EXPLORE SCIENCE

PLANNING MATERIAL

Zoom into Nano

Out of School Programs Guide

Credits and Rights

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Introduction

Welcome to *Explore Science—Zoom into Nano!* This Museum & Community Partnerships project is an initiative of the Nanoscale Informal Science Education Network (NISE Net). NISE Net is a national community dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology.

The *Explore Science—Zoom into Nano!* kit provides a great opportunity to do hands-on science, or STEM, in out-of-school settings. "STEM" stands for Science, Technology, Engineering, and Mathematics:

- **Science** is knowledge about the natural world, learned through experiments and observation
- **Technologies** are tools, machines, and equipment that have a practical use
- **Engineering** is the use of science to create useful things or structures
- **Mathematics** is the science of numbers

The kit includes activities that engage learners in STEM concepts and help them develop science and engineering skills. These hands-on activities engage learners in different aspects of the scientific process: asking questions, collecting data, interpreting data, solving problems, testing assumptions, and communicating ideas to others. The kit can also support learners in developing a positive attitude toward science and building important skills related to science.

The activities connect to concepts that are taught in school, and also connect to things learners know from everyday life. In addition to engaging students in STEM, the *Explore Science* program supports youth development goals. As they work together on these activities, students can grow confidence in themselves as learners and build skills in leadership and teamwork.

Everyone can do these activities, though different learners may need different support. The activities in this kit have been tested extensively with many different kinds of facilitators, including both professional educators and volunteers with no science, education, or youth development experience. They have also been tested extensively with many different kinds of learners, including children, teens, and adults of different backgrounds and abilities.

Successful implementation of the Explore Science activities will result in programming that is:

- **Student-led**, with guidance from educators
- **Experiential**, focused on learning by doing
- **Meaningful**, creating connections to everyday life, to school and career possibilities, and to issues the community cares about

Kit contents

The *Explore Science—Zoom into Nano!* kit contains 16 hands-on activities. These activities can be used individually, or presented in five units:

- Zoom into Nano
- Small and Surprising
- Labs and Tools
- Tech and Nature
- Nano and Our Lives

The units are especially designed for out-of-school settings. Each unit includes hands-on activities that illustrate key components of nanoscale science, engineering, and technology (or "nano" for short). As you deliver the units, students progress through activities that introduce how just small the nanoscale is, explore how properties can change in surprising ways on the nanoscale, examine labs and tools that nanoscale researchers use, discover ways that research is leading to new innovations, and consider the ways that nanotechnologies will be part of our lives.

You can use the units in whatever ways work best for your program. In an out-of-school program, you might offer one unit each day for a week, or one unit a week. Or you might choose to integrate individual activities from this kit into other programming. You can even use the activities to make one large event, inviting families to participate.

Planning and preparation

Before you use the kits, you'll want to do some basic planning and preparation. Get familiar with the Explore Science kits. Look through the materials and understand what the kit contains and how everything is organized. Be sure to watch the training videos: they'll show you everything you need to know to do a great job delivering each activity. Training videos for each activity are included in your kit and also online: vimeo.com/album/3636993. Then review the guides: they'll be handy references for you and your students while you're doing the activities.

Prepare yourself and your team by trying out the activities ahead of time. Your team can present the activities to each other to get practice with them. Talk about how you'll make them work with your space and group.

As you become familiar with the activities, notice how they're structured. Each activity is presented in three main blocks: **Try this!**, **What's going on?** and **How is this nano?** This format sets up a process of exploration, explanation, and making connections.

This *Out of School Programs Guide* will help you deliver the programming through the five units. It provides instructions, background information, suggested talking points, and tips for each

activity. It also suggests an introduction to each unit's activities and a wrap-up or reflection activity for learners (often contained in the unit's student activity book).

It's up to you to assess the needs, interests, and capabilities of your group, and to implement accordingly. Think about how you'll structure the programming. Will you use the units, or just choose individual activities? If you plan to do the different units spread out over time, your students may need a basic reminder about nanotechnology each time. A quick overview of what you did during the last section, or watching the *Nanotechnology: What's the Big Deal?* video each session might help recall and reinforce prior learning.

As you organize a time and place to do the activities, make sure you choose an appropriate space, where learners can work comfortably in small groups and don't need to worry about making a mess. Arrange to have enough facilitators, so that learners have the support they need and you can be sure that they're using the materials safely. Depending on the setting and the needs of your participants, you might plan to have one facilitator for every 5–10 learners.

Be sure you have enough materials! The kits contain materials for around 100 uses of each activity. When you need to restock your kit, the supplies are inexpensive and easy to find. Suggested sources are provided for any materials that you won't find at a general discount store.

Finally, and most importantly, *Explore Science—Zoom into Nano* is an opportunity to have fun! Be ready to enjoy the activities along with your group.

Leading hands-on science activities

The Explore Science kit is designed for learning by doing. The activities and materials are safe, appropriate, and fun for a broad range of learners. The activities are all thoroughly tested with educators and kids, so you can feel confident that you can facilitate them successfully.

Each activity is structured to follow the experiential learning cycle:

- Do and discover
- Share observations and results
- Generalize and apply learning
- Develop a science identity

As you do *Explore Science* activities with learners, there are many things you can do that will help create great learning experiences. Here, we'll go through some tips, relating them both to the experiential learning cycle and the structure of the Explore Science activities.

Develop a science identity

Hands-on science activities can help learners feel confident and interested in science. When a person feels that he or she can do science, that sense of identity helps them succeed in science classes in school and consider careers related to science, engineering, and technology.

There are many things you can do to help learners develop a science identity:

- Recognize and reinforce the idea that everyone can do STEM. That includes learners of different ages, genders, backgrounds, personalities, and abilities. (It also includes you!)
- Help to generate and sustain learners' motivation and engagement. Present STEM activities as a fun opportunity and encourage everyone to participate. Be excited about doing the activities yourself—that will help learners stay motivated and interested.
- Avoid stereotypes about who likes science, is good at science, or becomes a scientist. Make sure potential participants don't exclude themselves from science activities based on preconceptions about science.

These tips are relevant at any time! Be sure to keep them in mind as you introduce the opportunity to do hands-on science.

Do and discover

Experiential learning is the most effective way to learn and enjoy science. People learn science best if they try things for themselves, and make a discovery.

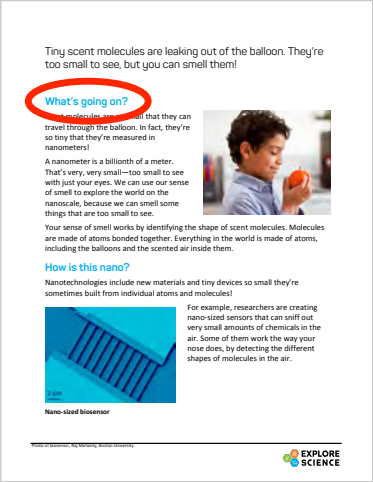
The activity guides include a section called **Try this!**, which provides clear instructions in words and pictures. You might choose to demonstrate some of the steps, and then let learners use their guides for reference. All the steps are included on the front side of the guide.

Try this! corresponds to the **Do and discover** stage of the learning cycle. At this stage, you can support learning by:

- Providing clear instructions, but letting learners do the activity themselves. Try not to over-supervise or direct.
- Letting learners experience and discover. Don't give away the results or the surprise of the activity before they do it!
- Asking open-ended questions that encourage learners to make predictions, think ahead, plan, and analyze what they're doing. For example, you can ask "What do you think will happen when you ...?"
- Avoiding telling learners what they "should" do, but do offer hints and suggestions about things they might notice or try if they are stuck.

Share observations and results

Learners need to make sense out of what they observe. Sharing what they notice and talking about why they think it happened can help them understand.


Tiny scent molecules are leaking out of the balloon. They're too small to see, but you can smell them!

What's going on?

Scent molecules are so small that they can travel through the balloon. In fact, they're so tiny that they're measured in nanometers!

A nanometer is a billionth of a meter. That's very, very small—too small to see with just your eyes. We can use our sense of smell to explore the world on the nanoscale, because we can smell some things that are too small to see.

Your sense of smell works by identifying the shape of scent molecules. Molecules are made of atoms bonded together. Everything in the world is made of atoms, including the balloons and the scented air inside them.

How is this nano?

Nanotechnologies include new materials and tiny devices so small they're sometimes built from individual atoms and molecules!

For example, researchers are creating nano-sized sensors that can sniff out very small amounts of chemicals in the air. Some of them work the way your nose does, by detecting the different shapes of molecules in the air.

Nano-sized biosensor

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The activity guides include a section called **What's going on?**, which explains what happens in the activity from a scientific point of view. You may choose to give learners a chance to describe, understand, and explain what's happening in their own way before providing this information. This section is on the back side of the guide, so you have the option to ask learners not to look at it until you're ready.

What's going on? corresponds to the **Share observations and results** stage of the learning cycle. At this stage, you can promote learning by:

- Asking questions that help learners make sense of what they observe and explain their thinking. Good questions include:

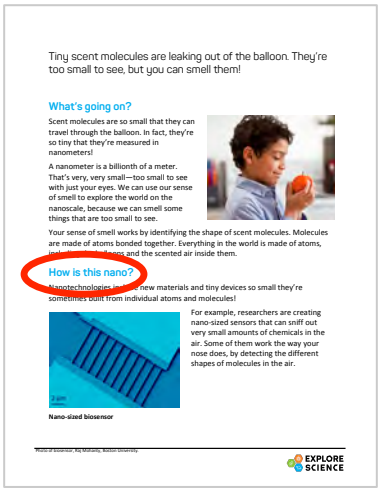
  "What did you notice?"
  "Why do you think that happened?"
  "How do you know?"
  "What ideas do you have?"

- Modeling that it's OK not to know something—what's important is thinking about good questions and trying to figure out answers. If you're asked a question you don't know the answer to, you can say:

  "That's a good question! I don't know the answer. How do you think we could find out?"

Generalize and apply learning

Science is integral and important to everyday life, but sometimes it takes a little thinking for learners to see how. Learners will be more motivated to learn and understand science if they see how it connects to things they know and care about.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Nano-sized biosensor

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The activity guides include a section called **How is this nano?**, which explains how the activity is connected to nanoscale science, engineering, and technology (or "nano" for short). This section also makes connections to other fields such as medicine or to products or inventions related to the activity. You may choose to give learners a chance to describe, understand, and explain what's happening in their own way before providing this information.

How is this nano? corresponds to the **Generalize and apply learning** stage of the cycle. At this stage, you can promote learning by:

- Asking open-ended questions that help learners make connections to things they've experienced before. For example, you can ask:

  "What does this remind you of?"
  "Where else could you use this?"

- Suggest ways that the activity relates to other things learners might be interested in or have heard about recently. For example, you might suggest how the activity relates to common interests for kids such as sports or animals, or to topics that concern adults such as community issues or career options for their children.

Units at a Glance

Unit 1: Zoom into Nano

- *Nanotechnology: What's the Big Deal?* video
- Get in Order
- Measure Yourself
- Tiny Ruler

Unit 2: Small and Surprising

- Gravity Fail
- Ready, Set, Fizz
- Smelly Balloons
- UV Bracelets

Unit 3: Labs and Tools

- Mystery Shapes
- Gummy Shapes
- Draw a Circuit
- Imagine Yourself as a Nano Scientist

Unit 4: Tech and Nature

- Morphing Butterfly
- Rainbow Film
- Invisible Sunblock
- I-Spy
- Draw Your Own Robot

Unit 5: Nano and Our Lives

- Stained Glass Art
- Mystery Sand
- You Decide!
- Nano Future Teller

Learning Objectives

Part 1: Zoom into Nano

Just how small is nano?

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

- A nanometer is a billionth of a meter. That's very, very small!

Part 2: Small and surprising

What happens when things get really small?

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

- Nano-sized things can behave in surprising ways.

Part 3: Tools and labs

How can we study and make tiny things?

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

- Nano scientists use special tools and equipment.

Part 4: Nature and technology

Where can we find nano?

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

- Nano research lets us create new technologies and understand nature.

Part 5: Nano and our lives

What's next for nanotechnology?

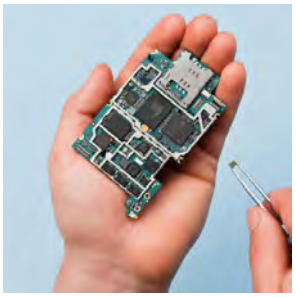
As a result of participating in this session, learners will understand that:

- Nanotechnologies will be part of our lives—now and in the future.

Content Overview

Zoom into Nano

Nanoscale science, engineering, and technology is a new, interdisciplinary field. Within the past couple decades, scientists have developed methods and tools that allow them to explore some of the most fundamental aspects of our natural world, and to develop new materials and technologies.



Small and Surprising

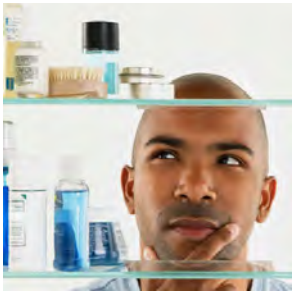
The great potential of nanotechnology comes from its tiny size. Nano research and development happens at the scale of atoms and molecules. Some things have different properties at the nanoscale, which allow scientists and engineers to create new materials and devices.

Labs and Tools

Nano scientists and engineers study and make tiny things less than 100 nanometers in size. Sometimes nanotechnologies and materials can be built from individual atoms! To work at such a small scale, nano researchers have developed new ways to investigate and build tiny things.

Nature and Technology

Some of the beautiful and surprising things we observe in nature are due to special nano properties. The iridescent color of insect wings and the "sticky" feet of geckos are examples of natural phenomena caused by tiny nanostructures. Researchers can be inspired by nature to create new materials and technologies.



Nano and Our Lives

Nano isn't just in the lab—we can already find it in our homes, stores, and hospitals. It's important for everyone to be informed about nanotechnologies, because they'll be an important part of our future. Since nanotechnologies are still developing, we can influence what they are and how they're used. We all have a role in determining how these new technologies will play out in our future.

To learn more, see the guide Engaging the Public in Nanotechnology.

Unit 1. Zoom into Nano

The five-part Explore Science program investigates the small and surprising world of nanotechnology. Unit 1 introduces nano through a video and hands activities.

As a result of participating in this unit, learners will understand that:

- A nanometer is a billionth of a meter. That's very, very small!

Introduce the *Zoom into Nano* unit

We're going to be exploring science—and not just any science, but a brand new kind of science that investigates nanoscale science, engineering, and technology, or "nano" for short.

We'll zoom into a world that is very tiny and very surprising! Nano lets us study and make things we've never been able to before.

We're going to do lots of hands-on activities and investigations, and record what we find out in our activity books.

But first, let's watch a short video that will explain what nano is and why it's a big deal!

Materials
Activity books
Pencils

Time
5 minutes

Staff training resources
Guide: *Engaging the Public in Nanotechnology*

Video: Nanotechnology: What's the Big Deal?

This video introduces nanotechnology—what it is, where we find it, and why we care about it.

Play the video *Nanotechnology: What's the Big Deal?*

Tip: You can use the DVD in your kit, or download it from www.nisenet.org/catalog/media/intro_nano_video

Use the activity books

Ask students to go to the *Nanotechnology: What's the Big Deal?* page in their activity book.

Before watching the video, ask students to draw or write down the smallest thing they can think of.

After the video, talk to the students about what they learned. What did they like? Ask them to write down the most surprising thing they learned about nanotechnology.

Ask students how many nanometers are in a meter? (Students can write their answers in their book.)

Ask other questions to help them reflect on the video, such as:

- What's the best part of the video? Why?
- What's the funniest or silliest thing that happens in the video? Why does that happen?
- What one thing do you think is most important to know about nano based on the video?
- How would you explain that to your family or friends?

Materials
Video
Activity books
Pencils

Time
10 minutes

Staff training resources
Guide: *Engaging the Public in Nanotechnology*

Activity: Get in Order!

This whole-group activity gets kids thinking about size and scale and how different-sized objects get measured and studied using different tools.

Facilitate the activity
Call seven volunteers to come to the front of the room and pass out the cards in a random order.

Tip: You can play this with fewer students by using fewer cards. If you choose to use fewer cards it's important to still have a range of sizes. We suggest keeping DNA, the pirate, and the Earth.

Try this!
1. Take a card.
2. Compare the picture on your card to the pictures on the other cards. Some things are big and others are small.
3. Try to line up in order of size. How fast can you get in order?

Use the activity books
Ask students to turn to the Get in Order page in their activity books and see if they can identify which object is nano-sized. The correct answer is the DNA.

What's going on?
The objects on the cards are organized according to powers of ten. Each number on the scale represents a ten-fold change in size. An object marked with a 0, like a person, is about a meter tall. An object marked +1 is around ten times bigger, and an object marked -1 is around ten times smaller (one-tenth the size).

How is this nano?
Really tiny objects, like DNA, are marked with even lower numbers. DNA (-9) is so tiny it's measured in nanometers! In the emerging field of nanotechnology, scientists work with things measured in nanometers.

Tip: Tape the cards to the wall, or prop them up so students can still see them for the remainder of the session.

Materials
Get in Order cards (large format)
Activity guide
Activity books
Pencils

Time
15 minutes

Sources
Graphic files can be downloaded from www.nisenet.org.

Staff training resources
Video: *Get in Order!*

Activity: Measure Yourself

This activity lets students measure themselves in nanometers—and consider whether they're super tall or nanometers are super small. This activity can be done simultaneously with Tiny Ruler if you have a large group.

Advance preparation

Before doing this activity, hang the Measure Yourself banner on an accessible wall with the bottom of the chart touching the floor. Students will need to be able to walk right up to the height chart banner. If you print the height chart or worksheet from the digital file, be sure you don't allow page scaling.

Demonstrate and facilitate the activity
Call two student volunteers over to the banner. Ask one to stand up straight, with their back against the banner and their feet against the wall. Help the other student read the first student's height in nanometers.

Tip: Ask the group questions, such as "Do we usually measure ourselves in nanometers?" or, "What measurement units are convenient for measuring something relatively big, like a kid?"

Try this!

1. Measure your height on the wall chart.
2. How tall are you in nanometers?

Use the activity books
Encourage students to write their height in nanometers on the Measure Yourself & Tiny Ruler page of their activity books. While they're waiting their turn for the height chart, they can use the lined paper to measure small things (or their hand) in nanometers. Go around to each group to check in on their progress and answer questions.

What's going on?
A nanometer is a billionth of a meter. That's really tiny! It takes a lot of nanometers to measure something relatively big, like a person.

How is this nano?
Nanoscale science focuses on things that are measured in nanometers, including atoms and molecules, the basic building blocks of our world. Nanometers are used to measure things that are too small to see.

Materials
Measure Yourself banner
Activity guide
Activity books
Pencils

Time
15 minutes

Sources
Graphic files can be downloaded from www.nisenet.org.

Staff training resources
Video: *Measure Yourself & Tiny Ruler!*

Reflection Activity: Tiny Ruler

This activity lets students reflect on and activate what they've learned in the session. If you have a large group, this activity can be done simultaneously with Measure Yourself. This activity can also be done at home as an extension.

Facilitate the activity

Nanometers are used to measure things that are too small to see, such as DNA. It takes a lot of nanometers to measure something relatively big, like a person.

The lines on the page let students measure small things in nanometers. What can they find to measure using nanometers?

Tip: They can trace objects (or their hand) onto the page to help them measure. If students choose to measure their hands, they should place the heel of their hand on the line marked "0 nanometers."

Materials

Activity guide
Activity books
Pencils
Small things to measure (examples include buttons, paperclips, or odds and ends)

Time

5–10 minutes

Staff training resources

Video: *Measure yourself & Tiny Ruler!*

Unit 2. Small and Surprising

Unit 2 of the Explore Science—Zoom into Nano! *program investigates some of the surprising forces and properties at the nanoscale.*

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

- Nano-sized things can behave in surprising ways.

Recap Unit 1
Remind students that we've been investigating a very special kind of science, technology, and engineering, which we're calling nano for short.

Review some of the things we've already learned about nano. Students can refer back to their Zoom into Nano activity books. Ask students to share something they learned last time.

As a group, brainstorm a list of things that are so small they can be measured in nanometers (*a nanometer is a billionth of a meter!*)

Introduce Unit 2
Nano is very, very small. This session demonstrates some surprising things that can happen when things get really small. Nano-sized things don't always behave the same way they do when they're bigger!

Materials
Activity books
Pencils

Time
5 minutes

Staff training resources
Guide: *Engaging the Public in Nanotechnology*

Activity: Gravity Fail

This activity lets students experiment with some surprising ways that forces can change when things get smaller. Students will try pouring water out of regular size and miniature cups. It's harder than it sounds!

Advance preparation

Fill the large plastic containers with water and set the activity materials out for small groups of students. Optional: Use food coloring to dye the water to make it easier to see and more fun.

Facilitate the activity

Try this!

1. Fill the regular cup by dipping it in the water. Try to pour the water back into the container. What happens?
2. Now fill the miniature cup with water. Can you pour the water back out?

Use the activity books

Encourage students to write down or draw their observations on the Gravity Fail page of their activity book. Go around to each group to check in on their progress and answer questions.

What's going on?

It's easy to pour water out of a full-size cup, but not out of a miniature cup. With a regular cup, gravity is much stronger than surface tension, so the water falls out when you tip the cup. With the tiny teacup, surface tension holds the drop of water in the cup even when you tip it upside down. *Surface tension* is the natural tendency of water molecules to stick together.

How is this nano?

Different physical forces dominate when things get very, very small. For example, gravity is very obvious at human size, but it's hardly noticeable to nano-sized things like water molecules. Other forces (like surface tension) are much more important.

Materials

Activity guide
Activity books
Pencils
5 plastic containers
5 regular teacup
5 tiny teacup
Water
Food coloring (optional)

For each group:

- 1 plastic container filled with water
- 1 regular teacup
- 1 tiny teacup

Sources

Miniature teacups are available at dollhouse suppliers such as www.dollhousesandmore.com (#CB2719)

Time

10 minutes

Staff training resources

Video: *Gravity Fail*

Activity: Ready, Set, Fizz

This activity lets students experiment with some surprising ways that forces can change when things get smaller. Students will observe the reaction between water and different-sized pieces of antacid tablets to see how much size really matters.

Advance preparation and clean up

Every group will need two measuring cups and two tubes.

- Pour 20 ml of water into each cup. Optional: Use food coloring to dye the water to make it easier to see and more fun.
- Break one antacid tablet in half and place both pieces into one tube, then crush the other tablet into lots of little pieces and pour the powder into the other tube.
- Afterwards, dump the contents of the tubes into a sink or waste container. It's best to let the tubes dry out between groups.

Safety

Supervision required. Do not eat or drink these materials. The antacid tablets contain medication.

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Look at the graduated cylinders. What do you notice? Do you think they'll react to the water in the same way?
2. At the **same time**, pour the water from each cup into a cylinder. Which fizzes faster, the tablet that's broken into just two pieces or the one that was crushed into lots of little pieces?

Use the activity books

On the Ready, Set, Fizz page of their activity books, encourage students to make a prediction about which tube will fizz the fastest. Go around to each group to check in on their progress and answer questions.

What's going on?

Both tubes have the same amount of medication, but the crushed tablet fizzes faster. That's because it has a greater surface area to volume ratio. The crushed tablet has more surface area—or exterior—to react with the water, so the chemical reaction happens faster. When things get small they can behave in surprising ways.

How is this nano?

A material can act differently when it's nano-sized. Small things have more surface area for their volume than larger things do. Some things that aren't reactive at all in big pieces are very reactive when they're tiny. For example, nano sized particles of aluminum are explosive!

Materials

Activity guide
Activity books
Pencils
10 100 ml graduated tubes (cylinders)
10 50 ml cups (beakers)
5 packets of effervescent antacid tablets
Water jug
Optional: food coloring

For each group:

- 2 100 ml graduated cylinders
- 2 50 ml beakers with 20ml of water
- 2 effervescent antacid tablets (1 broken in half, 1 crushed)

Sources

A good source for cylinders and beakers is www.ScienceLabSupplies.com

Time

10 minutes

Staff training resources

Video: *Ready, Set, Fizz*

Activity: Smelly Balloons

This activity lets students discover just how small nano-sized things really are. Tiny scent molecules can pass through the latex barrier of a balloon, and our very own noses are excellent tools that can be used to detect them.

Advance preparation

For each group, put a few drops of extract in each balloon. Use a different color balloon for each kind of extract. Blow up the balloons and tie them securely. Give them a shake. Tie the balloons to a piece of string. *Tip: A hand pump makes it much easier to inflate the balloons.*

Safety

These balloons contain latex. If any students have a latex allergy, you can skip this activity or have them observe but not touch the balloons (depending on the severity of the allergy).

Facilitate the activity

Try this!

1. Smell the balloons. Can you figure out which scent is hidden in each balloon?
2. Now, match them up! Color in the balloons and write the scent that's hidden inside next to each one.

Use the activity books

Students can color in the balloons on the Smelly Balloons page of their activity book. Then, encourage them to use their sense of smell to match the colors up with the scents.

What's going on?

Tiny scent molecules are leaking out of the balloon. They're too small to see, but you can smell them. Your sense of smell works by identifying the shape of scent molecules. Molecules are made of atoms bonded together.

How is this nano?

Nanotechnologies include new materials and tiny devices so small they are sometimes built from individual atoms and molecules. For example, researchers are creating nano-sized sensors that can sniff out very small amounts of chemicals in the air. Some of them work the way your nose does, by detecting the different shapes of molecules.

Materials

Activity guide
Activity books
Pencils
Balloons
Scented extracts
Markers
String
Optional: Hand pump

For each group:

- 3 extract scented balloons on a string (red, green and blue)
- 3 markers (red, green, and blue)

Time

10 minutes

Staff training resources

Video: *Smelly Balloons*

Activity: UV Bracelets

This activity lets students discover how small changes on the nanoscale can have surprising effects. Students can see special beads change color when the dye molecules in the beads are exposed to ultraviolet light.

Advance preparation

For each group, provide a UV flashlight, one pipe cleaner, two UV beads, and 3–5 ordinary pony beads. Use the small plastic cups to organize the beads.

Safety

The UV flashlight emits very low levels of UV radiation. It is safe to use, but avoid looking directly at the UV bulbs when the light is on. Alternatively, you can just rely on direct sunlight to change the beads.

Facilitate the activity

Try this!

1. Thread two UV beads onto a pipe cleaner. Add some additional ordinary beads.
2. Wrap the pipe cleaner around your wrist and twist the ends to tie it. Now, step into sunlight or shine the UV flashlight on the beads. What happens?

Use the activity books

Prompts and questions on the UV Bracelets page of the activity books encourage students to explore how the UV beads behave. Go around to each group to check in on their progress and answer questions.

What's going on?

Tiny dye molecules in the UV beads change shape in response to UV light (or sunlight), which changes their color.

How is this nano?

The UV dye molecules are too small to see, but we can tell when then change shape. Nanotechnology takes advantage of special properties at the nanoscale to create new materials and devices.

Materials

Activity guide
Activity books
Pencils
Pipe cleaners
UV beads
Ordinary pony beads
UV Flashlights

For each group:

- UV Flashlight
- Pipe cleaner
- UV beads
- Ordinary pony beads

Sources

UV beads are available from www.teachersource.com (#UV-AST)
UV flashlights are available from www.homedepot.com (#809-2717-D)

Time

10 minutes

Staff training resources

Video: *UV Bracelets*

Unit 3. Labs and Tools

Unit 3 of the program explores some of the techniques and tools scientists use to work on the nanoscale.

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

- Nano scientists use special tools and equipment.

Recap Unit 2
Remind students that we've been investigating a very special kind of science, technology, and engineering, which we're calling "nano" for short.

Review some of the things we've already learned about nano. Students can refer back to their Small and Surprising activity books. Ask students to share something they learned last time.

As a group, brainstorm some things that behave in surprising ways at the nanoscale.

Introduce Unit 3
Nano is very, very small. This session explores some of the special ways nanoscale scientists and engineers study and make tiny things.

Materials:
Activity books
Pencils

Time:
5–10 minutes

Staff training resources:
Guide: *Engaging the Public in Nanotechnology*

Activity: Mystery Shapes

This activity lets students model the way a special tool—a scanning probe microscope—is used to study and make things on the nanoscale. Students feel hidden objects and then draw or describe what they feel.

Advance preparation

For each group, place a handful of assorted plastic objects into a canvas bag. Don't let the students see what's hidden in the bags! You can find other mystery shapes for students to feel, in addition to those included in the activity.

Most students are enthusiastic about discovering the "mystery shapes," but some may hesitate to put their hands inside. You can reassure them that there's nothing scary or icky in the bag!

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Without looking inside, put your hand in the bag. What do you feel? Draw a picture of what you think is inside the bag.
2. Now, take the mystery object out of the bag and compare it to your picture. What information does your drawing include? What's missing?

Use the activity books

Encourage students to draw what they feel inside the bags on the Mystery Shapes page of their activity books.

Tip: Younger students, those with limited dexterity, or those with low-vision may prefer to describe what they feel rather than draw it.

What's going on?

When you feel a mystery object in the bag and draw a picture of what it looks like, you're modeling the way that a special tool called a *scanning probe microscope* (SPM) works. Your hand acts like the sensing part of the SPM, while your brain acts like the computer program that creates a picture of what the tool "feels."

How is this nano?

Scanning probe microscopes (SPMs) allow researchers to detect and make images of objects measured in nanometers—or even smaller. (A nanometer is a billionth of a meter.)

Tip: Refer students to the Atomic Force Microscope image sheet for detailed information about how this example of an SPM works.

Materials

Activity guide
Image sheet
Activity books
Pencils
Canvas bags
Assorted objects

For each group:

- 1 canvas bag
- Several assorted hidden objects

Time

10 minutes

Staff training resources

Video: *Mystery Shapes*

Activity: Gummy Shapes

This activity lets students experiment with goo to make squishy gummy capsules. These gummy droplets are similar to special nano capsules, and students learn that nano scientists use a process called self-assembly to make tiny nanostructures.

Advance preparation

Before beginning this activity fill each bowl with warm water and add half a spoon of "worm activator" calcium chloride. Stir to dissolve.

During the activity, you'll need a trashcan nearby to dispose of the polymer.

Safety

Do not ingest the chemicals. Students should be supervised when doing this activity. Refer to the MSDS sheets included in the materials for additional information.

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Put the strainer into the bowl of water. Squeeze the bottle of goo so that little droplets fall into the strainer.
2. Lift the strainer out of the water and feel the goo. Is it still liquid?

   Now, try squeezing one of the little balls. What happens?

What's going on?

When the liquid goo touches the salt water, a chemical reaction occurs and makes a polymer. A polymer is a long, chain-like molecule. The polymer forms on the outside surface of the goo, creating a gummy shell around a liquid interior.

How is this nano?

These polymer droplets are similar to *nanocapsules*, tiny particles with an outside shell and a hollow interior that can be filled. To make nanocapsules, scientists use a process called *self-assembly,* in which nanostructures actually build themselves! Nanocapsules can be designed to deliver cancer medicine to diseased parts of the body (tumors), bypassing healthy parts. These targeted delivery systems use much less medicine, so they can have fewer, less harmful side effects.

Materials

Activity guide
10 "worm goo" sodium alginate liquid in squirt bottles
5 packets of "activator" calcium chloride
5 Small bowls
5 Small mesh strainers
Water
Nearby trash can

For each group:

- 1 squirt bottle with sodium alginate liquid
- 1 small bowl of water and dissolved calcium chloride
- 1 small strainer

Sources

The chemicals for this activity are available from www.stevespangler.com

Time

10–15 minutes

Staff training resources

Video: *Gummy Shapes*

Activity: Draw a Circuit

This activity invites students to discover a new nanomaterial called graphene. Students will experiment with ways a similar material—graphite—can be used to complete an electrical circuit.

Advance preparation

Before beginning the activity, assemble a battery and buzzer circuit for each group. Use the alligator clip to connect the black wire of the battery to the black wire of the buzzer. Then use the red wires to touch the layer of graphite on the paper. The buzzer will not work if it is connected in the wrong direction. See the diagram on the next page for a visual layout.

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Lay down some graphite. Use the drawing pencil to color in the box on the paper. Make it nice and dark. (Graphite is the real name for pencil lead.)
2. Touch the two insulated wires to the graphite box. Listen closely—what happens? Now try moving the wires closer together and further apart. Do you notice a difference?

Use the activity books

Have students lay their graphite down in the boxes on the Draw a Circuit page of their activity books. Go around to each group to check in on their progress and answer questions.

Tip: If the buzzer sound is too faint, put down a thicker layer of graphite.

What's going on?

The buzzer sounds because the graphite conducts electricity. Graphite is made of many layers of carbon stacked on top of each other. Graphene, a relatively new nano material, is also made up of carbon atoms. It's only one atom thick—that's a fraction of a nanometer! (A nanometer is a billionth of a meter.)

How is this nano?

Graphene has a lot of useful properties. It's flexible, super strong, and nearly transparent—and it conducts electricity. Computer chip manufacturers are developing circuits from graphene, by modifying it to make it a semiconductor. One day, graphene could be used to make see-through, bendable electronic displays, and tiny, fast computer chips.

Materials

Activity guide
Activity books
Pencils
Image sheets
Circuit diagram
Battery and buzzer circuit (9V battery, snap connector, alligator clip, and buzzer)
Pencil sharpener

For each group:

- 1 Battery and buzzer circuit
- 5 pencils

Sources

Battery and circuit materials are available from www.radioshack.com

(9v battery #55039849, snap connector #270-324, alligator clip #278-1156)

Buzzer can be purchased from www.newark.com (#89K7985)

Time

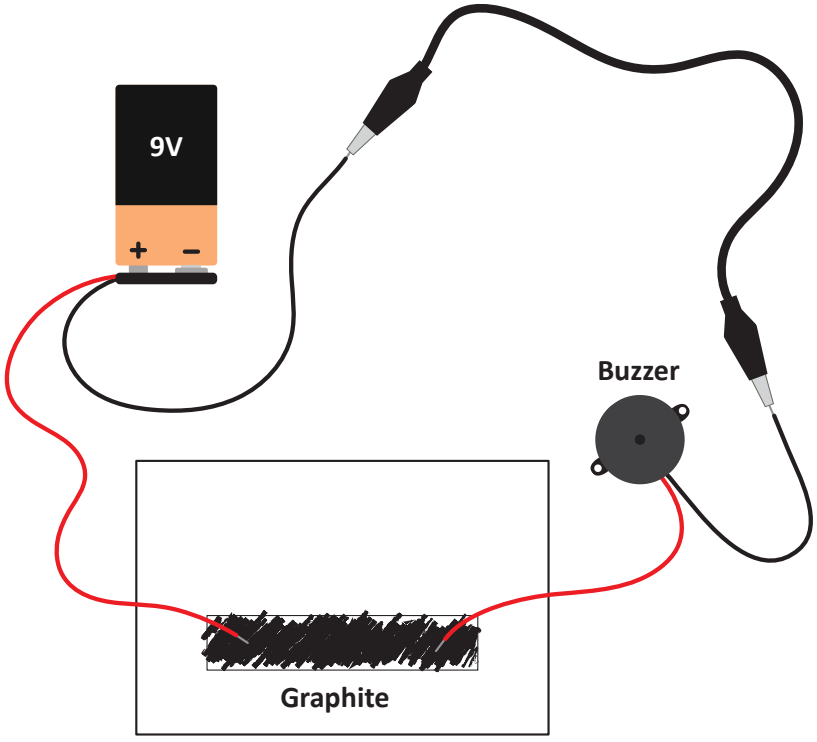
10–15 minutes

Staff training resources

Video: *Draw a Circuit*

Draw a Circuit Diagram

Before beginning the activity, assemble a battery and buzzer circuit for each group. Use the alligator clip to connect the black wire of the battery to the black wire of the buzzer. Then use the red wires to touch the layer of graphite on the paper. The buzzer will not work if it's connected in the wrong direction.



Reflection Activity: Imagine Yourself as a Nano Scientist

This activity lets students reflect on and activate what they've learned in the session. If you have limited time, this activity can also be done at home as an extension.

Facilitate the activity

Nano scientists do many different things! They create new fabrics, tiny robots, medical devices, better computer chips, food ingredients, water filters . . . and much more!

Many nano scientists work in places called clean rooms. They wear special suits—clean room suits—to help keep their labs super clean. In addition to protecting the researchers, these suits actually protect the work from dirt and other particles the scientists might carry in with them. A single particle of dust can destroy an entire nano-sized device!

Students can draw themselves into the picture of the clean room suit, and then draw or describe some things they might invent using nanotechnology. What problems might they hope to solve? Go around to each group to check in on their progress and answer questions.

Materials

Activity guide
Activity books
Pencils

Time

5–10 minutes

Staff training resources

Guide: *Engaging the Public in Nano*

Unit 4. Tech and Nature

Introduction

Unit 4 explores technologies that are enabled by nano and discovers examples of nano in nature.

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

- Nano research lets us create new technologies and understand nature.

Recap Unit 3
Remind students that we've been investigating a very special kind of science, technology, and engineering, which we're calling "nano" for short.

Review some of the things we've already learned about nano. Students can refer back to their Labs and Tools activity books. Ask students to share something they learned last time.

As a group, brainstorm some ways that scientists study and make things at the nanoscale. Can students describe how a scanning probe microscope gathers information?

Introduce Unit 4
Nanotechnology is a new field of science and engineering that focuses on studying and making very small things. This session explores examples of beautiful and surprising effects found in nature due to nanoscale structures. It also demonstrates some ways that nanotechnology is improving existing technologies.

Materials:
Activity books
Pencils

Time:
5–10 minutes

Staff training resources:
Guide: *Engaging the Public in Nanotechnology*

Activity: Morphing Butterfly

This activity lets students explore an example of nano in nature. Students discover how tiny, clear nanoscale structures on a Blue Morpho butterfly's wing reflect light back to our eyes making the wing appear blue.

Facilitate the activity

Try this!

1. Look at both butterfly wings. One wing is yellow on both sides. The other wing is blue on the front but brown on the back.
2. Now shine the light through the wings from the back. Do they look the same when you turn on the light?

Tip: Squeeze the light to turn it on!

What's going on?

When you turn on the light, the yellow wing stays yellow, but the blue one turns brown! That's because the yellow color comes from pigment, but the blue is created by the interference of light bouncing off tiny, colorless nano-sized structures.

How is this nano?

Some nanotechnologies and materials are inspired by nature. Scientists are working on new technologies that mimic the Blue Morpho's wings. They've invented low-energy smartphone displays, paints, and fabrics that change color by changing the spacing between materials.

Tip: If you're doing this activity near a bright window or other light source, the mini-light may not be effective. You might be able to hold the butterfly wing up to the window or light source to get the same effect (and not use the mini-light at all), or you might need to relocate the activity to a less brightly lit area.

Materials

Activity guide
Image sheet
5 protected blue butterfly wings
5 protected yellow butterfly wings
5 mini LED lights

For each group:

- 1 set of butterfly wings with LED light attached

Sources

Butterflies are available at www.butterfliesandthings.com

Time

10 minutes

Staff training resources

Video: *Morphing Butterfly*

Activity: Rainbow Films

In this activity, students create their own rainbow colored thin film bookmarks from clear nail polish. Thin films reflect light in special ways because they are only a few hundred nanometers thick.

Advance preparation

For each group, put about an inch or two of water into the plastic tray. Create a space for the bookmarks to dry once students are finished making them. The bookmarks dry best flat.

Bristol paper works best for this activity. You can use regular construction paper, but a lot of color will bleed from the paper into the water.

The nail polish should be completely clear (no shimmer or glitter), and regular formula (not fast-drying).

Black paper is used for this activity because it absorbs all visible light. The colors that appear are created by the interaction of light with the thin film.

Safety

Be sure to do this activity in a well-ventilated area.

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Write your name on a strip of black paper. Hold one end and slide the paper into the pan.

   Tip: Make sure the paper is under the water, except for the end you're holding.

2. Use the brush to drip one drop of nail polish onto the surface of the water. Watch what happens—the polish spreads out into a thin film!
3. Now lift the paper out of the water. The film of nail polish should stick to the paper. Does the nail polish still look clear?

What's going on?

The nail polish spreads out into a super thin film, and creates rainbow colors. The film is only a few nanometers thick, so it reflects light in special ways. The film is slightly thicker in some places and thinner in others. It reflects light differently depending on how thick it is, so you see different colors. Many beautiful things in nature get their iridescent colors in this same way, including bird feathers, butterfly wings, sea shells, and beetle shells.

How is this nano?

Nanotechnology takes advantage of special properties at the nanoscale to create new materials and devices. Researchers are creating thin-film batteries, solar cells, electronic displays, and coatings for different surfaces.

Tip: Writing their name with the permanent marker helps students identify their thin film later. The marker doesn't make the colors appear on the black paper—that's the thin film created by the nail polish!

Materials

Activity guide
Black paper strips (bristol)
5 plastic trays
5 bottles of nail polish

For each group:
- 1 paper strip per student
- 1 plastic tray
- 1 bottle of nail polish

Sources

Bristol paper is available at from most craft stores

Time

10 minutes

Staff training resources

Video: *Rainbow Films*

Activity: Invisible Sunblock

This activity lets students discover some common uses of nanotechnologies. Students experiment with two different sunblocks to see how nano-sized materials behave differently.

Advance preparation

For each group, squirt a small amount of each sunblock into a plastic cup. Divide up the cotton swabs and black construction paper squares.

Safety

To avoid potential reactions due to allergies or sensitivities, do not allow visitors to apply the ointment or sunblock to their skin.

Notes

Students may wonder how they can tell if their sun protection contains nanoparticles. Here are some guidelines:

- If a product includes zinc oxide or titanium dioxide, it's a mineral sunblock that works by absorbing UV rays. If a mineral sunblock rubs in clear, it probably contains nanoparticles.
- Products that contain avobenzone, oxybenzone, or PABA are chemical sunscreens that do not contain mineral nanoparticles.

More information on potential health concerns related to nanoparticles in sunblock can be found in the "Invisible Sunblock" program, available from www.nisenet.org.

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Use the cotton swab to place a small dab of each sunblock onto the paper.
2. Try rubbing it in. What happens?

   Tip: Remind students to try to use the same amount of each sunblock.

Use the activity books

Have students tape their sunblock rubbings right onto the Invisible Sunblock page of their activity books. Go around to each group to check in on their progress and answer questions.

What's going on?

One sunblock rubs in clear, but the other leaves a white film on the paper. The clear sunblock rubs in better because it contains tiny, nano-sized particles of zinc oxide. These nano-sized particles of zinc oxide are so small that they don't reflect visible light, making the invisible sunblock transparent. The other sunblock also contains zinc oxide, but the particles are much bigger.

How is this nano?

Nanotechnology takes advantage of the way things behave differently at the nanoscale to make new products and applications. Sunblocks containing nanoparticles are one of the most common applications of nanotechnology. Many other health and beauty products also contain nano-sized particles, including cosmetics and toothpaste.

Materials

Activity guide
Activity books
Nano sunblock
Non-nano sunblock
10 plastic cups
Cotton swabs
Construction paper squares
Tape

For each group:

- Dab of nano sunblock
- Dab of non-nano sunblock
- 2 pieces of paper per student
- 2 cotton swabs per student
- Tape

Sources

Many natural or organic baby sunblocks contain non nano-sized particles of zinc oxide or titanium dioxide.

Time

10 minutes

Staff training resources

Video: *Invisible Sunblock*

Game: I Spy

In the I Spy game, students compete to see who can spot the nano-related object most quickly. The nano-related objects in the game are a mix of technology and nature.

Play the game

Rules

1. Place the deck of playing cards in the center, blue side up (picture side down).
2. Each player chooses a game board.
3. Read the statement on the blue side of each card, and then turn it over.
4. Look at the objects on the card. Each game board has one of these objects on it.
5. All players search their boards to find an object that's identical to one on the card.
6. The first person to find their object says "Nano!" and takes the card.
7. Play with the next card in the deck until no cards remain in the center pile.
8. Whoever has the most cards wins!

Tip: If you have limited time, select fewer game cards. It doesn't matter which cards you remove from the game.

Use the activity books

Encourage students to find all the hidden objects on the I Spy—Hidden Pictures page of the activity books. If you have limited time, this can also be done as a take-home extension.

Materials

Activity guide
Activity books
5 sets of game boards
5 sets of game cards

For each group:
• 1 set of boards
• 1 set of cards

Tip: If you have more than 5 students in a group, pair students up to share a board.

Sources

Graphic files are available for download from www.nisenet.org.

Time

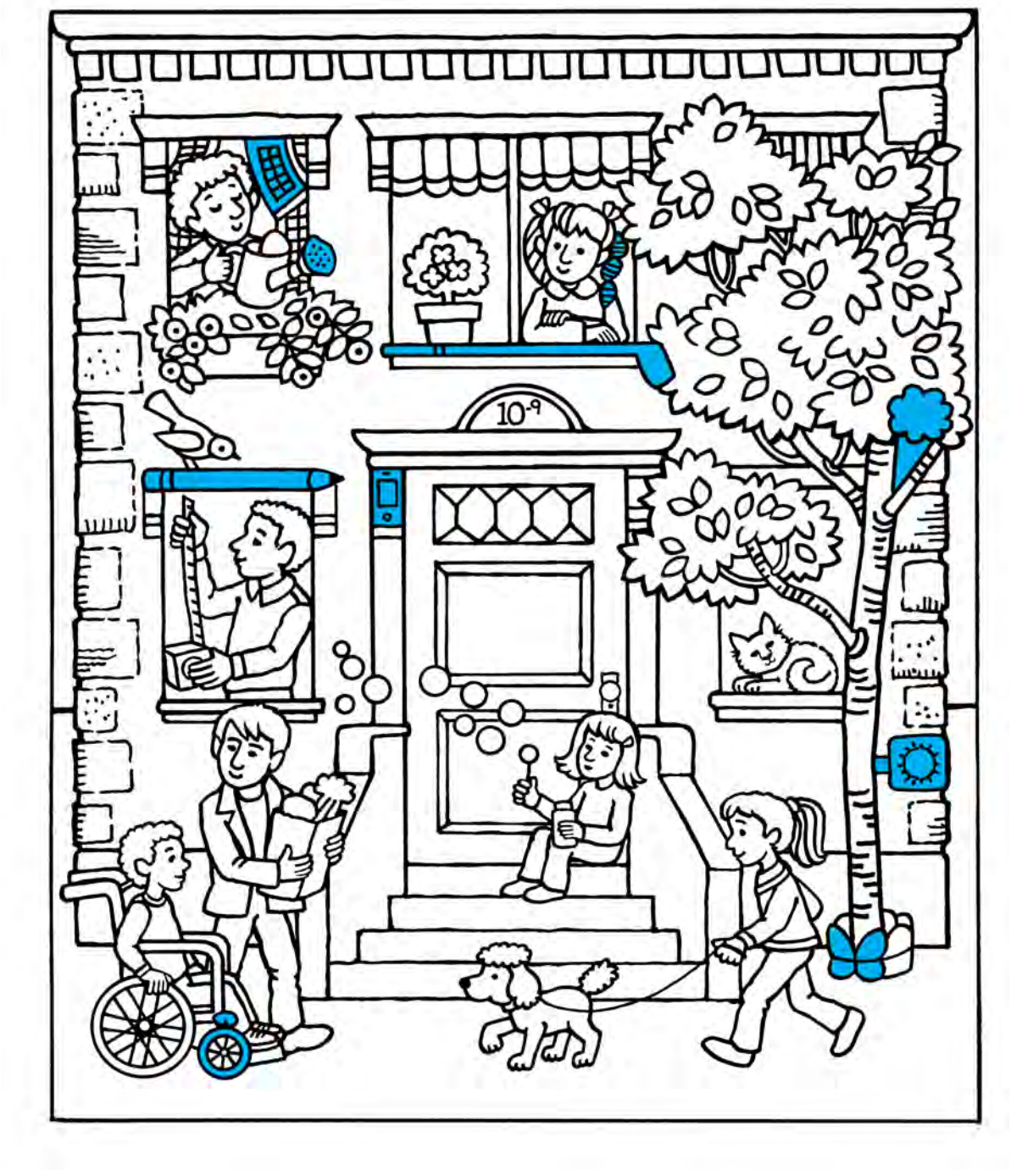
10–30 minutes

Staff training resources

Video: *I Spy*

I Spy—Hidden Pictures Answer Key

The activity books contain a Hidden Pictures activity. Here is where all the objects are hidden in the picture, and an explanation of their connections to nano.



Butterfly

The brilliant color of Blue Morpho butterfly is actually created by tiny, colorless nanostructures! Light waves bounce off the tiny structures, reflecting blue light to your eyes.

Diamond ring

Carbon atoms can form diamond, the hardest natural material known on Earth, but they can also form graphite, a very soft material. Atoms are the building blocks of nature, and they're even smaller than a nanometer.

DNA

DNA stands for *deoxyribonucleic acid*. DNA is present inside the cells of every living thing. It contains the chemical instructions and genetic information to help organisms develop and function. DNA is only two nanometers across.

Solar cell

New flexible solar cells contain nano-sized structures and materials, allowing them to be less expensive and more efficient.

Golf club

Tiny carbon nanotubes make some bicycles, golf clubs, and tennis rackets stronger and lighter.

Ice cream

Nanotechnology is already on the shelves of your supermarket. Edible nano structures make ice cream look and taste better.

Lemon

The shape of scent molecules gives them their smell. Molecules are made up of atoms. They're measured in nanometers, so your nose is your very own nano detector!

Pencil

Carbon atoms can form graphite (pencil "lead"), which is a very soft material, but they can also form diamond, the hardest natural material known on Earth. Atoms are the building blocks of nature, and they're even smaller than a nanometer.

Smart phone

Computer chips have tiny, nano-sized parts. So when you use a smartphone, computer, gaming console, or any other electronic device with a chip, you're using nanotechnology!

Socks

Some socks are made with tiny particles of nano-sized silver. Nano silver is naturally antimicrobial, so it keeps smelly germs away.

Sunblock

Many sunblocks contain nano-sized particles of zinc oxide or titanium dioxide, which protect skin from the sun's rays without leaving a visible white film.

Reflection Activity: Draw Your Own Robot

This activity lets students reflect on and activate what they've learned in the session. If you have limited time, this activity can also be done at home as an extension.

Facilitate the activity

Nano is all around us—in nature and in technology. Some researchers are inspired by nature to create new materials and technologies.

Encourage students to draw or describe a robot inspired by nanotechnology. Have them name the robot, describe its job, and describe how it might change their lives. Go around to each group to check in on their progress and answer questions.

Tip: If time allows, have students share their ideas with the whole group. Also, younger students may need to talk about these things rather than writing it all out.

Materials

Activity books
Pencils

Time

5–10 minutes

Staff training resources

Guide: *Engaging the Public in Nano*

Unit 5. Nano and Our Lives

Unit 5 explores some old and new examples of nanotechnology and considers ways that nano might transform our lives in the future.

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

- Nanotechnologies will be part of our lives—now and in the future.

Recap Unit 4
Remind students that we've been investigating a very special kind of science, technology, and engineering, which we're calling "nano" for short.

Review some of the things we've already learned about nano. Students can refer back to their Tech and Nature activity books. Ask students to share something they learned last time.

As a group, brainstorm some examples of nano in nature. What are some ideas students have for inventing new nanotechnologies?

Introduce Unit 5
The field of nanotechnology leads to new knowledge and innovation, and, like all new technology, will impact our lives in ways that we can't always predict. This session explores some old and new examples of nanotechnology and invites students to discuss ways they think nano might change their lives in the future.

Materials:
Activity books
Pencils

Time:
5–10 minutes

Staff training resources:
Guide: *Engaging the Public in Nanotechnology*

Activity: Stained Glass Art

This activity describes how people have been using nanotechnology since the Middle Ages. Students make art inspired by stained-glass windows.

Advance preparation

Before you begin this activity, divide up the craft materials. Precut the contact paper into squares, and cut strips of black construction paper for the borders. You can also have small pieces of multicolored tissue paper already available.

Tip: Peeling off the backing of the contact paper can be challenging. Sometimes it is hard to get the peel started. One tip is to bend and crease one of the corners. This sometimes helps to get the peeling started.

Facilitate the activity

Try this!

1. Peel the backing off a piece of contact paper. Use black paper to make a border. Place small pieces of colored tissue paper on the sticky side of the contact paper.
2. Take the backing off another piece of contact paper and carefully put it on top of the other piece, sticky sides together. Trim your artwork.
3. Now hold your design up to a light or window. What do you notice?

What's going on?

Tissue paper gets its colors from dyes that are added to the paper during the production process. But stained glass isn't dyed! Since the Middle Ages, tiny nano-sized pieces of gold and other metals have been used to color glass.

How is this nano?

Stained-glass windows are an early example of nanotechnology. Many nano materials behave differently as they get smaller. Big pieces of gold look shiny and golden, but tiny pieces of nano-sized gold can appear red, purple, or blue, because they interact differently with light.

Materials

Activity guide
Contact paper
Tissue paper
Black construction paper
Scissors

For each student:

- 2 squares of contact paper
- Assortment of colored tissue paper and black construction paper strips
- Scissors

Time

10 minutes

Staff training resources

Video: *Stained Glass*

Activity: Mystery Sand

In this activity, students experiment with colored sand and investigate how a nano-thin coating makes a big difference for this nanotechnology.

Advance preparation

For each group, put about a half a cup of each of the colored sands into plastic trays (one color per tray). Fill the small plastic containers with water. To reuse the hydrophobic sand when the activity is over, carefully pour out most the water. Shake the tray and use a sheet of paper towel to absorb the last drops of water. To reuse the ordinary sand, let it dry in the tray.

Facilitate the activity

Try this!

1. Investigate the two sands. Can you see or feel a difference?
2. Use the eyedropper to put a few drops of water on both kinds of sand. Try tilting the trays gently. Now can you see another big difference?

Tip: You may need to demonstrate to the students how to use an eyedropper. Remind students that all they need is a drop!

What's going on?

The blue sand is special. It has been coated with a silicon compound that makes it repel water! The hydrophobic coating is so thin you can't feel it, but you can see how it makes the sand behave differently.

The other sand is just ordinary sand that's been colored green. It acts like the kind of sand you find at the beach or playground. Water molecules and sand are attracted to each other, so ordinary sand gets wet.

How is this nano?

Nanotechnology takes advantage of the way things behave differently at the nanoscale to make new products and applications. Hydrophobic sand was invented to clean up oil spills in water. When the coated sand is poured on a spill, it bonds to the oil (but not the water) and sinks to the bottom, where it can be dredged and treated.

Materials

Activity guide
Blue mystery sand
Green ordinary sand
10 plastic trays
5 small plastic cups
Eyedroppers
Water

For each group:

- 1 tray of mystery sand
- 1 tray of regular sand
- 1 small plastic container filled with water
- A couple eye droppers

Sources

The mystery sand, often called Space Sand, is made by DuneCraft and is available from many online retailers, such as www.amazon.com.

Time

10 minutes

Staff training resources

Video: *Mystery Sand*

Game: You Decide!

This game encourages students to make decisions about which nanotechnologies we should make, and then invites them to think about how different people have different opinions.

Advance preparation

This activity is designed as an open-ended, conversational experience. There is no right or wrong way to sort the cards. To help students think about how to prioritize the technologies, you can ask them to think about which ones might be most useful or important and explain why they think so. After they choose a character card, you can ask them which technologies they think that person would find important, suggesting some factors the character might consider.

This activity is easy to facilitate with a little practice. Before doing it with visitors, become familiar with the cards and try it out a few times with a friendly audience.

(Activity instructions on following page.)

Facilitate the activity

Try this!

1. Look at all the green cards with different technologies. Which of these technologies are the most important, in your opinion? Put them in order. Do other people in your group have different opinions?
2. Now choose one of the yellow cards with people on them. Pretend you're the person on the card. Do you think that person would think the same technologies are important? Why might they choose differently?

Tip: For younger students, try starting with just 3–5 technologies, including the space elevator, the teabag water filter, or the invisibility cloak. Younger students may also have a hard time understanding the different perspectives represented by the character cards, but they might recognize that they would sort the cards differently from other people in their group.

What's going on?

Different people think different technologies are important. There is no right or wrong way to sort the cards. You might put the technologies in a different order from a friend, a family member, or someone else in a different part of the world.

How is this nano?

Nanotechnology allows scientists and engineers to make things like smaller, faster computer chips and new medicines to treat diseases like cancer. Our values influence the technologies we make and use.

Materials

Activity guide
You Decide game cards

For each group:
• 1 set of game cards

Sources

Graphic files are available from www.nisenet.org.

Time

10 minutes

Staff training resources

Video: *You Decide!*

Reflection Activity: Nano Future Tellers

This activity lets students reflect on and activate what they've learned in the session. Students will make origami-folded, interactive pocket games called Nano Future Tellers. If you have limited time, this activity can also be done at home as an extension.

Facilitate the activity

Make the Nano Future Tellers by following the instructions in the activity books.

Think how much the invention of the automobile or personal computer changed things! Some researchers expect nanotechnology to transform our lives just as much within the next decade or so.

Of course, we don't know if nanotechnology will really change the world. But researchers are working to develop nanotechnologies that could revolutionize life all over the globe by generating clean energy, fighting disease, purifying water, or improving food supplies.

Tip: Students can create their own nano futures, or for more inspiration refer to the Nano Future Tellers program available on nisenet.org.

Materials
Activity books
Pencils
Crayons or markers
Scissors (you can use the scissors from the Stained Glass Art activity)

Time
10 minutes

Staff training resources
Guide: *Engaging the Public in Nano*

Resources

NISE Network

The Nanoscale Informal Science Education Network (NISE Net) is a national community of researchers and informal science educators dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology. Nisenet.org is an online digital library of public nano educational products and tools designed for educators and scientists. In addition to the Explore Science kits, many more resources related to nano education and educator professional development are available on the project website. See more at www.nisenet.org.

Afterschool Alliance

The Afterschool Alliance is dedicated to raising awareness of the importance of afterschool programs and advocating for more afterschool investments. They provide resources related to getting started with STEM, funding afterschool STEM programs, research on STEM learning, and more. See more at www.afterschoolalliance.org/stem.cfm.

Boys & Girls Clubs of America

Boys & Girls Clubs of America offers DIY STEM, a hands-on, activity-based curriculum that connects youth to science themes they encounter regularly. It is available for use by Clubs, other non-profit organizations and the general public. See more at www.greatfutures.org/pages/TWC-DIYSTEM.aspx.

Center for the Advancement of Informal Science Education

The Center for the Advancement of Informal Science Education (CAISE) provides InformalScience.org, a central portal to project, research, and evaluation resources designed to support and connect the informal STEM education community in museums and other learning environments. See more at www.informalscience.org.

Click2Science

Click2Science is an interactive professional development site for trainers, coaches, site directors, and frontline staff/volunteers working in out-of-school time STEM programs, serving children and youth. It was developed by the UNL Extension in partnership with the Noyce Foundation and in collaboration with many other organizations. See more at www.click2sciencepd.org.

How to Smile

Howtosmile.org collects the best science and math activities, designed especially for those who teach school-aged kids in non-classroom settings. The project is a collaboration of educators at science museums and children's museums. See more at howtosmile.org.

National Girls Collaborative Project

National Girls Collaborative Project (NGCP) brings together organizations throughout the United States that are committed to informing and encouraging girls to pursue careers in STEM. NGCP offers many resources to strengthen collaborative networks and advance STEM education for girls. See more at ngcproject.org.

4-H

4-H science programs create hands-on learning experiences to encourage young minds and help fill our nation's shortage of young leaders proficient in science, engineering, and technology. Their professional development tools build understanding and support implementation and evaluation. See more at www.4-h.org/resource-library/professional-development-learning/science-training-guides-resources/.

Activity and Image Credits

Nanotechnology: What's the Big Deal Video

This video was created and produced by the Oregon Museum of Science and Industry for the NISE Network. Revised version. Copyright 2014 OMSI.

Get in Order

This activity was adapted from *Sizing Things Down,* developed by the Oregon Museum of Science and Industry for the NISE Network. It is a modified version of the NISE Network's educational product *Exploring Size—Powers of Ten*, available on www.nisenet.org. Photo of computer chip, iStock.com/all rights reserved.

Measure Yourself & Tiny Ruler

This activity was adapted from "How Many Nanometers Tall Are You?" from *It's a Nano World,* a traveling exhibition funded by the National Science Foundation and developed by the Sciencenter in Ithaca, NY; the Nanobiotechnology Center at Cornell University; and Painted Universe Inc. It is a modified version of the NISE Network's educational product *Exploring Size—Measure Yourself*, available on www.nisenet.org. Photo of human blood vessel, Roger Wagner, University of Delaware.

Gravity Fail

This activity was adapted from "Shrinking Cups: Changes in the Behavior of Materials at the Nanoscale," in Nanoscale Science: Activities for Grades 6–12 by M. Gail Jones, Michael R. Falvo, Amy R. Taylor, and Bethany P. Broadwell. pp. 89P94. Arlington, VA: NSTA Press. It is a modified version of the NISE Network's educational products *Exploring Forces—Gravity* and *DIY Nano Gravity Fail*, available on www.nisenet.org. Photo of water strider, iStock.com/all rights reserved. Photo of water droplet, A. Otten and S. Herminghaus, Göttingen, Germany.

Ready, Set, Fizz

This activity is a modified version of the NISE Network's educational products *Exploring Properties—Surface Area* and *DIY Nano Ready, Set, Fizz*, available on www.nisenet.org. Photo of packaging, iStock.com/all rights reserved.

Smelly Balloons

This activity is a modified version of the NISE Network's educational products *Exploring Size—Scented Balloons* and *DIY Nano Smelly Balloons*, available on www.nisenet.org. Photo of biosensor, Raj Mohanty, Boston University.

UV Bracelets

This activity was adapted from "Reversible Sunglasses" developed by The Franklin Institute, in partnership with Penn State MRSEC and the Cornell Center for Materials Research, through funding by the National Science Foundation and Penn State University. The original activity is available at www.mrsec.psu.edu. It is a modified version of the NISE Network's educational

product *Exploring Properties—UV Beads*, available on www.nisenet.org. Photo of sunglasses, iStock.com/all rights reserved.

Mystery Shapes

This activity is a modified version of the NISE Network's educational products *Exploring Tools—Mystery Shapes* and *DIY Nano Mystery Shapes*, available on www.nisenet.org. Photo of researcher using AFM by Charles Harrington Photography, Cornell Nanoscale Facility. Image of AFM tip by SecretDisc, Wikimedia Commons.

Gummy Shapes

This activity was adapted from *Sweet Self-Assembly*, developed by the Children's Museum of Houston for the NISE Network. It is a modified version of the NISE Network's educational products *Exploring Fabrication—Gummy Capsules* and *DIY Nano Gummy Shapes*, available on www.nisenet.org. Photo of nanocapsules courtesy Katarina Edwards, Uppsala University, Sweden.

Draw a Circuit

This activity is a modified version of the NISE Network's educational products *Exploring Materials—Graphene* and *DIY Nano Draw a Circuit*, available on www.nisenet.org. Photo of flexible graphene circuit, Ji Hye Hong. Illustration of graphite, Martin McCarthy. Illustration of graphene sheet, Jannick C. Meyer.

Imagine Yourself as a Nano Scientist

This activity is a modified version of the NISE Network's educational product *Exploring Tools—Dress Up Like a Nanoscientist*, available on www.nisenet.org.

Morphing Butterfly

This activity is a modified version of the NISE Network's educational products *Exploring Structures—Butterfly* and *DIY Nano Morphing Butterfly*, available on www.nisenet.org. Images of Blue Morpho wing with reflected and non-reflected light, F. Nijhout, Duke University. Photo of low-energy display, Qualcomm Technologies, Inc. Image of structures in Blue Morpho wing, S. Yoshioka, Osaka University.

Rainbow Film

This activity was adapted from *Create Some Iridescent Art* in the *DragonflyTV Nano Educator's Guide,* published by Twin Cities Public Television, 2009. The original activity is available at www.pbskids.org/dragonflytv/. It is a modified version of the NISE Network's educational products *Exploring Materials—Thin Film* and *DIY Nano Rainbow Films*, available on www.nisenet.org. Photo of soap bubbles, iStock.com/all rights reserved.

Invisible Sunblock

This activity was adapted from "Invisible Sunblock," developed by The Franklin Institute for the NISE Network. It is a modified version of the NISE Network's educational products *Exploring Products—Sunblock* and *DIY Nano Invisible Sunblock*, available on www.nisenet.org. Photo of

girl with sunblock, iStock.com/all rights reserved. Photo of nanoparticles in sunblock, NanoComposix.

I Spy

This activity is a modified version of the NISE Network's educational product *I Spy Nano*, available on www.nisenet.org. Image of climbing robot, M. Cutkosky, Stanford University. Image of low-energy display, Qualcomm Technologies, Inc. Photo of track shoes, Adidas. Image of snowflakes, Kenneth Libbrecht, www.snowcrystals.com.

Stained Glass Art

The original version of this activity was adapted by the Children's Museum of Houston from NISE Network's *Exploring Materials—Nano Gold*. It is a modified version of the NISE Network's educational products *Exploring Products—Stained Glass* and *DIY Nano Stained Glass Art*, available on www.nisenet.org. Image of nano gold particles, nanoComposix. Photo of stained glass, iStock.com/all rights reserved. Illustration of different colored gold nano particles, Emily Maletz.

Mystery Sand

The original version of this activity was adapted from two sources. 1. *Magic Sand,* developed by the Materials Research Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces at the University of Wisconsin-Madison for the NISE Network. 2. "Magic Sand," JCE Classroom Activity #23, *Journal of Chemical Education* 77(1): 40A-40B, January 2000. Available at www.JChemEd.wisc.edu. It is a modified version of the NISE Network's educational products *Exploring Products—Nano Sand* and *DIY Nano Mystery Sand*, available on www.nisenet.org. Photo of oil spill, iStock.com/all rights reserved.

You Decide!

This activity is a modified version of the NISE Network's educational product *Exploring Nano and Society—You Decide*, available on www.nisenet.org. The original version of this activity was created as a collaboration of the NISE Network and the Center for Nanotechnology in Society at Arizona State University. Photo of thin-film solar cell, Konarka Technologies. Photo of teabag water filter, Stellenbosch University, www.sun.ac.za.