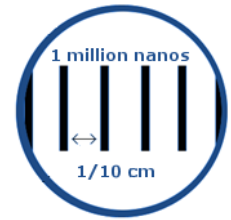




# What is a Nanometer?



Provided by TryEngineering - [www.tryengineering.org](http://www.tryengineering.org)

## Lesson Focus

Lesson focuses on how to measure at the nano scale and provides students with an understanding of how small a nanometer really is. "Students learn about electron microscopes, participate in hands-on activities to measure common classroom objects in the metric scale, and then convert the result to nanometers.

## Lesson Synopsis

The "What is a Nanometer?" lesson explores how small a nanometer really is. Students work in teams and measure a range of everyday classroom items, first using metric rulers and then convert the results to the nano scale.

## Age Levels

8-12.

## Objectives

- ✦ Learn about nanotechnology.
- ✦ Learn about scale.
- ✦ Learn about engineering design.
- ✦ Learn about teamwork and working in groups.

## Anticipated Learner Outcomes

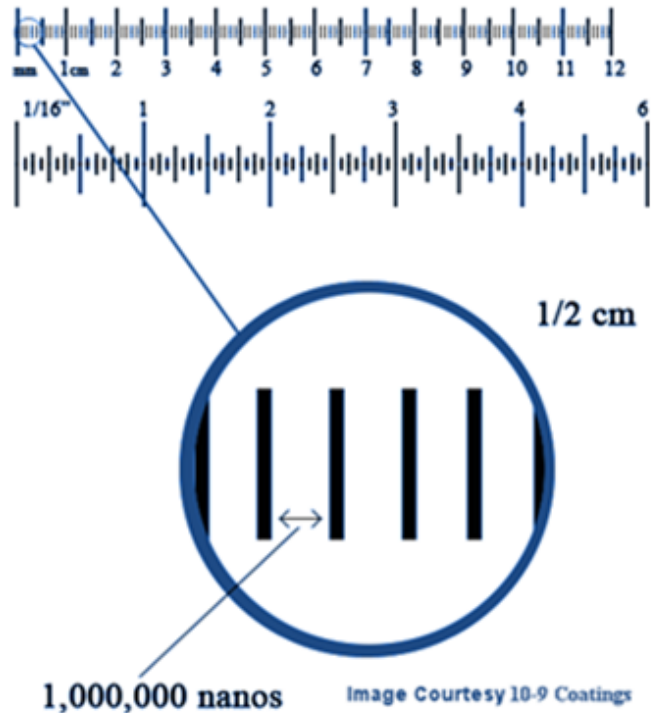
As a result of this activity, students should develop an understanding of:

- ✦ measurement
- ✦ nanotechnology
- ✦ problem solving
- ✦ teamwork

## Lesson Activities

Students learn how working at the nanoscale requires scientists and engineers to work at a much smaller scale. Students measure common classroom objects and convert the measurement to nanometers. They also learn about electron microscopes and find out about products that have been improved through the application of nanotechnology.

## WHAT IS A NANOMETER?



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## Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Worksheets (attached)
- ✦ Student Resource Sheets (attached)

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## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

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## Internet Connections

- ✦ TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))
- ✦ TryNano ([www.trynano.org](http://www.trynano.org))
- ✦ National Nanotechnology Initiative ([www.nano.gov](http://www.nano.gov))
- ✦ Dartmouth Electron Microscope Facility Images ([www.dartmouth.edu/~emlab/gallery](http://www.dartmouth.edu/~emlab/gallery))
- ✦ ITEA Standards for Technological Literacy: Content for the Study of Technology ([www.iteaconnect.org/TAA](http://www.iteaconnect.org/TAA))
- ✦ NSTA National Science Education Standards ([www.nsta.org/publications/nse.aspx](http://www.nsta.org/publications/nse.aspx))
- ✦ NCTM Principles and Standards for School Mathematics (<http://standards.nctm.org>)

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## Recommended Reading

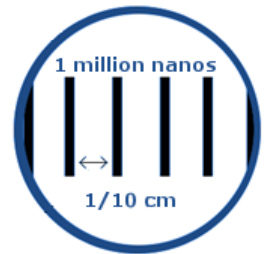
- ✦ Nanotechnology For Dummies (ISBN: 0764583689)
- ✦ Understanding Nanotechnology (ISBN: 0446679569)

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## Optional Writing Activity

- ✦ Write an essay or a paragraph with three examples about how the invention of the electron microscope has impacted the world.

# What is a Nanometer?



## For Teachers: Teacher Resource

### ◆ Lesson Goal

The "What is a Nanometer?" lesson explores nanotechnology and focuses on how to measure at the nano scale. The lesson provides students with an understanding of how small a nanometer really is. Students learn about electron microscopes, participate in hands-on activities to measure common classroom objects in the metric scale, and then convert the result to nanometers.

### ◆ Lesson Objectives

- ✦ Learn about nanotechnology.
- ✦ Learn about measurement.
- ✦ Learn about engineering design.
- ✦ Learn about teamwork and working in groups.

### ◆ Materials

- ✦ Student Resource Sheet
- ✦ Student Worksheets
- ✦ One set of materials for each group of students:
  - Ruler, eraser, pencil, pencil sharpener, other classroom objects of your selection.

### ◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Measurement Activity
  - a. Divide students into groups of 2-3 students, providing a set of materials per group.
  - b. Explain that students must work as a team to determine the measurement in nanometers of various classroom objects.
3. Evaluation - Students complete evaluation/reflection sheets

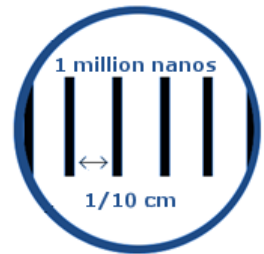
### ◆ Time Needed

One 45 minute session

### ◆ Optional Modelmaking Extension

Have students build a model representing how when working at the nano scale, surface area can be increased. This could be done with basketball that has table tennis or ping pong balls attached all over the surface. This will help visually illustrate how surface area can be manipulated at the nano scale.

# What is a Nanometer?



## Teacher Resource Measuring Nano - Sample Completed Worksheet:

You are part of a team of engineers who has been given the challenge of measuring ten objects in your classroom at the nano scale -- in nanometers (nm).

Measure each object in millimeters, and then convert using the following formula:

1 millimeter = 1,000,000 nanometers

or

1 centimeter = 10,000,000 nanometers

So, if used crayon was 4 centimeters long, it would also be 40,000,000 nanometers in length.

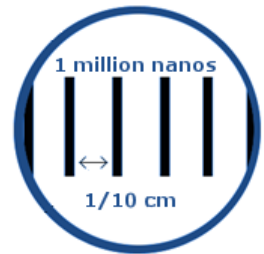


### ◆ Measuring Phase

Complete the following measurements as a group: *(examples below)*

Classroom Object	Original Measurement	Measurement in Nanometers
1. Dull edge child's scissor	11 centimeters	110,000,000 nanometers
2. New pencil with eraser	19 centimeters	190,000,000 nanometers
3. Used crayon	9 centimeters	90,000,000 nanometers
4. Pencil Eraser	5.5 centimeters	55,000,000 nanometers
5. Pencil Sharpener	2.55 centimeters	25,500,000 nanometers
6. Index card height	12.55 centimeters	125,500,000 nanometers
7. Used piece of chalk	23.5 millimeters	23,500,000 nanometers
8. Calculator	92.75 millimeters	92,750,000 nanometers
9. Doorknob	50.25 millimeters	50,250,000 nanometers
10. Roll of tape	47.55 millimeters	47,550,000 nanometers

# What is a Nanometer?

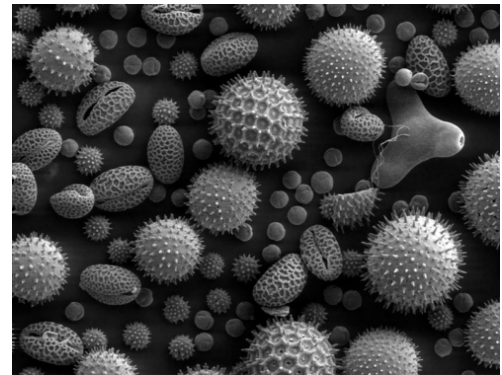


## For Students: What is Nanotechnology?

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.



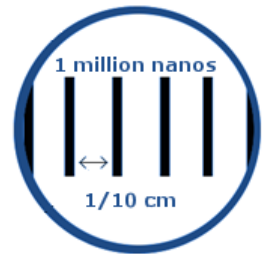
It was taken with a scanning electron microscope at the Dartmouth Electron Microscope Facility at Dartmouth College in New Hampshire, US. Other images are at [www.dartmouth.edu/~emlab/gallery](http://www.dartmouth.edu/~emlab/gallery).

### ◆ Nanotechnology Applications

An increasing number of products and materials are becoming commercially available that incorporate nanoparticles. These include nanoscale powders, solutions and suspensions of nanoscale materials as well as composite materials and devices having a nanostructure. Nanoscale titanium dioxide for instance is finding uses in cosmetics and sun block creams. At the nanoscale titanium dioxide is clear in appearance -- at a larger size it is white. Older sunblocks would go on white and people would ski or surf all day with bright white noses. With nanotechnology, the sunblocks are clear. Many consumer products using nanotechnology have entered the market (such as stain and wrinkle-free fabrics) and sports equipment where tennis racquets with better performance, tennis balls that last longer, and golf balls that fly further. Nano-coatings and nano-composites are being used in a wide range of consumer products from bicycles to automobiles. And, in healthcare, drug molecules can be coated with nanoparticles such as antibodies that recognize only the diseased areas of the body.



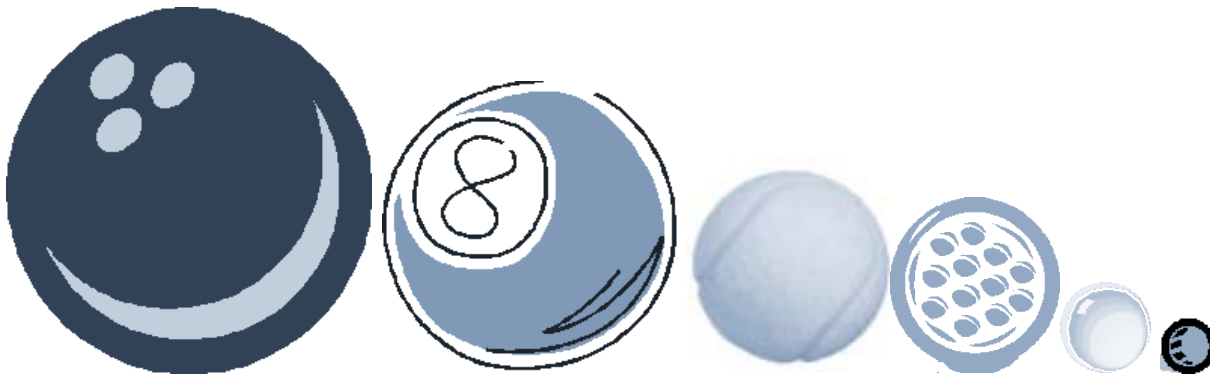
# What is a Nanometer?



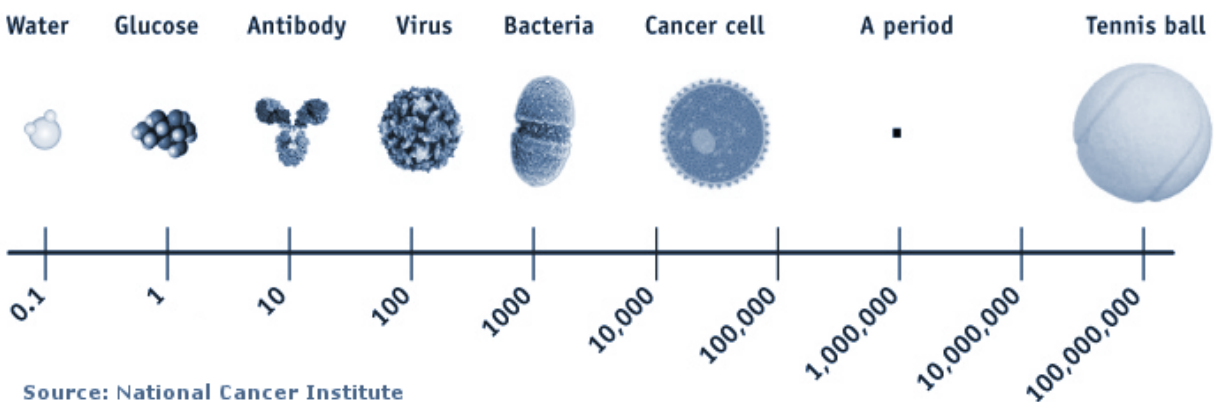
## Student Worksheet: How Big is Small?

It can be hard to visualize how small things are at the nanoscale. The following exercise can help you visualize how big small can be!

The following are drawings of items you may recognize.... a bowling ball, a billiard ball, a tennis ball, a golf ball, a marble, and a pea. Think about the relative size of these items.

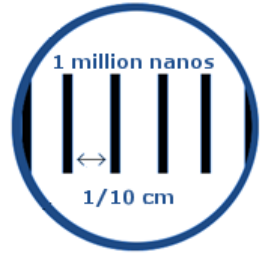


Now take a look at the chart below that was developed by the National Cancer Institute (U.S.) and think about how much smaller the various items are...moving down from the familiar tennis ball. The "." on this page is 1,000,000 microns -- quite gigantic compared to a virus or a single molecule of water (H<sub>2</sub>O).



Source: National Cancer Institute

# What is a Nanometer?

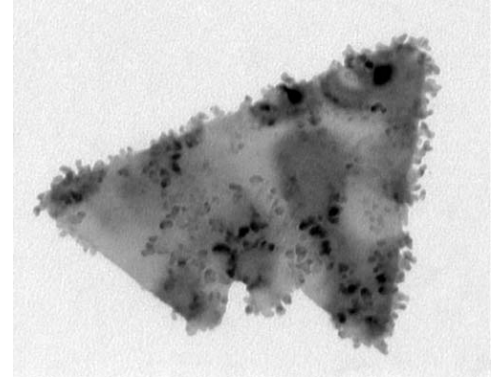


## Student Resource: How Small is Small?

It can be challenging to envision just how small a nanometer is!

### What is a Nanometer?

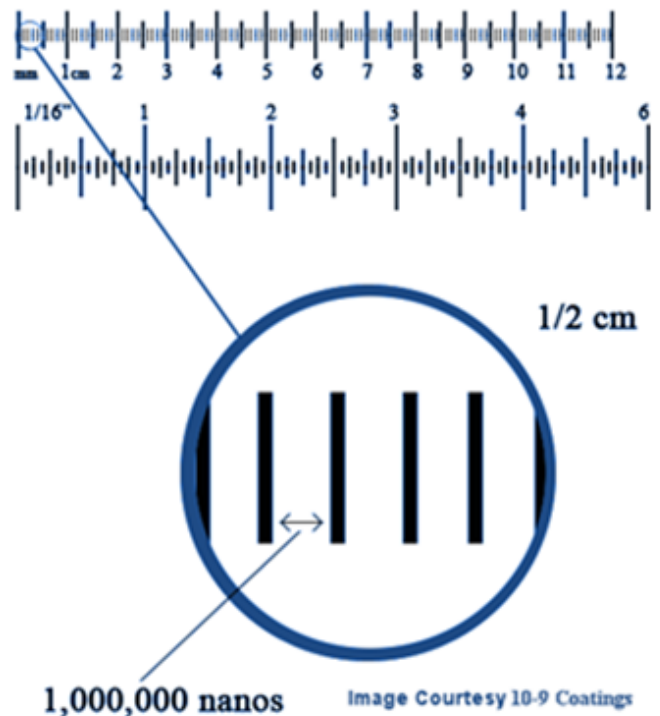
A sheet of paper is about 100,000 nanometers thick. But how big is that? The chart below should help you understand how small a nano really is. Notice that a centimeter is  $1/100^{\text{th}}$  of a meter. That also means that a meter is 100 times as big as a centimeter. If an object were a meter wide, it would also be 1,000,000,000 nanometers wide. So something that is only 1 nm wide is very small indeed.



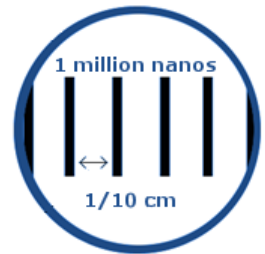
The picture to the right is of Single gold nanoparticle crystals formed using radiolysis at Sandia National Laboratory's Gamma Irradiation Facility. The gold nanoparticle is approximately 30 nm in size.

	Symbol	Relative Size
meter	m	about three feet or one yard
centimeter	cm	$1/100$ of a meter, about half of an inch
millimeter	mm	$1/1,000$ of a meter
micrometer or a micron	$\mu\text{m}$	$1/1,000,000$ of a meter, often called a micron
nanometer	nm	$1/1,000,000,000$ of a meter

## WHAT IS A NANOMETER?



# What is a Nanometer?



## Student Worksheet Measuring in Nanometers:

You are part of a team of engineers who has been given the challenge of measuring ten objects in your classroom at the nano scale -- in nanometers (nm).

Measure each object in millimeters, and then convert using the following formula:

1 millimeter = 1,000,000 nanometers

or

1 centimeter = 10,000,000 nanometers

So, if used crayon was 4 centimeters long, it would also be 40,000,000 nanometers in length.



### ◆ Measuring Phase

Complete the following measurements as a group:

Classroom Object	Original Measurement	Measurement in Nanometers
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

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## Student Worksheet (continued)

### Measuring in Nanometers:

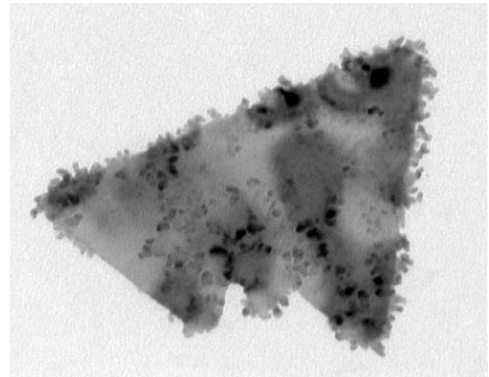
#### ◆ Evaluation Phase

Complete the following questions as a group:

1. What was the most surprising thing you learned about nanotechnology during this activity?

2. Do you think you would be able to see an element that was 10 nanometers wide without the aid of technology?

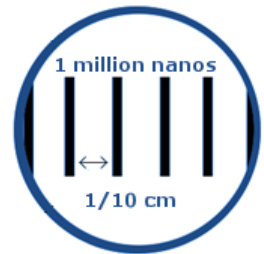
3. If a sheet of paper is about 100,000 nanometers thick, how do you think an engineer would go about moving an element that is only 30 nanometers thick -- such as the gold particle to the right?



4. Do you think that engineers working at the nano scale have a harder time doing their work than engineers who are working with larger objects, such as batteries, rockets, or sheets of steel? Why?

5. Do you think that nanotechnology might have the most impact on the development of materials, improvements in energy options, or in advances in healthcare? Why?

# What is a Nanometer?



## For Teachers: Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics.

### ◆ National Science Education Standards Grades K-4 (ages 4 - 9)

#### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

#### **CONTENT STANDARD B: Physical Science**

As a result of the activities, all students should develop an understanding of

- ✦ Properties of objects and materials

#### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understanding about science and technology

#### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor

### ◆ National Science Education Standards Grades 5-8 (ages 10 - 14)

#### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry
- ✦ Understandings about scientific inquiry

#### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop an understanding of

- ✦ Properties and changes of properties in matter

#### **CONTENT STANDARD E: Science and Technology**

As a result of activities in grades 5-8, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

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## For Teachers: Alignment to Curriculum Frameworks (continued)

### ◆Principles and Standards for School Mathematics (ages 6 - 18)

#### Number and Operations Standard

- ✦ Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- ✦ Understand meanings of operations and how they relate to one another
- ✦ Compute fluently and make reasonable estimates

#### Measurement

- ✦ understand measurable attributes of objects and the units, systems, and processes of measurement.
- ✦ apply appropriate techniques, tools, and formulas to determine measurements.

#### Problem Solving

- ✦ build new mathematical knowledge through problem solving.
- ✦ solve problems that arise in mathematics and in other contexts.
- ✦ apply and adapt a variety of appropriate strategies to solve problems.
- ✦ monitor and reflect on the process of mathematical problem solving.

#### Connections

- ✦ recognize and apply mathematics in contexts outside of mathematics.

#### Representation

- ✦ create and use representations to organize, record, and communicate mathematical ideas.
- ✦ select, apply, and translate among mathematical representations to solve problems.

### ◆Standards for Technological Literacy - All Ages

#### The Nature of Technology

- ✦ Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- ✦ Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

#### Design

- ✦ Standard 9: Students will develop an understanding of engineering design.

#### Abilities for a Technological World

- ✦ Standard 13: Students will develop abilities to assess the impact of products and systems.