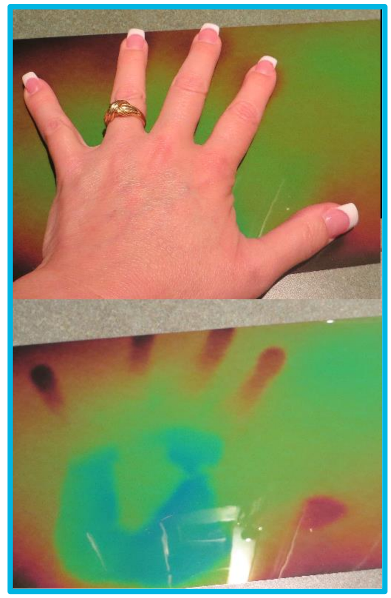
Try Your Hand at Nano

Lesson Focus

Lesson focuses on two simple activities younger students can do to gain an appreciation of nanotechnology. First, students measure their hands in nanometers, second students learn about liquid crystals, their applications and nanotechnology connections and test how the heat of their hands changes the color of the crystals. They observe what they see, present their findings to the class, and reflect on the experience.

Lesson Synopsis



The "Try Your Hand at Nano" lesson shows younger students how small a nano really is and introduces the concept of how elements may change behavior at smaller sizes -- for example, liquid crystals change their behavior and their color when exposed to different temperatures. Students work in teams to measure their hands in nanometers, and test a liquid crystal sheet. Teams review their experiences, present their findings to the class, and reflect on the experience.

Age Levels

8-11.

Objectives

- Learn about nanotechnology.
- Learn about liquid crystals.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- nanotechnology
- liquid crystals
- electricity
- teamwork

Lesson Activities

Students explore nanotechnology through a measurement and temperature exercise involving liquid crystals. They learn about liquid crystal applications, and how size can impact how a material behaves. Student teams consider their experience, present to the class and reflect on the experience.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- TryNano (www.trynano.org)
- National Nanotechnology Initiative (www.nano.gov)
- Liquid Crystals (National Science Foundation uTube) (www.youtube.com/watch?v=nAJgchCI3kg)
- Liquid Crystal Introduction - McGill University (http://barrett-group.mcgill.ca/tutorials/liquid_crystal/LC02.htm)

Recommended Reading

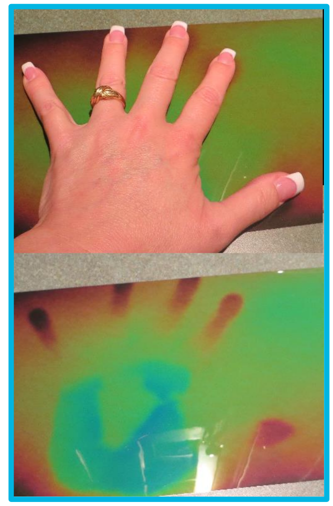
- Nanotechnology For Dummies (ISBN: 978-0470891919)
- Science at the Nanoscale: An Introductory Textbook (ISBN: 978-9814241038)
- Liquid Crystal Displays: Fundamental Physics and Technology (Wiley Series in Display Technology) (ISBN: 978-0470930878)

Optional Writing Activity

- Write a paragraph about how liquid crystal displays have impacted how we watch television.

For Teachers:
Teacher Resource

◆ Lesson Goal
The "Try Your Hand at Nano" lesson shows younger students how small a nano really is and introduces the concept of how elements may change behavior at smaller sizes -- for example, liquid crystals change their behavior and their color when exposed to different temperatures. Students work in teams to measure their hands in nanometers, and text a liquid crystal sheet. Teams review their experiences, present their findings to the class, and reflect on the experience.



◆ Lesson Objectives
- Learn about nanotechnology.
- Learn about liquid crystals.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

◆ Materials
- Student Resource Sheets
- Student Worksheets
- Class Materials: Liquid crystal sheet size 20cm x 20cm roughly (available via Amazon, and many science and educator supply services).
- Student Team Materials: ruler, pencils, paper.

◆ Procedure
1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students how large their hand would be in nanometers.
3. If internet access is available, have students review the resources at www.trynano.org. The site will provide additional background information about nanotechnology and the industries where it is having great impact.
4. Activity 1: Have students hypothesize and then actually measure their hand in nanometers, centimeters and inches. Have students compare the actual number with their hypotheses and consider how small a nanometer is.
5. Activity 2: Review sheets about liquid crystals and their applications, then have students take turns putting their hand on a large liquid crystal sheet and observe what happens. Student teams make hypotheses and then test what happens when they put various items on top of the sheet: their hand, an apple, an ice cube or cup of cold water.
6. Teams observe what happened, compare their hypotheses to the actual results, complete a reflection sheet, and present their experiences to the class.

◆ Time Needed
One to two 45 minute sessions.

For Students:
What is Nanotechnology?

Imagine being able to observe the motion of a red blood cell as it moves through your vein. What would it be like to observe the sodium and chlorine atoms as they get close enough to actually transfer electrons and form a salt crystal or observe the vibration of molecules as the temperature rises in a pan of water? Because of tools or 'scopes' that have been developed and improved over the last few decades we can observe situations like many of the examples at the start of this paragraph. This ability to observe, measure and even manipulate materials at the molecular or atomic scale is called nanotechnology or nanoscience. If we have a nano "something" we have one billionth of that something. Scientists and engineers apply the nano prefix to many "somethings" including meters (length), seconds (time), liters (volume) and grams (mass) to represent what is understandably a very small quantity. Most often nano is applied to the length scale and we measure and talk about nanometers (nm). Individual atoms are smaller than 1 nm in diameter, with it taking about 10 hydrogen atoms in a row to create a line 1 nm in length. Other atoms are larger than hydrogen but still have diameters less than a nanometer. A typical virus is about 100 nm in diameter and a bacterium is about 1000 nm head to tail. The tools that have allowed us to observe the previously invisible world of the nanoscale are the Atomic Force Microscope and the Scanning Electron Microscope.

◆ How Big is Small?
It can be hard to visualize how small things are at the nanoscale. The following exercise can help you visualize how big small can be! Consider a bowling ball, a billiard ball, a tennis ball, a golf ball, a marble, and a pea. Think about the relative size of these items.

◆ Scanning Electron Microscope
The scanning electron microscope is a special type of electron microscope that creates images of a sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. In a raster scan, an image is cut up into a sequence of (usually horizontal) strips known as "scan lines." The electrons interact with the atoms that make up the sample and produce signals that provide data about the surface's shape, composition, and even whether it can conduct electricity.

Many images taken with scanning electron microscopes maybe viewed at www.dartmouth.edu/~emlab/gallery.

For Students:
Nanoscale Properties

Properties of materials at the nanoscale are different in many cases from the properties of materials observed in other scales. Consider, for example, the melting point of metals. Nanoparticles often exhibit a lower melting point than the corresponding metals in bulk, and these melting points depend on size. For example, bulk Gold melts at 1064 degrees Celsius, but a 4nm Gold particle melts at roughly 850 degrees Celsius.

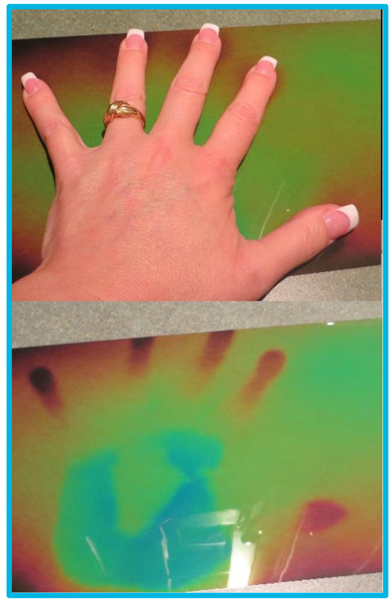
The color of a material can also be size dependent. The appearance of color is caused by the partial absorption of light by electrons in that material; the unabsorbed part of the light remains visible.

On most smooth metal surfaces, light is entirely reflected by the very high density of electrons; this is why the surfaces of slabs of metal have mirror-like appearance. In contrast, small particles absorb some of the light, leading to the appearance of color. This property depends on size.

For example, Gold exhibits a different color depending on its particle size. Extremely tiny particles of Gold have been used to color glasses since the very early days of glass making. Ruby vases (with color that is pink to blood-red) were made using finely dispersed Gold particles for centuries. Many stained glass windows exhibit red color because of doping with gold Nanoparticles.

Nanosystems are not large enough for many classical laws of physics to apply. For example, Ohm's law, which describes the relation between current and voltage in a conductor, does not describe current conduction through a tiny nanowire. Here other effects, known as quantum mechanical effects are more important.

Student Resource:
Liquid Crystals



◆ Liquid Crystals
Liquid crystals (LCs) are in a state of matter that has properties between those of a usual liquid and those of a solid crystal. For instance, an LC may flow like a liquid, but its molecules may be oriented in a crystal-like way. There are a few different types of liquid crystals, but thermotropic liquid crystals change their properties as the temperature changes. If you apply something hot (like your hand) to an encased liquid crystal sheet, it will change color according to the temperature variation. The colors shift from red to orange to yellow, then green, blue and purple as they get hotter!

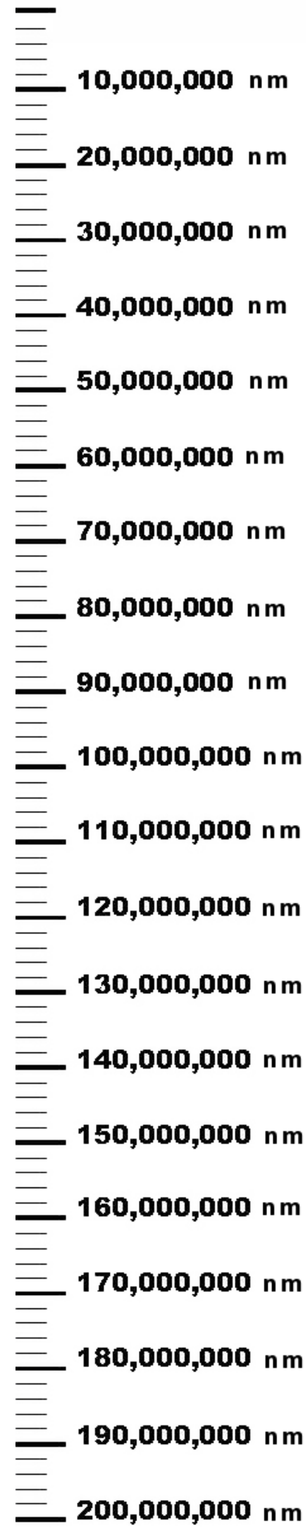
◆ How is this Nano?
Changes in a material's structure are usually too small to view directly, but often we can instead observe changes in the material's properties as a result of the structural changes. Thermotropic liquid crystals change color when exposed to different temperatures -- so we see the color property change even though we cannot observe in a classroom the change in their molecular structure. The liquid crystals change color as a result of adjustments in the arrangement of their molecules at the nanoscale. In nanotechnology, scientists take advantage of the peculiar properties of materials at the nanoscale to engineer new materials and devices.

◆ Thermometer Applications
Liquid crystal color transitions are used in sheets on many aquarium and pool thermometers as well as on thermometers for infants or baths. Other liquid crystal materials change color when stretched or stressed. Thus, liquid crystal sheets are often used in industry to look for hot spots in a manufacturing process, or to map the flow of heat.

◆ Liquid Crystal Displays
A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. LCDs are used in many products such as computer monitors, televisions, instrument panels, gaming devices, clocks, watches, calculators, and even telephones. LCDs have replaced cathode ray tube (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in. LCDs are, however, susceptible to image persistence. The LCD is more energy efficient and offers safer disposal than a CRT.

Student Resource:
Measurement in Nanometers!

The ruler on this page is calibrated to a 100% print size…
how big is your hand in Nanometers?



Student Worksheet:
Liquid Crystal Investigation

◆ Research Phase
Read the materials provided to you by your teacher. If you have access to the internet, also explore resources at www.trynano.org.

◆ Hypothesis
As a team, you have been given the challenge of investigating how temperature impacts a liquid crystal sheet. In the boxes below describe what you think will happen as you test the sheet. Try to predict what colors and shapes you might see, and how long it will take before the liquid crystal sheet changes again.

If I place my hand on it for 5 seconds…	**If I place my hand on it for 30 seconds…**

If I place an apple on it for 5 seconds…	**If I place an apple on it for 30 seconds…**

If I put an ice cube or cup of cold water on it for 5 seconds…	**If I put an ice cube or cup of cold water on it for 30 seconds…**

◆ Investigation
In the boxes below describe what really happened as you tested the sheet.

Hand on it for 5 seconds…	**Hand on it for 30 seconds…**

Apple on it for 5 seconds…	**Apple on it for 30 seconds…**

Ice cube or cup of cold water on it for 5 seconds…	**Ice cube or cup of cold water on it for 30 seconds…**

Student Worksheet:
Activity Two - Liquid Crystal Investigation (continued_

◆ Observation and Results

Answer the questions below:

1. How different were your hypotheses from the actual results you saw?

2. Which test surprised you the most? Why?

3. Think of an idea for using a smaller -- or larger sheet of liquid crystals?

4. Have you ever heard of a "mood" ring? How do you think this works?

◆ Presentation and Reflection Phase

Present your original hypothesis and actual measurements to the class.

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆ **National Science Education Standards Grades K-4 (ages 4-9)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆ **National Science Education Standards Grades 5-8 (ages 10-14)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Properties and changes of properties in matter

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Personal health
- Risks and benefits
- Science and technology in society

For Teachers:
Alignment to Curriculum Frameworks (cont.)

◆**National Science Education Standards Grades 5-8 (ages 10-14)**

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- Nature of science
- History of science

◆**Next Generation Science Standards Grades 2-5 (Ages 7-11)**

Matter and its Interactions

Students who demonstrate understanding can:

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- 5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

◆**Standards for Technological Literacy - All Ages**

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Design

- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 13: Students will develop abilities to assess the impact of products and systems.