Teacher's Preparatory Guide

Sometimes We Need Large Numbers to Describe Small Things

Purpose:
The purpose of this lesson is to help students visualize how small a nanometer is by relating the size to the numbers- millions, billions and trillions and then relating those numbers to how small particles of matter are. It begins to lay the foundation for future learning about atoms in the middle grades.
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Time required:
Two class periods

Level:
Elementary Grades 3-5

Teacher Background:
In the book *How Much is a Million?* author David M. Schwartz, along with illustrator Steven Kellogg, help young readers conceptualize — and more importantly visualize — how much a million actually is. The book does this with the help of Marvelosissimo the Magician. Marvelosissimo magically stands a million children on each other's shoulders. He waves his wand to create a goldfish bowl for a million goldfish — and large enough to contain a whale. He conjures 100,000 stars spanning seven pages of the book and states now just take this seven-page journey ten times.

The National Council of Teachers of Mathematics states that for students to understand measurable attributes of objects and the units, systems, and processes of measurement a fifth grade student should be able to:

- 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;
- Understand that measurements are approximations and how differences in units affect precision;

The *National Science Education Standards* states that students in grades K-4 (Physical Science Content Standard B) have established the idea that the particles of matter have the same properties as the parent material; that is they are a tiny piece of the substance. This lesson gives an opportunity for students to see how small those tiny pieces of matter can be.

In the book *The Big Ideas of Nanoscale Science and Engineering A Guidebook for Secondary Teachers*, it states that certain aspects of size and scale are particularly relevant to nanoscale science and engineering. The most fundamental aspect is the definition of the nanoscale and

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how it relates to other scales. This lessons helps students begin to learn size and scale concepts that they may later use in their study of atoms in the middle grades.

A nanometer is one-billionth (1×10^{-9}) of a meter. So for students to understand what one out of a billion would be they must first understand what a billion is. Depending on the atom it would take between 3-10 atoms end-to-end to make a length of one nanometer. Relating objects that are nanometers in size to larger, more familiar objects can help students understand just how small this measurement is. One nanometer is about the size of 10 hydrogen or 5 silicon atoms and the width of a human hair is about 60,000 to 100,000 nanometers. Objects that are a few to several hundred nanometers in width are called nanoparticles.

Materials:

Book *How Much is a Million* by David M. Schwartz (1985, HarperCollins Publishers, ISBN 978-0-688-09933-6)
Ruler (inches and centimeters)
10, 100, and 1000 bead containers (Used in this center were 6 mm airsoft air gun pellets by Crosman Airsoft) (Plastic containers can be any small clear container that can Hold beads)
Becker Bottle

Flinn Scientific AP4559
10 Bead Card (Index card with 10 of the beads glued in a line)
Measuring tape (inches and feet) (Any length can be used)
Solid, Liquid, Gas Phase Containers (Made out of clear CD cases and air pellet beads; a picture of containers are included at the end of the lesson)
Sheets of drawing paper
Tri-fold sheets (pattern included in lesson)
Center bucket (Picture of bucket used for this lesson included at end of lesson; Can be a plastic container with a lid)

Advance Preparation:

Teacher will either purchase the book or access it at the school media center. The lesson can be teacher led or center based.
Instructions for creating center: Center cards are included in appendix of this lesson. They will need to be printed, laminated, and cut. The container for the center needs to have several pockets. Pictures of an example container are below.

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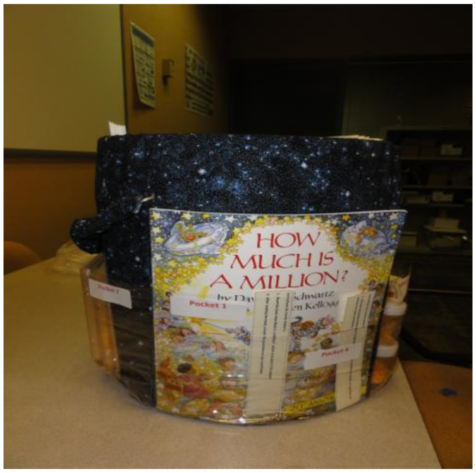

A learning center made out of a bucket that has several pockets inside and out.

The following materials should be put into numbered pockets in the container:
Pocket 1-Instruction card and book *How Much is a Million?*
Pocket 2- Instruction card, container of 10 beads, container of 100 beads, and container of 1000 beads
Pocket 3-Instruction card, plain paper, ruler
Pocket 4-Instruction card (beaker bottle should be in learning center container)
Pocket 5-Instruction card, card with 10 beads glued side-by-side, ruler
Pocket 6-Instruction card, tape measure
Pocket 7- Instruction sheet, Solid, liquid, and gas containers (picture of cases follow in the Appendix-they can be made by adding beads to empty cd cases)
Pocket 8-Instruction sheet, trifold sheets (copy in appendix)

Safety Information:
Small beads are used in this lesson. If the beads are a concern for your students use a larger object.

Lesson Procedure:
Below is a guided dialogue for the lesson if teacher-led. If this lesson uses the center approach, the instructions for the eight parts of the center are included in the appendix and the students will complete the center using the worksheet**.**

Essential Question: Why in science do we need large numbers like millions, billions, and trillions?

1. Read the book *How Much is a Million?* by David M. Schwartz to the class.
   A. On the worksheet have students circle the numbers one million, one billion, and one trillion.
   B. Ask "How many millions would it take to make a billion, a trillion?"
   C. Ask "How many billions would it take to make a trillion?"
   D. Ask students to complete. "So a billion is ________ times larger than a million and a trillion is ______ larger than a billion."

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2. Question: Does increasing or decreasing the size of a number by 10 make a difference?
   A. Look at the container that has 10 beads.
   B. Look at the container that as 100 beads. That container has 10 times more beads than the first container.
   C. Look at the container that has 1000 beads. That container has 10 times more beads than the 100 bead container.
   D. Think about how the number of beads would have looked if we had increased by 100 each time.
3. What would happen if we increased or decreased the size of something by 10?
   A. Measure the sides of the box on your worksheet in inches and centimeters. Write on worksheet your measurements in both inches and centimeters.
   B. On a sheet of drawing paper, draw the box 10 times larger. Take your length and multiply by 10. That is the new length of your sides.
   C. On the same sheet of paper, draw a box that would be 10 times smaller than the box you measured. Take the length and divide by 10. That is the length of the sides of the new box.
   D. Would you be able to draw the box on your worksheet 100 times larger on the sheet of paper that you have? Why or why not?
4. What would the number of beads look like when you increase them by 10 each time to a million?
   A. Take out the Becker Bottle. This bottle contains one million beads. In the container are 100,000 yellow beads. Are the yellow beads hard to find in the container?
   B. In the container are also 10 green beads. Move the jar around and see how many green beads you can find. Are the green beads hard to find? Why or why not?
   C. There is one black bead in the container. Did you see it?
   D. Do you think a million objects are a lot of objects? Why or why not?
5. Question: What length would a million beads lined up end to end be?
   A. On Card A you have 10 beads lined up. Measure the length in both inches and centimeters.
   B. What would be the length of a 100 beads in inches? In centimeters?
   C. What would be the length of a 1000 beads in inches? In centimeters?
   D. What would be the length of a 10,000 beads in inches? In centimeters?
   E. What would be the length of 100,000 beads in inches? In centimeters?
   F. What would be the length of 1,000,000 beads in inches? In centimeters?
   G. What would be the length of 1,000,000,000 beads in inches? In centimeters?
   H. Could you line the one million beads up in your classroom?
6. Question: Could you line up the one million beads in your classroom?
   A. Measure the length of your classroom using the measuring tape. If the tape is not long enough figure out how to use it to measure the room.
   B. How many classrooms would it take to line up a million beads?
   C. How many classrooms would it take to line up a billion beads?
7. Question: How many Cesium atoms (or particles) could be lined up end-to-end across a centimeter?
   A. Write your guess _____________.
   B. Background Information:

      All things are made of **matter**. Matter has three forms. It can be a solid, liquid or, gas. The smallest particle of matter is called an **atom**. One of the largest of the particles called atoms is the Cesium atom. Matter has **properties**. A property

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describes how matter looks or behaves. One way to describe matter is to measure how long, high, or wide it is. You can use a ruler, a meter stick, or something larger or smaller to measure with. A **centimeter** is a unit used to measure length-, width, or height. A **nanometer** is another unit used to measure length, width, or height. It would take 10,000,000 nanometers to equal the length of one centimeter. The Cesium atom is .7 nanometers across.

C. Look at the plastic cases that are labeled solid, liquid, and gas. We are going to let these beads represent the particles that make up a solid, liquid, and gas. Move the containers around. The solid beads move only a little bit, the liquid beads can roll around some, but the gas beads are spread out and can move fast in the container.

D. On your worksheet draw what the particles (atoms) that make up a solid, liquid, and gas look like.

E. On your worksheet draw, in the box provided, the smallest thing that you know. Estimate the length in centimeters and write on your worksheet.

F. Draw a line that is one centimeter in length on your worksheet.

G. Looking at the length of 10 beads from step 5A, what is the length of a single bead?

H. Would you describe this object as being large or small? Why?

I. Using the following, determine how many Cesium atoms would fit across the centimeter length that you have drawn.
1 centimeter = 10,000,000 nanometers
1 Cesium atom = .7 nanometers average diameter (across)

J. Are the Cesium atoms smaller than the beads you have been working with?_________

8. Complete the tri-fold giving examples of things that you would need the numbers million, billions and trillions to describe.

Cleanup:
All materials can be returned to the pockets of the center except the drawing paper and tri-fold which the students will attach to their worksheet.

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Student/Center Worksheet
(answers in red)

Sometimes We Need Large numbers to Describe Small Things

Introduction

You will be working on activities contained in a center or given instructions by your teacher. If completing the worksheet using center, each activity is labeled and the instructions to each activity is included at the center. You are to record your answers for activities on this worksheet.

Write one example of when you would need to use a number like a million, billion, or trillion.

__________(examples may include stars in the sky, ants in a mount, grains of sand on beach etc.)_______________

Activities:

1. A. Read the book *How Much is a Million?* or after listening to teacher
   B. Circle the number one million
      1,000,000,000,000
      1,000,000,000
      1,000,000
      1,000
   C. Circle the number one billion
      1,000,000,000,000
      1,000,000,000
      1,000,000
      1,000
   D. Circle the number one trillion
      1,000,000,000,000
      1,000,000,000
      1,000,000
      1,000

   E. Complete the following statements.
      It would take ___1,000________ millions to make a billion.
      It would take ___1,000,000________millions to make a trillion.
      It would take ____1,000_______billions to make a trillion.
      A billion is ____1,000________ times larger than a million and a trillion is ____1,000_______ times larger than a billion.

2. After looking at the containers with the 10, 100, and 1000 beads think about the following question. Would the containers have looked different if you had increased from one container to the next by increasing by 100 each time? ___yes___________ If your answer was yes, how would they have looked different? ____Example answer: Each time there would have been a lot more beads.____________

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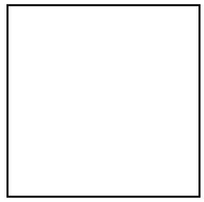
3. A. Measure the box below in both inches and centimeters. Write your measurements below the box



Each side 1 inch or 2.54 centimeters

B. Using a separate sheet of paper, make a drawing of this box 10 times larger and attach it to your worksheet. (Sheet would have a box that was 10 inches by 10 inches or 25.4centimeters by 25.4 centimeters)

C. Would you have been able to draw the box 100 times larger on the sheet of paper you were given? _No____ Why or why not?_Paper would have to be at least 100 inches wide and long__

4. A. Were the yellow beads hard to find?__No they were hard to see___________

B. Are the green beads hard to find? _yes_ Why or why not? _Most students may say they did not see a green bead because there are so many of the yellow and blue beads._

C. Did you see the black bead? _Most students may not see the black bead__

D. Is a million beads a lot of beads? __Most students will say yes_ why or why not? (Answer will depend on student)___

5. A. Length of 10 beads. __2 ¼ or 2.25_inches ___5.9 or 6__centimeters

B. Length of 100 beads ____22.5___ inches ____60.0___centimeters

C. Length of 1000 beads ____225_ inches ___600_____centimeters

D. Length of 10,000 beads ____2,250__ inches _____6,000____centimeters

E. Length of 100,000 beads ___22,500___ inches ____60,000_____centimeters

F. Length of 1,000,000 beads ___225,000__ inches ___600000____centimeters

G. Length of 1,000,000,000 beads _225,000,000 inches _600,000,000_centimeters

H. Could you line the one million beads up in your classroom? __No_ 225,000,000 is 18,750,000 feet or 3,551 miles

6. A. Length of classroom __Example 40 feet______________________

B. Number of classrooms to line up a million beads. ___18,750,000 divided by 40 equal 218,750 classrooms__

C. Number of classrooms to line up a billion beads. ___218,750,000______________

7. A. How many Cesium atoms (particles) could be lined up across the length of a centimeter? ___(student guess)____________________

B. In the box below draw the smallest object that you can think of and write down what you think the length would be in centimeters.

Smallest Object	Length in Centimeters
Examples might include ants, beads, sand	Students guess

C. Using your ruler draw a line that is one centimeter in length on your worksheet.

D. Length of a single bead. ___(2.25 divided by 10 = .25 inches)____________
E. Is this bead large or small? ___(Student answer)_________ How do you know? _____(Student Answer)______

F. Calculate how many cesium atoms (particles) would fit across the length of a centimeter. Show your work and circle your answer.
1 centimeter = 10,000,000 nanometers
1 cesium atom = .7 nanometers average diameter

10 000 000 nanometers/centimeter divided by .7 nanometer/atom

= ___14285714.29_______________ atoms/ centimeter

Draw Conclusions
1. Using the tri-fold in the center, give examples of things that you would need the numbers million, billion, and trillion to describe. (Will include at least two examples for each)

Assessment and rubrics
Use the worksheet answers and the tri-fold as your assessment instruments

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Resources:
To learn more about nanotechnology, here are some web sites with educational resources:
www.nnin.org
http://www.nanooze.org/main/Nanooze/English.html
www.moleculárium.com
http://www.nanowerk.com/n_neatstuff.php
http://nanozone.org/

Books:

- *How Much is a Million? By David M. Schwartz* (1985, HarperCollins Publishers, *ISBN 978-0-688-09933-6)*
- *National Science Education Standards* National Research Council (1996, National Academy of Science, ISBN 0-309-05326-9)
- *The Big Ideas of Nanoscale Science and Engineering : A Guidebook for Secondary Teachers* (2009, NSTA press ISBN 978-1-935155-07-2)

Additional sites for learning about millions, billions, and trillions:
Charles and Ray Eames on Power of 10 http://vimeo.com/819138
http://statistics.about.com/od/Applications/a/Millions-Billions-And-Trillions.htm
http://www.squidoo.com/billion

National Science Education Standards
Grades K-4
Content Standard A: as a result of activities in grades K-4, all students should develop abilities necessary to do scientific inquiry.
Content Standard B: As a result of the activities in grades k-4, all students should develop an understanding of properties of objects and materials.

National Council of Teachers of Mathematics

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Understand numbers, ways of representing numbers, relationships among numbers, and number systems

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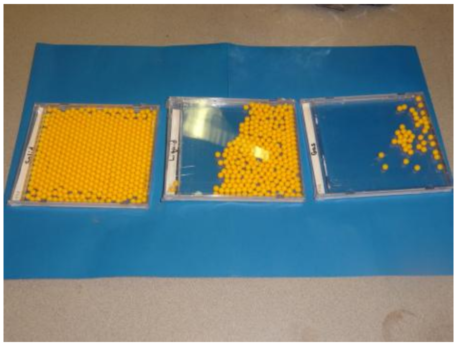
Solid, Liquid, and Gas Phase Containers



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