

What happens to the spaces between the particles of water when heated?

Spaces become larger.

Where does the crystal go when heated?

Molecules of crystal separate and go between the spaces of water.

Why do more crystals dissolve when the water is heated?

Particles of water move faster, bump into each other, cause larger spaces and thus more crystals dissolve.

Do you think that the identifying properties of the crystal or water change when they are mixed?

No, crystals are still the same crystals and the water is still wet. They can be separated by a physical means.

Explain why this is a mixture.

It can be taken apart.

Does dissolving a crystal cause a chemical change?

No. When there is a chemical change, materials that combine cannot be separated by physical means.

What happens to the mixture when it cools?

Particles slow down and there is less space between them.

What happens to the crystals when the mixture cools?

The spaces get smaller, there is less room for crystal molecules, so they pack together into special shapes called crystals.

How can we get more crystals to form?

Leave the solution and when the water evaporates there will be even less room for the crystal molecules.

The scientific definition of a crystal is based on its internal structure rather than its outward appearance. All matter on Earth is made up of atoms or combinations of atoms called molecules. If the molecules of a substance are arranged in a regular repeating pattern, the substance is a crystal. A collection of crystal atoms is called a unit cell. The three-dimensional pattern, made up of many unit cells lined up in all directions, is called the crystal lattice. Examples include table salt (sodium chloride)--its molecules are

arranged in a cubic pattern, which is why salt crystals are cubic in appearance. Other examples of crystals include metals, salts, and powders, precious and semiprecious gems.

Possible related subjects:

- Uric Acid Crystals - Arthritis, Gout
- Semiconductors
- Healing Power of Crystals
- Solar Cells
- Use of crystals in everyday life
- Use of crystals in business

Possible Activities:

Aside from the basic activities included in this lab the teacher could expand the exploration on crystals by:

Having student groups (using the same chemical) through daily observations and measurements compete in a crystal growing race-the students would practice observation and reporting skills as well as the practice of good lab techniques.

Having students pretend that they are geologists and have them draw pictures of their crystals including all details as was done before photography was widely used. Those pictures could then be compared to actual pictures or crystals for comparisons.

Having students imagine that they are cave explorers (spelunkers). Students could share what they have seen if they have actually visited caves. Students could write about the patterns, shapes, or formations that they might see OR have actually seen.

Inviting a guest speaker such as a crystallographer, geologist, a jeweler or in other related fields could be invited to speak to the class and display other examples of crystals. The speaker will show examples of crystals as well as give the students information on possible careers dealing with crystals.

Having students make rock candy (see work cited for internet sources).

Having students use only one substance but vary the concentrations of the solutions and then have the students compare results.

Other common crystals to observe:

- Mica
- Granite
- Quartz
- Borax
- Alum Ammonium (alum)
- Bicarbonate of soda (baking soda)
- Washing soda

Fun Facts:

Table salt crystals are shaped like a cube.

All metals are crystals.,

Most metals allow electricity to flow through them easily, but electricity will not flow well through many other crystals.

Many crystals allow light to pass through them, but light will not pass through many metals. Water will dissolve table salt, sugar, and some other crystals, but will not dissolve diamonds, quartz, or most metals.

When a thin layer of quartz crystal is squeezed, electricity can be produced.

Crystals are used in photovoltaic cells, special devices that change light into electricity.

A thin quartz crystal vibrates at a constant rate so it can be used in a watch to keep time.

Crystals are used in transistors, and important part of radios, televisions, and other electronic devices.

Crystals grown in space, in low gravity, will have a more perfect shape for use on Earth.

Suggestions for Assessment:

1. Teacher approval of experimental design (before conducting).
2. Group presentation (see 2 rubrics on the following pages):
The Experimental Design Rubric is quite detailed. I feel that this is one way to provide the students with the criteria that will be used to evaluate their presentations.
The Poster and Presentation Grading Sheet is appropriate for investigations that are assessing a more general process with less detail.
3. Each student will submit a formal write-up of investigation (see official guidelines for “a controlled experiment”)

Work Cited:

The Best of Wonder Science: Elementary Science Activities. Delmar Publishers. 1997. pp. 265-272.

Dictionary of Science. Neil Ardley. Dorling Kindersley Publishing Inc. New York, New York. 1994. pp. 142-143.

Physical Science Activities For Elementary and Middle School. Compiled & Edited by Mark R. Malone. Clearing house for Science, Mathematics, and Environmental Education. Ohio State University. December, 1987. pp. 205-207.

The Usborne Book of Science Experiments. Jane Bingham. EDC Publishing. Tulsa, OK. 1996. page 43.

Web Sites:

http://laue.chem.edu/student_faqs/xtal.html

<http://trc.ucdavis.edu/Coursepages/EXCITES/activities/gc.html>

http://www.comptons.com/encyclopedia/ARTICLES/0025/00490496_A.html

<http://www.crystalgrowing.com/recipes/sugar/sugar.html>

<http://www.the-aps.org/education/k12curric/activities/BIGHAM.PDF> (source of rubrics)

<http://www.freeweb.pdq.net/headstrong/crys.html>

<http://www.Kings.edu/~chemlab/vrml/nacl.html>

<http://www.microscopy.fse.edu/optics/activities/crystal.html>

<http://www.newton.dep.anl.gov/askasci/gen99/gen99068.html>

<http://www.teachnet.com/lesson/science/crystals040999.html>

<http://www.yale.edu/ynhti/curriculum/units/1989/6/89.06.06x.html>

<http://www.yale.edu/ynhti/pubs/A5/vanwagner.html>

Investigation: _____

Members: _____

**Experimental Design Rubric
(Poster and Presentation Evaluation)**

Topic	Criteria For Assessment (circle the points earned)	Possible Points=100
Problem	Clearly stated as a question	12
	Clearly stated, but not a question	8
	Stated as a question, but not clearly	4
	Not stated	0
Background Research	Research attached, addresses problem, leads to hypothesis	12
	Research addresses problem, does not lead to hypothesis	8
	Research does not address problem	4
	Research not attached	0
Hypothesis	Hypothesis stated and attempts to answer problem	4
	Hypothesis stated, but does not address the problem	2
	Hypothesis not stated	0
Materials	Supplies needed and their quantities listed	4
	Supplies listed, but not their quantities	2
	Supplies not listed	0
Procedure	Written clearly, step by step, at least 3 repetitions, could be duplicated	16
	Written clearly, step by step, not 3 repetitions, could be duplicated	12
	Written clearly, not step by step, at least 3 repetitions, can't duplicate	8
	Not written clearly	0
Data Recorded (chart/table)	Data recorded, variables labeled, metric measures	12
	Data recorded, variables labeled, not metric measures	8
	Data recorded, variables not labeled, not metric measures	4
	Data not recorded in chart/table	0
Data Display	Graph complete: labels, legend, all data present, clear relationships	16
	Graph complete: labels, legend, all data present, relationships not clear	12
	Graph complete: labels, legend, data incomplete	8
	Graph not complete: labels, legend, or some data missing	4
Analysis/ Conclusion	No graph	0
	Analysis addresses hypothesis, is complete, data supports, logical	12
	Analysis is complete, data supports, but does not address hypothesis	8
	Analysis addresses the hypothesis, but is not supported by data	4
Presentation to Class	Analysis is incomplete	0
	All members participate, visuals are clear and neat, organized	12
	All members participate, visuals organized but not clear and neat	8
	All members do not participate, but visuals are clear and neat	4
	No criterion is met	0
	Total Points	

A Controlled Experiment

Directions:

Use the format below to help you design the experiment, identify factors, and develop your procedure. You will not use/address all the conditions listed in every investigation.

1. Identify the problem (?):

2. Gather information about the problem (evidence):

3. Form a hypothesis (educated guess):

4. Experiment (procedure to test the hypothesis):
 - A. Identify Factors-
Constants: 1. _____ 4. _____ 7. _____
 2. _____ 5. _____ 8. _____
 3. _____ 6. _____ 9. _____

Variables:
 Manipulated: _____
 Responding: _____
 - B. Identify Setups:
Control(s): _____
Experimental(s): _____
 - C. Operational Definition: _____

 - D. Record Data: 1. _____ 2. _____
 3. _____ 4. _____
 5. _____

5. Analyze Data:

6. Draw Conclusion:

Names: _____

Poster and Presentation Grading Sheet

Investigation: _____ _____

		Possible Points	Points Earned
Problem	Stated Stated as a question	10	_____
Research	Attached Addresses problem	10	_____
Hypothesis	Is supported by research	5	_____
Experimental Design	Lists materials and amounts Procedure is step by step in logical order Identifies variables Includes 3 repetitions	20	_____
Recorded Data	In chart or table Correctly labeled	10	_____
Display Data	Appropriate type graph or chart X and Y axes labeled correctly Equal intervals	15	_____
Analyze Data	State conclusion Supported by collected/displayed data	10	_____
Communicate Results	Poster displays above items Attractive and neat	10	_____
Presentation to Class	All group members participate Shows organization/planning	10	_____
Total Points		100	