NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 1 HR 30 MINS

Properties of Matter: Macro to Nano Scale

Through a series of video and hands-on demonstrations, students explore and discuss how certain properties of matter change at the nanoscale.

GRADES

6 - 8

SUBJECTS

Biology, Engineering

CONTENTS

5 Videos, 2 PDFs

OVERVIEW

Through a series of video and hands-on demonstrations, students explore and discuss how certain properties of matter change at the nanoscale.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/properties-matter-macro-nano-scale/

Program

DIRECTIONS

1. Activate students' prior knowledge about properties of matter and the nanoscale.

Ask: *What is a property of matter?* Elicit from students that properties of matter are the characteristics that determine how different types of matter behave. Unique combinations of properties make them similar to or different from other types of matter. Ask: *What are some examples?* (Student examples will vary, but may include color, surface area, mass, and weight.)

Introduce the properties that will be the focus of the demonstrations by writing them on the board: color, visible light, reactivity, surface area to volume ratio, and surface tension. As a class, briefly discuss what each property means. Explain that it's okay if students don't fully understand the properties yet. They will learn more about them throughout the activity. Write the term "nanoscale" on the board and have student pairs discuss what they think the term means. Then, as a class, ask students to share aloud some of their ideas. Encourage students to break the term down into its root words, nano and scale. Address any incorrect responses and make sure they understand that nanoscale has something to do with measurement.

2. Have students view and discuss the NISE Net video, "Intro to Nano."

Tell students that they will next watch a video that will teach them more about the nanoscale and properties of matter. As they view the NISE Net video "Intro to Nano" (3 min. 10 sec.), tell them to look and listen for the words that include or refer to "nano," "properties," and "scale." On their own paper, have them record these words. After viewing, discuss the video as a class. Ask: *What words did you write down?* Answers will vary but should include the terms nanoscale, nanotechnology, nanometer, and nanoparticle.

On their papers, have students arrange the terms *macro*, *nano*, and *micro* in order from biggest to smallest. Explain that objects on the macro scale are the largest, and we can see them with our naked eye. Objects at the micro scale require us to use special instruments, like optical microscopes, to see them. The smallest objects, like atoms and molecules, are on the nanoscale. Ask: *From the video, do you remember how big a nanometer is compared to a meter?* Hold up a meter stick and explain that a nanometer (nm) is a unit of length equivalent to one billionth (10^{-9}) of a meter. For comparison, explain that one inch equals 25.4 nanometers, and that the sheet of paper they have been writing on is approximately 100,000 nanometers thick. At this nanoscale (1-100 nm), scientists can alter individual atoms and molecules. These alterations can lead to changes in the physical, chemical, biological, and optical properties of matter. Ask: *From what you learned in the video, what types of nanotechnologies are scientists creating by altering properties of matter?* Elicit from students nanotechnologies that include medicines, cures for cancer, cheaper and cleaner energy, water filtration systems, and stain-resistant clothing.

3. Distribute the Nano Properties worksheet and introduce the demonstration activity.

Depending on your available class time and curricular needs, determine whether you want your students to do all or just some of the demonstrations listed in Step 4 below. Explain to students that for the rest of the activity, they will use a series of video and hands-on demonstrations (demos) to further explore how certain properties of matter differ at the macro and nanoscales.

Ask students to recall the difference between macro and nanoscales discussed in Step 2. Explain to students that while they cannot actually see what's happening at the nano scale, the demos and videos will serve as models that represent how properties change at different scales. As needed, elaborate on what a model is and/or provide examples.

Distribute the Nano Properties worksheet and read aloud the directions. Have students fill in the first column with the titles of the demos they will be doing. Address any questions, making sure students understand what to do during and after each demo. If needed, go over the meaning of each property once more. (NOTE: Unless there is a specific reason, the demos should be completed in the order listed on the worksheet. As the activity is written, *Gold*, *Aluminum*, and *Plants & Fabrics* are video-only demos. The hands-on demos are *Sunscreen*, *Bubbles*, *Water Cups*, and *Antacid Tablets*. Except for *Sunscreen* and *Antacid Tablets*, all of the hands-on demos have an associated video, so if materials or time are limited, they could be done as video-only demos.)

4. Have students observe the demonstrations and complete the Nano Properties worksheet.

In conducting the demos, please refer to the instructions and information included here and on the Nano Properties worksheet key.

a. **Gold**:

- Video Demo: NISE Net video, "Intro to Nano"
- Time: Video - 3 minutes, 10 seconds
- Properties: color, visible light
- Instructions: This demo is included in the "Intro to Nano" video shown in Step 2. After observing the video, students should complete the worksheet in small groups or as a class.

b. Aluminum:

- Video Demo: NISE Net video, “Nano and Me: Aluminum”
- Time: Video - 33 seconds
- Properties: reactivity, surface area to volume ratio
- Instructions: After observing the video, students should complete the worksheet in small groups or as a class.

c. Sunscreen:

- Hands-on Demo: There is no video associated with this demo.
- Time: 2-3 minutes
- Properties: visible light
- Instructions: Divide students into small groups and distribute samples of sunscreens containing zinc oxide or titanium dioxide. Each group should get a sample that is sheer (nanoparticles) and one that is non-sheer (larger particles). Tell them to apply small amounts of each and then compare and contrast what they observe. Students should complete the worksheet in small groups or as a class.

d. Bubbles:

- Hands-on and Video Demo: NISE Net video, “What’s Nano About Bubbles?”
- Time: Hands-on - 5 minutes; Video - 38 seconds
- Properties: visible light, surface tension
- Instructions: Divide students into small groups and distribute samples of soapy water and straws. Have students experiment with forming bubbles and making observations as they go. After filling in the “observations” and “properties” sections of their worksheets, watch the video as a class. Students should then complete the worksheet in small groups or as a class.

e. Water Cups:

- Hands-on and Video Demo: NISE Net video, “Nano and Me - Gravity”
- Time: Hands-on - 5 minutes; Video - 32 seconds
- Properties: surface tension
- Instructions: Divide students into small groups and distribute plain water and large and small “cups.” Tell students that the regular-sized cup represents the macro scale and the small cup (toothpaste cap or small thimble) represents the nanoscale. Instruct students to fill their cups with water and slowly pour them out, recording their observations of what

happens. After filling in the "observations" and "properties" sections of their worksheets, watch the video as a class. Explain that static electricity, like gravity and surface tension, behaves differently on macro and nano scales. Students should then complete the worksheet in small groups or as a class. If time allows, students can experiment with how the surface tension of the soapy water (from Bubbles demo) and plain water compares.

f. **Antacid Tablets**:

- Hands-on Demo: There is no video associated with this demo.
- Time: Hands-on - 5 minutes
- Properties: reactivity, surface area to volume ratio
- Instructions: Divide students into small groups, giving each group two clear cups of plain water (equal volume), two clear empty cups, two antacid tablets, a piece of paper, and a tool to crush one of the tablets (inside the paper). Tell students to place the whole tablet in one of the empty cups and to crush and add the second tablet to the other empty cup. Tell students they will be adding two drops of food coloring and equal volumes of water to the tablets. Before adding the water, ask students to predict what will happen when water is added to each of the cups. Remind them to pour the water at approximately the same rate. Students should complete the worksheet in small groups or as a class.

g. **Plants & Fabrics**:

- Video Demo: NISE Net video, "I Got No Stains on Me"
- Time: Video - 3 minutes, 43 seconds
- Properties: surface tension
- Instructions: After observing the video, students should complete the worksheet in small groups or as a class. Instead of watching the video right away, this can be turned into a hands-on demo by providing students with samples of different lettuces and greens from the grocery store. Using eyedroppers and water, they can experiment with which leaves or lettuces are water-resistant and water-repellant. Hearty greens like kale and collard greens will repel water, while softer lettuces like iceberg will absorb water.

5. Have students reflect on and discuss what they learned about properties of matter and the nanoscale.

Have students select two of the properties they learned about in the demos and discuss with a partner other examples of those properties that they have observed. For example, students may have seen a paperclip float or sink in a cup of water depending on how it was placed in the water. That is an example of surface tension. Students may have seen the colors of the rainbow (spectrum of visible light) after a rain shower or observed how sugar or salt dissolve more quickly in hot water (reactivity).

Next, have student pairs list at least three examples of nanotechnology products or uses and have them share as a class. Challenge students to come up with nanotechnology applications not discussed in the activity demos.

To conclude, emphasize that understanding how different properties of matter change at the nanoscale is a key component of nanotechnology. Nanotechnology applications are highly varied and are revolutionizing many different aspects of science and industry, including energy, environmental science, homeland security, transportation, food safety, information technology, and medicine. The more scientists learn about nanoscale properties, the more the field of nanoscience will continue to grow.

Modification

Instead of observing all of the demos, students could be divided into seven groups—one per demo—and complete the worksheet in their group. Then each group could present its findings to the class.

Tip

Preview and queue up the videos before beginning the activity. Unless there is a specific reason, the demonstrations should be completed in the order listed on the worksheet. This will help with the flow of the activity and will better integrate the video and hands-on portions.

Informal Assessment

Use students' completed Nano Properties worksheet to assess their comprehension.

Extending the Learning

- Have students observe and discuss additional molecular properties included in the demonstrations, including hydrophobia, hydrophilia, cohesion, adhesion, and self-assembly.

- Have students select, research, and do a class presentation on one of the nanotechnologies discussed during the activity.

OBJECTIVES

Subjects & Disciplines

- **Biology**
- Engineering

Learning Objectives

Students will:

- Distinguish between objects at the macro and nano scales
- Define the terms nanoscale, nanometer, and nanotechnology
- Identify and describe properties of matter, including color, visible light, reactivity, surface area to volume ratio, and surface tension
- Describe at least three ways nanoscale properties are used in nanotechnology applications

Teaching Approach

- Constructivist
- Learning-for-use

Teaching Methods

- Cooperative learning
- Demonstrations
- Hands-on learning
- Information organization
- Multimedia instruction

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-1:**
Properties and changes of properties in matter
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard F-5:**
Science and technology in society

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Depending on demos selected, provide these: sunscreen (sheer and non-sheer sunscreens containing zinc oxide or titanium dioxide) water soap straws clear plastic containers/cups toothpaste cap or small thimble writing paper antacid tablets food coloring rock or hammer (for crushing antacid tablets)

REQUIRED TECHNOLOGY

- Internet Access: Required

- Tech Setup: 1 computer per classroom, Projector, Speakers
- Plug-Ins: Flash

PHYSICAL SPACE

- Classroom

SETUP

Arrange the desks so students can alternate between small-group work and all-class discussions and video demonstrations.

GROUPING

- Large-group instruction
- Small-group work

OTHER NOTES

Portions of this activity could be completed during different class periods if needed.

BACKGROUND & VOCABULARY

Background Information

A nanometer (nm) is a unit of length equivalent to one billionth (10^{-9}) of a meter. At this nanoscale (1-100 nm), interacting forces and changes in the physical, chemical, biological, optical, and kinetic properties of matter are observed. Understanding the nano world is challenging because of the small size of the nanoscale and because nanoparticle properties can change significantly at the macro and nano scales. However, with more advanced and powerful microscopes, scientists not only can observe these different properties, they can manipulate them deliberately to create new, usable materials and products. Nanotechnology applications are used in cleaning up pollution, making better sunscreens, producing cosmetics, treating diseases, making water- and stain-proof fabrics, among others. There are currently hundreds of nanotechnology-based consumer products available, with more being created every day. However, with any new technology comes the responsibility to examine potential unintended consequences, especially those that could impact human and environmental health.

Prior Knowledge

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Recommended Prior Activities

- Nanotechnology Kills Cancer Cells
- Nano World Revealed
- Seeing is Believing
- Seeing Nature's Slow Motion

Vocabulary

Term	Part of Speech	Definition
macro-	*prefix*	large.
micro-	*prefix*	small.
nanometer	*noun*	(nm) billionth of a meter.
nanoparticle	*noun*	material that has an average particle size of 1-100 nanometers.
nanoscale	*noun*	length scale whose relevant unit of measurement is the nanometer (nm), or a billionth of a meter. Also called the nanoscopic scale.
nanotechnology	*noun*	development and study of technological function and devices on a scale of individual atoms and molecules.
surface tension	*noun*	property of the surface of a liquid where the molecules act like a thin, elastic film, allowing it to resist external forces.
visible light spectrum	*noun*	light and colors that can be seen by human beings.
volume	*noun*	space an object occupies.

For Further Exploration

Websites

- National Geographic: Encyclopedic Entry – Nanotechnology
- National Nanotechnology Initiative: Nanotechnology 101

- Nanoscale Informal Science Education Network: K-12 Resources
- Lockheed Martin: Nanotechnology

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