NATIONAL GEOGRAPHIC

RESOURCE LIBRARY I ACTIVITY : 1 HR 30 MINS

Nano World Revealed

Using media resources and online research, students explore the world of nanoscience and nanotechnology.

GRADES

9 - 12

SUBJECTS

Biology

CONTENTS

8 Photographs, 1 PDF, 3 Links, 4 Resources

OVERVIEW

Using media resources and online research, students explore the world of nanoscience and nanotechnology.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/nano-world-revealed/

Program

MYSTERIES OF THE UNSEEN WORLD

DIRECTIONS

1. Activate students' prior knowledge of microscopy and the nanoscale

Ask: *What does micro mean? In what contexts have you heard that word?* Elicit from students that micro means something is small and cannot be seen with the unaided human eye. Tell students that objects on the micro scale are measured in micrometers and that there are 1 million micrometers in a meter. Micro objects need to be viewed using tools such as optical microscopes. Ask: *What does nano mean? In what contexts have you heard that word?* Elicit from students that nano means something is very, very small and cannot be seen with the unaided human eye or even with most microscopes. Tell students that things on the nano scale are measured in nanometers and there a 1 billion nanometers in a meter. Nano objects need to be viewed using advanced, powerful electron microscopes.

To help students better visualize the difference between micro scale and nanoscale, ask them to recall a time when they used an optical microscope, one that uses visible light to illuminate magnified objects. Optical microscopes have multiple lenses and can magnify objects hundreds of times their actual size so students can see microscopic objects like blood cells and plant tissues in great detail. Ask: *Can you think of any objects smaller than a blood cell or plant tissue?* Elicit from students that nanoscale objects include DNA molecules and single carbon atoms, which are so small they can't be viewed with optical microscopes. This is because the wavelength of visible light is too big (400-750 nanometers) to reflect off them and make them visible to the human eye.

Use a meter stick to demonstrate the nanoscale. Remind students that within 1 meter there are 1 billion nanometers. Ask: *How many nanometers would be in one millimeter?* Explain that there are 1 million nanometers in a single millimeter. Tell students that a dime is around 1 millimeter thick and ask them how many micrometers and nanometers that would be.

2. Build background on nano microscopy and observe nanoscale images from the FEI Company

Explain that unlike optical microscopes that use light to illuminate magnified objects, electron microscopes use electrons to magnify objects, including those on the nanoscale. A scanning electron microscope (SEM) uses this specialized technology. The resolving power of electron microscopes is greater than light microscopes, so objects can be magnified up to about 10 million times, compared with 2,000 times for optical microscopes.

To view and manipulate nanoscale objects, including individual atoms and molecules, some high-powered electron microscopes use very tiny, sharp tips that move across the surface of the object. This method is called scanning probe microscopy (SPM). In SEM and SPM, the scanning beam or tip is connected to a computer that processes the information to create an image of the magnified object. Both types of microscopy are being used in many different applications of nanoscience and nanotechnology. Continue to build background, engage students, and help them visualize the micro scale and nanoscale by displaying and briefly discussing the FEI images listed below, located in the activity resource carousel.

As you observe the images, engage students in determining the sizes of the objects depicted. Note the scale bar at the bottom of each image. This bar may be different for different images. The scale is noted most often in micrometers (μm), but sometimes in nanometers (nm). These scale bars are used much like the bar scales on maps—where 1 inch might equal 100 miles, for example. Have students measure the image on the screen (white board, projected image, or computer monitor—depending on how you are showing these images). Use a piece of paper, a ruler, or other measuring device to determine the size of the object according to the scale on the image. Then have students list the images on the board or on paper, in order, according to size—from largest to smallest.

- FEI Image 1: FEI SEM Microscope – This is an image of a scanning electron microscope.
- FEI Image 2: Ant – This is an image of the anterior (head) of an ant.
- FEI Image 3: MRSA Antibiotic Resistant Bacteria – This is an image of MRSA bacteria on the surface of a wound dressing.
- FEI Image 4: Nano Mirrors – This is an image of Digital Light Processing (DLP)—a component used in video projectors.
- FEI Image 5: Pollen of Birch Tree – This is an image of pollen on a birch tree stick on the stigma of a passion flower.
- FEI Image 6: Spirals – This is an image of a dark-field image showing spirals in nanometer-sized lead embedded in aluminum.
- FEI Image 7: ZnO Nanowires – This is an image of zinc oxide nanowires produced at Lawrence Livermore National Laboratory. These wires only a few nanometers across have unique properties that make them useful in applications such as electronics, optics, and photonics.
- FEI Image 8: Snow in the Mountains – This is an image of a butterfly wing with environmental pollution.

If you would like to present more scanning electron microscope images—and give students more opportunities to practice using the scale bars to measure—you might want to access and project the FEI image media spotlights listed below.

Around the House: Microscopic Images

Yuck Factor: Microscopic Images

Human Body: Microscopic Images

Natural World: Microscopic Images

3. Have students view and discuss the Lockheed Martin video "Speaking of the Future – Nanotechnology"

Tell students they are going to watch a Lockheed Martin video called "Speaking of the Future: Nanotechnology" (3 min. 9 sec.). Explain that the video will introduce them to some of the ways nanoscientists are using nanoscale objects to create new products and materials that can help humans in many different ways. As they watch the video, have students write down three different technologies mentioned by the scientists. After the video, lead a brief class discussion in which students share aloud the technologies they wrote down and why those technologies were of interest to them.

4. Build background on nanoscience and nanotechnology

Continue to build students' background on nanoscience and nanotechnology. Ask: *Based on what you've learned so far, how would you define nanoscience? What about nanotechnology?* Elicit from students that nanoscience is the area of science studying objects at the nanoscale (1 to 100 nanometers). The nanometer-scale is the scale of atoms and molecules. So nanotechnology involves the manipulation of matter at 1-100 nanometers or at the atomic level.

Nanotechnology is the application of nanoscale materials and properties to create new products and solve problems. Explain that the field of nanotechnology focuses on developing new ways to measure and make very small structures, as well as identifying and manipulating properties of matter at the nanoscale to create new technologies. Examples of products already developed or being developed using nanotechnologies include many different consumer products, such as cosmetics, anti-aging skin creams, antiseptics, sheer sunscreens, lighter and stronger sports equipment, water-proof and antimicrobial fabrics, and scratchproof coatings.

Tell students that nanotechnology has led to the development of increasingly smaller electronics and computer components, including processors and batteries.

5. Have students conduct research on nanotechnology

Distribute the Nanotechnology Research worksheet and introduce the activity by telling students they are going to learn more about nanotechnology applications using Northwestern University's DiscoverNANO: Applications of Nanotechnology website. Assign students to 12 small groups. Make sure that students understand they will answer the questions on the Nanotechnology Research worksheet by conducting research. Each group will research one of four fields (environment, security, energy, or medicine) and be assigned one of the following nanotechnology types: renewable energy, remediation, sensors, communications, our troops, detection & diagnosis, biological markers, regeneration, treatment, energy efficiency, or new energy producers I & II. After conducting their research, they will present their findings to the class.

6. Have student groups present their nanotechnology research and discuss what they learned

Have student groups present their nanotechnology research to the class. The order of presentations does not matter, but all groups in each of the four fields (environment, security, energy, medicine) should present one after the other. After each group presents, allow for a brief discussion that includes time for questions. As needed, use the questions on the Nanotechnology worksheet to facilitate discussion and check for student comprehension.

Informal Assessment

Use students' completed Nanotechnology Research worksheets and group presentations to assess their comprehension.

Extending the Learning

- Have students use online resources and interactives to investigate scanning probe microscopy and other electron microscope technologies. Some possible websites:
  - Scanning Probe Microscopy
  - What is Electron Microscopy?
  - Types of Electron Microscopes
- Have students use the recommended resources to expand upon their research and write a formal paper on one or more nanotechnologies.
- Investigate other types of nanotechnology using the following websites:

- National Geographic: Encyclopedic Entry: Nanotechnology
- National Nanotechnology Initiative: Nanotechnology and You: Benefits and Applications
- National Nanotechnology Initiative: Big Things from a Tiny World

OBJECTIVES

Subjects & Disciplines

Biology

Learning Objectives

Students will:

- distinguish between objects at the micrometer-scale and nanometer-scale
- define the terms nanoscience and nanotechnology
- describe the difference between optical microscopes and electron microscopes
- explore types of products or materials created through the use of nanotechnology
- determine through research some risks associated with the use of nanotechnology

Teaching Approach

- Learning-for-use

Teaching Methods

- Cooperative learning
- Discovery learning
- Information organization
- Multimedia instruction
- Research

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
  - Life and Career Skills
    - Initiative and Self-Direction

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-2:**
Structure and properties of matter
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard G-1:**
Science as a human endeavor

PREPARATION

What You'll Need

REQUIRED TECHNOLOGY

- Internet Access: Required

SETUP

Arrange the desks so students can view the projected video and images as a whole class.

GROUPING

- Large-group instruction
- Small-group instruction

OTHER NOTES

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

RESOURCES PROVIDED: WEBSITES

- Lockheed Martin: Speaking of the Future – Nanotechnology
- Northwestern University: DiscoverNANO
- DiscoverNANO: Applications of Nanotechnology

RESOURCES PROVIDED: HANDOUTS & WORKSHEETS

- Nanotechnology Research

RESOURCES PROVIDED: IMAGES

- SEM Microscope
- Ant Head
- MRSA
- Nano Mirrors
- Pollen of Birch Tree
- Spirals
- ZnO Nanowires
- Snow in the Mountains
- Around the House: Microscopic Images
- Yuck Factor: Microscopic Images
- Human Body: Microscopic Images
- Natural World: Microscopic Images

BACKGROUND & VOCABULARY

Background Information

Advanced microscopes allow scientists to observe and even manipulate objects at the nanoscale (1-100 nm), where properties of matter can be very different from what they are at the macro scale. Unlike optical microscopes that use visible light to illuminate magnified objects, electron microscopes use electrons so things as small as molecules and atoms can be seen. Using an electron beam or tip, scanning electron microscopes (SEM) and scanning probe microscopes (SPM) send scanned information to computers that produce images of nanoscale materials. This allows scientists to manipulate the objects or materials to produce new materials. Both types of microscopy are being used in many different applications of nanotechnology. These applications include cleaning up pollution, purifying water, making better sunscreens, improving energy efficiency, designing smaller electronic devices, producing cosmetics, diagnosing and treating diseases, designing lighter and stronger materials, and making stain-proof fabrics.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
electron microscope	*noun*	powerful device that uses electrons, not light, to magnify an image.
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.

For Further Exploration

Websites

- National Geographic: Encyclopedic Entry – Nanotechnology
- National Nanotechnology Initiative: Benefits and Applications
- Nanoscale Informal Science Education Network: K-12 Resources
- Northwestern University: DiscoverNANO

FUNDER

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