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# Nano Mystery

**Lesson on Nano in nature**

**6th Grade Science**

## Background:

**One need not look much further than to the plants and animals around us to find nano-sized solutions to many of today's challenges. These solutions give our living plants and animals a competitive advantage toward survival from which humans can learn a great deal toward theirs too. By mimicking nature's nano structures, scientists are able to apply these technologies to fabrics that will not burn, always stay dry, or remain clean in the dirtiest environments. This lesson includes a unique inquiry into one Nano mystery called the Lotus Effect. This lesson includes one activity, one lab, and one very special presentation from an Atomic Force Microscope of the Elephant Ear plant.**

### Overview:

The following overview is from Dr. Gail Jones et. al., Chapter 10, *Nanoscale Science* , 2007 NSTA's Press.

"For hundreds of years, humans have looked to nature for ideas about concepts that can be applied to the human world. The flight of birds inspired the Wright brothers to build a flying machine, Velcro mimics the cocklebur, and thousands of medications based on botanical compounds are now over-the counter drugs. What better model than nature for us to learn from? The recent development of new tools permits scientists to manipulate matter at the nanoscale, allowing engineers to design new materials. Scientists are now mimicking nature at the nanoscale in an area of study known as biomimicry.

You may have noticed in the grocery store that water beads up and easily rolls off some plants, such as mustard greens and broccoli. These plants have a property known as the lotus effect named for the Asiatic Lotus, a culturally important plant that represents purity in some Asian countries. If you were to look at the surface of a lotus leaf with a microscope you would find the surface is covered in tiny wax particles (as small as a thousandth of a millimeter) making the surface appear very rough. This roughness, along with the hydrophobic nature of the waxy

### Classroom time:

55 minutes

material, causes the leaf surface to be superhydrophobic because of the reduced contact area between the water and the solid leaf surface. What's more, the droplets pick up small particles of dirt as they roll around; giving the leaves a cleaning mechanism. It is believed that plants evolved this adaptation dirt as a way to cleanse the surface of debris and fungi spores. Now scientists are taking this property and applying it to everyday materials; resulting in self-cleaning toilets, windows, and clothing. By mimicking the lotus effect in nature, scientists can build new properties for even better solutions."

## Objectives:

- Develop skills making observations and recording qualitative data.
- Explain how an Atomic Force Microscope works
- Accurately interpret nano size surface image data from an Atomic Force Microscope

## Science Standards:

### Related Next Generation Science Standards (NGSS):

- **MS-PS1.A: Structure and Properties of Matter**
- MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- **MS-ESS2.A: Earth's Materials and Systems**
- **HS-PS1.A: Structure and Properties of Matter**

Science and Engineering Practice

- Asking questions and defining problems
- Developing and using models

Materials:

**Lab Kit (one per two students) to include the following:**

- **One Water Dropper**
- **One plastic cup**
- **One beaker 50mL of water**
- **One gram of graphite dust (made from pencil lead)**
- **Three leaf samples (one from an Elephant ear, two from any waxy leaf species)**
- **Shoebox**
- **One wooden skewer**
- **Lab sheet**

### Related North Carolina Standards:

- NC SCOS Goal 6.P.2: Understand the structure, classifications and physical properties of matter.

Safety:

Each table should have a clean cloth available for students to wipe up any spilled water. Safety goggles should be worn during the lab portion of this lesson.

**Lesson Preparation:**

- Create one Shoebox for each student pair ahead of class. The shoebox is a simplified demonstration of how an Atomic Force Microscope produces an image. When complete, each shoebox should contain a mystery item, the lid taped closed, and have an identifying number on the bottom of the box. Be sure to record the mystery item for each box number on an answer key.

- Schedule a remote session with a university scientist to image lab specimens of the same kind of sample leaves used in the engagement activity (Elephant Ear leaf, and two other waxy surface leaves). Arrange in advance the time and activity to be shared by remote video connection with the classroom. If a remote session is not possible, have the university scientist email the images to the teacher ahead of time so that the teacher can present the specimen scans to the class.

- Create a lab kit for each student pair ahead of class. Each kit contains the following:
  One Water Dropper
  One plastic cup
  One beaker 50mL of water
  One gram of graphite dust (made from pencil lead)
  Three leaf samples (one from an Elephant ear, two from any waxy leaf species)
  Shoebox
  One wooden skewer

- Download and print the Lab sheet (enough for each student).

## Teacher Instructions:

**Engage (15min)**

Engagement activity

1. **Ask students to draw and label a data table on a sheet of paper as below.**

| | Specimen 1 | Specimen 2 | Specimen 3 |
|---|---|---|---|
| Description of Dry Leaf | | | |
| Description Wet Leaf | | | |

| | | | |
|---|---|---|---|
| Description Dusty Leaf | | | |

2. After students have made their table, Ask them to work in pairs. Each pair will have their own lab kit. Have them check to have the following items:
    - One Water Dropper
    - One plastic cup
    - One beaker 50mL of water
    - One gram of graphite dust (made from pencil lead)
    - Three leaf samples (one from an Elephant ear, two from any waxy leaf species)
    - Shoebox
    - One wooden skewer

3. Walk the students through each procedure of this lab by demonstrating each step.
    **Step 1.** Find in the kit 3 separate leaf samples
    **Step 2.** Decide which samples will be specimen 1,2, and 3.
    **Step 3.** Make an observation about each of the specimens as they are dry and record this observation in the data table.
    **Step 4.** Using a Water Dropper from the kit, drip water on each of the three specimens and record your observations on your table.
    **Step 5.** From the kit, locate the graphite and sprinkle a dusting of the black graphite onto the surface of each of the three specimens. Then drop water onto the graphite dust on the leaf. Record your observations on the data table.

4. When the students have finished with their activity, have them share their findings with another lab team. The teacher should also facilitate a class discussion about their observations with the following questions:
    - How do the specimens look different dry?
    - Did you observe the specimens all react with water in the same way?
    - How did the specimens react to dust, or dust and water?
    - Do you think there might be something unique about the surface of the specimens?

Lab

*__Explore & Evaluate (15 minutes lab activity)__*

*The teacher should now hand out the* Lab sheet and read through the background paragraph and model the procedures for this lab with the students per the instructions on the lab sheet. Please make sure the students are wearing eye protection and know the danger of the wooden skewer and how to safeguard against a puncture accident.

After the teacher has modeled this lab and the students have drawn and discussed their mystery object on their lab sheet, the teacher may disclose the answers to the students from their answer key (see Lesson Preparation section above).

Now bring the students back to thinking about the three specimens from the engagement activity. Ask them what they might learn about the surface of the specimens to explain their earlier observations. After a brief discussion, introduce the virtual webcast host scientist that will be demonstrating a live imaging session of the AFM using the same type of specimen samples the students used in the engagement activity.

## Discuss and Reflect

1. The students should notice a difference in the surface structure of the specimen images from the AFM.  The Elephant Ear plant will image will show nano-size hydrophobic fibers, the waxy leaf images will not have the same fibers as the Elephant Ear specimen. Ask the students how these fibers might explain how the leaf repels water and dust. Also ask if the lack of hydrophobic fibers might explain why the other leaf specimens did not repel water or dust.
2. Ask the students to work together to see how scientists might be able use hydrophobic nano fibers to solve real world problems. Some ideas you can discuss include, clothing that stays dry, hygiene products, medical bandages, food prep surfaces, bathroom surfaces, etc.

## Assessment:

Assess students by making observations during the engagement and lab activity as well as an assessment of their individual lab sheets that are turned in for grading. Specific skills to observe include:

- Student was able to accurately record observations and qualitative data.
- Student is able to demonstrate or explain how an Atomic Force Microscope works
- Student is able to accurately interpret nano size surface image data from an Atomic Force Microscope by pointing out the surface, scale, and nano-sized structures.

## Extensions:

This Royal Society Publishing Journal webpage has really good AFM images of super hydrophobic plant nano structures under section 4.
http://www.uwyo.edu/wisdome/_files/documents/jones.pdfhttps://royalsocietypublishing.org/doi/full/10.1098/rsta.2011.0502

Video on how the AFM works
https://www.youtube.com/watch?v=Ha53tFTsmW8

## Resources

**Jones, M. (2007). *Nanoscale science*. Arlington, Va: NSTA Press.**