RESEARCH TRIANGLE NANOTECHNOLOGY NETWORK

How Small is a Nanometer?

Overview

This lesson is designed to create a conceptual understanding of the size and scale of nano. It works to answer questions such as what is the nanoscale and allows students to create their own examples of the difference between a nanometer and a meter using objects from their everyday life. This lesson begins with a provided google slides presentation which walks through necessary background information before introducing the activity for students. This activity focuses on students creating their own scale, where an object of their choice represents a nanometer with the goal of applying their scale to help gain a conceptual understanding of the size of a nanometer relative to a meter. After groups complete the handout or finish the task, they will share their findings with the class through a google slide presentation. Students should gain a conceptual understanding of the size of a nanometer through their scale.

Key Search Words

Math 1, nanotechnology, nanometer, hands-on, scientific notation, metric conversions, proportions

Learning Objectives

Students should be able to:

- understand scientific notation and how to convert between metric units
- create and solve one variable linear (quadratic) equations
- have a conceptual understanding of the size of a nanometer

Curriculum Alignment

NC.M1.A-CED.1
Create equations and inequalities in one variable that represent **linear**, exponential, and quadratic relationships and use them to solve problems.

NC.M1.A-REI.3
Solve linear equations and inequalities in one variable.

Classroom time required

50 minute class period

Lesson launch/ explanation: 10-15 minutes
- includes background information and a little about why this is important in presentation format

Activity: 20-30 minutes
- students will work in groups to create their own size comparison and make a presentation

Presentations: 10-20 minutes (allow about 2 minutes per group)
- students will share their presentations including how they solved the problem and their findings

Materials & Technology

- Meter stick
- Whiteboards and Expo markers to do scratch work/ examples (can substitute with paper and pencil)
- Teacher presentation (access to google slides for the teacher)
- Student Handout
- Printer access
- Access to google slides (or workspace of choice) for student presentations (teacher and students)
- Computers for each student (If unavailable can be done with one computer per group)

Safety

There are no special safety considerations for this activity.

Teacher Preparation for Activity

Teachers should do the following before beginning this lesson:

- review slides (make a copy and edit if necessary)

- make a copy of the Student presentation slides and share with students (can wait to share until class)
- try the activity yourself (optional)
- create groups or have a plan on how to divide students

Student Preparation for Activity

Students should have a basic understanding of scientific notation, exponent rules, and metric prefixes before beginning this lesson. The presentation does include some review on scientific notation and metric prefixes. Students should know what a scale factor is.

Procedure

1. Have the teacher slides ready to go at the start of your lesson
2. Present the slides to the students
    a. Slide 2 introduces the idea of nano; future slides will go into further detail. Be sure to talk about what 10^-9 is and emphasize just how small it is!
        i. For example 10^-9 of one billion dollars is just one dollar (and a billion is 1,000 million)
        ii. A hair is about 60 micrometers or 60,000 nanometers wide
    b. Slides 3-5 may be review- take time as needed
        i. Slide 3 reviews scientific notation. This is strictly about writing the same number in a different format (no conversions are being made yet).
        ii. Slide 4 introduced metric conversions and prefixes. If possible, try to pass around a meter stick so students can see a few examples (meters, centimeters, millimeters, etc) and gain a conceptual understanding of what a meter is.
        iii. Slide 5 has an example of a conversion being worked out. This slide is critical as it introduces how to do the problems that students will be asked to do by themselves later in the student activity.
    c. Slide 6 has examples of unit conversions: allow students to solve these individually on their whiteboards (or scratch paper) before asking for volunteers/ working out problems on the board. **Answers and solutions are provided in the appendix**
        i. be sure to emphasize the use of one variable equations here
    d. Slide 7 has a link to a figure which shows the size of various objects on the nanoscale: you can choose to go over all of them or pick a few of the most interesting examples
    e. Slide 8 begins the activity introduction
        i. note that if you have class norms already or have different rules in your classroom you may choose to edit slide 8
    f. For slide 9, ask students about the biggest and smallest things they have seen. Be sure to encourage opposite ends of the scale. Also, note you may want to edit this slide to add your students' examples. This slide is just to get them thinking. **All examples must be visible to the naked eye.**
3. When you reach the student activity (slides 10 and 11), explain the activity then assign groups and allow students to split off into their groups (set a timer if needed). If you haven't already, now would be a good time to **share the student presentations slide with your students.**
    a. In groups, students will create their own example of the difference between a nanometer and a meter using objects from their everyday life.
    b. Their chosen objects must include one small object and one large object. Both of these objects must be something they can physically see with the naked eye and something they have seen.
4. Pass out the student handout if applicable (see appendix for a copy of the handout)
5. Walk around the classroom while students are working on the activity and help students as needed
    a. ensure presentations are on track and in the right place as you go
6. Have each group present their slides
    a. Allow about 2 minutes for each presentation
    b. Presentations should include group members' names, pictures, and how many of their large objects represent a single meter on their scale. Groups should also be prepared to share their work, their ideas, and answer questions.
    c. allow for questions and time for students to visualize/ conceptualize each example
7. If you have extra time consider trying an example with area or volume as a class

Differentiation

Some possible modifications to this lesson include:

- To make the activity more challenging:
    - Using the same concept but instead of length using area or volume
        - students would scale their small object to be $1\ nm^2$ or $1\ nm^3$
    - Having students work individually

- To make the activity less challenging:
    - Giving the students a worked out example of the activity

Assessment/Check for Understanding

The intended assessment for this lesson is the students' presentations to the class. Teachers can assess understanding by checking the accuracy of students' presentations and judging their comfort with the nanoscale.

Alternatives:

- Some students may be unable or unwilling to present in front of the class, these students could be assessed on their contributions to their groups slide or present to just the teacher. Ideally, teachers will create work groups where at least one student will be able to present and encourage participation within groups rather than putting pressure on the presentation itself.
- Another method of assessment would be to require the handout and collect it to check for understanding of metric conversions, scientific notation, and creating and solving one variable equations.

Required resources

How small is a nanometer? Teacher Slides

- This slide deck contains everything needed for the lesson including background information, examples, the student activity, and the same link to the student presentations. **Important**: once you make a copy of the student presentations you will need to use that link.

Student Presentations

- This is a slide deck for you to create a copy of and share with students so groups can each use a slide for their presentation.

Handout (optional- can be found in the appendix)

- There is a slide on the teacher slides which has the instructions and questions contained on the handout but if you or your students prefer having a physical worksheet this handout can be passed out when you get to the activity.
- Use the handout found here if you would prefer for students to work individually

Teacher Key (found in the appendix)

- The teacher key contains solutions for all the examples included in the teacher slides worked out as well as an example of the completed handout. There is no key for the handout since students have the freedom to choose their own objects.

Author comments

- When doing examples emphasize the use of one variable equations
- develop a common language with your students, and make sure they understand any vocabulary before starting the activity
- try to ask questions and involve students as much as possible
- do not give an example of the activity itself or tell students how to solve unless modifying the lesson as this will significantly lower cognitive demand (see differentiation)
    - there is an example available for your use but it is strictly intended for the teachers understanding to allow you to help your students

Sources

https://introtonanotechnology.weebly.com/the-nanoscale.html

Appendix

Please attach any student handouts (with answer keys if available) to the end of your lesson.

How small is a nanometer?

Student Worksheet

Instructions:
In groups, you are going to create your own example of the difference between a nanometer and a meter using objects from your everyday life.

Your chosen objects must be:
- One small object
- One large object
- Something you can physically see the size of with the naked eye
- Something you have seen before

For each question, you must show your work and where applicable write an equation

We chose _____ as our small object.

We chose _____ as our large object.

Our small object is _____ long. *hint: include units
You can use the length of a side or diameter if applicable

Our large object is _____ long. **hint: include units*

For the following questions you must show your work: do not try to use the internet

How many meters is your small object? (write and solve an equation)

How many meters is your large object? (write and solve an equation)

How many nanometers is your small object? (write and solve an equation)

Prefix	10^n	Abbreviations
tera-	10^{12}	T
giga-	10^{9}	G
mega-	10^{6}	M
kilo-	10^{3}	k
hecto-	10^{2}	h
deca-	10^{1}	da
(none)	10^{0}	*(none)*
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	µ
nano-	10^{-9}	n
pico-	10^{-12}	p

Creating your own scale:

Set the length of your small object to be 1 nanometer. What is your scale factor? (write and solve an equation)
**hint: what do you need to multiply the actual length of your small object by to get 1 nanometer?*

Use your scale factor to scale a meter. According to your scale: how many meters represent a scaled meter?

Use the information above to find how many of your large objects represent one meter. Show your work.

Create a presentation to share your findings with the class!

How small is a nanometer?

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mega-	10^{6}	M
kilo-	10^{3}	k
hecto-	10^{2}	h
deca-	10^{1}	da
(none)	10^{0}	*(none)*
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	µ
nano-	10^{-9}	n
pico-	10^{-12}	p

Student Worksheet: Teacher Key

Instructions:
In groups, you are going to create your own example of the difference between a nanometer and a meter using objects from your everyday life.

Your chosen objects must be:

- One small object
- One large object
- Something you can physically see the size of with the naked eye
- Something you have seen before

For each question, you must show your work and where applicable write an equation

We chose a blueberry as our small object.

We chose A football field as our large object.

Our small object is 10 millimeters (diameter) long. *hint: include units
You can use the length of a side or diameter if applicable

Our large object is 110 meters long. **hint: include units*

For the following questions you must show your work: do not try to use the internet

How many meters is your small object? (write and solve an equation)

$10\,mm = x\,m$

$10\,\frac{millimeters}{meters} \bullet \left(\frac{1\,meter}{1000\,millimeters}\right) = x$

$\frac{10}{1000} = 10 \div 1000 = 0.010$

$x = 0.01 = 1 \bullet 10^{-2}$

$10\,mm = 0.01\,m = 1 \bullet 10^{-2}\,m$

How many meters is your large object? (write and solve an equation)

$110\,meters = x\,meters$110 meters = x meters

$x = 100$

How many nanometers is your small object? (write and solve an equation)

$1 \bullet 10^{-2}\,m = x\,nm$

$1 \bullet 10^{-2}\,\frac{meters}{nanometers} \bullet \left(\frac{1 \bullet 10^{9}\,nanometers}{1\,meters}\right) = x$

$(1 \bullet 10^{-2}) \bullet (1 \bullet 10^{9}) = 1 \bullet 10^{7} = x$

$1 \bullet 10^{-2}\,m = 1 \bullet 10^{7}\,nm$

Creating your own scale:

Set the length of your small object to be 1 nanometer. What is your scale factor? (write and solve an equation)
**hint: what do you need to multiply 1 nanometer by to get the actual length of your small object?*

$(1\ nm)\ \times x\ =\ 1\ \bullet\ 10^{7}\ nm$

$x\ =\ (\frac{1 \bullet 10^{7}\ nanometer}{1\ nanometers})$ = $1\ \bullet\ 10^{7}$

scale factor: $1\ \bullet\ 10^{7}$

Use your scale factor to scale a meter. According to your scale: how many meters represent a scaled meter?

$1\ meter\ \times\ 1\ \bullet\ 10^{7}$ = $1\ \bullet\ 10^{7} meters$ represents 1 actual meter

Use the information above to find how many of your large objects represent one meter. Show your work.

$(1\ \bullet\ 10^{7} meters)\ \div\ 110\ meters\ =\ 90,909.1\ football\ fields$

Create a presentation to share your findings with the class!

Teacher slides Key:

1. $x\,m = 1\,nm$

   $x = 1\,\frac{nanometers}{1\,meters}$

   $x = (1\,\frac{nanometers}{1\,meters}) \bullet (\frac{1\,meter}{10^{9}\,nanometers})$

   $x = 10^{-9}$

   $10^{-9}\,m = 1\,nm$

2. $\frac{1\,meter}{x\,nanometers} = 1$

   $1\,meter = x\,nanometers$

   $(\frac{1\,meter}{nanometers}) \bullet (\frac{10^{9}\,nanometers}{1\,meters}) = 10^{9} = x$

   $x = 10^{9}$

   $1\,m = 10^{9}\,nm$

3. $3.6\,km = x\,\mu m$

   $3.6\,km \bullet (\frac{1 \bullet 10^{3}\,meters}{1\,kilometer}) = 3.6 \bullet 10^{3} m = x\,\mu m$

   $3.6 \bullet 10^{3} m = x\,\mu m$

   $3.6 \bullet 10^{3}\frac{meters}{micrometers} = x$

   $(3.6 \bullet 10^{3}\frac{meters}{micrometers}) \times (\frac{1 \bullet 10^{6}\,micrometers}{1\,meters}) = 3.6 \bullet 10^{9} = x$

   $3.6\,km = 3.6 \bullet 10^{9}\,\mu m$

4. $45,200\,nm = x\,mm$

   $(45,200\,\frac{nm}{mm}) \bullet (\frac{1\,meter}{1 \bullet 10^{9}\,nanometers}) \bullet (\frac{1 \bullet 10^{3}\,millimeters}{1\,meters}) = x$

   $0.0452 = 4.52 \bullet 10^{-2} = x$

   $45,200\,nm = 0.0452\,mm = 4.52 \bullet 10^{-2}\,mm$

5. $5 \bullet 10^{-5}\,cm = x\,nm$

   $5 \bullet 10^{-5}\,\frac{centimeters}{nanometers} \bullet (\frac{1 \bullet 10^{9}\,nanometers}{1\,meters}) \bullet (\frac{1\,meter}{100\,cm}) = x$

   $x = 500$

   $5 \bullet 10^{-5}\,cm = 500\,nm$

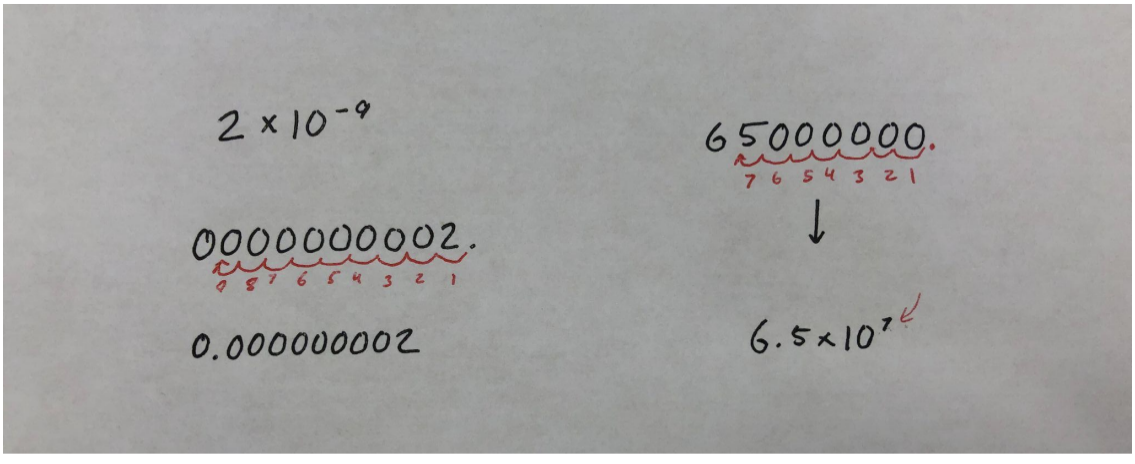
Slide 9: Allow students to make their own examples. Below are some ideas:
small: sand, salt, ladybug, dime, diameter of pencil lead, human hair, etc
large: football field, house, cruise ship, school bus, etc

How small is a nanometer?

What is a nanometer?

- A nanometer is a very small unit of measurement
- A nanometer is 10^-9 meters

Scientific notation review



Metric conversions

Prefix	10^n	Abbreviations
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mega-	10^{6}	M
kilo-	10^{3}	k
hecto-	10^{2}	h
deca-	10^{1}	da
(none)	10^{0}	*(none)*
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ
nano-	10^{-9}	n
pico-	10^{-12}	p

If you have a 6 millimeter diameter blueberry, how many meters is the diameter of the blueberry?

$$6\,mm = x\,m$$

$$6\,\frac{millimeters}{meters} \bullet \left(\frac{1\,meter}{1000\,millimeters}\right) = x$$

$$\frac{6}{1000} = 6 \div 1000 = 0.006$$

$$x = 0.006$$

$$6\,mm = 0.006\,m$$

Examples

1. How many meters is a nanometer?
2. How many nanometers are in a meter?
3. 3.6 km = x micrometers (solve for x)
4. 45,200 nm = x mm (solve for x)
5. 5 * 10^-5 cm = x nm (solve for x)

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mega-	10^{6}	M
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hecto-	10^{2}	h
deca-	10^{1}	da
(none)	10^{0}	*(none)*
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ
nano-	10^{-9}	n
pico-	10^{-12}	p

Size and scale

Click here to view a figure depicting the size of some common objects on the nanoscale.

https://introtonanotechnology.weebly.com/the-nanoscale.html

Expectations

- Participate
- Respect and listen to your group members
- Remain on task
- Raise your hand if you need help

What are the smallest and largest things you have ever seen?

Smallest	Largest

Activity Introduction

In groups you are going to create your own example of the difference between a nanometer and a meter using objects from your everyday life.

Your chosen objects must be:

- One small object
- One large object
- Something you can physically see the size of with the naked eye
    - For example you cannot see the entire ocean or an atom so these would not be suitable objects
- Something you have seen before (for example if you have never seen a blue whale, do not choose blue whale as your big object)

Work slide (handout)

For each step students should show all of their work and write equations where applicable

- Choose a small object and large object
- Find the length of both objects *hint include units*
- Find the length of both objects in meters. Write an equation (do not use the internet)
- Find the length of your small object in nanometers. Write an equation.
- Create your own scale by scaling your small object to be 1 nm
- Use the same scale to calculate how many of your large object represent 1 meter

Create a slide on the student presentation to share your findings

Presentations

Student Presentations