

Teacher's Preparatory Guide

What's the Smallest Thing You Know?

Purpose:

The purpose of this lesson is to encourage students to think about the size of objects through the use of literature and mathematics.

Time required:

2 class 50 minute class periods

Level:

Elementary K- 5th grade (Suggested level of the book is for grades 1-6)

Teacher Background:

Nanoscale Science and Engineering (NSE) is defined as the understanding and control of matter at dimensions between 1 and 100 nanometers, where unique phenomenon enable novel applications. The emerging fields of nanoscience and nanotechnology promise to have extensive implications for all of society. In the book *The Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers* (BI) size and scale is considered to be one of the “big ideas” which represent the basic science content necessary to the understanding of nanoscale science and engineering. Much of the understanding of size and scale, scaling and proportionality, and shape that students need to understand in grades 7-12 begin in the elementary years. This lesson is designed to lay the foundations for this understanding by providing activities focused on size and scale.

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (FK-12SE) indicates that students at all grade levels should be able to ask questions about the texts they read and the features of the phenomena they observe. Reading a book about objects students may not be familiar with is a good way to help students think and question about the world around them.

In addition, FK-12SE states that at the elementary level, students need support to recognize the reason to record observations- whether in drawings, words, or numbers. Increasing student familiarity with the role of mathematics in science is central to developing a deeper understanding of how science works. As soon as students learn to count, they can begin using numbers to find or describe patterns in nature by using instruments such as rulers, protractors, and thermometers.

The importance of mathematics is supported by the *National Science Education Standards (NSES)* for K-4: Content Standard A for Science as Inquiry to use simple equipment and tools to gather data; Physical Science Content Standard B which includes properties of objects and materials; Life Science Content Standard C which includes understanding of the characteristics of organisms.

The book *What's Smaller Than A Pygmy Shrew?* by Robert E. Wells helps students see that a pygmy shrew is among the tiniest of mammals and that a ladybug is even smaller. But in the book, they will also find even smaller things that they ordinarily do not see. This is the beginning of understanding students must have to be able to conceptualize the behavior of matter at the nanoscale and the tools used to explore this world.

Materials: For each student or pair of students

- Book- *What's Smaller Than A Pygmy Shrew* by Robert E. Wells (only one copy needed per class)
- Size sorting cards (in appendix)
- Card Stock Ruler cut apart (pattern included in appendix)
- Reference materials
- Paper tape or string

Advance Preparation:

This lesson can be conducted as a teacher led lesson or as a learning center. Below are the advance prep needed for both methods.

- Purchase book or obtain from media center
- Print and cut size sorting cards and place in small zip loc bags
- Print rulers on card stock
- Make arrangements to use media center if doing optional activity
- Gather materials for students to draw with such a colored pencils, crayons, or markers.

If doing the lesson as a learning center you must:

- Obtain a container for center
- Print, laminate, and cut apart the Instruction for Center cards located at the end of lesson.
- Put into the center container the following materials:
 - Station 1- colored pencils, markers, crayons
 - Station 2- set of size soring cards in small zip loc bag
 - Station 3- A 3.5 meter long piece of string
 - Station 4- Copy of ruler located at the end of lesson
 - Station 5-Copy of ruler located at the end od lesson
 - Station 6- Colored pencils, markers, crayons

Safety Information:

Make sure that students who are using resources in the media center follow media center and school policies.

Directions for the Activity:

- Have students draw the largest and smallest objects they can think of.
- Read to the class the book *What's Smaller Than A Pygmy Shrew?*.

- Distribute size sorting cards and have students line cards up from largest object to smallest object. Teacher can use this as a time to work on the development of terms such as: bigger, smaller, bigger than, smaller than, large, small, length, etc.
- Have students look at the card containing the picture of the elephant and tell them that the African Savanna Elephant, the largest of all elephants, is the largest land animal, with males standing 3.2 metres (10 ft) to 4 metres (13 ft) at the shoulder. (If possible have a strip of paper taped to the wall that shows how tall that is. If the ceiling is not high enough measure that distance on the floor). Let students take turns standing next to this strip of paper or laying on floor next to the strip to compare their size to the size of an elephant.
- Ask students to look at their cards and discuss which object is the smallest. Ask students if there is anything in the classroom that would be the same size as that object. (This would be an opportunity for the teacher to discuss that all the objects in the classroom are made up of smaller objects called atoms and molecules and that these are made up of even smaller things called electrons, protons, neutrons and quarks as was mentioned in the book. You might want to use a visual aid to help students understand that large objects contain small objects. Examples might be a book contains pages, which contain words, that contain letters or have a box that when you open it has smaller and smaller boxes).
- Have the students suggest objects in the classroom that they think would be the same “length” as the pygmy shrew. List these on the board.
- Distribute inch block rulers (included in appendix). Discuss with students that three of the squares would be the same length as a pygmy shrew. Have students measure with their block rulers the objects that they suggested would be the same size as the pygmy shrew.
- As a class decide on an object that comes closest to being the size of a pygmy shrew.
- Distribute the inch part of ruler and have students draw a line that would be three inches long.
- Tell students that you can use other things to measure with besides the inch ruler. Ask them to suggest some other things that they might measure this length with. (Suggestion could include: their fingers, the eraser on their pencil, length of paper clip). List these on the board and have students pick one and measure the line using this method.
- Distribute the centimeter and nanometer part of the ruler. Have students measure the 3 inch line that they drew. Discuss with students that centimeters and nanometers are other ways to measure the length of an object. Discuss with students which unit would be best to measure really small objects. (You may also want to talk about other units such as millimeters or show the SI units of measurement)
- Have students complete student extension worksheet. (optional located in appendix)
- Have students again draw the largest and smallest object they know after having learned more about size and scale. Have students compare their original drawings to their final drawings and discuss any differences that they suggest.

Student Worksheet when using Learning Center

(suggested answers in red)

What's the Smallest Thing You Know?

Materials

Station 1- Crayons, markers
 Station 2- Size Sorting Cards
 Station 3-3.5 meter long string
 Station 4-Inch/centimeter/
 nanometer ruler
 Station 5-Inch/centimeter/
 nanometer ruler
 Station 6-crayons, markers

Introduction to lesson

Measuring an object or assigning a numerical value to the length or height of an object allows you to compare one object's size to another object's size. Starting with station 1 you will use the material in each pocket to complete the instructions included with the station. Include answer on your worksheet when instructed to do so.

Procedure:

Station 1:

Smallest Object	Largest Object
<p style="color: red; text-align: center;">May include any small object</p>	<p style="color: red; text-align: center;">May include any large object</p>
Name of object	Name of object

Station 2:

Largest Object to Smallest Object

___elephant___, ___pygmy shrew___, ___paramecium___,
 ___amoeba___, ___bacteria___, ___Water molecule___,
 ___Atom___

Question 3: Which object is smaller than bacteria? ___water molecule or atom___

Which object(s) is/are larger than the pygmy shrew ___elephant___

Station 3:

What is something that would be the same size as an elephant? Example answers might include a car or bus

Would you be able to get an elephant in your classroom? No Why or why not? To big to get through door

What was the smallest object in your cards? Atom

Can you find this object in your classroom? yes If so where? Make up everything in classroom

Station 4:

Draw a line 3 inches long below:

Would draw a line three inches long

What is an object in your classroom that would be the same size as the line you just drew? Example might be a pencil, a crayon

Length of the line you drew in centimeters 7.6 cm and nanometers _____.

Station 5:

Object 1 name _____ Length _____ These would depend on what they choose

Object 2 name _____ Length _____

Object 3 name _____ Length _____

Object 4 name _____ Length _____

Why did you measure these objects using the measurement that you did (inches, centimeters, or nanometers)? Answers will vary

Station 6:

Smallest Object	Largest Object
Atom or water molecule	Elephant
Name of object	Name of object

Assessment and rubrics:

Assessment of this activity can be determined by the pre and post drawing that the students produce. Determine if they have changed the large and small objects that they originally drew to even larger and smaller scaled objects. Or, you may have students complete the extension activity.

Cleanup:

Cleanup will include putting up drawing materials, size sorting cards, and measuring devices.

Resources:

- Stevens, S., Sutherland, L.; and Krajcik, J., *The Big Ideas of nanoscale Science and Engineering: A guidebook for Secondary Teachers*, NSTA Press, 2009
- Wells, R. *What's Smaller Than A Pygmy Shrew?*, Albert Whitman & Company, 1995.
- *A framework for k-12 Science Education: Practices, Crosscutting concepts, and core Ideas*, The National Academies Press, 2011

Sources of images for cards:

Elephant

<http://www.telegraph.co.uk/news/newsttopics/howaboutthat/1952452/Swiss-couple-on-safari-has-close-encounters-of-the-elephant-kind.html>

Pygmy Shrew

<http://www.flickr.com/photos/sam2cents/512599584/>

Lady bug

<http://naturescrusaders.wordpress.com/2009/05/04/ladybug-goo-best-offence-is-best-defense/ladybug-2/>

Amoeba

http://www.biologyjunction.com/protozoan_notes_b1.htm

Paramecium

<http://kersteaheartsbio.blogspot.com/2008/12/protists.html>

Bacteria

<http://sustainabledesignupdate.com/2007/11/409/>

National Nanotechnology Infrastructure Network

www.nnin.org

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Water molecule

http://commons.wikimedia.org/wiki/File:Water_molecule_2.svg

Water molecule showing atoms

<http://www.webbofscience.com/2009/06/06/molecule-of-the-week-water/>

Picture of a Quark

<http://newscenter.lbl.gov/feature-stories/2005/10/27/closing-in-on-the-elusive-glueball/>

To learn more about nanotechnology, here are some web sites with educational resources:

<http://education.nin.org>

www.molecularium.com

<http://pbskids.org/dragonflytv/nano/index.html>

<http://nanozone.org/>

National Science Education Standards

K-4:

Content Standard A for Science as Inquiry - use simple equipment and tools to gather data;

Physical Science Content Standard B- includes properties of objects and materials

Life Science Content Standard C- understanding of the characteristics of organisms.

National Council of Teachers of Mathematics Measurement Standards

Pre-K-2 Expectations: In pre-K through grade 2 all students should

- Recognize the attributes of length, volume, weight, area, and time;
- Compare and order objects according to these attributes;
- Understand how to measure using nonstandard and standard units

Grades 3-5 Expectations: In grades 3-5 all students should

- Understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute;
- Understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems;
- Carry out simple unit conversions, such as from centimeters to meters, within a system of measurement.

Appendix: Size Sorting Cards



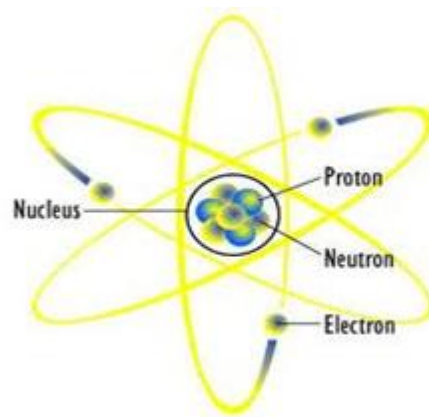
Elephant



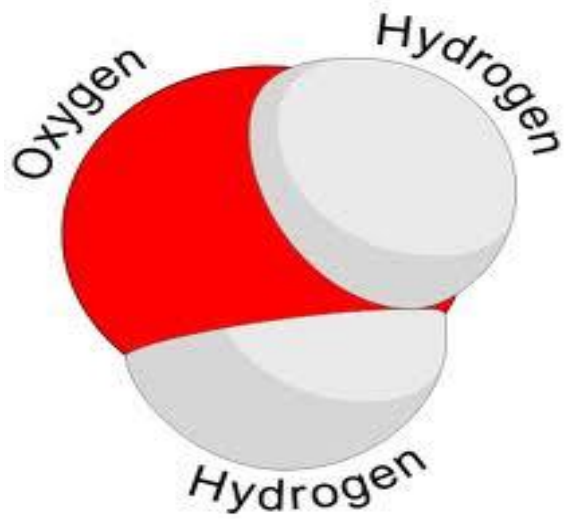
Bacteria



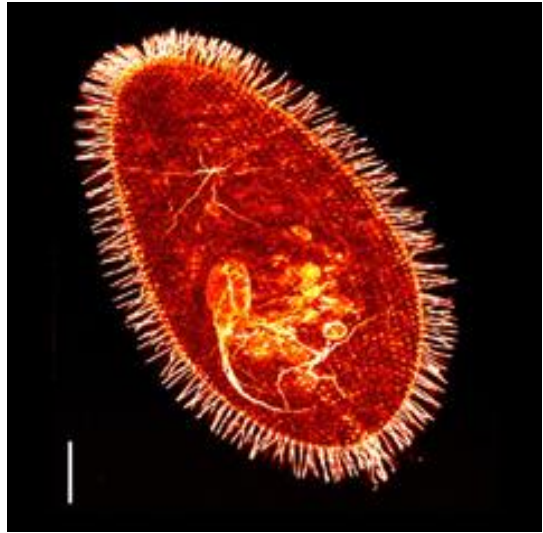
Pygmy Shrew



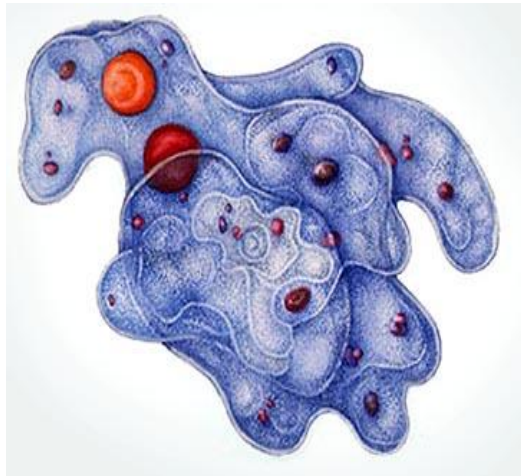
Atom



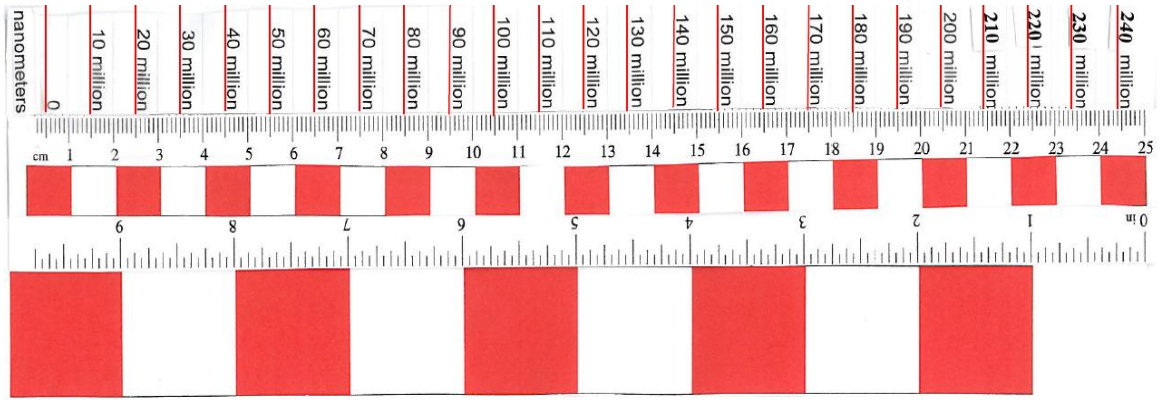
Water Molecule



Paramecium



Amoeba



Because this is a copy you will need to enlarge the ruler so that it is the correct size.

Extension Activity

Student Worksheet

(suggested answers in red)

What is the smallest thing that you know?

Materials

- Reference material located in media center or online

Introduction to lesson:

Measuring an object or assigning a numerical value to the length or height of an object allows you to compare one object's size to another object's size. In this activity, you will be using measurement of length or height to compare the objects mentioned in the book.

Procedure:

1. Using reference material fill in the following information for the objects below:

African Savannah Elephant

Average height of male elephants ___10 to 13___ feet

Average age when they reach adulthood ___20___ years

Two interesting facts about elephants that you did not know:

- 1. Answers will vary
- 2.

Source of answers provided ___Answer will vary___

American Pygmy Shrew

Length of a pygmy Shrew including its tail ___3-5___ inches

Average weight ___2-4___ grams

Where is the Pygmy Shrew usually found in North America _____

___Alaska, Canada, Northern United States through Appalachian Mountains___

Source of answers provided ___answers will vary___

Ladybug

Range in length from ___0.04___ inches to ___0.4___ inches

Why do scientist increasingly refer to these insects as ladybird beetles or lady beetles? _____
Because they are not true bugs

Source of answers provided _____
Answers will vary

Amoeba

Average length of an amoeba is 0.3 mm to 0.6 mm

Why does this length vary? Only has cell membrane that changes shape

The amoeba was first discovered by August Joham Rosel von Rosenhof

Source of answers provided Answers will vary

Paramecium

Average length of a paramecium is 0.07 mm to 0.35 mm

Paramecium are covered by small hair like projections called cilia

which help the paramecium move and gather food

Source of answers provided Answer will vary

Bacteria

Average length of bacteria is .0002 mm to .005 mm

Bacteria can range in shape from spheres, rods, and spirals

Bacteria were first observed by Antonie von Leeuwenhoek using a single-lens microscope of his own design.

Source of answers provided Answers will vary

Atom

Diameter of atoms can vary from 0.1 nm to 0.5 nm

The atom is the basic unit of matter.

Atoms are made up of protons, neutrons, electrons,

and quarks.

Source of answers provided answers will vary

Analysis:

Convert the following

1. Your elephant height in feet to meters
1 meter = 3.28 feet so 10 feet / 3.28 ft/m = 3.05 meters
2. Your Pygmy Shrew length from inches to centimeters
1 inch = 2.54 centimeters so 3 inches x 2.54 cm/in = 7.62 centimeters
3. Your ladybug length from inches to centimeters
1 inch = 2.54 centimeters so .04 inches x 2.54 cm/in = .1016 cm
4. How much larger than the Pygmy Shrew is the elephant (set up a ratio)
Elephant 1 m = 100 cm so 3.05 meters x 100 = 305 centimeters so
Elephant/pygmy shrew = 305 cm/7.62cm means elephant is about 40
larger than Pygmy Shrew
5. Which is larger the average length of an amoeba or the average length of a Bacteria? Amoeba

Bonus: How much larger is the average bacterium than an atom?

Bacterium 1 mm = 1 000 000 nm so .0002 mm x 1 000 000 = 200 nm

Bacterium/ atom so 200 nm/.1 nm = 200 times larger

Draw Conclusions:

What is the largest object that you know? *Answers will vary*

What is the smallest object that you know? *Answers will vary*