PHYSICAL SCIENCE INVESTIGATION

Teacher's Lesson Description

Title	**Music of the Spheres**
Brief Description of Videos	Through a series of activities in which Dante adds energy to a material, we observe the results of changes in crystal structure and molecular arrangement.
Time Needed	1 Class Period - 40 minutes
Ohio Science Benchmarks and Indicators Addressed in This Activity	• Grades 6-8 Physical Science, Benchmark A • Grades 6-8 Physical Science, Benchmark B • Grades 6-8 Physical Science, Benchmark D
Ohio Grade Level Indicators Addressed in This Activity	• Grade 6, Physical Science Indicator 4 • Grade 7, Physical Science Indicator 3) • Grade 8, Physical Science 4
Concepts Developed	Students will understand the effects of adding kinetic energy – heat or motion - on a material's properties. They will conduct investigations that demonstrate how crystalline structures can be manipulated and changed by adding or subtracting kinetic energy from a material.
Lesson Rationale	Students will develop comprehension of the effects of changing the kinetic energy added to a

	material. These activities should translate into making real-world connections between the classroom and the industrial processes that create much of our material environment. Opportunities abound for further research into how adding energy to metals in various processes results in desirable properties for practical uses.
Background Knowledge for Teachers	In addition to a grasp of the meaning of kinetic energy, teachers should become familiar with crystal structure as well as the basic definitions of annealing, quenching, and tempering as they apply to metals technology.
Classroom Procedures	Part 1 - Introductory activity Each student receives a fairly thick rubber band. Using both index fingers, the student pulls the rubber band taut, then holds it against his/her forehead or upper lip to feel its temperature. As the tension in the rubber band is relaxed, the student feels the temperature again. The heat emitted by the rubber is noticeably reduced, to the point where it actually feels cool when the tension in the rubber band is released. Discuss the changes. Part 2 - Work Hardening Metal Materials: 6 inch length of fairly thick copper wire (one per student), fine point Sharpie marker, pliers, heat source Procedure: 1. Students begin by creating 90 degree bends at each end of the wire, 1 ½ to 2 inches from the end. 2. Students make a straight line in the middle of the wire using their Sharpie. Next, they twist (rotate) the ends of the wire in opposite directions, one clockwise and one counterclockwise, noting both how the line they have drawn is altered and the increase in force required to continue the turning process. 3. (optional) After students have found that the can not turn it any further, they should hold the

	metal vertically in a flame until it is red hot, then try to twist it again. 4. Discuss the changes in the metal and have students develop some hypotheses about why the properties of the metal changed. NOTES: • Although the teacher should instruct the students to try to turn the wire so that they continue to twist it around the midpoint, students will find, by observing their drawn line, that the affected area moves out to the sides. • It will take an increasing amount of strength to turn the wire. This is work hardening. As they add energy to the system by twisting the metal, they increase the number of dislocations within the copper's crystal structure, and these dislocations become "pinned", or "jammed", the more they try to twist the wire. • Heat treating will release some of those jams, giving the atoms enough mobility to re-grow the crystals within the metal, and the wire can be worked more easily, but it will work-harden again as it cools. <u>Part 3 - Making Changes in Steel: - Annealing, Quenching, and Tempering</u> Materials: 4 bobby pins, 4 large paperclips, heat source (such as Bunsen burner), tongs or pliers, candle, container of ice water. Procedure: 1. Save one bobby pin and one paper clip as controls. 2. Heat the loop of one bobby pin and of one paperclip to red hot and remove them from the flame to air cool gradually (ANNEALING).

	3. Heat another pin and clip to red hot, but this time cool them rapidly in ice water (QUENCHING). 4. Repeat step #3, but this time reheat the metals in a candle flame for a few seconds, not allowing them to become red hot (TEMPERING). 5. Test the bobby pins, then the paper clips by pulling the heat-treated loops open. Compare them to the controls (untreated) and record all observations on a data table. 6. Propose, and possibly research reasons for, differences in results. NOTES: -Bobby pins usually have a plastic coating which will burn off. -Bobby pins are high carbon steel and paper clips are low carbon steel. -Annealing gives a flexible, less elastic, softer metal. -Quenching will make the bobby pin brittle, usually not the case with the clip. -Tempering results in a metal that feels much like the control.
Materials Needed	Thick rubber bands, fine point markers, tongs or pliers, thick gauge copper wire, bobby pins, large paperclips, heat source (such as Bunsen burner), candle, ice water.
Science Connections	The way materials are combined, joined, strengthened and changed has become an important part of chemistry. This area is known, generally, as materials science. The Department of Materials Science at Case Western Reserve University is eager and willing to send representatives to middle schools in northeast Ohio for talks and demonstrations about materials and their chemical properties. Interested teachers may contact James D. McGuffin-Cawley, Ph.D., Department Chairman and Arthur S. Holden Professor of Engineering (Phone: 216-368 6482, Email: jxc41@case.edu). Teachers can also increase their own practice and understanding of materials by attending "Materials Camp." Information is located here: http://asmcommunity.asminternational.org/portal/site/www/Foundation/Educators/TeachersCamp/

Additional Web Resources	ASM International- City Of Materials: http://www.cityofmaterials.com/portal/site/cityofmaterials/ http://asmcommunity.asminternational.org/portal/site/www/ PBS Video: NOVA: Secrets of the Samurai Sword (deals beautifully with how medieval Japanese metal smiths determined the chemistry of metals long before atomic theory and crystalline structure were understood). http://www.pbs.org/wgbh/nova/samurai/ Michigan Tech University has some interesting virtual experiments in materials science: http://www.mse.mtu.edu/outreach/virtualexperiments.html Flinn Scientific has a very useful Middle School Safety Contract to review before conducting other experiments: http://www.flinnsci.com/Documents/miscPDFs/safety_contract_MS.pdf

Ohio Science Standards Abbreviations:

ES – Earth/Space Science
LS – Life Sciences
PS – Physical Sciences
SI – Scientific Inquiry
ST – Science and Technology
SW – Scientific Ways of Knowing