
Scale Inquiry Activity: Cut To Size

Instructor Guide

Notes to Instructor

This activity is an inquiry activity for the *Comparison of Scale Learning Module*. This activity allows the participants to explore the macro, micro and nano- scales. It helps the participants to begin thinking about the types of objects found in the micro and nano-scales. This activity is supported by a primary knowledge unit, additional activities, and an assessment.

This activity would be a good inquiry activity prior to assigning or discussing the material presented in the primary knowledge unit.

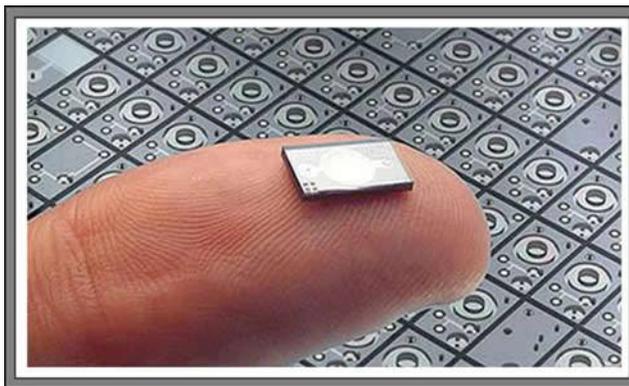
The *Comparison of Scale Learning Module* consists of the following.

- A Comparison of Scale: Knowledge Probe (KP) Pre-test
- A Comparison of Scale: Macro, Micro, Nano (PK)
- **Scale Inquiry Activity: Cut to Size**
- The Scale of Biomolecules Activity
- Scale Activity: Zoom in / Zoom Out
- A Comparison of Scale Assessment

The companion Instructor Guide (IG) contains all of the information in the PG as well as answers to the Post-Activity questions.

Introduction

To understand microsystems, their applications and fabrication, you need to have a good understanding of size and scale. This leads to a better understanding of the function of micro-sized objects and the applications in which they are used.



*Microchip containing a nano-sized insulin pump
[Printed with permission from Debiotech S.]*

For example, this picture shows a microchip of a nano-sized pump used to supply a continuous infusion of insulin to a diabetic. This device is small enough to be mounted on a disposable skin patch. The nanopump inside the micro-size chip is able to control delivery at the nanoliter level, the amount very close to the physiological delivery of insulin⁽¹⁾ This pump is constructed using MEMS technology fabrication techniques.

In this activity you will discover similar devices in the macro, micro, and nano-scales. You will identify objects that exist in each of these scales given a specific length. You will be asked to think of ways that these objects can be used to perform a necessary task.

Description and Estimated Time to Complete

This activity allows you to explore the macro, micro and nano- scales and to begin thinking about the types of objects found in these scales. In this activity you will cut a 20 cm paper ruler in half, then continue to cut each new piece in half until it becomes too small to cut. For each cut, you will identify an object that has the length of the remaining size. Even after the ruler becomes too small to cut, you will continue to identify objects for several lengths all the way down into the nano-scale.

Estimated Time to Complete

Allow approximately 60 minutes to complete this activity.

Activity Objectives and Outcomes

Activity Objectives

- Demonstrate your knowledge of metric scales by identifying at least 15 objects that range in size from the nano-scale to the macro-scale.
- Identify at least 3 macro-size objects that perform the same tasks but in the micro-scale.

Activity Outcomes

For each cut of the ruler you will indicate on a chart the length of the new ruler and at least one object that measures that length. When you are no longer able to cut the ruler in half, you will continue to identify objects that measure specific micro and nano lengths as indicated on the activity chart. By the end of this activity you should be able to answer the following questions:

- How many cuts would it take to get to the size of a water molecule (approximately 1 nm)?
- How do you denote lengths using the metric system?
- What are some objects that overlap the micro and nano-scales?
- What is an object in the micro or nano-scale that performs the same function or task as a macro-sized object?
- What are some tasks that micro or nano-sized objects perform that affect your life?

Team

It is recommended that you complete this activity with one or two other participants. Working with others will promote more discussion and ideas.

Supplies

- One 20 cm long strip of ruled paper. (One is provided on the Cut to Size Activity Chart at the end of this activity).
- One piece of stock paper (or thick printer paper) – if available
- One pair of scissors
- One Cut to Size Activity chart (last 2 pages of this activity)
- One pencil
- Computer with Internet access
- Computer with PowerPoint or Adobe Reader

Documentation

- Record your observations during this activity.
- Complete the Cut to Size Activity Chart.
- Record the results for each step of the activity.
- Revise your hypothesis to reflect the results.
- Summarize your discussions with other participants.
- Answer the Post-activity questions.

Think About the Outcome

Answer the following based on what you think will be the outcome of this activity.

Expectations:

- You will discover functional objects that range from the nano-scale to the macro-scale.
- You will identify micro and nano-sized objects that work as efficiently as macro-sized objects with equivalent functions.

Observations:

- What is the difference between a micro-sized object and a nano-sized object?
- Describe any previous experience or observations that you have had relating to micro and nano-sized objects.
- What types of objects do you think of when you think "micro"?
- What types of objects do you think of when you think "nano"?

Hypothesis:

- Write a statement on what you expect to discover in fulfilling the expectations.

Predictions:

- What types of objects will you find in the micro and nano-scales that perform the same functions as objects macro-scales (> 100 microns)?
- What types of objects will you find in the micro-scale?
- What types of objects will you find in the nano-scale?

Inquiry Activity: Cut To Size

Description

This activity allows you to explore the macro, micro and nano- scales. You will cut a 20 cm long paper ruler as small as you can get it and identify an object that has the length of each cut size. This activity will help you begin to think about objects in the micro and nano-scales.

1. View the Presentation: "Macro, Micro, or Nano?"

Description View either the PowerPoint or Flash version of the presentation "Macro, Micro, or Nano?"

- How did you do?
- How many did you get correct?

2. Print out the Cut to Size Activity Chart

Description

- Print out the Cut to Size Activity Chart at the end of this handout.
- Print page 2 of the chart on stock paper, if available.
- Cut out the metric ruler along the red line.

3. Cut the ruler in half.

Description Cut the ruler in half.
Discard one half of the ruler.
Answer the following questions:

- a. What is the new length of the ruler? Record the length on the activity chart. (Be sure to use metric notation).
- b. Give an example of an object of this size. (You are welcome to Google images for ideas)
- c. What is the function (task) of this object? (i.e. red blood cells (6 to 8 μm in diameter) carry oxygen from the lungs to the body)
- d. Is this object macro, micro, or nano in length? Refer back to the presentation if you need to.
- e. Record your answers to these questions on the chart.

4. Repeat Step 3

Description Repeat step 3 until the ruler gets too small to cut in half.
Use the activity chart to keep track of the number of times you cut.

5. How many cuts did you get?

Description How many cuts did you get before the ruler got too small to cut?

On the activity chart, highlight the number of cuts you were able to do before the last piece was too small to cut.

6. Complete the Activity Chart

Description For the remaining cuts indicated on the chart, answer the following.

- Give an example of an object of this size?
- What is the function of this object?
- Is it macro, micro, or nano?

7. How many cuts to 1 nm?

Description

- Determine how many cuts it would take to get to 1 nanometer.
- How many cuts? _____
- What are two objects that are 1 nm in length or diameter?

8. Revisit your hypothesis and predictions

Description

- Revise your hypothesis to reflect your results.
- How well did your results match your predictions? (Be specific)

9. Answer the Post-Activity Questions

Description Answer the Post-Activity Questions at the end of this procedure.

10. Discuss results with other participants

Description Discuss your activity results with other participants.

11. Write up your documentation

Description See the Documentation section and complete your documentation for this activity.
Submit your documentation as required.

Post-Activity Questions

1. How many cuts would it take to get to the size of a molecule approximately 1 nm in diameter?
2. What types of objects did you find in the micro-scale? Nano-scale?
3. Based on the types of objects that you found in the micro and nano-scales, what types of professions do you think directly utilize the functional capabilities of these objects? (Be specific)
4. What are some objects that overlap the micro and nano-scales?
5. What is an object in the micro-scale that performs the same function or task as a macro-sized object?
6. What are some functions that micro and nano-sized object perform that affect your life?

Post-Activity Questions / Answers

1. How many cuts would it take to get to the size of a molecule approximately 1 nm in diameter?
(Answer: 27 (1.49 nm) to 28 (0.74 nm) cuts) Answers may vary a little based on how the student rounded the numbers; however they should reach "around 1 nm" on the 27th or 28th cut.
2. What types of objects did you find in the micro-scale? Nano-scale?
Answers will vary: (micro-scale) bacteria, grain of sand, point of needles, phytoplankton, skin thickness; (nano-scale) atoms, molecules, antibodies, proteins, viruses, DNA, nanotubes, probe tips, molecular motors
7. Based on the types of objects that you found in the micro and nano-scales, what types of professions do you think directly utilize the functional capabilities of these objects? (Be specific)
Answers will vary: numerous bio-medical professions (research, diagnostics, therapeutics), environmental monitoring, homeland security, consumer product development, genetics, chemist, physicist, engineer...
3. What are some objects that overlap the micro and nano-scales?
Answers will vary: viruses, structures generated (or self-assembled) from nano-sized objects, fibers, various sensors, electronic components, mechanical components
4. What is an object in the micro-scale that performs the same function or task as a macro-sized object?
Answers will vary: linear motors, rotary motors, pumps, probes, gears
5. What are some functions that micro and nano-sized object perform that affect your life?
Answers will vary. Look for answers that indicate that the student has recognized that everything consists of micro and nano-sized objects; therefore they affect our lives in infinite ways.
The nano-sized particles that make up the body protect us from disease, determine our genetic make-up, help to convert food into energy. They can also attack our bodies causing disease.
Micro-sized objects enable us to have computers, PDAs, MP3 players.
Micro-sized objects such as needles and micropumps enable the delivery of minute amounts of fluids (medical applications, consumer products such as inkjet printers)
Nano-sized particles are used to speed up chemical reactions
Micro and Nano-sized particles protect surfaces (Skin, Teflon – respectively)

Summary

This activity allowed you to explore objects in three different scales – macro, micro, and nano. Even though nano, and most micro-sized objects cannot be seen with the naked eye, you should have found that there still exists billions and billions of functional objects within these scales.

It is important that you get a sense of relative size and develop a good understanding of scale and units. This understanding will assist in all aspects of your life.

References

1 "Debiotech's Insulin Nanopump™". MedGadget. April 23, 2007.
http://medgadget.com/archives/2007/04/debiotechs_insulin_nanopump.html

Disclaimer

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For the Instructors – Answers

Cut to Size Activity Chart

Cut #	Length of Paper (as power of 10)	Length of Paper (using metric prefix)	Object	Function of Object	Macro, Micro, Nano
Cut 1	$10 \times 10^{-2} \text{ m}$	10 cm	Coaster	To protect a table top from drips	Macro
Cut 2	$5 \times 10^{-2} \text{ m}$	5 cm	The diameter of a drinking glass	To hold liquids	Macro
Cut 3	$2.5 \times 10^{-2} \text{ m}$	2.5 cm	Answers will vary	Answer depends on object	Macro
Cut 4	$1.25 \times 10^{-2} \text{ m}$	1.25 cm			Macro
Cut 5	$6.25 \times 10^{-3} \text{ m}$	6.25 mm			Macro
Cut 6	$3.125 \times 10^{-3} \text{ m}$	3.125 mm			Macro
Cut 7	$1.56 \times 10^{-3} \text{ m}$	1.56 mm			Macro
Cut 8	$7.8 \times 10^{-4} \text{ m}$	0.78 mm = 780 μm			Macro
Cut 9	$3.9 \times 10^{-4} \text{ m}$	0.39 mm = 390 μm			Macro
Cut 10	$1.95 \times 10^{-4} \text{ m}$	0.195 mm = 195 μm			Macro
Cut 11	$9.75 \times 10^{-5} \text{ m}$	97.5 μm			Micro
Cut 12	$4.875 \times 10^{-5} \text{ m}$	48.75 μm			Micro
Cut 13	$2.44 \times 10^{-5} \text{ m}$	24.4 μm			Micro
Cut 14	$1.22 \times 10^{-5} \text{ m}$	12.2 μm			Micro
Notice we start skipping cuts at this point. So keep track!					
Cut 17	$1.52 \times 10^{-6} \text{ m}$	1.52 μm			Micro

Cut 19	$3.8 \times 10^{-7} \text{m}$	$0.38 \mu\text{m} = 380 \text{nm}$			Micro
Cut 22	$4.75 \times 10^{-8} \text{m}$	47.5 nm			Nano
Cut 25	$5.94 \times 10^{-9} \text{m}$	5.94 nm			Nano
Cut 27	$1.49 \times 10^{-9} \text{m}$	1.49 nm			Nano
Cut 28	$0.74 \times 10^{-9} \text{m}$	0.74 nm			Nano

