Education and Outreach: Nanotechnology Activity Guides

NanoWeights

Audience: Middle and high school students
Time Needed: 30-45 minutes

Objectives:

- To help students achieve an understanding of the nanoscale and nanograms by weighing out small amounts of sand

Related Wisconsin Model Academic Science Standards:

- *C.4.4* Use simple science equipment safely and effectively, including rulers, balances, graduated cylinders, hand lenses, thermometers, and computers, to collect data relevant to questions and investigations
- *C.4.5* Use data they have collected to develop explanations and answer questions generated by investigations

Activity Materials:

- Sand
- Buckets
- Measuring cups
- Measuring spoons
- Balance scale
- Weights
- Student worksheets

Activity Instructions:

Introduction (3-5 minutes)
The prefix "nano" means "one-billionth". So a nanometer is one billionth as long as a meter, and a nanogram is one billionth as heavy as a gram. Scientists who work with the nanoscale, or nanotechnologists, face unique challenges in terms of measuring out materials in nanograms.

Weighing Activity (15-30 minutes)
Divide the students into small groups. Each group of students should have a bucket of sand, a set of measuring cups and spoons, a scale, weights, and the worksheets. Allow each group of students to work through the worksheets on their own.

Wrap Up Discussion (5-10 minutes)
Explain that it's impossible to weigh single grain of sand using an ordinary balance scale. Discuss the methods the students brainstormed for weighing tiny amounts of sand. For example, you might weigh a larger amount of sand, and then divide the weight by the number of grains of sand in the sample to get the average weight for a grain of sand.

The nanoscale deals with atoms and molecules that weigh much, much less than a grain of sand. Scientists don't use ordinary scales to weigh out nanograms. Instead, they make a solution of the material they are trying to weigh, and then dilute the solution until it reaches a concentration of one part of material per billion parts of solution. This is equivalent to having one nanogram of material per milliliter of solution. Scientists use a special piece of equipment called a quartz crystal microbalance (QCM) to weigh such tiny amounts. A QCM calculates mass and other properties of a substance by attaching it to an oscillating crystal and determining the change in frequency that results.

Math Activity (optional, 5-10 minutes)
Students should use Avogadro's number (6.022 1023) to calculate the number of atoms of different elements that are in a gram and a nanogram.

Required Background Information:

Students should be familiar with how to weigh materials and with basic arithmetic. A basic understanding of concentrations would also be helpful for the final discussion. For the optional math activity, students should be comfortable working with decimals and scientific notation, and know what molar mass is.

Supplemental Materials:

- Handout: Weighing Worksheet (doc)
- Handout: Avogadro's Number Worksheet (doc)

References:

- Materials Research Science and Engineering Center, UW-Madison - http://mrsec.wisc.edu/
- National Nanotechnology Initiative - http://www.nano.gov/centers.htm
- Center for Biofilm Engineering Glossary (scroll down for Quartz Crystal Microbalance) - http://www.erc.montana.edu/Res-Lib99-SW/glossary/gee&m.html
- Stanford Research Systems Quartz Crystal Microbalance - http://www.thinksrs.com/html/qcm.html
- QCM-D Technology - http://www.q-sense.com/qcmd_tech.html

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