Teacher's Preparatory Guide

The Micro and Macro World Around Us

Overview: This activity gives students a sense of size and scale using objects that cannot be seen with the naked eye. This activity focuses on scale and the importance of using scale bars, for this is the most common feature when presenting nanoscale structures or nanoscale science. Understanding size and scale is fundamental to learning about nanotechnology as size defines the nanoscale (1-100nm in one dimension). Size is often divided into scales – macro, micro, nano and atomic. Helping students understand these "worlds" is an important part of their science knowledge and will help them to understand the relatively small size of the nanoscale. It can be introduced into K–12 curriculum by discussing scientific measurement. This activity connects well to the introduction of atoms and cell structures as well as advancements in technology.

Purpose: This activity is designed to help students understand the size and scale of objects that can and cannot be seen with the naked eye.

Time Required: 15 minutes

Level: Elementary, middle school, and high school; general science, life science, mathematics

Big Idea: Size and Scale

Teacher Background: Students often have trouble understanding size and scale in science, due to the different measurement units taught (metric and English), the different types of units used for length and volume, and the lack of consistent practice through their educational career. These lessons are aimed at presenting size and scale to students from kindergarten to high school. Common student misconceptions[1] include:

- mixing units such as centimeters and inches
- not realizing the connection between relative and absolute sizes of two objects
- the inability to use measurement tools accurately
- believing that objects that cannot be seen with the naked eye are approximately the same size

This lesson introduces the importance of using a scale bar with an image. Most pictures that students encounter have a reference scale that is inherent to the subject, for instance, people, buildings and animals. Just as it is important to include units with all measurements, images used as data should have a reference scale. This activity addresses the importance of such a scale as well as demonstrating the beauty of the natural world in all scales.

Source:

1. Stevens, S., Sutherland, L., Krajcik, J., *The Big Ideas of Nanoscale Science and Engineering*. NSTA Press, 2009.

Materials per class:

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- maps of the local area with scale bars on them to show as examples
- *The Micro and Macro World Around Us* PowerPoint or a set of images (from PPT) without a scale and a set of the images with a scale bar (see *Advance Preparation*)

Advance Preparation: Acquire a computer and projector to present the PowerPoint slides that go with this activity (*The Micro and Macro World Around Us*). If this is not possible, you could print out the slides onto transparencies and present them on an overhead or document camera. If you do this, please notice the animations within each slide. For example, slide 2 first presents the top picture only, and when you click, it presents both images (the 2nd image having a scale bar). If you print onto transparency paper and use an overhead projector, please be sure to separate all even-numbered slides into 2 transparencies each: one with the top image only, and the second with both images.

Instructional Procedure: (*for Grades 3 –12*)

Time	Activity
Day 1	**The day of the activity**
5 min	Ask the students to identify the purpose of a scale bar on a map.
15 min	1. Discuss with the students the importance of scale bars on a map. Sample maps can be shown and used as examples. 2. Using images one at a time, ask students to try to identify images from the PPT without the scale bar. Have them compare answers with another student. Then ask for volunteers to justify their image identification by way of a feature in the image or patterns. 3. For each image that you analyze, next show the same image but this time with the scale bar. Now ask the students if they will need to change their answers. Reveal the identification of the object before going on to the next image.
Homework (Grades 7–12)	Have the students create their own images with and without scale bars similar to those in the PPT. Since scale bars may be difficult to incorporate onto a digital image, one option could be to include a penny or their hand as a reference scale. Or, students can draw the scale bar directly onto the picture.

Going Further:

- You can take an image and hide most of the image with a large piece of construction paper revealing only a small portion of the image. Then ask the students to guess what that image may be based on that small piece of information. Encourage class discussion with not only guesses but logical justification. You can model this in class to promote practice in effective scientific articulation.
- Hide an image with a piece of paper of the same size but cut into a grid of at least 24 rectangles. Then reveal part of the image a portion at a time by removing one of the rectangle portions, each time asking the students to guess the identification of the object. Initially, invite the students to choose which rectangles to remove, but subsequently randomize the "data collection". This is a good exercise in data collection and determining the value of a good sample size.
    - It might be helpful to use a piece of "cover" paper that is sticky on the backside so that the rest of the "cover" paper stays adhered to the image while the desired

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parts are taken away. If possible, instead of a grid, one can punch small circles in the "cover" paper so that less data is revealed at each removal.

Cleanup: Collect all materials.

National Science Education Standards (Grades K–4, 5–8, 9–12)

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science

- Properties of objects and materials (Grades K–4)
- Properties and changes of properties in matter (Grades 5–8)
- Structure and properties of matter (Grades 9–12)

Content Standard E: Science and Technology

- Understandings about science and technology
- Abilities to distinguish between natural objects and objects made by humans (Grades K–4)

Principles and Standards for School Mathematics

Measurement

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

Numbers and Operation

- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Compute fluently and make reasonable estimates

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