NanoLeap

Nanoscale Materials and Their Properties
Teacher Guide Unit 1: *Nanoscience: What Is It?*
Lesson 1.3 What Makes Nanoscience so Important?

Objectives for *Nanoscience: What Is It?*

Lesson objectives: What Makes Nanoscience so Important? **(bold)**

Students will be able to:

1. Define nanoscience as the study of the fundamental principles of structures having at least one dimension lying roughly between 1 and 100 nanometers.
    a. Compare and contrast the size of atoms, ions, and molecules to the size of nanoparticles.
    b. Identify structures that are appropriately measured in nanometers.
    c. Compare and contrast nanoparticle samples to atomic and macro-level samples in terms of the particle size, number of atoms, and operational model.
2. **Explain the importance of nanoscience research and technology.**
3. **Evaluate the ethical considerations associated with nanoscience research and nanotechnology.**
4. **Recognize the interdisciplinary nature of nanoscience.**
5. **Identify the requirements of nanoscience and nanotechnology, including:**
    a. **new production methods,**
    b. **new measurement instruments, and**
    c. **a cleanroom environment for nanoscale research and technology.**

Suggested Time Frame: 90 Minutes

Chemistry Concepts

- Physical and chemical properties
- Instrumentation

At a Glance for the Teacher

- Review the interdisciplinary nature of nanoscale science
- Identify physical and chemical properties of objects
- ❖ Describe how size and shape as well as composition affect nano material properties
- ❖ View a video about the Atomic Force Microscope (AFM)
- ❖ Model an AFM using magnets
- ❖ Discuss ethical implications of nanoscience

❖ **New Concept**
• **Review**

- ❖ Describe why nanoscale science is so important
- ❖ Complete “L” from K-W-L chart
- ❖ Following this lesson, complete the Poster Assessment introduction as introduced in the teacher version of the student handbook
- Answer “Making Connections” questions
- Review “Flow Chart”

Materials

- PowerPoint – *Nanoscience: What is it? What Makes Nanoscience so Important?*
- Computer with LCD Projector and Speakers
- AFM Demo from: http://www.mcrel.org/nanoleap/multimedia/index.asp
- Teacher video: *Magnetic Probe Model* from: http://www.mcrel.org/nanoleap/multimedia/index.asp
- Student Handbook
- Student Handbook –Teacher Version
- Refrigerator Magnets
- Scissors
- Marker

Advanced Preparation

For a demonstration of how to set up the magnetic probe activity see video *Magnetic Probe Model*.
For each student (or each group of students):

- 1 refrigerator magnet per student. A rectangular magnet that is 2” x 3” works well, but the size of the magnet is not critical.
- 1 probe strip per student. These can be made from the rectangular magnet. To do this, cut ¼ inch strip along each edge of the magnet. Place the unprinted side of one of the magnets against the unprinted side of the ¼ inch strip. Drag the strip across the back of the magnet in both directions. Repeat with the second strip. One of the strips will alternatively attract and repel (bounce) as it is dragged in one of the directions while the other will not. Retain the strip that bounces which will be the probe strip and discard the other.
- 1 metric ruler per student
- 1 whiteboard per group of students
- 1 set of whiteboard markers per group of students

<u>Slide #</u> **Student Handbook Page #**	*<u>Teacher Background Information and Pedagogy</u>* **Teacher Script**
Slide 1	**Let's consider our last question... "What makes nanoscience so important?"** **Think about some of the applications shown in the *NanoSize Me* video. What do <u>you</u> think might make nanoscience so important?** *Student answers might include ideas from the* NanoSize Me *video.*
Slide 2	**Nanoscale materials represent a new realm of solid matter.** **Is nanoscale science different from chemistry? At its most basic level, nanoscience involves the breaking and the making of chemical bonds among very small numbers of particles, resulting in novel and dramatic transformations in the properties and performance of materials formed.** 1) *Have students define these disciplines as you make each click.* **What subjects/science disciplines are involved with nanoscience?** {Click} **Nanoscience is where** {Click} **chemistry, (stuff)** {Click} **physics, (movement/motion)** {Click} **engineering, (making things/designing/problem solving)** {Click} **materials science, (anything that is around us)** {Click} **biochemistry, and molecular biology converge, and it involves the manipulation and characterization of matter at the nanoscale level.** **Nanoparticle products in the *NanoSize Me* video were applications of different science disciplines. Some of them were chemical in nature, but what other sciences have been applied in the examples in the video?** *Examples: physics; engineering and materials science (space elevator); biochemistry/molecular biology (medical diagnostics/treatment).*
Slide 3	**Nanoscale materials exhibit different properties from what we normally observe in large samples of these materials.** 2) *Ask the students for examples of chemical and physical properties that they studied in the past.* **Chemical and physical properties include** {Click} **size,** {Click} **shape,**

	{Click} **composition,** {Click} **bonding,** {Click} **structure,** {Click} **melting/boiling point, and** {Click} **reactivity.** 3) *Ask students to predict how these properties might be different for nanoparticles.*
Slide 4	**What do you recall about the properties of nanoparticles?** • **that many of their properties do not just depend upon <u>composition</u>,** • **but also upon <u>size</u> and <u>shape</u> of the particle.** **Even if scientists know the size and properties of a nanoparticle for a given element or compound, those properties may change as the size or shape of the particle changes. That makes prediction at the nanoscale very challenging!** **Can we use just the periodic table to predict properties at the nanoscale?** *Probably not, because characteristics depend on size and shape as well as composition.* **If you knew how the properties of <u>carbon</u> structures change at the nanoscale level, could you predict some of the properties of <u>silicon</u> structures at that level?** *Maybe, because carbon and silicon are in the same periodic family, which give us similarities in composition, but their properties might also depend on shape and size.*
Slide 5	**Because properties of nanoscale materials are not predicted in the same way as macroscale samples, working with nanoscale materials is challenging.** **New instrumentation is required.** **New instrumentation sounds simple, doesn't it? But imagine trying to cut a piece of paper in half, in half again, and again, and again, until your scissors cannot cut it anymore. Maybe you can now use a razor blade or a sharp knife to continue cutting the sample into halves. Eventually, you run out of suitable tools to cut the sample smaller. Then, what do you do? Design a new tool!** 4) *This slide contains an audio clip from Professor David Goldhaber-Gordon (Stanford Nanofabrication Facility).* 5) *Refer back to the* NanoscaleMe *computer interactive and call students' attention to the instrumentation used at the different ranges found at the bottom of each image sort.*

Slide 6 "Activity 2–Imaging What is Too Small to See" Student Handbook-TV: Page 30 Student Handbook Page: 14	6) *Refer to the section "Imaging and Measurement Tools that Enable Nanoscale Science and Engineering" in the Teacher Resource Guide on page 19.* 7) *Direct students to complete "Activity 2–Imaging What is Too Small to See." See annotated teacher's guide for instructions and answers for this activity. Begin by providing the following information and asking the questions below.* **Scanning-probe instruments can be used both to measure and to prepare nanostructures on surfaces. In the simplified graphic shown here, an Atomic Force Microscope (AFM) uses a scanning-tip to measure the interactions between the tip and the nanostructure surface.** **In this activity you will model how measurements are obtained from this type of instrument and how the measurements are converted by computer into images of the surfaces they probed.** **How would you demonstrate an AFM with a magnet? What would you do to detect variations on the surface? What would you feel? Predict what you will feel.** **Note: Depending on the type of magnet used, the vibrations might be subtle.** 8) *Once students have completed the activity, have them answer the two questions in their handbook.* 9) *If time permits, have students complete a short white board activity with their representation of the "surface of the nanoparticle" (represented by the magnet surface). Have them compare their representations with other groups. Ask students: Are all of the representations identical? How are they different?* 10) *Click on the Play button to hyperlink to* AFM Demo video. *The video is also found at: http://www.mcrel.org/nanoleap/multimedia/index.asp. The video demonstrates how an Atomic Force Microscope (AFM) is used to image the surface of a DVD.*
Slide 7	**There are scientists and engineers who predict that nanoscience and technology will change the nature of almost every human-made object in the next century. Consider these quotations:** {Click} **"Just wait—the 21st century is going to be incredible. We are about to be able to build things that work on the smallest possible length scales, atom by atom. These nanothings will revolutionize industries and our lives."** **Do you think this prediction is full of promise or do you see it as threatening?**
Slide 8	**What societal and ethical implications related to nanotechnology can you think of?** **Let's consider some very real ethical problems that have accompanied past scientific research.** *Students might suggest the development of the internal combustion engine for pollution, nuclear technology for*

	weapons, chemical weaponry, and pesticides. (Click) **What happens when engineered nanoparticles are found to have unexpected negative side effects?** *For example, the MTBE additive to gasoline to reduce air pollution is soluble in water and poisonous, and it can leak from underground storage areas.* **What happens when pharmaceutical companies do not fully disclose the negative side effects of drugs?** *An example might include Vioxx, which was used for the reduction of arthritis pain, but increased the user's risk of heart attack and stroke. Students might also note commercial drugs that contain disclaimers for numerous side effects.*
Slide 9 Poster Assessment Student Handbook-TV: Page 101 Student Handbook Page: 62	**How should we approach the privacy issues that accompany the use of nanoparticle applications, such as the implanting of nano sensors, GPS systems, or ID systems, in human bodies? How many of you have a chip in a dog or cat?** *Students will probably reply that there might be societal benefits with these new technologies, but that there may be infringements on individual rights and privacy.* **Are these issues that scientists should be concerned about? If so, why? If not, who, if anyone should be concerned?** *Expect that students' answers will be on opposite sides of the spectrum.* **Remember these questions (and their answers) as you research the application of your choice for the final assessment of the module.** **Why is nanoscale science so important?** *With nanoscale science, we have opened up a whole new world of unknowns (new materials with unknown potential, risks, and benefits).* *11) During K-W-L follow-up, have students identify the questions that were answered in this PowerPoint component.* *12) Have students identify further questions that were raised in this PowerPoint component.* Complete Poster Assessment introduction as introduced in the teacher version of the student handbook.
Slide 10	*13) The "Making Connections" questions at the conclusion of each lesson can be used at the end of the class period or the beginning of the next day as a warm up. Generally the first few questions are a review of the present lesson, while the last question is a preview of future lessons.* *Answer for question one: nanoscale science is interdisciplinary because it involves science from many disciplines in science (e.g.,*

	biology, chemistry, physics). *Answer for question two: nanoparticle properties depend on size, shape, and composition of the nanoparticle.* *Answer for question three: as the probe is dragged across a surface there will be a difference in force felt by the probe tip as it is closer or farther away from atoms in the surface. The magnitude of the deflection is captured by a laser that reflects at an oblique angle from the very end of the cantilever. A plot of the laser deflection versus tip position on the sample surface provides the resolution of the hills and valleys that constitute the topography of the surface. The AFM can work with the tip touching the sample (contact mode), or the tip can tap across the surface (tapping mode).* *For question five:* **in the next lesson we will learn about two different fabrication techniques (top down, bottom up).**
Slide 11	*14) The pilot-test teachers highly recommend using this flow chart at the end and/or beginning of each lesson. The end of each lesson contains this flow chart that provides an opportunity to show students the "big picture" and where they are in the lesson sequence.*