School Field Trip Framework

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General Description

Audience:

School group of students ages 8 to 11 year old

Type of program:

Classroom activity: This one-hour module engages school field trips in nanoscale science, technology, and engineering. Through hands-on activities, students are encouraged to investigate nanoscale properties, structures, products, and new materials. Through facilitated conversation they can explore how technologies and society influence each other and how people's values shape the ways nanotechnologies are developed and adopted. This field trip framework includes activities to cover all four main ideas of the NISE Net content map (further explained in the Engaging the Public in Nano Key Concepts document available at nisenet.org) and can also be easily modified depending on available resources and the age of the target audience.

Program Objectives

Big idea:

Nano is small and can be found all around us.

Learning Objectives:

As a result of participating in this session, students will understand that

- A nanometer is one-billionth of a meter. Nanometer-sized things are very small.
- Nanometer-sized things often behave differently than larger things do.
- Specialized microscopes allow scientists to observe nanoscale structures.
- Researchers and engineers are using nanoscale science to produce new and/or improved materials.
- Technologies and society influence each other.
- People's values shape how nanotechnologies are developed.

NISE Network content map main ideas:

[X] 1. Nanometer-sized things are very small, and often behave differently than larger things do.

[X] 2. Scientists and engineers have formed the interdisciplinary field of nanotechnology by investigating properties and manipulating matter at the nanoscale.

[X] 3. Nanoscience, nanotechnology, and nanoengineering lead to new knowledge and innovations that weren't possible before.

[X] 4. Nanotechnologies have costs, risks, and benefits that affect our lives in ways we cannot always predict.

National Science Education Standards:

[X] 1. Science as Inquiry
- [X] K-4: Abilities necessary to do scientific inquiry
- [X] K-4: Understanding about scientific inquiry
- [X] 5-8: Abilities necessary to do scientific inquiry
- [X] 5-8: Understanding about scientific inquiry
- [ ] 9-12: Abilities necessary to do scientific inquiry
- [ ] 9-12: Understanding about scientific inquiry

[X] 2. Physical Science
- [X] K-4: Properties of objects and materials
- [ ] K-4: Position and motion of objects
- [X] K-4: Light, heat, electricity, and magnetism
- [X] 5-8: Properties and changes of properties in matter
- [ ] 5-8: Motions and forces
- [ ] 5-8: Transfer of energy
- [ ] 9-12: Structure of atoms
- [X] 9-12: Structure and properties of matter
- [ ] 9-12: Chemical reactions
- [ ] 9-12: Motions and force
- [ ] 9-12: Conservation of energy and increase in disorder
- [ ] 9-12: Interactions of energy and matter

[ ] 3. Life Science
- [ ] K-4: Characteristics of organisms
- [ ] K-4: Life cycles of organisms
- [ ] K-4: Organisms and environments
- [ ] 5-8: Structure and function in living systems
- [ ] 5-8: Reproduction and heredity
- [ ] 5-8: Regulation and behavior
- [ ] 5-8: Populations and ecosystems
- [ ] 5-8: Diversity and adaptations of organisms
- [ ] 9-12: The cell
- [ ] 9-12: Molecular basis of heredity
- [ ] 9-12: Biological evolution
- [ ] 9-12: Interdependence of organisms
- [ ] 9-12: Matter, energy, and organization in living systems
- [ ] 9-12: Behavior of organisms

[ ] 4. Earth and Space Science

- [ ] K-4: Properties of earth materials
- [ ] K-4: Objects in the sky
- [ ] K-4: Changes in earth and sky
- [ ] 5-8: Structure of the earth system
- [ ] 5-8: Earth's history
- [ ] 5-8: Earth in the solar system
- [ ] 9-12: Energy in the earth system
- [ ] 9-12: Geochemical cycles
- [ ] 9-12: Origin and evolution of the earth system
- [ ] 9-12: Origin and evolution of the universe

[X] 5. Science and Technology

- [X] K-4: Abilities to distinguish between natural objects and objects made by humans
- [X] K-4: Abilities of technological design
- [X] K-4: Understanding about science and technology
- [X] 5-8: Abilities of technological design
- [X] 5-8: Understanding about science and technology
- [ ] 9-12: Abilities of technological design
- [ ] 9-12: Understanding about science and technology

[X] 6. Personal and Social Perspectives

- [ ] K-4: Personal health
- [ ] K-4: Characteristics and changes in populations
- [ ] K-4: Types of resources
- [ ] K-4: Changes in environments
- [X] K-4: Science and technology in local challenges
- [ ] 5-8: Personal health
- [ ] 5-8: Populations, resources, and environments
- [ ] 5-8: Natural hazards
- [ ] 5-8: Risks and benefits
- [X] 5-8: Science and technology in society
- [ ] 9-12: Personal and community health
- [ ] 9-12: Population growth
- [ ] 9-12: Natural resources
- [ ] 9-12: Environmental quality
- [ ] 9-12: Natural and human-induced hazards
- [ ] 9-12: Science and technology in local, national, and global challenges

[ ] 7. History and Nature of Science

- [X] K-4: Science as a human endeavor
- [X] 5-8: Science as a human endeavor
- [ ] 5-8: Nature of science
- [ ] 5-8: History of science
- [ ] 9-12: Science as a human endeavor
- [ ] 9-12: Nature of scientific knowledge
- [ ] 9-12: Historical perspective
- [ ] K-4: Properties of earth materials

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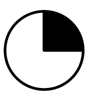
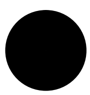
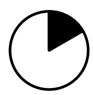
Time Required

Set-up	Program	Clean Up
		
15 minutes	60 minutes	10 minutes

Background Information

Definition of terms

Nano is the scientific term meaning one-billionth (1/1,000,000,000). It comes from a Greek word meaning “dwarf.”

A nanometer is one one-billionth of a meter. One inch equals 25.4 million nanometers. A sheet of paper is about 100,000 nanometers thick. A human hair measures roughly 50,000 to 100,000 nanometers across. Your fingernails grow one nanometer every second.

(Other units can also be divided by one billion. A single blink of an eye is about one-billionth of a year. An eyeblink is to a year what a nanometer is to a yardstick.)

Nanoscale refers to measurements of 1-100 nanometers. A virus is about 70 nm long. A cell membrane is about 9 nm thick. Ten hydrogen atoms are about 1 nm.

At the nanoscale, many common materials exhibit unusual properties, such as remarkably lower resistance to electricity, or faster chemical reactions.

Nanotechnology is the manipulation of material at the nanoscale to take advantage of these properties. This often means working with individual molecules.

Nanoscience, nanoengineering and other such terms refer to those activities applied to the nanoscale. “Nano,” by itself, is often used as short-hand to refer to any or all of these activities.

Materials

Detailed materials lists, sources, and set-up instructions are available in the lesson plans and activity guides on www.nisenet.org. Depending on the size of the school group, you may need to have multiple copies of the materials for the students to explore.

Set Up

Time: 15 minutes

Follow the step-by-step explanation of how to prepare each of the activities provided in the activity guides and lesson plans available at www.nisenet.org. The activities work best with small groups (4-6 students). While one facilitator can lead the activities, enough tables and materials will be needed to accommodate each of the small groups.

Program Delivery

Safety

Review specific safety precautions for each activity, as outlined in the individual lesson plan or activity guide available at www.nisenet.org.

Talking Points and Outline:

This fieldtrip lesson is designed to provide a broad overview of nanoscale science, engineering and technology. It starts with an introduction to size and scale. Then students progress through several activities that highlight how properties can change on the nanoscale, how nanoscale research can lead to new technologies, and how scientists are able to work on the nanoscale. The session ends with a look at how nanotechnology and society influence each other and how people’s values shape how nanotechnologies are developed and adopted.

Whole Group:

- Exploring Size–Get in Order! (5min)

Small Groups:

- Exploring Properties–Surface Area (10min)
- Exploring Structure–Butterfly & Exploring Materials–Thin Films (10min)
- Exploring Products–Computer Hard Drives (10min)
- Exploring Tools–Mystery Shapes (10min)
- Exploring Nano & Society–Space Elevator (15min)

INTRODUCTION: Today we are going to explore nanoscale science and engineering. When we talk about the nanoscale, we are talking about things that are very, very tiny. A nanometer is a billionth of a meter. Let's look at some objects of different sizes to see how small a nanometer is.

[Lead students through the **Exploring Size–Get in Order!** activity. This is an activity where students use cards of different-sized objects and try to order them from largest to smallest.]

[To modify **Exploring Size – Get in Order!** for the classroom, use volunteers from the class and have them try to line up in front of the class from largest to smallest without saying a word. Discuss the size difference between the objects on the cards as an entire class.]

EXPLORING PROPERTIES—SURFACE AREA: Materials behave in a different way at a small scale than they do at a larger scale. At the nanoscale, a material may exhibit different properties. We can explore some of the ways properties change when a material becomes small by doing the following activity.

[Lead students through the **Exploring Properties–Surface Area** activity.]
http://www.nisenet.org/catalog/programs/exploring_properties_-_surface_area_nanodays_08_09_10

This is a hands-on activity that demonstrates how a material can act differently when it's nanometer-sized. Students compare the reaction rate of an effervescent antacid tablet that is broken in half with one that is broken into many pieces.

[To modify **Exploring Properties–Surface Area** for the classroom, be sure to have enough materials for each group to have their own setup.]

EXPLORING STRUCTURES—BUTTERFLY & EXPLORING MATERIALS—THIN FILMS: Light waves are something that is measured in nanometers, so nanoscale structures can affect how light behaves. By examining the Blue Morpho Butterfly, we can see how nature uses nanoscale features to manipulate light and we can manipulate light in a surprising way with just water and clear fingernail polish.

[Lead students through the **Exploring Structures–Butterfly** and **Exploring Materials –Thin Films** activities.] http://www.nisenet.org/catalog/programs/exploring_structures_-_butterfly_nanodays_2012 and
http://www.nisenet.org/catalog/programs/exploring_materials_-_thin_films_nanodays_2011

Exploring Structures – Butterfly is a hands-on activity in which students investigate how some butterfly wings get their color. They learn that some wings get their color from the nanoscale structures on the wings instead of pigments. Exploring Materials –Thin Films is a hands-on activity in which students create a colorful bookmark using a super thin layer of nail polish on water.

[To modify **Exploring Structures–Butterfly** for the classroom use one set of butterflies and have the materials rotate between the groups as they do the Exploring Materials –Thin Films activity. While these two activities pair well together, if you do not have a Blue Morpho Butterfly specimen, this activity can be omitted.]

[To modify the **Exploring Materials–Thin Films** activity for the classroom, be sure to have enough materials for each group to have their own setup.]

EXPLORING PRODUCTS—COMPUTER HARD DRIVES: There are many products we use today that would not be possible without nanotechnology. One of the most common is the modern day computer. Nanotechnology allows us to create smaller and smaller computers that are capable of holding more and more information. Let's look at how this done through the use of tiny magnets.

[Lead students through the **Exploring Products–Computer Hard Drives** activity.]
http://www.nisenet.org/catalog/programs/exploring_products_-_computer_hard_drives_nanodays_2013

This is a hands on activity in which students learn how magnets are used to store information in binary code. Students will also see how smaller magnets would allow for more information to be stored in the same amount of space.

[To modify the **Exploring Products–Computer Hard Drives** activity for the classroom, be sure to have enough materials for each group to have their own setup.]

Investigating the nanoscale would be impossible without special tools that allow us to image tiny nano-sized features. In this next activity we will explore how special microscopes can detect and make images on the nanoscale.

[Lead students through the **Exploring Tools–Mystery Shapes** activity.]
http://www.nisenet.org/catalog/programs/exploring_tools_-_mystery_shapes_nanodays_2013

This is a hands-on activity in which students use their sense of touch to investigate hidden objects. They learn that researchers use special tools, including scanning probe microscopes (SPM), to detect and make images of nanoscale objects. The mystery box is an analogy for the way an SPM works. Just like the tool, our sense of touch allows us to develop a picture of something we can't see.

[To modify the **Exploring Tools – Mystery Shapes** activity for the classroom, be sure to have enough materials for each group to have their own setup. If you do not have enough tactile boxes, you can substitute pillowcases for your mystery box.]

EXPLORING NANO & SOCIETY—SPACE ELEVATOR: For the last activity we are going to explore how nanotechnology may affect the future world that we live in. Currently, some scientists and engineers are working on making an elevator to space. Your job is to imagine what this elevator might look like, how it is used and what other technologies it might enable.

[Lead students through the **Exploring Nano & Society–Space Elevator** activity.]
http://www.nisenet.org/catalog/programs/exploring_nano_society_-_space_elevator

This is an open-ended conversational experience in which students imagine and draw what a space elevator might look like, what support systems would surround it, and what other technologies it might enable. Conversation around the space elevator leads students to explore how technologies and society influence each other and how people's values shape the ways nanotechnologies are developed and adopted.

[To modify **Exploring Nano & Society–Space Elevator** for the classroom, use a large sheet of butcher paper for each group. Have the group work collaboratively to design their space elevator. They must discuss and decide within their group what things to add. The facilitator will rotate through the groups to ask questions of the students to draw out how the technologies and society influence each other and how people's values shape the ways nanotechnologies are developed and adopted. For additional resources on how to facilitate a conversation visit, http://nisenet.org/catalog/tools_guides/nano_society_training_materials]

WRAP-UP: Thank you for participating in today's activities. Hopefully you have learned a little bit about how tiny the nanoscale is, how properties can change in unexpected ways, how research in this area is helping to develop new technologies and products we all use, and how we all have a role in how our future may be affected by these technologies.

Tips and troubleshooting

If there is enough staff, some of the activities can be set up as a "round robin" so students can rotate in small groups from one activity to another. This requires that the staff be comfortable presenting the individual activities. One example of how to rotate through four stations is as follows:

Whole Group:
- Exploring Size–Get in Order! (5min)

Round Robin (if enough staff to lead each activity):
- Exploring Properties–Surface Area (10min)
- Exploring Materials–Thin Films (10min)
- Exploring Products–Computer Hard Drives (10min)
- Exploring Tools–Mystery Shapes (10min)

Whole Group:
- Exploring Nano & Society–Space Elevator (15min)

Going further…

If your museum has the Nano Mini-Exhibition, students can use the **Nano mini-exhibition student worksheet for school field trips** to assist in exploring it. The worksheet can be found at: http://www.nisenet.org/catalog/exhibits/nano_mini-exhibition

Other NanoDays activities can be substituted, as needed, for any of the activities in this framework. Be aware that you may need to make modifications to the activity to make it appropriate for a classroom format. See Appendix A for suggested substitutions.

Universal Design

This program has been designed to be inclusive of visitors, including visitors of different ages, backgrounds, and different physical and cognitive abilities.

The following features of the program's design make it accessible:

[x] 1. Repeat and reinforce main ideas and concepts
- Content is repeated and reviewed each day, building on prior knowledge.

[x] 2. Provide multiple entry points and multiple ways of engagement
- The content is connected to students' prior experiences and knowledge, and to their questions.
- Concise key phrases are used to support main ideas.
- Main ideas are presented through multiple senses (sight, hearing, and touch).
- students can stay at activities for more or less time to accommodate their needs.

[x] 3. Provide physical and sensory access to all aspects of the program
- Main ideas are presented through multiple senses (sight, hearing, and touch).
- Presentations are made accessible by using large, high-contrast text and images; using clear fonts and graphics; and using color to make distinctions.

To give an inclusive presentation of this program:

- Allow students to spend as much or as little time as needed at each activity
- Repeat and reinforce main concepts and vocabulary

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Appendix A

Activity Name	Key Concepts *	Modification for Classroom	Possible Substitutions
Exploring Size–Get in Order!	Size and Scale	Assign cards to volunteers from the class and have them try to line up in front of the class from largest to smallest without saying a word. Discuss the size difference between the objects on the cards as an entire class.	Exploring Size–Measure Yourself
Exploring Properties–Surface Area	Novel Properties	Have enough materials for each group to have their own setup.	Exploring Forces–Gravity Exploring Forces–Static Electricity
Exploring Structure–Butterfly Exploring Materials–Thin Films	Manipulating Matter	Butterfly: If available, have enough butterfly specimens for each group. Otherwise, use one set of butterflies and have the materials rotate between the groups as they do the Exploring Materials–Thin Films activity. While these two activities pair well together, if you do not have a Blue Morpho Butterfly specimen, this activity can be omitted. Thin Films: Have enough materials for each group to have their own setup.	Exploring Materials–Memory Metal Exploring Materials–Hydrogel Exploring Materials–Ferrofluid
Exploring Products–Computer Hard Drives	Consumer Products	Have enough materials for each group to have their own setup.	Exploring Products–Liquid Crystal Displays Exploring Products–Nano Fabrics Exploring Products–Sunblock

Exploring Tools–Mystery Shapes	Tools	Have enough materials for each group to have their own setup. If you do not have enough tactile boxes, you can substitute pillowcases for your mystery box.	Exploring Tools–Special Microscopes
Exploring Nano & Society–Space Elevator	Nanotechnology and Society	Use a large sheet of butcher paper for each group. Have the group work collaboratively to design their space elevator. They must discuss and decide within their group what things to add. The facilitator will rotate through the groups to ask questions of the students to draw out how the technologies and society influence each other and how people's values shape the ways nanotechnologies are developed and adopted.	Exploring Nano & Society–You Decide!

* Key concepts correlate to those found in the Engaging the Public in Nano, NISE Net content map: http://www.nisenet.org/catalog/tools_guides/engaging_public_nano