Learning about the nanoscale and the SI system of measurement

Student Worksheet

Make a Prediction about how many nanometers is the diameter of a penny

_____

_____

Materials

- candy – assorted sizes
- coins – assorted sizes
- Metric ruler
- NanoRuler
- Paper
- pencil,
- construction paper
- magazines
- colored pencils
- glue
- markers
- scissors

Procedure

Procedure (from Student Activity Guide)

Part I. Measuring at the nanoscale --

1. Read the article "What is Nanotechnology?"
2. Complete the worksheet for the article "What is Nanotechnology?"
3. Gather the materials to be measured for the activity from your teacher.
4. Estimate the diameter of your objects in centimeters and millimeters.
5. Record your estimates in the table provided.
6. Obtain a metric ruler and NanoRuler from your teacher and carefully measure your object using both rulers.
7. Record your answers in the table provided.
8. Make a nanoposter using the pictures on this page/internet search/or use magazines.

Part II. Exploring NanoProducts

9. You will create a poster on nanoproducts to be presented in class.
10. You have three options to choose from for your poster:
    i. Choose products that are currently available and indicate what is nano about them;
    ii. Choose a non nanoproduct and think of ways it could be changed with nanotechnology; or
    iii. Think of a product you would like to see developed using nanotechnology.
11. Your teacher will direct you on what resources you may use to create your poster. You must include an SI measurement in your poster.
12. Be creative!

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Data Table

Object	Estimated Diameter	Diameter in Centimeters (cm)	Diameter in Millimeters (mm)	Diameter in Nanometers (nm)
Penny				
Nickel				
Dime				
Quarter				
Textbook				
Notebook				
Pencil				
M&M				
Mint				
Miniature Candy Bar				
Stick of Gum				

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Student Worksheet

1) What are the basic units of measurement in the SI system? _____

_____

2) Why are metric measurements important? _____

_____

3) What did you learn about metric units?_____

_____

4) Were your estimated measurements similar to your actual measurements? _____

_____

5) If not, how did your estimates differ from the actual measurements? _____

_____

6) How did the NanoRuler measurements compare to the metric measurements? _____

_____

i) What does this make you think about the nanoscale? _____

_____

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What is Nanotechnology?

This is an article from the National Nanotechnology Infrastructure Network's education portal. It can be accessed from http://www.nnin.org/nnin_what.html.

Nanotechnology is the science and technology of small things – in particular things that are less than 100nm in size. One nanometer is 10^{-9} meters or about 3 atoms long. For comparison, a human hair is about 60-80,000 nanometers wide.

Scientists have discovered that materials at small dimensions—small particles, thin films, etc- can have significantly different properties than the same materials at larger scale. There are thus endless possibilities for improved devices, structures, and materials if we can understand these differences, and learn how to control the assembly of small structures.

Most members of the scientific community agree that three things are important aspects that constitutes nanotechnology.

1. Small size, measured in 100s of nanometers or less
2. Unique properties because of the small size
3. Control the structure and composition on the nm scale in order to control the properties.

Nanostructures--- objects with nanometer scale features-- are not new nor were they first created by man. There are many examples of nanostructures in nature in the way that plants and animals have evolved. Similarly there are many natural nanoscale materials….. catalysts, porous materials, certain minerals, soot particles, etc that have unique properties particularly because of the nanoscale features. What is new about nanotechnology is that we can now, at least partially, understand and control these structures and properties to make new functional materials and devices. We have entered the era of engineered nanomaterials and devices.

One area of nanotechnology has been evolving for the last 40 years and is the source of the great microelectronics revolution- the techniques of micro- and nano-lithography and etching. This is sometimes call "top-down" nanotechnology. Here, small features are made by starting with larger materials and patterning and "carving down" to make nanoscale structure in precise patterns. Complex structures including microprocessors containing 100s of millions of precisely positioned nanostructures can be fabricated. Of all forms of nanotechnology, this is the most well established. Production machines for these techniques can cost millions of dollars and a full scale microprocessor factory can cost one billion dollars. In recent years, the same "top down" nanoprocessing techniques have enabled many non-electronic applications, including micromechanical. Microptical, and microfluidic devices.

The other fundamentally different area of nanotechnology results from starting at the atomic scale and building up materials and structures, atom by atom. It is essentially molecular engineering- often called molecular or chemical nanotechnology. Here we are using the forces of nature to assemble nanostructures – the term "self assembly" is often used. Here, the forces of chemistry are in control and we have, at least to date, somewhat less flexibility in making arbitrary structures. The nanomaterials created this way, however, have resulted in a number of consumer products. Significant advances are expected in the next decade in this area as we understand more completely the area of chemical nanotechnology.

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And there are many exciting applications that combine both bottom up and top down processing- to create for example single molecule transistors that have large (macroscopic) leads fabricated by top-down and single molecule assembled from bottom up.

Elsewhere on this site are highlighted some of the current applications of nanotechnology as well as those that we can reasonably forecast.

These materials have unique properties because of their small size. At the nanoscale, properties of materials behave differently and are said to behave under atomic and molecular rules. Researchers are using these unique properties of materials at this small scale to create new and exciting tools and products in all areas of science and engineering.

Nanotechnology combines solid state physics, chemistry, electrical engineering, chemical engineering, biochemistry and biophysics, and materials science. It is a highly interdisciplinary area – meaning that it involves ideas integrated from many traditional disciplines. Some universities have begun to issue degrees in nanotechnology; others view it as a portion of existing academic areas. Either way many trained scientists, engineers, and technicians in these areas will be required in the next 30 years.

The federal government believes that nanotechnology is one of the most important research endeavors for our country. In 2001 it established the National Nanotechnology Initiative (NNI) as an umbrella organization to promote and organize nanotechnology research across the government. Under NNI, ten federal agencies fund nanotechnology research with a current budget of approximately $1 billion per year. An aggressive set of technology milestones and grand challenges have been set by NNI. In 2004, President Bush signed into law the 21st Century Nanotechnology Research and Development Act which further promoted nanotechnology research. Other countries around the world have followed with significant programs in Nanotechnology.

Many are predicting that nanotechnology is the next technical revolution and products resulting from it will affect all areas of our economy and lifestyle. It is estimated that by 2015 this exciting field will need 7 million workers worldwide. The workforce will come from all areas of science and engineering and will include those with two-year technical degrees up to PhD researchers in universities and industry.

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"What is Nanotechnology?" Worksheet

1. Define nanotechnology. _____

_____

_____

2. What is the diameter of a human hair? _____
3. One nanometer is equal to _____
4. List the three important factors included in nanotechnology.

   a._____

   b._____

   c. _____

5. What is new about nanotechnology? _____

_____

6. What is meant by top-down nanotechnology? Give an example. _____

_____

_____

7. What are the branches of science involved in the study of nanotechnology? _____

_____

8. In reading the article, the term "highly interdisciplinary area" was used. Explain what is meant by highly interdisciplinary. _____

_____

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