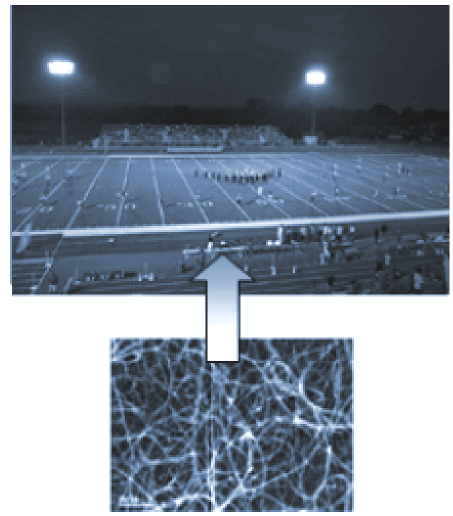
Nano Waterproofing

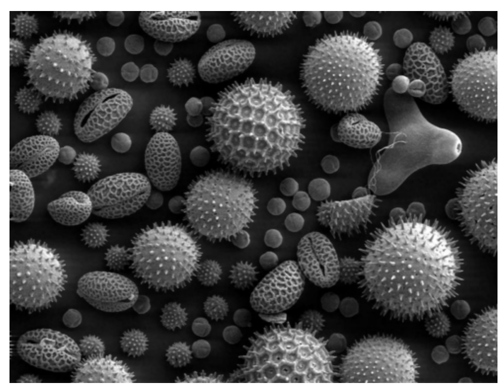
For Students:
What is Nanotechnology?



Four grams of carbon nanotubes has the same surface area of a football field.

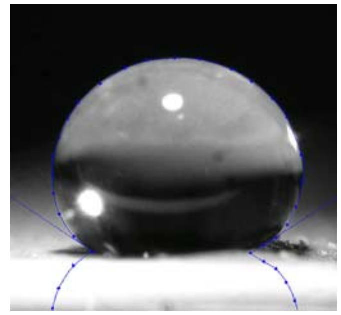
Imagine being able to observe the motion of a red blood cell as it moves through your vein. What would it be like to observe the sodium and chlorine atoms as they get close enough to actually transfer electrons and form a salt crystal or observe the vibration of molecules as the temperature rises in a pan of water? Because of tools or 'scopes' that have been developed and improved over the last few decades we can observe situations like many of the examples at the start of this paragraph. This ability to observe, measure and even manipulate materials at the molecular or atomic scale is called nanotechnology or nanoscience. If we have a nano "something" we have one billionth of that something. Scientists and engineers apply the nano prefix to many "somethings" including meters (length), seconds (time), liters (volume) and grams (mass) to represent what is understandably a very small quantity. Most often nano is applied to the length scale and we measure and talk about nanometers (nm). Individual atoms are smaller than 1 nm in diameter, with it taking about 10 hydrogen atoms in a row to create a line 1 nm in length. Other atoms are larger than hydrogen but still have diameters less than a nanometer. A typical virus is about 100 nm in diameter and a bacterium is about 1000 nm head to tail. The tools or new "scopes" that have allowed us to observe the previously invisible world of the nanoscale are the Atomic Force Microscope and the Scanning Electron Microscope.

◆ **Scanning Electron Microscope**



The scanning electron microscope is a special type of electron microscope that creates images of a sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. In a raster scan, an image is cut up into a sequence of (usually horizontal) strips known as "scan lines." The electrons interact with the atoms that make up the sample and produce signals that provide data about the surface's shape, composition, and even whether it can conduct electricity. The image to the right is Pollen from a variety of common plants, magnified about 500 times. It was taken with a scanning electron microscope at the Dartmouth Electron Microscope Facility at Dartmouth College in New Hampshire, US. Other images are at www.dartmouth.edu/~emlab/gallery.

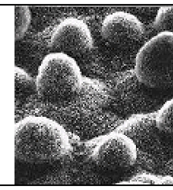
For Students:
What is The Hydrophobic Effect?



Hydrophobic comes from the word hydro (water) and phobos (fear). It can be demonstrated by trying to mix oil and water. And, also is evident if you look at some leaves and flower petals that repel water in droplets after a rain storm. For the leaves, the water repellant can sometimes be a waxy coating on the leaves, or can be the existance of tiny hairlike projections off the surface of the leaf which causes a buffer of air between the hairs -- the air keeps the water away.

◆ Superhydrophobic Surfaces

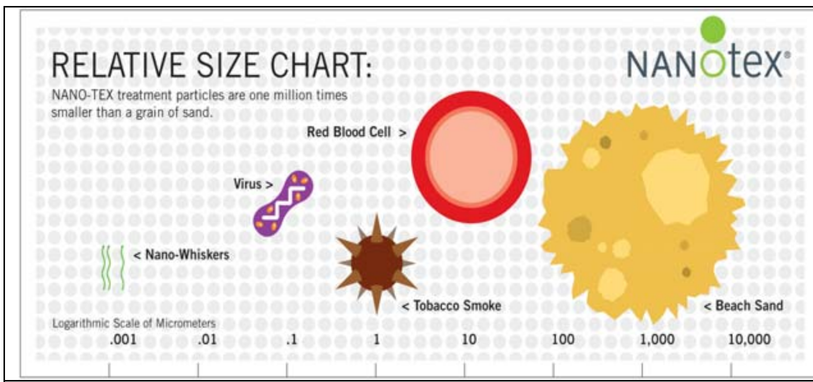
Superhydrophobic surfaces such as the leaves of the lotus plant have surfaces that are highly hydrophobic, or very difficult to wet. The contact angles of a water droplet exceeds 150° and the roll-off angle is less than 10°. This is referred to as the Lotus effect and the image to the right illustrates this concept.



This is a picture of a lotus leaf taken with a scanning electron microscope. Notice all the bumps! Image Credit: U.S. Environmental Protection Agency.

◆ Fabric Applications?

Scientists and engineers who were aware of the hydrophobic effect decided to apply nanotechnology to the surfaces of fabrics to make them water proof too! The waterproof feature often also helps protect fabrics from staining because liquid cannot easily soak into the fabric fibers. A good example is the work done by a company called Nano-Tex. The company adds nano "whiskers" to cotton fibers in the same way that some leaves have little "hairs" on their surface. Creating the effect for fabric is a little tricky -- a cotton fiber is shaped like a round cylinder, and NanoTex adds tiny nano "whiskers" all around the cylinder so it has a fuzzy surface. The fabric doesn't appear any different or feel any different, but it does repel liquids. And, because liquids do not soak into the fabric, the process also helps the fabric resist staining too. Nano-Tex utilizes nanotechnology to: 1) design molecules with specific performance attributes; 2) engineer the molecules to assemble on the surface of textile fibers with extreme precision, and 3) ensure that they permanently attach to the fibers through patented binding technology. If the molecules were not permanently attached then the fabric might lose its ability to push water away after several machine washings. Over 80 textile mills worldwide are using Nano-Tex treatments in products sold by more than 100 apparel and commercial interior brands. This is just one example of an industry applying nanotechnology to solve problems -- explore more examples at www.trynano.org.



This illustration compares the relative size of Nano-Tex whiskers created on the surface of the fabric vs. other objects. Image Credit: Nano-Tex, Inc.

Nano Waterproofing

Student Activity:
Waterproofing Challenge

You are part of a team of engineers who have been given the challenge to develop a new process for waterproofing clothing. You have been provided with several pieces of cotton along with many possible materials you might decide to use for your waterproofing technique. For the purposes of your challenge, "waterproof" means that water should not be absorbed by the fabric, but will bead up on the fabric instead. You may try two or three different solutions and see which works best!

◆ Planning Stage

Meet as a team and discuss the problem you need to solve. Use the box below to describe your solution and list the materials you think you'll need to meet the challenge. Explain why you think your solution will solve the problem!

Fabric A Your plan and hypothesis: Materials Needed:
Fabric B Your plan and hypothesis: Materials Needed:
Fabric C Your plan and hypothesis: Materials Needed:

Nano Waterproofing

Student Activity:
Waterproofing Challenge (continued)

◆ **Manufacturing Stage**
Execute each of your plans (be sure to mark each piece of fabric, so you know what process you applied to it).

◆ **Investigation Stage**
If you have access to a microscope, examine each of your pieces of fabric and in the box below describe what you see, noting both what you see and how they differ from the other fabric samples. You'll have a chance to examine a sample of fabric that has been altered at the nano level too! Consider whether the fabric surfaces appear smooth, bumpy, convex, concave, or have other characteristics.

Surface Observations			
Fabric A	Fabric B	Fabric C	Nano Fabric

◆ **Testing Stage**
Over a wash basin or sink pour water over your fabric and see if it beads up or is absorbed. If your teacher agrees, you may wish to use a colored water or juice to more easily see if the water is absorbed at all. Mark your observations below.

Water Test Observations			
Fabric A	Fabric B	Fabric C	Nano Fabric

Student Activity: Waterproofing Challenge (continued)

◆ **Evaluation Phase**

Complete the following questions as a group:

1. Did any of your fabrics prove to be waterproof?

If yes, which procedure do you think was the best, and why?
If no, why do you think your procedures did not work?

2. What solution of another team do you think worked best? Why?

3. What do you think would happen if you washed and dried your fabric? Would it retain the waterproofing?

4. What was the most surprising observation during the microscope comparison (if you completed that part of the activitiy)?

5. How did the nano treated fabric compare to your most successful fabric in the water test?

6. How did the nano treated fabric compare to your most successful fabric under the microscope?

Student Activity:
Waterproofing Challenge (continued)

7. If you had to do it all over again, how would your team have approached this challenge differently? Why?

8. Do you think that materials engineers have to adapt their original ideas during product testing? Why might they?

9. Did you find that there were many different solutions in your classroom that met the project goal? What does this tell you about how engineering teams solve problems in the real world?

10. Do you think you would have been able to complete this project easier if you were working alone? Explain…

11. What other applications can you think of where a surface might be changed at the nano scale to improve function or performance? One idea is coating windshields so water flows off faster…..what can you think of?