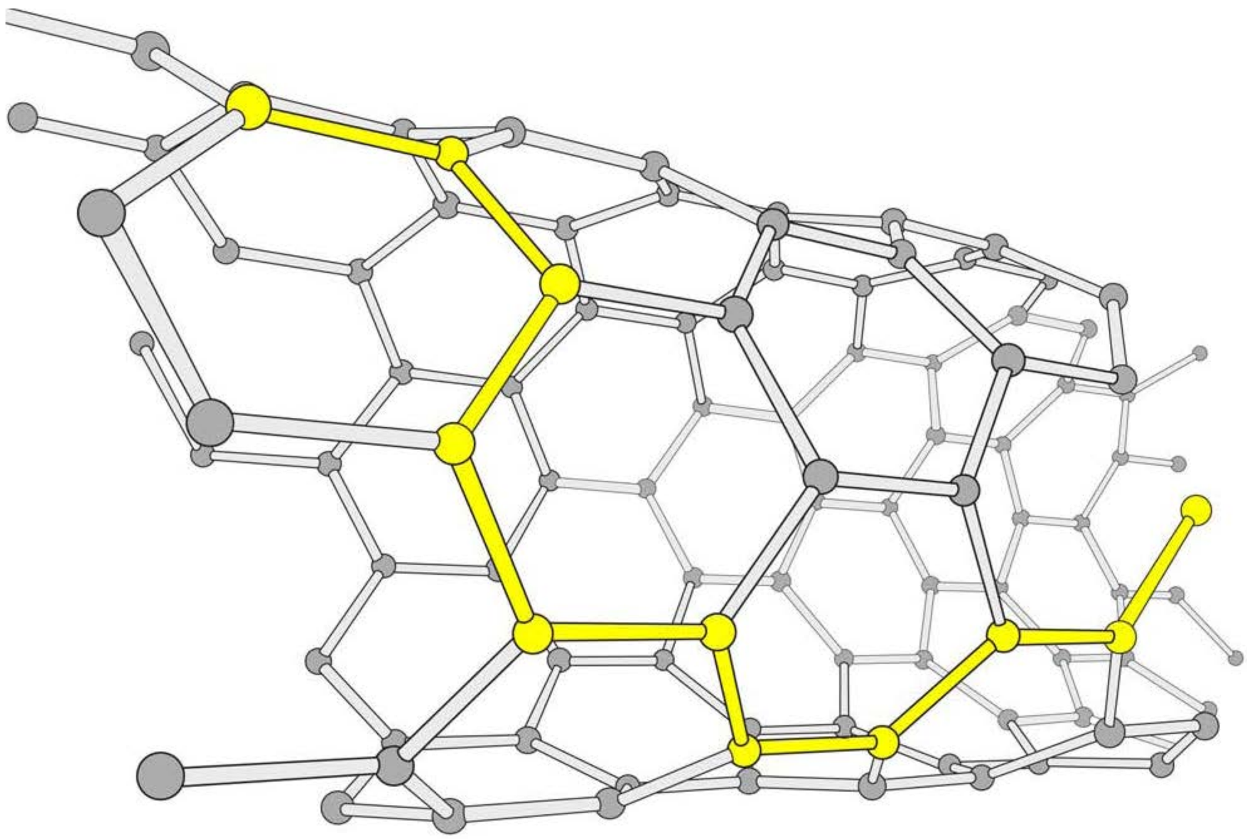
Southeastern Nanotechnology Infrastructure Corridor (SENIC) Outreach Demonstration Guide



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Outreach Demonstration Guide

This guide consists of a variety of demonstrations that the SENIC Education Office at Georgia Institute of Technology uses with visiting groups. Some of the materials were developed under the National Nanotechnology Infrastructure Network (NNIN;www.nnin.org)), some come from other nano-education groups, and others from SENIC. We site the source for these additional materials and provide information on how we **adapt** the lesson for use as a **demo** with a group. The activities can be used with middle/high school students and the general public.

Typically we set up several stations (the number depends on how many people can work the stations) and have the groups (~10 people to a group) cycle through the stations about every ten minutes. Each table has an acrylic stand indicating the name of the demonstration and its description. These are included for each demonstration. Alternatively, we use these demos as a "show" and ask for volunteers to assist in the presentation. This works well with large groups of visitors. Individual tables work best as the participants can see the demo much better and the visitors can be engaged as active participants. These are not meant to be full lessons/activities. However, we do provide the links to access the full activities should you wish to explore these.

Below is an **example** of a schedule used with a school group of 40-50 students:

Time	**Red Team**	**Blue Team**	**Green Team**	**Purple Team**
9:30-10:00	Intro to Nano Presentation	Intro to Nano Presentation	Intro to Nano Presentation	Intro to Nano Presentation
10:00-10:40	Forces at the Nanoscale	Ferrofluids and Magnetism	Exploring Self-assembly	Shape Memory Alloys - Nitinol
	Ferrofluids & Magnetism	Exploring Self-assembly	Sahpe Memory Alloys - Nitinol	Forces at the Nanoscale
	Exploring Self-assembly	Shape Memory Alloys - Nitinol	Forces at the Nanoscale	Ferrofluids and Magnetism
	Shape Memory Alloys - Nitinol	Forces at the Nanoscale	Ferrofluids and Magnetism	Exploring Self-assembly
10:40-11:00	Cleanroom Tour/Snack	Snack/Cleanroom Tour	Hitachi TM3000 SEM	Hitachi TM3000 SEM
11:00-11:20	Hitachi TM3000 SEM	Hitachi TM3000 SEM	Cleanroom Tour/Snack	Snack/Cleanroom Tour
11:20-12:00	Surface Effects	Allotropes of Carbon	Liquid Crystals	Exploring Magic Sand
	Allotropes of Carbon	Liquid Crystals	Exploring Magic Sand	Surface Effects
	Liquid Crystals	Exploring Magic Sand	Surface Effects	Allotropes of Carbon
	Exploring Magic Sand	Surface Effects	Allotropes of Carbon	Liquid Crystals
12:00	Depart/Surveys	Depart/Surveys	Depart/Surveys	Depart/Surveys

List of Demonstrations

This Outreach Guide represents a compilation of various resources available on the Internet. We are providing this resource to assist those who wish to have a set of demonstrations that work well with groups. We refer you to the individual web sites to obtain more detailed information or the full lesson from a particular nanoeducation program from which we have developed our demonstrations.

We hope you find this guide useful in your efforts to educate individuals about nanotechnology. These demonstrations are only a few that are available from our colleagues in nanoeducation but are ones that we have found engage groups of students and adults.

Note about safety: These demonstration are designed to be done with adult supervision. Younger children should not do these at home or without adult guidance.

1. Exploring Hydrophobic Properties - Magic Sand

The NNIN lesson *Exploring Magic Sand* will give you the background information for the full lesson (http://www.nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/exploring-properties-magic-sand). It also has resources to buy the materials but you can Google "magic sand" and find other sources plus several YouTube videos.

Materials:

1. container of magic sand (small vials or bottles) plus a larger container with magic sand (we use the one pound container it is shipped in)
2. container of regular sand (small vials or bottles) plus a larger container of regular sand
3. plastic spoons to make sand demos (see picture above)
4. rubber cement or spray mount
5. small petri dishes or small clear cups (2-3 depending on demo used) each half filled with water
6. water in squirt bottle or use beaker/cup with water and eye dropper/pipet
7. funnel and fast flow filter paper (or coffee filters)
8. beaker/cup to catch liquid from funnel
9. clear beaker or cup
10. water
11. untreated plastic spoon
12. small dropper bottle of surfactant (if doing this part of demo) – dish soap or vegetable oil (you may add food color to this so it is easier to see)
13. paper towels and/or sponge
14. plastic table cloth (optional)

15. hand held microscope (Amazon search ~$10) or USB digital scopes (Dino-Lite, ProScope, Motic EcoLine, etc)

Advance Prep:
Prepare demo pieces in advance of event:

1. Spread out a sheet of paper or a tray to work over.
2. Coat spoon with rubber cements or spray with adhesive and sprinkle with sand. Shake off excess. Best method is to place "glued" spoon directly into a container of sand (we use a plastic cup with sand). Unused sand may be returned to the container.
3. Make regular sand and magic sand spoons.
4. Pour water into two petri dishes or shallow bowls.

To do a demo:
Part 1: Ask what does hydrophobic and hydrophilic mean. Ask what will happen when sand is poured into a Petri dish with water. Ask for volunteers to sprinkle sand in one of the Petri dishes of water. Ask another volunteer to sprinkle magic sand in the other Petri dish with water. Explain what is occurring and why this is nano (see lesson). You can also demonstrate what happens when there is a surfactant by adding drops of vegetable oil into a Petri dish and sprinkle with magic sand.

Part 2: Distribute the two types of spoons and ask students/visitors to place drops of water on them using squirt bottle or dropper. Have extra spoons as we use several for each group and they also get "damp" and need to dry out if used for a long period of time. You may also use the handheld scope to look at the two sands to see if differences can be observed. The magic sand is typically more rounded, less angular to allow for the monolayer to adhere.

Part 3: Have a clear container filled halfway with water. Pour a larger amount of magic sand into the container. Hand container to students and let them "play" with the magic sand by stirring it or lifting the sand up with the untreated plastic spoon above the water's surface (it will be dry). When all have seen this demo, pour water and sand into filter paper and show how the sand is dry. You will need to discard the Petri dish with the magic sand and surfactant. You can reuse the magic sand from the other Petri dish by filtering it. We usually discard the contents of the dish of water with regular sand.

There is a good YouTube video demonstrating the properties of magic sand.
http://www.youtube.com/watch?v=-1id-gHQjbs

A variation of the demo can be found on NISE Net
http://www.nisenet.org/catalog/programs/magic-sandnanosurfaces

To extend this activity you can demonstrate with hydrophobic leaves (Lotus Effect) such as elephant ears, lotus plants, nasturtium, collards, cabbage, or mustard greens. If you use any of the greens **do not** use the prewashed packets only the non-washed whole-leaf varieties. There are good YouTube videos of the Lotus Effect. http://www.youtube.com/watch?v=LJtQ6dvcbOg and http://www.youtube.com/watch?v=MFHcSrNRU5E

To show how nature's hydrophobic properties are duplicated in consumer products use NanoTex™ fabric (samples available from the company; http://www.nanotex.com/index.html) or nanopants (Target Cherokee Stain Resistant); stain resistant shirts (Dockers); stain resistant scrubs (Meridys.com). Use water to demonstrate the hydrophobic properties of the material. Sto Corporation makes Lotusan™ a building wall covering but it takes 30 days to cure the materials so it may not be worthwhile to make your own demo pieces. However, they have a nice video showing the effect http://www.stocorp.com/allweb.nsf/lotusanpage. Other hydrophobic products are Rustoleum's NeverWet - https://www.youtube.com/watch?v=hoKXTlqmUb8 and NanoWater Guard -- https://www.youtube.com/watch?v=z4EFycryEU4. We coat petri dishes with NeverWet with a section masked to remain untreated and have visitors place water in the dishes to see the difference between the treated and untreated surface.

2. Shape Memory Alloys - Nitinol

The NNIN lesson *Shape Memory Alloys – Smart Materials* provides the background information for the full lesson (http://nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/smart-materials-shape-memory). It also has resources to buy the materials but you can Google nitinol or shape memory alloys to find additional sources. There is also a handout on SMAs developed by our colleagues at Howard University that can be given to the students (http://www.nnin.org/sites/default/files/files/SMA%20brochure.pdf).

Materials:

1. pieces of Nitinol wire (~ 3 inches in length; 5-10 pieces)
2. piece of copper and/or aluminum wire (~ 3 inches in length)
3. source of heat:
    a. hotplate
    b. small lighter
    c. heat gun/hair dryer
4. tweezers or forceps (clamping; long handled)
5. If using the hotplate version, set a glass bowl with flat bottom and fill 2/3rds with water – heat to nearly boiling. We keep the bowl of water on the hotplate to maintain the water's temperature above the transition temperature of our nitinol (~50°C). We find it is also good to have either a carafe or another hotplate heating water for additions to the bowl as the water evaporates over time. Alternatively an electric kettle (such as Target's "Chef Choice Cordless Electric Kettle") can be used to have a steady source of hot water.
6. Safety glasses (recommended)
7. Hot pad

To do the demo:

SAFETY: We caution students that there is hot water on the table and a hotplate and not to touch either. We do not to use open flames unless we are in a lab setting.

First, have volunteers twist and drop copper and aluminum wires into the hot water. Ask what happened – nothing occurs. Remove wires from water using forceps. Next have them twist a piece of nitinol wire (do not let them tie into a knot) and have them to drop the nitinol in the hot water. Remove wires each time using forceps. The nitinol cools instantly so can be re-used. Once the excitement has “worn off”, explain about the solid state phase transition.

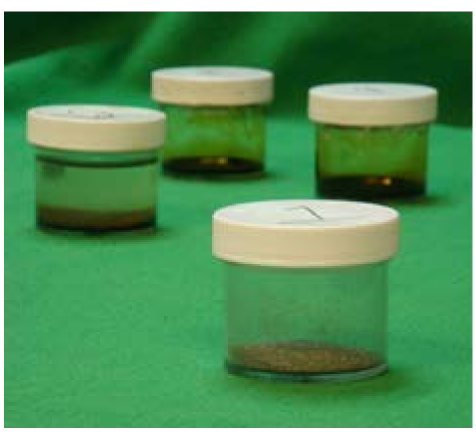
Discuss applications of the material (braces, cell phone antenna, eyeglasses, robotic arms, aortic stents, etc). There are numerous articles on the Internet regarding nitinol applications as well as YouTube videos. We emphasize that they are observing the realignment of atoms (Ni and Ti) at the nanoscale which has a macroscale level effect (i.e., the wire goes back to its original shape once it attains its transition temperature).

This can also be done using disposable lighters or heat gun as the heat source and long tweezers but non-lab facilities do not allow open flames and with school groups it can be **very** problematic. There are no such concerns with a heat gun or hair dryer but the reaction is less “dramatic” than the hot water method. Use forceps to hold the bent wire while you apply heat.

Caution: We suggest safety glasses be worn by students at the demo table. Students are very “creative” and can manipulate the wire so that it shoots out of the water thus making it a projectile.

3. Ferrofluid – Nanotechnology and Magnetism

The NNIN lesson *What does Nanotechnology have to do with Magnetism?- A Ferrofluid Activity* provides the background information for the full lesson. It can be found at http://nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/magnetism-and-nanotechnology. It provides resources for buying ferrofluid or Google ferrofluid to locate sources to purchase. You may make your own as several methods are available on the Internet. Several questions are suggested below and your choices will depend on the age of your audience.



Materials:

Prepare ahead of time:

1. closed container of iron filings; label #1
2. closed container of iron filings and water; label #2
3. closed container of ferrofluid; label #3
4. closed container of ferrofluid and a penny; label #4
5. several pairs of latex/nitrile gloves
6. several small magnets (we use neodymium)
7. PTFE thread sealant tape to help seal containers and prevent leakage

To do the demo:

Part 1:

Begin demo by asking what they think is in container #1. Follow-up questions may include: Why do you think that? Do you think this substance is a solid or a liquid? How do you know? What makes a solid a solid? What makes a solid a solid at the atomic level? *Before you leave this part of the demo explain that the container contains iron filings* and ask if they think the iron filings are magnetic.

Next have students/visitors place a magnet on top of container #1, turn container over, and then set the container in the upright position. Ask what happens to the iron filings. Follow-up questions may include: Why are the iron filings attracted to the magnet? Are the iron filings a permanent magnet? How do they know? What do we call something that is magnetic only when it is in the magnetic field of another magnet?

Discuss the movement of electrons in a non-magnetic substance and how the movement is aligned in a domain of a magnetic substance.

Part 2:

Now look at container #2. Ask what is in the container? Ask if they think a liquid can be a magnet? Follow-up questions may include: What makes a liquid a liquid? What makes a liquid a liquid at the atomic level? What do you think will happen if you put the magnet on top of the container and flip it over like you did with container #1?

Tell them to put magnet on top of the container, flip it over and then set it upright like they did for container #1. Ask them what happened. Why do you think that the iron filings stayed at the top and not the water?

Ask them to think about how atoms behave differently in liquids and solids.

Part 3:

CAUTION!!! <u>DO NOT tilt or turnover container #3 as the ferrofluid will stain the wall and make it difficult to see.</u>

We recommend wearing gloves when handling containers of ferrofluid.

Have students/visitors look at container #3. Ask what they think is in the container?

Tell them that the container contains ferrofluid which is a colloidal mixture of nanosized particles of a paramagnetic material. Tell them that this means that there are solid particles suspended in a liquid. (The supplier of our ferrofluid states that the particles are around 10 nm.) You may want to ask some of the following questions: What is a colloid? If the container has a solid and a liquid in it like container #2, why doesn't the solid in #3 settle to the bottom of the container like in #2? *Discuss with students that at the nanoscale electrostatic forces are greater than gravity. So the particles' attraction for each other is greater than the pull of gravity that would pull them down.*

Have them place the magnet ***under*** container #3 and move it around. Ask them what is happening? Follow up questions may include: Why is the liquid and the solids following the magnet? Why are spikes forming where the magnet is at?
Note that the electrostatic attraction of the particles is so great that the paramagnetic particles are attracted to the magnet and the liquid particles are attracted to the paramagnetic particles so they move with the magnet also.

Part 4:
CAUTION: DO NOT tilt or turnover container #4 as the ferrofluid will stain the wall and make it difficult to see.
Ask students/visitors to define density. Ask what determines when something floats? *Tell them that a unique feature of ferrofluid is that when it is in the magnetic field of another magnet its density changes.*
Ask them to look at container #4. Ask if they can see the penny that is in the container? *Explain that the penny is on the bottom of the container because its density is greater than the ferrofluid. Remind them that if materials are able to move they will layer themselves with the most dense at the bottom and the least dense at the top.*
Have them put the magnet ***under*** the container and move it around. Ask what is happening and why. *They should see that the penny is now trying to get on top of the ferrofluid because the penny is now less dense than the ferrofluid.*

As a wrap up to the demo, we provide ferrofluid display cells available online from a variety of vendors (Educational Innovations, Flinn Scientific, Arbor Scientific, among others) and a magnet with each. While these are in use, we discuss applications of ferrofluid such as in audio speakers, shock absorbers, medical applications, etc.

4. Size and Scale – Size sorting activity

Materials:

1. printed set of images (two sources below)
2. printed set of number scale images (two sources below)
3. string (optional)
4. clips to secure images to string (optional)

To do the demo:
We use one of two activities to demonstrate size and scale. The first is the *Size and Scale* unit on the NNIN education portal http://nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/size-and-scale. To do this activity, print pictures, and have students either

attach them in order on a string attached between two surfaces or have them sort images on tables/desks/floor. It is best to laminate these for future use.

The alternative activity is from *NanoSense Size Matter Lesson 2: Size and Scale – The Number Line activity* - http://nanosense.sri.com/activities/sizematters/sizeandscale/SM_Lesson2Teacher.pdf (answers) and http://nanosense.sri.com/activities/sizematters/sizeandscale/SM_Lesson2Student.pdf (images). It is a similar activity with pictures to be sorted. These can be printed as small pictures and laminated so that they can be used at a desk.

Begin the activity by defining what is a nanometer. Using some of the available analogies helps with demonstrating the "smallness" of a nanometer. For example, a nanometer is like a marble compared to the size of the earth, it takes 24 years for a one nanometer tall person to walk across a dollar bill, fingernails grow a nanometer each second, or the number of years (21.1) it would take to count the number of nanometers (counting 2 nanometers per second) of a 2 meter (6"6") tall person.

Have students/visitors sort the cards along the size continuum from largest to smallest or vice versa. This activity is best done with students/visitors working in groups so they can discuss where the images fit along the number line. Discuss with students the metric system of measurement and the powers of 10 (logarithmic scale). Ask what the largest object that they can think of is and the smallest one. This helps with the discussion of placing objects on a log scale rather than a linear scale. Once the cards have been sorted, have a group discussion about the placement and make any corrections necessary. Answers are provided in each lesson.

5. Nanoproducts – Exploring consumer products

This demo is based on the NNIN lesson "Exploring Nanotechnology through Consumer Products." (http://www.nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/exploring-nanotechnology).

Materials:

1. 5 or more nanoproducts in zipper envelopes or storage bags
2. product description sheets (printed and laminated)
3. water in squirt bottle or dropper bottle
4. hand held scope (assorted available online; or digital USB scopes such as ProScope, DinoLite, Motic EcoLite)

To do the demo:

Each bag contains a nanoproduct and a laminated product description sheet.
In the nanoproducts demo, we select a few of the nanoproducts from the NNIN lesson and display them on a table. We then talk about each product. Explain what is nano about each product (see product sheets from the lesson) and that these are now available in stores. Nano pants (now at Target in Cherokee brand stain resistant plus other sources such as Eddie Bauer) and socks are the most favorite because the participants can actually see the water rolling off the pants (use squirt bottle with water) and the silvery fibers (emphasize not seeing nanoparticles) in the socks (with a handheld scope like the one available from RadioShack). Alternatively, have students/visitors choose a product from the selection, read the information sheet, and then present to the group.

Ask for other uses they might think of for the nanotechnology used in the product or potential problems the technology may pose for society. You might ask how they would test the claims of the products (a possible science/class project). Explain that there are over 1,600 products on the market that use nanotechnology. In addition, direct them to the Project on Emerging Technologies nanoproducts inventory to explore additional consumer products. (http://www.nanotechproject.org/inventories/consumer/)

6. Liquid Crystals - A liquid and a solid crystal?

This demo is based on materials from NISE Net, the University of Wisconsin MRSEC, and a lesson from Optics Excellence.org.
http://www.nisenet.org/catalog/programs/exploring-liquid-crystals
http://education.mrsec.wisc.edu/228.htm
http://www.opticsexcellence.org/SJ_TeamSite/pdfs/lcmoodpatch_lesplan_v3.pdf

Materials:

1. Examples of items that use liquid crystals (LC) such as a watch, calculator, laptop computer, cell phone etc.
2. Liquid crystal sheets with different temperature ranges such as 20 to 25 ^{0}C, 25 to 30 ^{0}C, 30 to 35 ^{0}C. (These can be purchased from Edmund Scientific and Educational Innovations.)
3. Beaker of ice
4. Hot plate with beaker of warm water

The optional activity below will require some additional materials depending on which version you choose to use.

To do the demo:
Begin the demo by showing students/visitors everyday objects that use liquid crystals and ask if they can describe how the display screens work. Next ask for a volunteer to place their hand on the top of the table. If their hand is not warm have them rub their hands together, As you wait about 30 seconds, discuss how liquid crystals work. After the hand is removed from the table, lay a liquid crystal sheet on the table where the hand was. They can see the outline of the volunteer's hand indicating that heat from their hand was transferred to the table. Then take a liquid crystal sheet and place along the top edge of a heated beaker of water. As students watch the liquid crystal sheet, the color will change as the heat moves out from where the sheet touches the beaker. On one edge of the sheet that was on the hot beaker next place a piece of ice to show that the sheet will change color as the sheet cools down. Repeat this demo with sheets having different temperature ranges.

If you have access to the Internet, the Nobel Prize site has a liquid crystal video game that the students can play: http://nobelprize.org/educational_games/physics/liquid_crystals/.

Optional Activity: Students can also produce their own liquid crystal sensor. However, for demos, this can be time consuming and not fit into a rotating demo schedule. We typically rotate our demo groups on a 10 minute schedule. There is also a safety concern with the chemical when working with a large group of students. We recommend that this be done in a lab setting. To have them make their own sensor we refer you to the following links:
http://education.mrsec.wisc.edu/228.htm and
http://www.opticsexcellence.org/SJ_TeamSite/pdfs/lcmoodpatch_lesplan_v3.pdf

7. Bunny Suit Contest – Who is the fastest?

Materials:

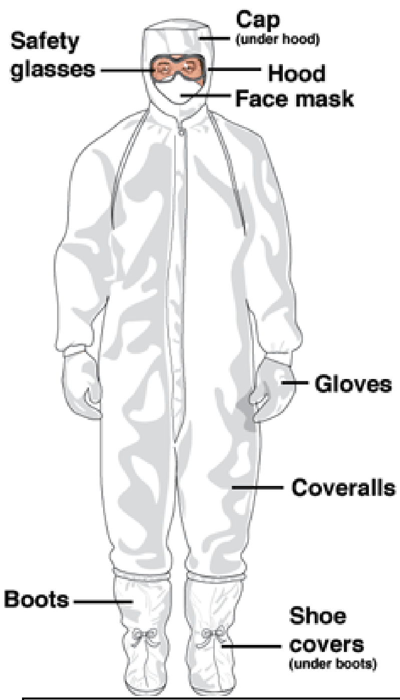
1. Computer with internet access or a CD/DVD/USB drive showing gowning procedure
2. "Used" bunny suits (small through extra large)
3. Gloves, masks, shoe covers, boots, hoods, safety goggles
4. Timers/stopwatch – most smart phones have this option

To do the demo:
This is a good activity for an open house or if you need to burn some energy off of the visiting group. We have **used** cleanroom suits (the ones ready to be discarded) in assorted sizes including hood, boots, and gloves.

Show the group Georgia Tech's Institute for Electronics and Nanotechnology gowning video which is on its YouTube channel at: http://www.youtube.com/watch?v=qRGcdjxMHd0 Alternatively demonstrate the donning procedure yourself to the group. Next ask for either volunteers to race against each other (one on one) or with large groups do relay races to see which group can finish first (such as girls versus boys; teachers versus students; parents versus children). You can award prizes for the fastest time, fastest group, etc. We have the order of the gowning procedure listed of a large piece of self-stick easel paper to help student remember the order.

The NNIN site at Stanford has used this activity at their community day and given the participants a nanotechnology certificate.



Permission to use image provided by Cole Palmer

Order of Gowning Procedure

1. Shoe Covers
2. Face Mask
3. Bouffant cap/hair net
4. Hood
5. Jumpsuit
    a. Hood tucked inside suit
6. Booties
    a. Suit legs inside boots
7. Gloves
    a. Pull over suit sleeves
8. Goggles

8. Forces at the Nanoscale – size matters

NiseNet NanoDays kit has a wonderful and simple activity to show the importance of intermolecular forces as objects move into smaller size scales. The demo comes from the book: Nanoscale Science: Activities for Grades 6-12 by Jones et al (2007), NSTA Press. The demo can be found at: http://www.nisenet.org/catalog/programs/exploring-forces.

Materials:

1. Regular size tea cup
2. Dollhouse size tea cup (with a string and fob so it does not get lost)
    a. Available at hobby stores or online at dollhouse supply companies
3. Container of water (large enough scoop water into large cup)
4. Paper towels/sponge
5. Plastic table cloth (optional)

*** We have recently found that some of the ceramic dollhouse cups appear to be coated with a material that allows the water to pour out. We recommend that you buy the plastic version of dollhouse cups which appear to work fine.***

To do the demo:

The demo shows how you can easily pour water out of a regular size cup while not from a dollhouse size cup.

Have the students/visitors dip the regular size cup in water and pour out the contents back into the container. Next ask them to do the same with the dollhouse size cup. Often they will tap the bottom of the smaller cup with their hand to get the water to return to the container of water but you must explain that they are using a force they did not use with the regular cup.

Explain that different forces are operating on the water depending on the size of the cup. In the regular size cup gravity is the dominant force on the water. With the smaller cup it is surface tension which plays a more important role than gravity.
When you tip the regular cup, the force of gravity pulls the water out of the cup. But with a small amount of water, surface tension can counteract gravity. So when you tip the miniature cup, gravity isn't strong enough to overcome the natural tendency of water molecules to stick together, and the water stays in the cup. We discuss how water is "slippery" at the macroscale (think of slippery pavement/grass during rain) and "sticky" at the nanoscale.

A variation of this is using granulated sugar and powdered sugar. Have equal amounts of the two sugars in separate clear cups. Have students pour out granulated sugar and powdered sugar to show how the electrostatic forces on small particles are greater than the pull of gravity. The granulated sugar pours out but a lot of powdered sugar sticks to the sides of the cup.

9. Forces – Exploring self-assembly

To demonstrate self-assembly, we use a part of a lesson from UCLA's California NanoSystems Institute's Science Outreach Program. We use the floater demo as a great way to teach about atomic forces and the arrangement of atoms. Here are hints we have learned about assembling the demo. The first website is for a list of all of their units while the second link takes you directly to the self-assembly lesson:
http://cnsi.ctrl.ucla.edu/nanoscience/pages/
http://cnsi.ctrl.ucla.edu/nanoscience/pages/selfAssembly
UCLA has restricted access to these materials and you will need to contact them to get the full lesson.


Materials

1. One square metal or glass bake pan and one round one
    a. We use the aluminum "disposable" ones that come in multi-packs. **Warning** - they do not ship well as they develop cracks and thus leak.
2. Foam circles and foam squares (3/4 inch on a side or diameter). Number depends on pan size but for an 8-9 inch you will need about 20-24.
    a. We have a die cut machine to cut the shapes but you can hand cut them. Use the foam sheets available at craft stores such as Michael's or online at such sites as Discount School Supply. This is not Styrofoam but the thin foam (around 2mm thick) used by crafters. If you use the sheets that are the same color on each side, you will need to either mark your stirrer containing the magnet so the same pole is facing up when floaters are in the water; glue two different colored foam shapes together so you can determine that one color will be the same pole; or mark the foam pieces to denote the same pole direction. Alternately, you may use white sheets and spray paint one side a color and use either one as your choice for the same magnetic pole.
3. Drink stirrers, round with a diameter of ~ ¼"
4. Awl or other sharp object to punch hole in center of foam pieces.
5. Magnets ¼" x ½" – We order ours from Forcefield magnets (http://www.forcefieldmagnets.com/catalog/) and use the neodymium-iron-boron magnet model #0016.
6. Nail polish or permanent marker (to mark pole direction if needed)

To make the floaters:

Make a small hole in the center of each foam circle and square with an awl or other sharp object. Cut a ¾" piece of stirrer and insert the magnet into one end. Then insert the straw into the foam piece such that the same magnetic pole is associated with the same color of the foam piece. One way to make sure you have the same pole associated with the same color of foam is to have a container of water. Fix one floater and place it in the container. Then test every floater you fix by placing in the container of water. The two floaters should repel each other if you have the magnets placed correctly. If they do not repel take the magnet out of the new piece and flip over. If the foam piece is the same color on each side then mark one end of the stirrer with a magic marker or nail polish to note pole direction (i.e, the marked end will be the same magnetic pole). These magnets are powerful. We recommend that you store these pieces in craft containers that have separate compartments. Otherwise, they will stick together and pull magnets out of the stirrers.

To do the demo:
Start by asking the students/visitors if they can think of anything that self assembles? A great example is the student/visitor – started from two cells to become a complex organism. DNA is another excellent example. The discussion should include atomic interactions. This activity is very good to help students visualize how repulsive and attractive interactions cause atoms to order themselves.

Once you have your foam shapes assembled, add water to the pans and have the participants slowly place the pieces into the pans – round in the round pan and squares in the square pan. They must place them with the same magnetic dipole facing up (one color side up or marked stirrer end). Discuss the shapes that form (see UCLA lesson which also has some great photos). Ask if there is a difference between the round and square pans. Then have the participants turn over a foam piece and see what happens – chemical bonding and self-assembly!

10. Encapsulation - A New Way for Drug Delivery

This demo introduces encapsulation (the trapping of substances inside a rigid structure) and what happens to the substances trapped inside when the environment around the capsule changes. This activity has a great connection to the science curriculum (such as how cell membranes work, diffusion, osmosis, tests for the presence of starch or acids), and current research (targeted drug delivery and detection). There are two different versions that we have used: "Self-Assembly" from DragonflyTV Nano Educator's Guide pages 50-51
http://www.pbskidsgo.org/dragonflytv or
"Connecting Acids and Bases with Encapsulation.....and Chemistry and Nanotechnology" from the Journal of Chemical Education, V84 N7 p1136-1139 Jul 2007. If you not a member of ACS, see if your library can access the journal to download the materials.

Materials: The solutions make enough for you to have several reaction plates going at the same time. Materials needed will depend on which version you use. Either version of this activity will explain how to put together the mixtures that you will need for the demo. We use food grade of the sodium alginate and calcium chloride. To make solutions see one of the versions below.

Dragonfly Version Materials:

1. Sodium alginate (purchased from willpowder.net)
2. Calcium chloride (purchased from willpowder.net)
3. 2 bowls
4. Food coloring (optional)
5. Small strainer
6. Measuring cups and spoons
7. Room temp water
8. Small disposable pipettes or eye droppers (1 per demo)
9. Blender (a blender is not needed if hot water is used and the alginate is added little by little and mixed into the water with a wire whisk or spoon to prevent clumping)
10. 2 small cups per demo (optional)
11. Flavored syrups such as chocolate and strawberry

JCE Version Materials:

1. Sodium alginate (purchased from willpowder.net)
2. Calcium chloride (purchased from willpowder.net)
3. Liquid laundry starch (purchased from grocery store)
4. Bottle of tincture of iodine (purchased at grocery or drug store)
5. Food coloring
6. Water
7. Small disposable pipettes
8. 6 well reaction plate
9. Small plastic spoons or tweezers
10. 5 small cups or beakers

You can also do this activity with Gaviscon which is a commercial antacid that contains sodium alginate as a thickening agent.

To do the demo:

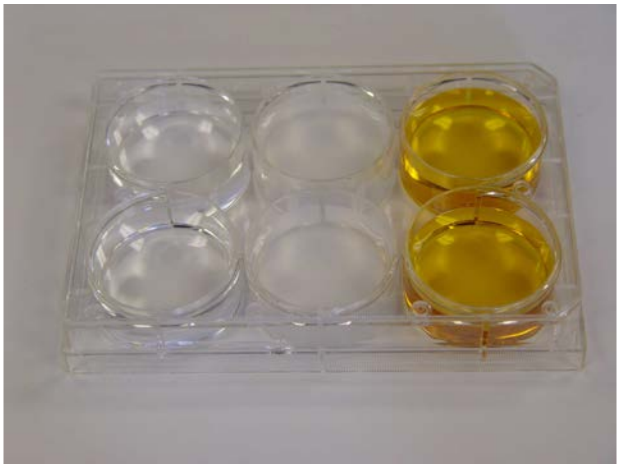
Part 1:

We begin the demo by discussing how biomedical research is looking for ways to deliver drugs more effectively and how they are looking at nano structures as possible solutions. We ask what type of problems researchers may be running into. *Hopefully in the answers someone will suggest that they will have to figure out how to get the medicine into these structures and then how to get it delivered to the target.*

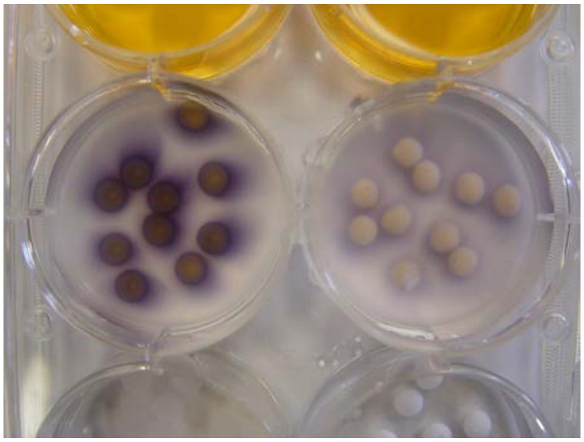
Part 2:

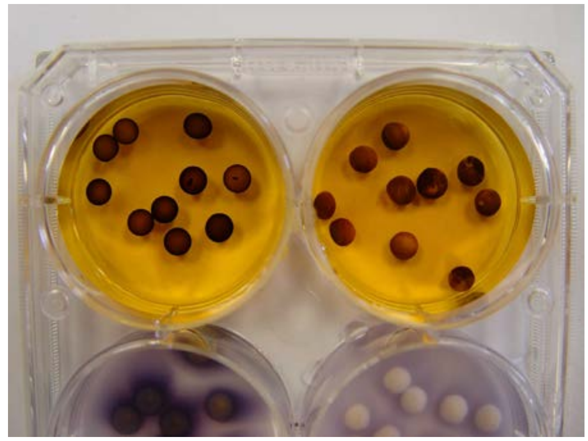
You may do this or ask for volunteers to do the steps under your guidance. This is the demo we do based on the JCE article. To do a demo from Dragonfly TV Nano series use their step by step instructions to make edible encapsulations.

1. To begin the demo, place calcium chloride solution into the upper and lower left wells of the reaction plate. Next place starch solution in the middle wells (top and bottom) and then iodine solution into the top and bottom wells on the right.



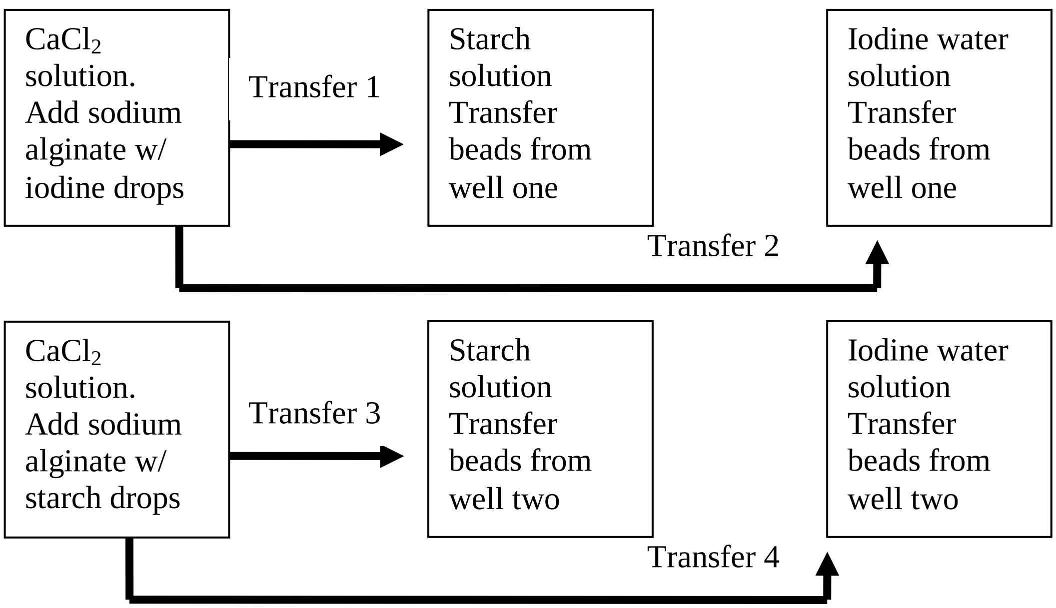
2. Draw some of the sodium alginate with **iodine** mixture into a pipette. Holding the pipette a few centimeters above the surface of the upper well with $CaCl_2$ solution begin releasing drops of the alginate-iodine mixture into it. Allow sufficient time for the spheres to develop.
3. Using forceps, take half of the spheres that are created in upper well one ($CaCl_2$ w/ sodium alginate with iodine) and place in the starch solution well (upper middle). Put the other half in the iodine solution (upper right well).
4. Draw some of the sodium alginate with **starch** mixture into a pipette. Holding the pipette a few centimeters above the surface of the lower $CaCl_2$ well begin releasing drops of the alginate-starch mixture into it. Allow sufficient time for the spheres to develop.
5. Using forceps, take half of the spheres that are created in lower well two ($CaCl_2$ w/ sodium alginate with starch) and place in the starch solution well (lower middle). Add other half of spheres to lower right well – iodine water solution.
6. Have students look at the changes that occur in the spheres that were placed in the starch water and the iodine water. *The spheres that are in the upper middle well (sodium alginate iodine) should show that the starch water is getting blue or black because the iodine can travel through the outer covering of the sphere. The spheres ($CaCl_2$/starch)that are in the iodine water should show that the spheres (lower right) are turning blue or black because the starch molecules are too big to travel through the sphere outer covering but the iodine molecules are small enough to travel into the spheres through the covering.*





Explain to students that observing the combinations as they appear will provide insights into the molecular processes (nanoscale) that go on inside and outside of the macrospheres. This will introduce them to an important biological phenomenon that occurs in cells and will be the first step towards understanding how encapsulation can be used in the battle against a disease like cancer.

Below is a chart to show the six different wells and the transfer steps of the spheres:



11. Edible Chips – How chips are made

This is an activity that we use with younger students especially when the visit for several hours and they have taken a tour of the cleanroom. The edible chips also provide a nice snack for the students.

Materials:

1. Cookie (large sugar cookie or ½ of a graham cracker); one per student
2. Small paper or foam plates that have had a simple design cut in the middle (several of each design; at least three designs; pictures of plates we use follow). These are the masks and each one should be marked with an arrow to align the masks in your desired pattern. Label each #1-3.
3. Frosting (any flavor, homemade or purchased)
4. Flavored milk powder (we use Nestle Nesquik® chocolate and strawberry) and or sprinkles.
5. Container of colored sugar (the type you buy in cake decorating section of the grocery)
6. Small paper or foam plates (one for each student)
7. Plastic knives and spoons (several depending on the size of the group)
8. Paper towels/sponge
9. Markers
10. Plastic table covering
11. Examples of processed silicon wafers with chips and electronic devices showing chips/integrated circuits (optional)
12. Plastic or paper bags to put finished “wafers” in (optional)

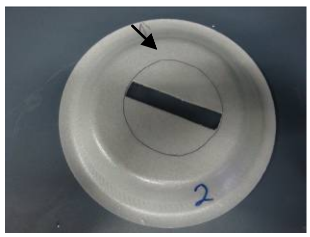
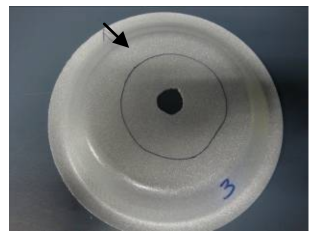
To do the demo:

Begin the activity by showing students a completed silicon wafer. There are several good YouTube videos on how chips/integrated circuits are made that can be shown to students. Examples are: https://www.youtube.com/watch?v=aWVywhzuHnQ; https://www.youtube.com/watch?v=-GQmtITMdas; https://www.youtube.com/watch?v=F2KcZGwntgg among many others.

We often explain how the wafers become important parts of electronics. Next pass out paper plates and cookies. Each plate should be marked with an X or an arrow along the edge to line up with the masks which also have an X or an arrow.

Explain that the cookie will be their silicon wafer. Next explain that they will put down a thin film layer. Instruct them to spread a thin layer of frosting over their cookie. They will then place over their cookie the first mask (this is the plate that has a #1). The plate will be up-side down over the cookie and they will line up the X or arrow of the mask with the corresponding X or arrow of their plate. Using a spoon they will sprinkle a small amount of strawberry Nesquik® powder (photoresist) over the opening. They will then take off plate #1 and put plate #2 over their cookie making sure that their arrows line up. They will sprinkle chocolate Nesquik® powder (second photoresist) or sprinkles over their cookie. They will take off plate #2 and place over cookie plate #3 lining up arrows. They will then sprinkle over their cookie colored sugar. When they remove this plate they should have a completed pattern on their cookie.

This demo is a good way to show students that patterns on wafers are often developed as a series of adding and removing materials on the wafer.

12. Surface Effects – Surface area and reaction rates

We use either of two different demos which are very similar – one from *NanoSense's Size Matters* (http://nanosense.sri.com/activities/sizematters/properties/SM_Lesson3Teacher.pdf) or one from NISE Net (http://www.nisenet.org/catalog/programs/exploring-reactions).

Materials: (NanoSense)

1. water
2. Alka Seltzer® tablets
3. mortar and pestle (or spoon to grind tablet on a piece of paper)
4. empty film canisters (Educational Innovations or your local film processing center for free ones)
5. safety glasses
6. plastic table cloth
7. paper towels and/or sponge
8. timers

Materials (NISE Net)

1. water
2. Alka Seltzer® tablets
3. small paper or plastic cups
4. (2) 100 ml graduated cylinders
5. food color
6. plastic table cloth
7. paper towels and/or sponge

To do the demo:
Follow the directions found in NanoSense's Lesson 2 *Unique Properties at the Nanoscale Lab E More Surface Effects – Faster Explosions?* or NISE Net's *Exploring Properties – Surface Area.*

The NanoSense lesson has the students/visitors break the tablets in half and finely grind one half in the mortar. Place the half piece in one canister and the ground material in another. Then quickly fill the canisters about ½ with water (DO NOT FILL COMPLETELY) and immediately place the caps on the canisters. Place the canister lid side down and stand back. Too much water and there is very little explosion. Have the students time the two reactions. You may direct the groups to plot the data for the two reactions for everyone to see and to use in the follow-up discussion.

NISE Net's activity has the students measure out 50 ml of died water into two separate cups. They are given two tablets one of which is dropped whole into a graduated cylinder (dry one) and the other tablet is broken up into many small pieces and dropped into another graduated cylinder. Next they are told to simultaneously pour the water into the two cylinders and observe the reactions.

We often allow the students to repeat the reactions so plan on having extra sets of materials on hand. You will also need a place to deposit the materials from the reactions and from cleaning out the canisters or cylinders.

Once the reactions are completed, ask students why one reaction was quicker than the other. NanoSense has a nice figure showing that as surface area to volume increases there is a greater amount of the material in contact with its surrounding material i.e., more atoms are on the surface with which to react.

13. Allotropes of Carbon – What are they?

The activities are based partly on ones from the University of Wisconsin's MRSEC http://education.mrsec.wisc.edu/143.htm; http://education.mrsec.wisc.edu/64.htm; http://education.mrsec.wisc.edu/69.htm and from NISENet - http://www.nisenet.org/catalog/programs/forms_carbon

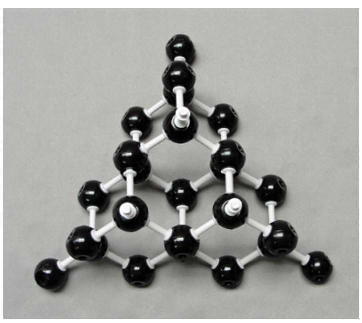



Image Credit: MolecularModelsCompany.com

Materials:

1. models of diamond and graphite
2. models of buckyball and carbon nanotube(s)
3. buckyball templates
4. scissors, tape
5. transparencies of CNTs
6. pencil
7. diamond-tip cutter
8. glass slide or piece of mirror

To do the demo:

Introduce the ideas of allotropes of carbon by showing the models of graphite and diamond. Have students/visitors explain how these are different. Next have them use a pencil to write on paper and a diamond tip cutter to write on a glass slide or piece of mirror. Discuss why these two forms of carbon behave differently and how these differences result from what occurs at the nanoscale (atomic bonding).

Next, discuss C60 and CNTs and how these forms of carbon are created at the nanoscale. Note that C60 looks like a soccer ball and is made up of hexagonal and pentagonal rings. CNTs are "rolled" sheets of carbon molecules but emphasize that they assemble this way at the atomic level and that we do not "roll" them to form the tubes.

Explain that just as with graphite and diamond, the molecular arrangement of C60 and CNTs leads to unique properties (what nanotechnology is all about). CNTs are supposed to be 100 times stronger than steel and 1/6th its weight. Note that CNTs have electrical conductivity, mechanical (tensile strength), and thermal conductivity properties. Discuss current and potential applications of CNTs and C60. Examples may include C60 drug delivery, tennis rackets, baseball bats, car frames, electronic devices, etc.

You can make models of the three types of CNTs using chicken wire. Use these to demonstrate the different forms - armchair, zigzag, and chiral. Alternatively, you can create the basic forms on transparency film and have students roll the forms. The University of Wisconsin MRSEC provides patterns (http://education.mrsec.wisc.edu/222.htm). Another activity is to provide printed templates of buckycalls and have students cut these out and tape together Templates are on the web at http://gemsclub.org/yahoo_site_admin/assets/docs/buckyball2.43131957.pdf
http://www-tc.pbs.org/wgbh/nova/education/activities/pdf/2216_buckybal.pdf
http://www.wonderville.ca/asset/buckyball-origami
And http://nisenet.org/catalog/programs/exploring_structures_-_buckyballs_nanodays_08_09_10
These can also be used as a take home from the event along with the word search and crossword puzzles developed by the University of Wisconsin MRSEC (http://education.mrsec.wisc.edu/documents/ NanoArchitechture.pdf
Vega Science Trust has directions for making buckyballs including one that is a map of the world - http://www.vega.org.uk/video/internal/18.

14. Tools of Nano – Using the right tool: AFM

This demo is designed to let students/visitors understand that nanotechnology requires special tools in order to "see" and manipulate at the nanoscale. The demo is based on materials from the University of Wisconsin MRSEC (Nanotechnology Mitten Challenge & Refrigerator Magnet Activity Guide) and NISE Net (Exploring Tools – SPM).
http://education.mrsec.wisc.edu/56.htm
http://education.mrsec.wisc.edu/57.htm
http://nisenet.org/catalog/programs/exploring_tools_-_special_microscopes_nanodays_08_09_10_11

Materials:

1. LEGO® or other similar building materials
2. Model of graphite and or diamond (numerous vendors sell these) or build LEGO® Molecular-Scale models found at: http://education.mrsec.wisc.edu/77.htm
3. Oven mitts (we use Mickey Mouse hand gloves from Disney)
4. Refrigerator magnets (with a piece of the short edge cut off to be used as a probe strip)
5. Image of how an AFM works
6. AFM images

To do the demo:
Part 1:
Ask the students/visitors what is the smallest thing they can think of. Ask what is the smallest thing they have seen with their eyes. Next, guide the conversation to atoms and molecules and show the molecular model(s). Ask if there are any LEGO building experts or any volunteers to build a model (you can have them duplicate the molecular models you have or show them the various models available at the University of Wisconsin MRSEC site noted above).

Once you have one or two volunteers tell them that the atoms (LEGOs®, etc,) are in the nano world and they (the volunteers) are not. Thus, to imagine what it would be like for us to build in the nanoworld they will need to build their models while wearing oven mitts. Provide them enough time to struggle with the building of the model. Then ask why is it so difficult to build the models? Can they provide examples of needing the right size of something to perform a task? Examples could include scissors to cut paper but not hedge trimmers; knife to butter toast but not a sword, a hammer to hit a nail but not a sledgehammer.

Part 2:
The next part of the demo will use the refrigerator magnets. Have the students/visitors separate the magnet from the probe strip and turn the magnet onto the black side. Have them move the strip lengthwise over the magnet and then widthwise. Ask if they felt a difference depending on which way they moved the probe strip across the larger magnetic surface. The students should feel a slight bumpiness with one of the directions. The NISE Net link has some nice graphics to show how the magnetic field is in bands and that what they are feeling is the probe being repelled and attracted across the bands. They can't see these forces but they can feel them. This is how the AFM works – feeling the forces of the surface it is scanning.

This part of the demo then leads into the use of scanning probe microscopes to "see" and manipulate the atomic world. Explain how an AFM scans the nanosurface with a fine tip, detects the forces at that level, and generates an image of the surface. Show the students a graphic of the basic components of the AFM and some AFM images.

There are two variations you can add to this demo. One variation is to have the students take a fingertip and run it down the length of their arm. Ask what occurred as the "tip" passed over shirt, skin, knuckles, jewelry. Did this provide an idea of the variations of the surface?

Additionally you could have the students view objects using a digital microscope hooked up to a laptop (ProScope, DinoLite, Motic EcoLine etc.). This would encourage discussion of needing a tool to see small things or details not possible with the unaided eye.

A good graphic comparison is to have remote sensing images of the seafloor (examples can be found at http://www.noaanews.noaa.gov/stories2007/images/maverick-waves.jpg; http://www.ceps.unh.edu/news/releases04/images/seamount.jpg) along with AFM images. Both images are representations of things we can't see – one on the macroscale and the other on the nanoscale.

15. Tools of Nano – Using the right tool: SEM

This activity is based in part on the NNIN lesson: Seeing Nano: Using Scanning Electron Microscopy (SEM) to view nano-size objects.
http://nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/seeing-nano-using-scaning

Materials:

1. Assorted objects that can be viewed with an SEM.
2. USB digital scopes such as Motic EcoLite, DinoLite, Proscope, among others
3. SEM images of objects printed

This activity has students/visitors try to match the SEM image of an object to the actual object. We use a variety of materials to scan which include insects, pollen, textiles, Styrofoam, paper, twine, snake skin, animal hair/fur, etc. We place the objects in containers such as petri dishes or other small containers. This allows them to pack well to travel to events.

The objects and their SEM images are placed on a table with the digital USB scopes and magnifier lens. Students/visitors use the scopes to examine the objects and try to match them to the SEM image. We tend to use a high enough magnification for the SEM images to capture detail not seen with the scopes or magnifiers. The name of the object and its magnification are written on the back of its image. We use the SEM information sheet to explain how an SEM works and why SEMs are important tools for nanotechnology researchers.

16. Creating Colors by Changing Scale – Thin films

Developed by Ethan Allen - Center for Nanotechnology, University of Washington

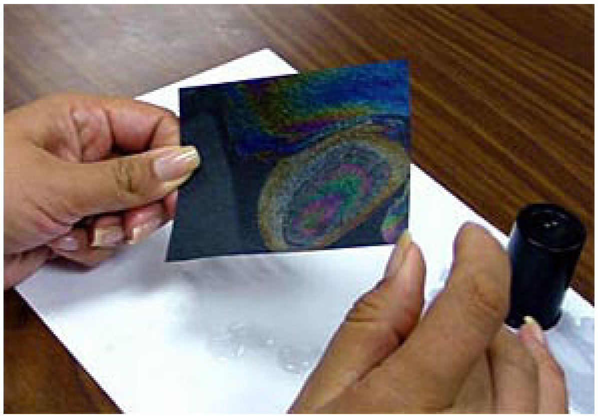
This is a demonstration about thin films.

Materials

1. Clear fingernail polish – any brand works fine.
2. Black Tyvek®, card stock, or construction paper, cut into ~4"squares. Construction paper is OK, but absorbs water, drips out black dye, and takes quite a while to dry. Using Tyvek, as it is non-absorbent, avoids these issues, enables much more rapid drying of the films, and thus permits much shorter turn-around times for processing this demonstration/interactive.
3. Shallow plate or dish, with enough water to cover or submerge one of the black squares (we use cake pans).
4. Paper towels to clean up excess water.
5. Forceps to remove paper (optional)
6. Printout of information folder (below) to place paper into (optional)

To do the demo:

1. Place a black square under water so that just its corners are exposed.
2. Pick up some clear nail polish from the bottle with the brush.
3. Drop ONE small bead of nail polish from the brush onto the water. (If needed, just touch the drop of polish to the surface of the water.)
   Watch the colors appear as the drop spreads out into a thin film!
4. Carefully lift the square to catch as much of the film as possible, draining off excess water. Do not let the film slide off the square.
5. Let the film and square dry.



What is going on?

How can we see really tiny structures without using a microscope?

Here we make a very thin film from a drop of clear fingernail polish. Flattening the droplet to a film of microscopic (a few thousand nanometers) thickness makes the material appear brightly colored.

Where else do we see colors that are based in the scale of the material?
The sheen you see in soap bubbles and the 'rainbow' effect in some oil slicks are examples of this same thin film phenomenon. Closely related are the iridescent colors that appear on CDs and DVDs, and in some bird feathers, butterfly wings, and some beetles. These result from the material having a regular, repeated structural unit that is about the same size as the wavelength of light – a few hundred nanometers.

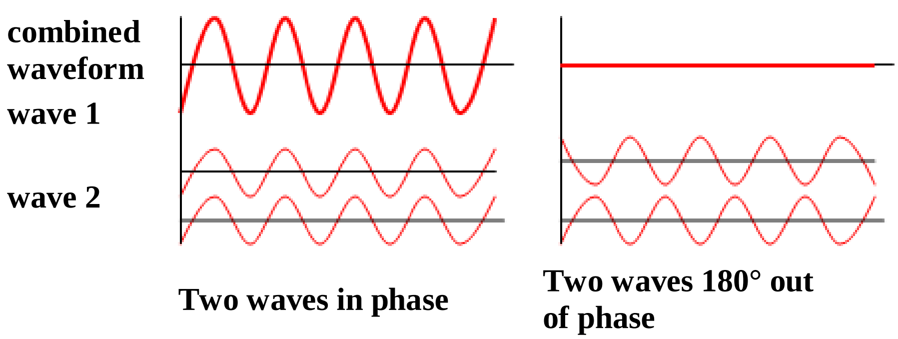
How does this work?
Why does the clear liquid become a colorful film?

As the small drop of liquid spreads out on the water, its thickness decreases to a few microns. (A micron is one thousandth of a millimeter.) The bright iridescent colors in the film result from the interference of light reflecting back from the top and bottom of this thin film.

Most light passes through the clear film. But some of the light from above reflects back up off of the smooth top surface of the film; and some of the light passes into the film and then reflects back up off of the bottom surface of the film.

This light reflecting back up from the bottom surface of the film then emerges from the top surface but, because it has traveled very slightly further than the light reflecting from the top surface, is now out of phase with the light reflecting off the top surface. The two sources – reflections from the top and bottom surfaces of the thin film – interfere with one another; sometimes they reinforce each other, producing bright colors, and sometimes they cancel each other out, producing no color (see the diagram below).

The varying thickness of the film at its edges produces these bands of changing colors called 'interference fringes.' Much of the center of the film is more or less of uniform thickness and thus will tend to be of a single color.



[diagram from Wikipedia - http://en.wikipedia.org/wiki/Interference_fringe - on 1/5/10]

Extension

Make several films and let them dry. Observe and compare them carefully to one another. What do you note about the progression of colored bands from the outermost edges toward the center? What does this indicate about the specific sequence of color bands that you see?

Some Other Questions:

1. What happens if you use colored nail polish?
2. What happens if the nail polish is thicker (more viscous) or thinner (more watery)?
3. What happens if you use a bigger or smaller drop of nail polish?
4. What happens if you put one thin film on top of another?
5. How could you find out how thick the film is?
6. How do the colored bands around the edge of the film correspond to film thickness?
7. What happens if you view the film under different colored lights?

We use the following to place the paper containing the thin film in and provide information to participants

Scientist/educator Ethan Allen developed this activity to help make nanoscale phenomena visible and accessible, with support from the:

University of Washington's Center for Nanotechnology,
National Nanotechnology Infrastructure Network,
and
Pacific Science Center

Funded by the National Science Foundation

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Changing Colors by Changing Scale

The colorful form enclosed is a single drop of clear fingernail polish. It was dripped onto water, where it spread out into a thin film, and was then lifted out on the square of black material.

This illustrates how properties of materials change with scale. The round droplet of clear nail polish has become a microscopically thin layer.

Light waves reflecting from the top and bottom surfaces of the thin, clear layer interfere with one another. This interference produces a somewhat uniform color across the center of the film, where it is of one thickness. The changing bands of colors around the edge are caused by the changing interference patterns as the film thins further.

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Funding for the development of this Outreach Guide was provided by the National Science Foundation Award ECS 0335765

17. Exploring Sunscreens

This activity has students explore the effectiveness of sunscreens. It asks the questions:

- Does the appearance of a substance (its opacity) relate to its ability to block UV light?
- Does the sun blocking claim of a product hold up to testing? Is a sunscreen with nanoparticles more effective than one without? The activity is based on the NanoSense lesson Clear Sunscreen: How light interacts with matter: http://nanosense.sri.com/activities/clearsunscreen/index.html and in particular lesson one: http://nanosense.sri.com/activities/clearsunscreen/introduction/CS_Lesson1Teacher.pdf

Materials: (1-9 for version 1)

1. Different sunblocks/sunscreens (nano and non-nano; at least one of each). Use at least four types taking into account opacity and label them 1-4.
    a. Nano: Blue Lizard, Neutrogena, Banana Boat; Bull Frog Sunscreen (no nano)
    b. zinc oxide (no nano is white version & nano is clear version)
        i. try to use both opaque and clear versions such as Banana Boat spray which is clear.
2. Sunscreen Smear Sheet: transparency with four squares marked off. We cut the transparency into a 2 inch strip to create the sheet
3. Black construction paper also cut into 2 inch strips (for judging opacity of white substances; opacity guide below)
4. UV light source (handheld; black light)
5. UV sensitive beads (use white ones)
6. Craft sticks
7. UV bead color guide
8. Cotton swabs
9. Paper and pen to record results of test
10. Plastic bag (version 2)
11. Amber bottle (version 2)
12. Yarn and UV beads (version 2)

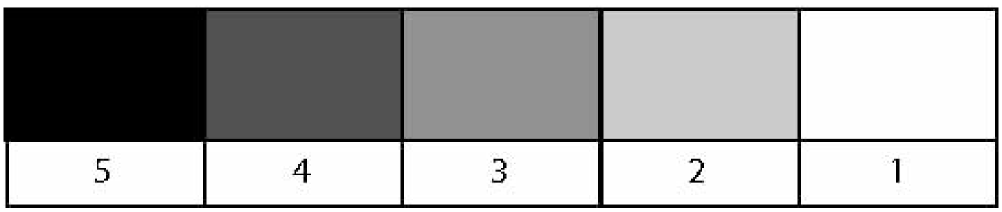
Requires glue gun and toaster oven to make UV tester sticks

To make the bead tester, place some UV beads into a warm toaster oven until they melt. We put them on aluminum foil for easy removal. Glue a melted bead to a craft stick to create the bead tester stick (see image below).

To do the demo (Version 1):

1. Place a sunscreen smear sheet on top of a black sheet of paper.
2. Label one square with the name of each substance you are going to test.
3. Using a cotton swab, spread an equal amount of each sunscreen on the smear sheet in the squares labeled 1-4 (corresponding to the sunscreen numbers). Cover the whole square..
4. Determine how well can you see through the substance to the black sheet of paper using the Opacity Guide.
    a. 5= no opacity and 1= complete opacity
5. To test the sunscreens: Place a UV bead tester stick under each square. Testing can be done simultaneously but is easier if done one at a time. Keep another tester stick as the control to be exposed directly to UV light. Expose the beads that are under the sunscreens for at least 30 seconds. Compare UV bead color using UV bead color guide. Record the results.

Opacity Guide

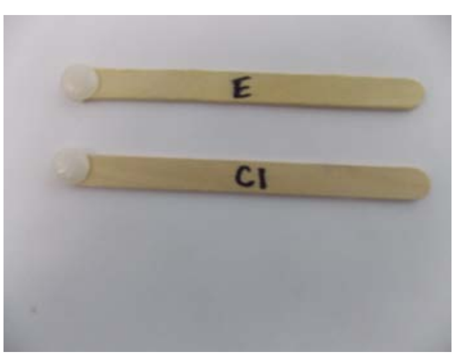


Questions:

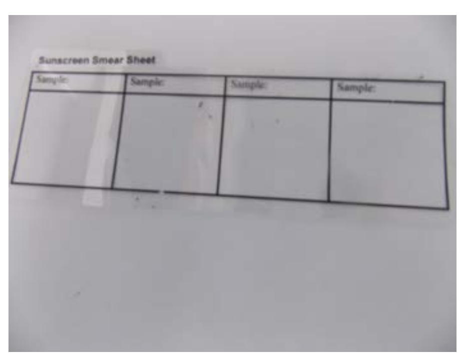
1. Do the results help answer the questions in the introduction?
2. Do thicker, whiter sunscreens protect us better than transparent sprays?
3. Can we tell how well something will block UV rays by looking at its appearance?
4. Are the claims of products really true?
5. Do sunscreens that use nanotechnology provide better protection?

To do the demo (Version 2):

1. Shine a black light on the UV bead (do not use the UV bead sticks but just a UV bead).
2. Place the UV bead inside a snack size and then using a Q-tip spread sunscreen onto bag to cover the bead. Shine the black light on the UV bead. What happens?
3. Place a UV bead inside and amber colored bottle and shine the black light on to the side of the bottle. What happens?
4. Thread a UV bead on a piece of yarn and tie as a bracelet.



Bead testers



Smear sheet