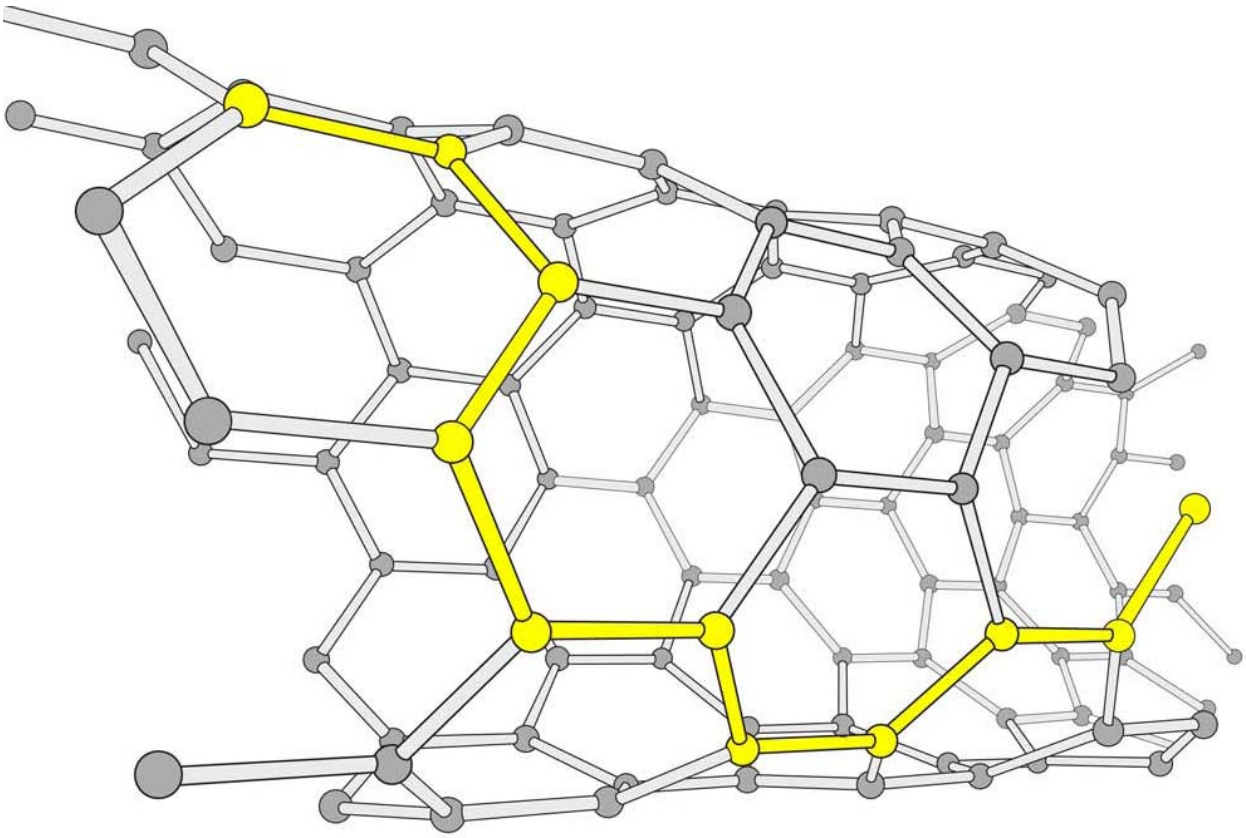
National Nanotechnology Infrastructure Network

Outreach Demonstration Guide



NNIN
Nanoscale Science, Engineering & Technology

Georgia Tech Nanotechnology Research Center

NSF

This work was supported by NSF award ECS 0335765

NNIN Outreach Demonstration Guide

This guide consists of a variety of demonstrations that the NNIN Education Office at Georgia Institute of Technology uses with visiting groups. Some of the materials were developed by NNIN and some of the materials come from other nano-education groups. 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 materials 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 a small easel indicating the name of the demonstration and often has an accompanying poster or other informational materials. Alternatively, we use these demos as a "show" and ask for student volunteers to come up and assist. This works well with large groups of visitors. Individual tables work best as the participants can see the demo much better and the students 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 to be used with a group of 40-50 students:

Time	**Red Team**	**Blue Team**	**Green Team**	**Purple Team**
10:30-11:00	Intro to Nano Rm 102A	Intro to Nano Rm 102 A	Intro to Nano Rm 102 A	Intro to Nano Rm 102 A
11:00-11:30	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
11:30-11:45	Cleanroom Tour/Snack	Snack/Cleanroom Tour	Nanooze Exhibit	Nanooze Exhibit
11:45-12:00	Nanooze Exhibit	Nanooze Exhibit	Cleanroom Tour/Snack	Snack/Cleanroom Tour
12:00-12:30	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
12:30-1:00	Surveys	Surveys	Surveys	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.

1. Magic Sand Demo – Exploring Hydrophobic Properties

The NNIN lesson *Exploring Magic Sand* will give you the background information for the full lesson (http://www.nnin.org/nnin_k12teachers.html). It also has resources to buy the materials but you can Google “magic sand” and find other sources plus 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. 2-3 inch cardboard pieces to make sand demos (see picture above)
4. rubber cement
5. small petri dishes or small clear cups (2-3 depending on demo used) each filled ½ with water
6. water in squirt bottle or use beaker/cup with water and eye dropper
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 and stirring rod
11. small drop 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)
12. paper towels
13. plastic table cloth (optional)
14. hand held scope (optional) (Radio Shack Illuminated Microscope Model MM-100 Catalog # 63-1313)

To do a demo:

Prepare demo pieces in advance of event:

1. Cut circles or squares from cardboard (minimum size 2”) – such as from a shipping box. We use a die cut machine to cut circles or squares.
2. Spread out a sheet of paper to work over.
3. Spread rubber cement over cardboard piece and sprinkle with magic sand (press as necessary to stick). Shake off excess sand and reuse or return to container.

4. Spread rubber cement over cardboard piece and sprinkle with regular sand (press as necessary to stick). Shake off excess sand and reuse or return to container.

Part 1: Ask students what hydrophobic and hydrophilic mean. Ask what will happen when you pour sand 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 another Petri dish. 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: Hand students the two types of circles and have them place drops of water on them using squirt bottles or eye droppers. Bring extra circles as we use 2-3 for each group and they also get wet and need to dry out. You may also let students use the handheld to look at the two sands to see if they can see differences. The Magic Sand is typically more rounded, less angular to allow for the monolayer to adhere.

Part 3: Have a clear container filled ½ - 2/3 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 stirrer above the water's surface (it will be dry). When all have seen this demo, pour water 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. Prepare for your next group or reuse the Petri dishes without doing the pouring of materials with the next group.

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.nano-tex.com/) or nanopants (Target Cherokee Stain Resistant) or stain resistant shirts (Dockers). 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. There is a poster on our web site of the Lotus Effect. http://www.mirc.gatech.edu/education/documents/LotusEffectinfoforLotusan.pdf

2. Nitinol - Shape Memory Alloys Demo

The NNIN lesson *Shape Memory Alloys – Smart Materials* will give you the background information for the full lesson (http://www.nnin.org/nnin_k12teachers.html). 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/nnin_k12alloys.html)

Materials:

1. pieces of Nitinol wire (about 3 inches in length; 5-10 pieces)
2. piece of copper or aluminum wire
3. source of heat:
    a. hotplate
    b. small lighter
    c. heat gun
4. tweezers or forceps (clamping; long handled)
5. glass bowl with flat bottom (with water – heated 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^{o}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")
6. goggles

To do the demo:

We typically have the poster "Shape Memory Alloys" from the Georgia Tech web site placed along a wall or on the table. It can be found at - http://www.mirc.gatech.edu/education/teacher_resources.php. We use it to talk about the phases of matter and eventually the forms of nitinol. We caution them that there is hot water on the table. We tend not to use open flames unless we are in a lab setting.

If using the copper and aluminum wire, have volunteers twist and drop these in first. Have students twist their piece of nitinol wire (do not let them tie into a knot) and then tell them to drop it in the hot water. Have nitinol pieces dropped in one at a time. Once the excitement has "worn off", explain about the solid state phase transition. Discuss applications of the material (cell phone antenna, eyeglasses, robotic arms, aortic stents, etc). There are also several articles on the Internet about how nitinol is being used that we show to students and discuss.

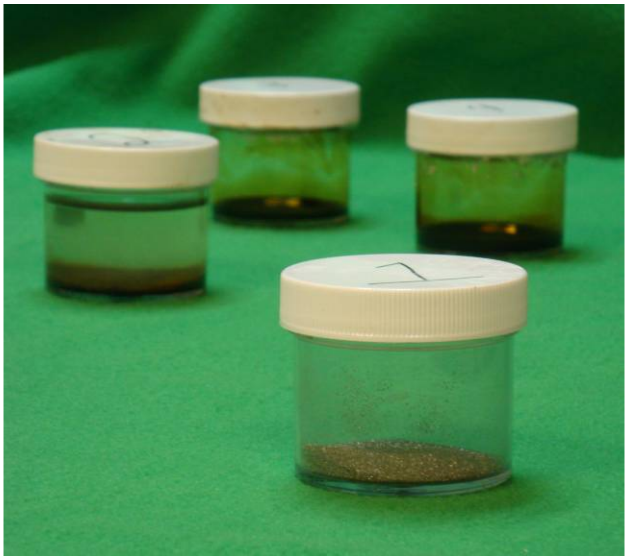
We emphasize with the students that what is happening at the nanoscale (atoms) has a macroscale level effect which they can see (i.e., the wire goes back to its original shape once it attains its transition temperature).

This can also be done using disposable lighters or heat gun as the heat source and long tweezers but non-lab facilities do not like open flames and with school groups it can be **very** problematic.

Caution: We suggest safety glasses be worn by students at the lab 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* will give you the background information for the full lesson. It can be found at http://www.nnin.org/nnin_k12magnetism.html. It also 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
7. Parafilm® to help seal containers and prevent leakage

To do the demo:

Part 1:

Begin demo by asking students what they think is in container #1. Follow-up questions may include: Why do you think it is? 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 demo tell them that the container contains iron filings* and ask if they think the iron filings are magnetic.

Next have student(s) place a magnet on top of container #1, turn container over, and then set the container in the upright position. Ask students 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:

Have students look at container #2. Ask what is in the container? Then ask students 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?
Tell students to think about how atoms behave differently in liquids and solids.

Part 3:

We recommend that the students wear gloves when they handle containers of ferrofluid.
Have students 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 students 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 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.*

Tell students to 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?
Remind the students that the electrostatic attraction of the particles are 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:

Ask students 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.*
Tell 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 ferrofluids. 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.*
Tell them to put the magnet *under* the container and move it around. Ask them 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.*

4. Size and Scale

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://www.nnin.org/nnin_k12teachers.html. 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://www.nanosense.org/activities/sizematters/sizeandscale/SM_Lesson2Teacher.pdf. 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.

Start out the activity by defining what is a nanometer. Using some of the available analogies helps with demonstrating the "smallness" of a nanometer. For examples, a nanometer is like a marble compared to the size of the earth, it takes 24 years for a nanometer size person to walk across a dollar bill, 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.

Both activities are best done with students 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 them what is the biggest object that they can think of and the smallest one. This helps with the discussion of placing objects on a log scale rather than a linear scale. Once the students have sorted the objects, have group discussion about the placement and make any corrections necessary.

5. Nanoproducts

This demo is based on the NNIN lesson “Exploring Nanotechnology through Consumer Products.” (http://www.nnin.org/nnin_k12teachers.html). You may want to download the nanoproducts poster for the demo station or create one of your own to show various products (http://www.mirc.gatech.edu/education/teacher_resources.php).

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 with eye dropper
4. hand held scope (Radio Shack Illuminated Microscope Model MM-100 Catalog # 63-1313)

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 NNN 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 in the socks (with a handheld scope like the one available from RadioShack). Alternatively, have students choose a product, read the information sheet and then present to the group.

Ask the students 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 them how they would test the claims of the products (a possible science/class project). Explain that there are over 1,000 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. Exploring Liquid Crystals

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://mrsec.wisc.edu/Edetc/IPSE/educators/lcSensors.html
http://www.opticsexcellence.org/SJ_TeamSite/pdfs/lcmoodpatch_lesplan_v3.pdf

A good description of how liquid crystals works can be found in the Educational Innovations, Inc catalog. We have taken this information and use it in a poster that we can display at the same time that we are conducting the demo.

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 3-4 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 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 everyday objects that use liquid crystals and ask the students if they can describe how the display screens work. Next ask for a volunteer to place their hand on the top of the table. As you wait a couple of minutes, discuss with the students (with the aid of the poster) how liquid crystals work. After the student removes their hand from the table, lay a liquid crystal sheet on the table where the hand was. The students 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 it on the top of a beaker of water that has been heated on the hot plate. 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 we then place a piece of ice to show students that the sheet will change color also as the sheet cools down. We repeat this 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 demos for 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://mrsec.wisc.edu/Edetc/nanolab/LC_prep/index2.html and
http://www.opticsexcellence.org/SJ_TeamSite/pdfs/lcmoodpatch_lesplan_v3.pdf

7. Bunny Suit Contest

Materials:

1. computer with internet access or a CD/DVD showing gowning procedure
2. "used" bunny suits (small through extra large)
3. gloves, masks, shoe covers, boots, hoods, safety goggles
4. timers

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 the Georgia Tech's gowning video which is online at: http://grover.mirc.gatech.edu/userServices/Gowning.mpg. 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). You can award prizes for the fastest time, fastest group, etc.

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

8. Forces at the Nanoscale

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 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 dollhouse supply companies such as Dollhouse Collectibles (http://yhst-4107290884353.stores.yahoo.net/cla90750.html)
3. container of water (large enough scoop water into large cup)
4. paper towels
5. plastic table cloth (optional)

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.

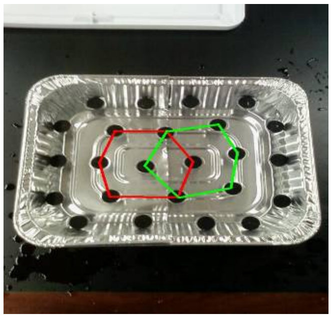
Have the students dip the regular size cup in water and pour out the contents back into the container. Next ask them to do the same with the dollhouse size cup. Often the students will tap the smaller cup with their hand to get the water to return to the container but you must explain that they are using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

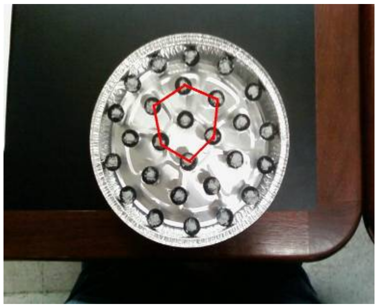
Explain to the students that different forces are operating on the water depending on the size of the cup. In the regular size cup gravity is the dominant force on the water in the cup. With the smaller cup it is surface tension which plays a more important role than gravity.
When you tip the regular 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.

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. 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





Source: http://cnsi.ctrl.ucla.edu/nanoscience/pages/selfAssembly.

Materials

1. One square metal or glass bake pan
    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 25.
    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 or glue two different colored foam shapes together so you can determine that one color will be the same pole. 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 foam
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 if they can think of anything that self assembles? A great example is the student – 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, then add water to the pans and have the participants slowly place the shapes into the pans. 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). Then have the participants turn over a floater and see what happens – chemical bonding and self assembly!

10. Encapsulation

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 (cancer cell identification and drug delivery). 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 , V84n7 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 will 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

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 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

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 such as buckyballs and quantum dots 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 left well of the reaction plate
2. Draw some of the sodium alginate with iodine mixture into a pipette. Holding the pipette a few centimeters above the surface of the $CaCl_2$ solution begin releasing drops of the alginate-iodine mixture into it. Allow sufficient time for the spheres to develop.
3. Place into the middle well of reaction plate liquid laundry starch solution (starch mixed with water). Take a few of the spheres that are created in well one and place in the starch solution 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 $CaCl_2$ well begin releasing drops of the alginate-starch mixture into it.
5. Place into the upper right well of the reaction plate iodine water (water that a few drops of iodine have been added to). Take the spheres that are created in well one and place in the iodine solution well.
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 middle well 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 that are in the iodine water should show that the spheres 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.

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

11. Edible Chips

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.

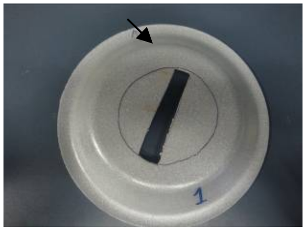
Materials:

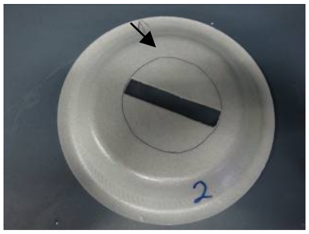
1. cookie (large sugar cookie or ½ of a graham cracker); one for each student
2. small paper or foam plates that have had a simple design cut in the middle (several of each design; at least three designs; pictures of plates we use follow). These are the masks and each one should be marked with an arrow 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)
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
9. markers
10. plastic table covering
11. examples of processed silicon wafers with chips and electronic devices showing chips/integrated circuits (optional)
12. LCD projector and PowerPoint "How Chips are Made" (http://www.mirc.gatech.edu/education.php) (optional)

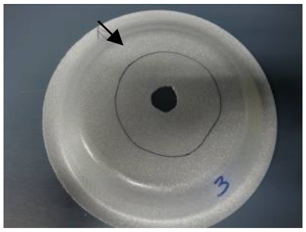
To do the demo:

Begin the activity by showing students a completed silicon wafer. If using the LCD Projector and PowerPoint quickly discuss how a wafer is made. We often explain how the wafers become important parts of electronics. Next pass out paper plates and cookies to each student. Tell students 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 the cookie the first mask (this is the plate that has a #1). The plate will be up-side down over the cookie. Have them put a mark on their cookie plate where the arrow is so they will know how to line up the next 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 over their cookie plate #2 making sure that their arrows line up. They will sprinkle chocolate Nesquik® powder (second photoresist) 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

We use either of two different demos which are very similar – one from *NanoSense's Size Matters* (http://www.nanosense.org/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 smooth stone 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. (3) 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 break the tablets in half and they finely grind one half in the mortar. Place the half 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. 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

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 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 make sure the students understand 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://mrsec.wisc.edu/Edetc/IPSE/educators/carbon.html). 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://www.seed.slb.com/uploadedFiles/Science/Laboratory/Hands-

On_Lab/Earth_Science/Build_a_Buckyball/Related_Articles/exp.pdf and http://invention.smithsonian.org/centerpieces/ilives/kroto/buckyball.pdf. 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://mrsec.wisc.edu/Edetc/IPSE/educators/carbon.html 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

This demo is designed to let students 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://mrsec.wisc.edu/Edetc/EExpo/probes/index.html
http://mrsec.wisc.edu/Edetc/IPSE/educators/activities/mittenChall.html
http://www.nisenet.org/catalog/programs/exploring-tools-spm

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://mrsec.wisc.edu/Edetc/LEGO/crystal.html
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 what is the smallest thing they can think of. Ask the students 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 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 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 the students 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 (Rope on a Scope, DinoLite, 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.

Creating Colors by Changing Scale

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® 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.
4. Paper towels to clean up excess water.

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?

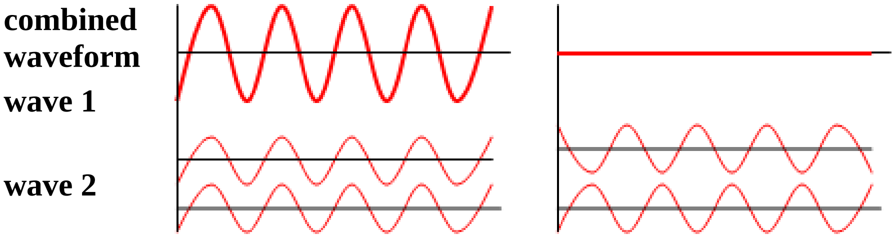
As the small drop of liquid spreads out on the water, its thickness decreases to a few microns. (A micron is one thousandth of a millimeter.) The bright iridescent colors in the film result from the interference of light reflecting back from the top and bottom of this thin film.

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.



Two waves in phase **Two waves 180° out of phase**

[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

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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.