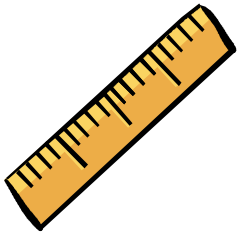
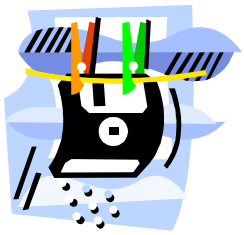
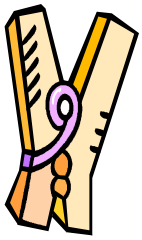
National Science Foundation

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

Teacher's Guide

Size and Scale – Learning about Measurement

Purpose
Students will visualize the order of numerical properties of objects from the nanoscale to visible scale using exponents and decimals. Students will make size comparisons of objects. Students will develop an understanding of how small a nanometer is in comparison to common objects. They will also learn about the metric system.

Level
Upper elementary to middle school

Time required
20-25 minutes

Advance Preparation
Download the pictures of items of various sizes. Also included are images for different units of measurement such as one meter, one millimeter, etc. To use these images multiple times it is recommended to laminate each one. Place size markers (1 meter, etc.) along the "scale" by using a logarithmic scale where each equidistant point equals a base ten. You will mark out from 10^{-9} to 10^{3} for a total of 13 points along the "scale." For elementary students the 1 Meter image may be placed on the line as the first example.

Materials
- Images of objects and the units of measurement (available for download below)
- String, rope, or clothesline to create the "scale"
- Clothespins or clips to secure images to the "scale"

Safety Information
There are no safety concerns for this unit

National Science Foundation

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

Teacher's Guide

Instructions Hand out an equal number of pictures to each student along with the clothespins. Have them interact with each other to determine how to arrange the pictures on the clothesline in order from smallest to largest. Once completed, have the students present their results to the class and have a class discussion about the order. Correct any misplaced items and explain to the students why the item(s) is out of order. For example, a common misconception is that a virus is larger than a bacterium.

Background Information

Useful resources for this activity include:

- *Powers of Ten* explores the relative size of things from the microscopic to the cosmic -- http://powersof10.com
- Teaching resources on the metric system can be found at the U.S. Metric Association -- http://lamar.colostate.edy/~hillger/
- *Scale of Objects* by Nanosense offers a series of units designed for high school students: http://www.nanosense.org
- *How Small is Nanotechnology?* offers activities to explore the size of the nanoscale including the nanometer ruler. http://nanozone.org/How.htm
- *Zoom and Re-Zoom* by Istvan Banya are interesting picture books related to size and scale. Although designed for younger children, even adults enjoy the books' images.
- *NNIN Nanotechnology Poster* is a simple poster about nanotechnology with a graphic on relative size of objects. (attached and also at http://www.mirc.gatech.edu/education.php/teacher.resources.php
- *The Scale of Things* poster from the Office of Basic Energy Sciences is available at http://www.er.doe.gov/bes/scale_of_things.html
- *How big is a…?* is a interactive size comparison found at http://www.cellsalive.com/howbig.htm

National Science Foundation

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

Teacher's Guide

Teaching Strategies
This works best with students in groups of 10-12. Prior to beginning the activity, the teacher should introduce or review the metric system. Questions to prompt the discussions:

- Who has heard of the metric system of measurement?
- What is the metric system? (The metric system is a decimalised system of measurement based on ten)
- How does it differ from our system of measurement (inch, foot, yard, mile, which is not base ten)
- How many inches are there in one meter? (39.37 inches)
- What is the smallest thing you can think of? (atoms, electrons, molecules). Most students say a grain of sand, dust, a flea etc.
- What is a nanometer?
    - How many nanometers are in one meter? (1,000,000,000nm)
- Can you tell which objects are manmade and which ones made by nature?

Explain to students that there is enormous scale in our world and in our universe – from tall mountains to red blood cells; from the solar system to the bacterium that causes disease and illness. The table below includes some of the International System of Units (SI) of measurements.

Latin prefix w/ meter	Measure as an exponent	Measure as a number	Common Expression
Terameter	10^{12}	1,000,000,000,000	One Trillion
Gigameter	10^{9}	1,000,000,000	One Billion
Megameter	10^{6}	1,000,000	One Million
Kilometer	10^{3}	1,000	One Thousand
METER	**10^{1}**	**1**	**One**
Millimeter	10^{-3}	0.001	One Thousandth
Micrometer	10^{-6}	0.000001	One Millionth
Nanometer	10^{-9}	0.000000001	One Billionth
Picometer	10^{-12}	0.000000000001	One Trillionth

National Science Foundation

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

Teacher's Guide

Size information of objects (pictures) used in this lesson.

Alphabetical

Object	Approximate size
Airport runway	3.35 km
Anthrax bacteria	1µm
Apple	76mm
Atom (He; 3 across)	1nm
Bike in a bag (length)	1.3 m (130cm)
Boeing 767 400ER jet	64m
Cat (average length)	.45m
Dalmatian (average length)	1.0m
Dime thickness	1mm
DNA width	2.5nm
Driveway (average length)	15.2m
Flea	2.5mm
Field mouse (average length)	152 mm
Football field length	110m
Grain of sand	0.5mm
Hair diameter	60-80µm
Head of a pin	2.0mm
Hummer H1	4.7m
Influenza virus (diameter)	20nm
IPOD length	90mm
Pollen grain	30µm
Queen Mary II cruise ship	345m
Red blood cell	7µm
Soccer ball	254mm
Yellow Jacket	12.7mm

Size

Object	Approximate size
Airport runway	3.35 km
Queen Mary II cruise ship	345m
Football field length	110m
Boeing 767 400 ER jet	64m
Driveway (average length)	15.2m
Hummer H1	4.7m

Teacher's Guide

Bike in a bag (length)	1.3m (130cm)
Dalmatian (average length)	1.0m
Cat (average length)	.45m
Soccer ball	254mm
Field mouse (average length)	152mm
IPOD (length)	90mm
Apple	76mm
Yellow jacket	12.7mm
Flea	2.5mm
Head of a pin	2.0mm
Dime thickness	1.0mm
Grain of sand	0.5mm
Pollen grain	30µm
Red blood cell	7µm
Anthrax bacterium	1µm
Hair diameter	60,000-80,000nm
Influenza virus (diameter)	20nm
DNA width	2.5nm
Atom (He;3 across)	1nm

National Science Foundation

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

Teacher's Guide

Object	Approximate size
Atoms (3)	1nm
DNA (width)	2.5nm
Influenza virus (diameter)	20nm
Anthrax bacteria	1µm
Red bool cell	7µm
Pollen grain	30µm
Hair diameter	60-80µm
Grain of sand	.5mm
Dime thickness	1mm
Head of a pin	2mm
Flea	2.5mm
Yellow jacket	12.7mm
Apple	76mm
iPod length	90mm
Field mouse (average length)	152mm
Soccer ball	254mm
Cat (average length)	.45m
Dalmatian (average length)	1m
Bike in a bag (length)	1.30m
Hummer H1	4.7m
Driveway (average length)	15.2m
Football field (length)	110m
Boeing 767 400ER	64m
Queen Mary II	345m
Airport runway	3.35km

National Science Foundation

National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

Teacher's Guide

Size and Scale Learning about Measurement link to Science and Mathematics Standards

NCTM Standards 3-5

- understand the place-value structure of the base-ten number system and be able to represent and compare whole numbers and decimals;
- explore numbers less than 0 by extending the number line and through familiar applications;

NCTM Standards 6-9

- compare and order fractions, decimals, and percents efficiently and find their approximate locations on a number line;
- develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation

National Science Education Standards

Elementary Content Standards (exercise is recommended for upper elementary)

- Standard A
  - Abilities to do scientific inquiry
- Standard B
  - Properties of objects and materials
- Standard E
  - Abilities to distinguish between natural objects and objects made by humans
- Standard G
  - Science as a human endeavor

Middle Content Standards

- Standard A
  - Abilities necessary to do scientific inquiry
- Standard B
  - Properties and changes of properties in matter
- Standard G
  - Nature of science

These units for the number scale have been adapted from
http://www.nanosense.org/activities/sizematters/sizeandscale/SM_Lesson2Student.pdf

10^{-9}m
(1 nanometer)

10^{-8}m
(10 nanometers)

10^{-7}m
(100 nanometers)

10^{-6}m
(1 micron)

10^{-5}m
(10 microns)

10^{-4}m
(100 microns)

10^{-3}m
(1 millimeter)

10^{-2}m
(10 millimeters)

10^{-1}m
(100 millimeters)

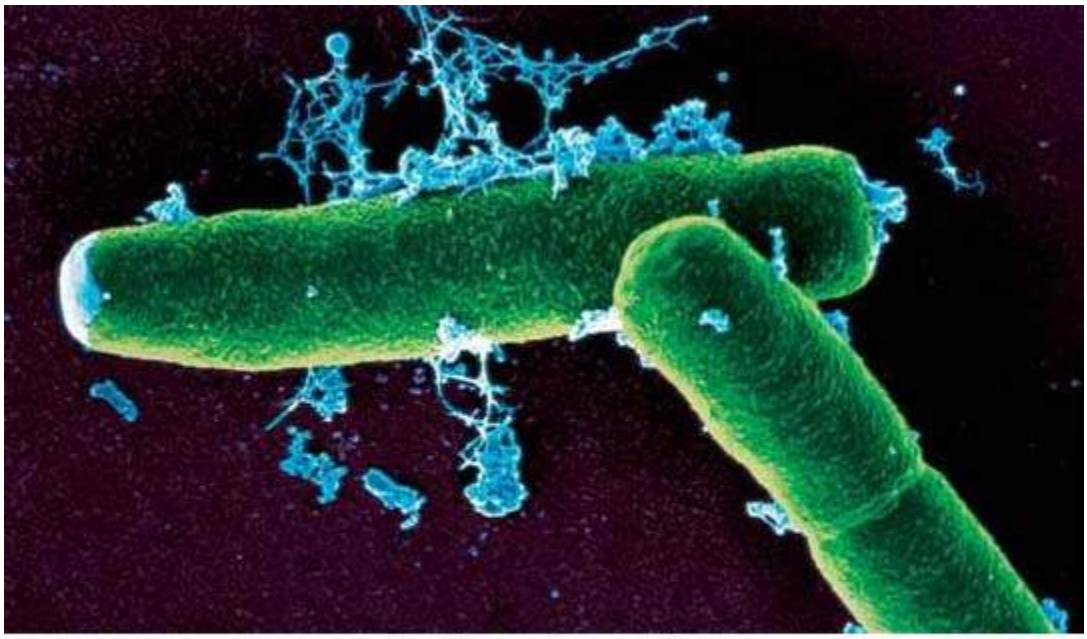
10^0m
(1 meter)

10^{1}m
(10 meters)

10^2m
(100 meters)

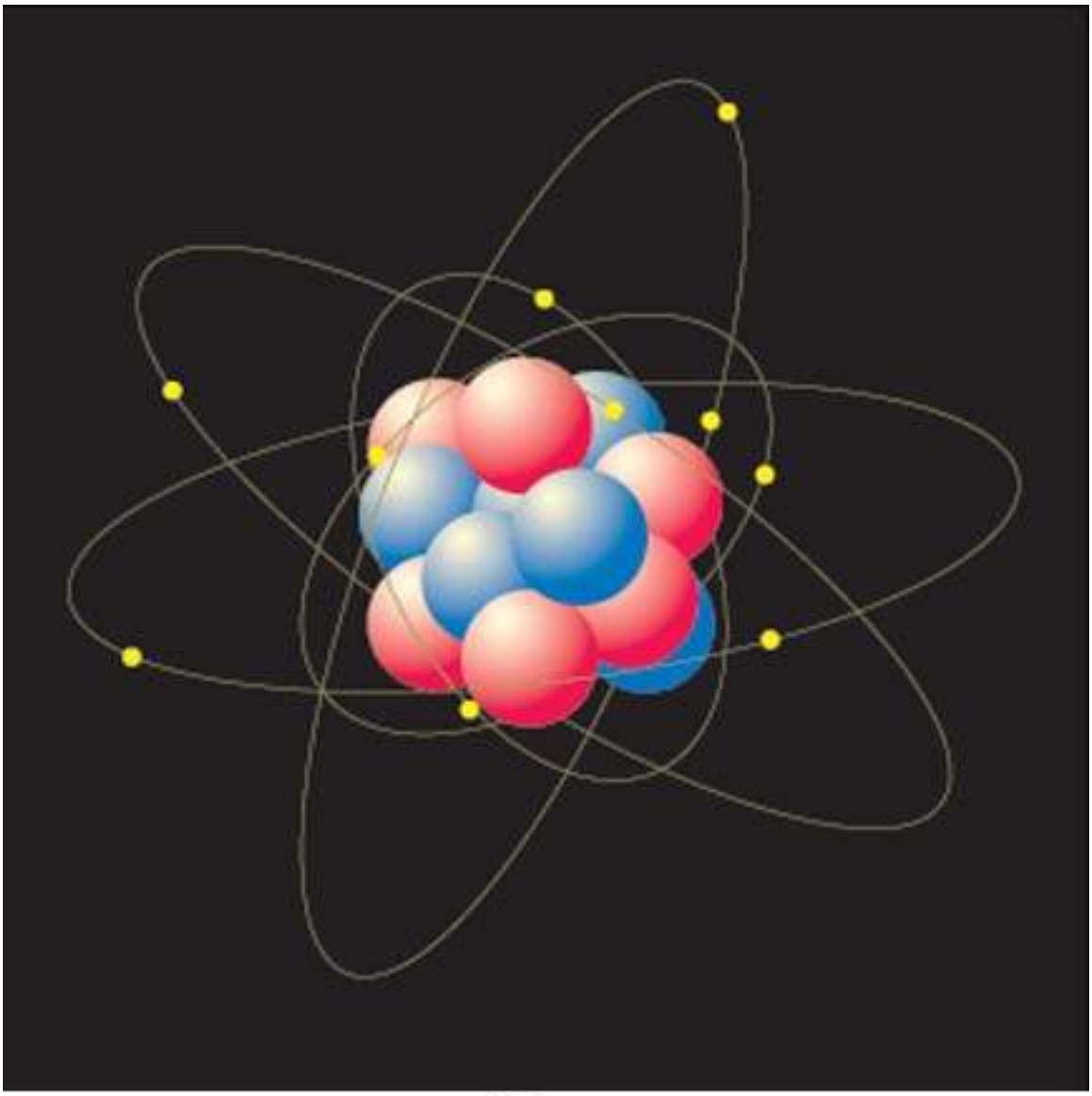
10^3m
(1 kilometer)

Airport Runway



Anthrax Bacteria

Apple



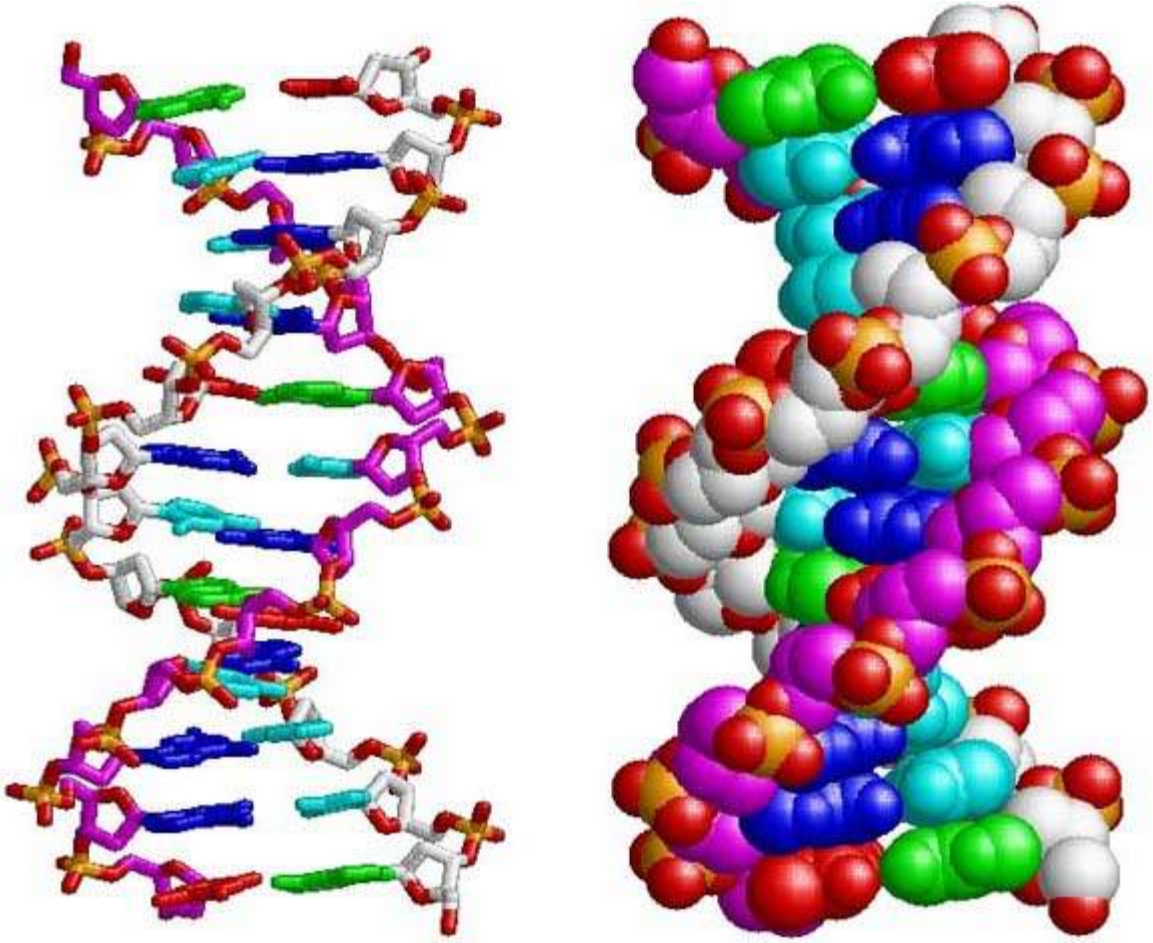
Atom

Bike In A Bag.com

Boeing 767 400ER

Cat

Dalmatian



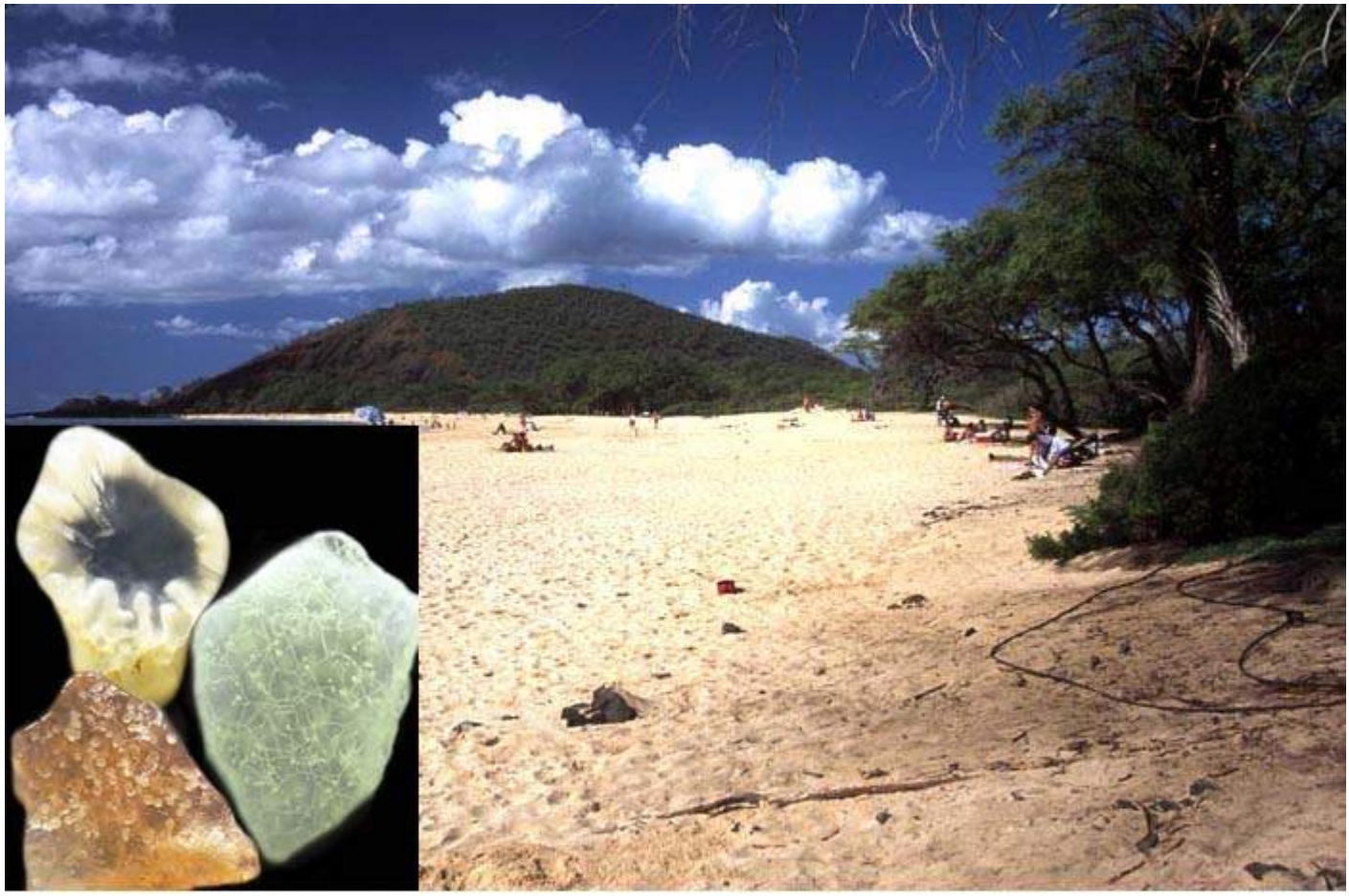
DNA

Driveway

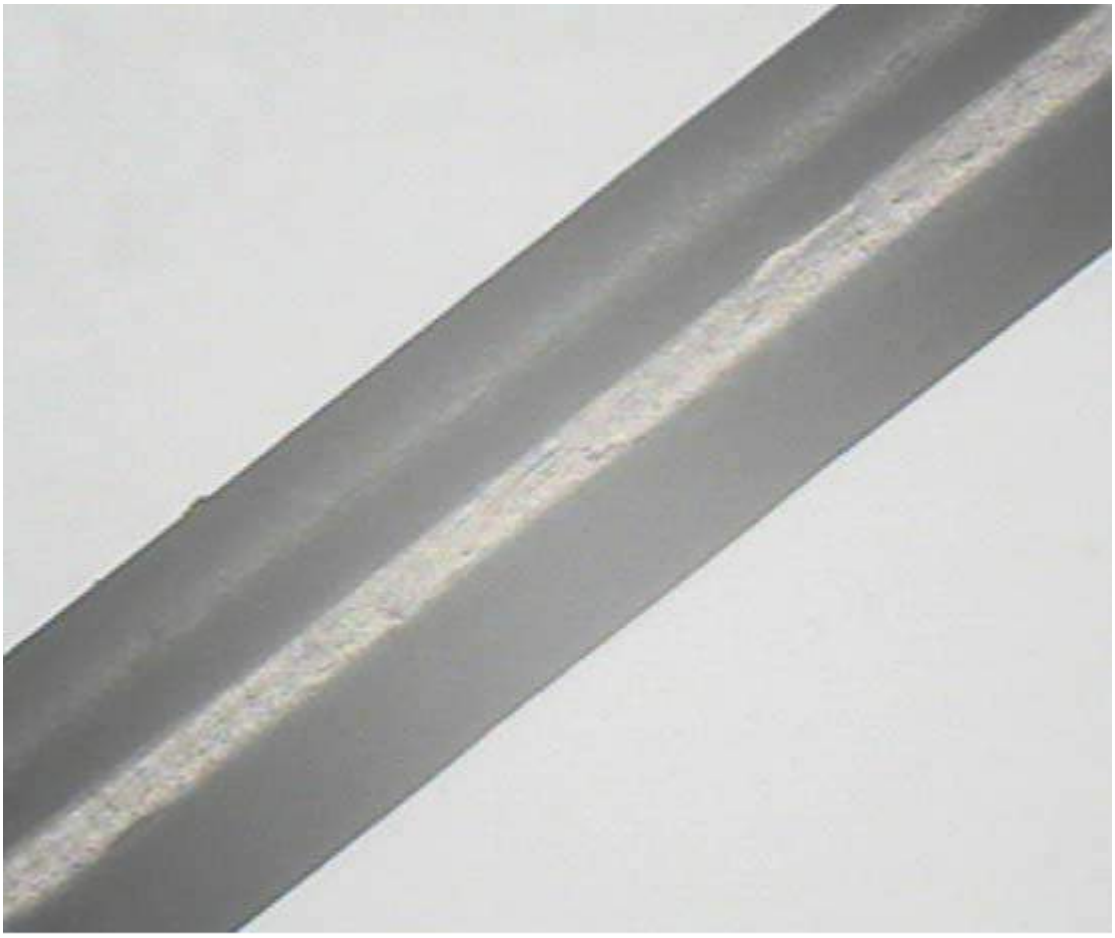
Field Mouse

Flea

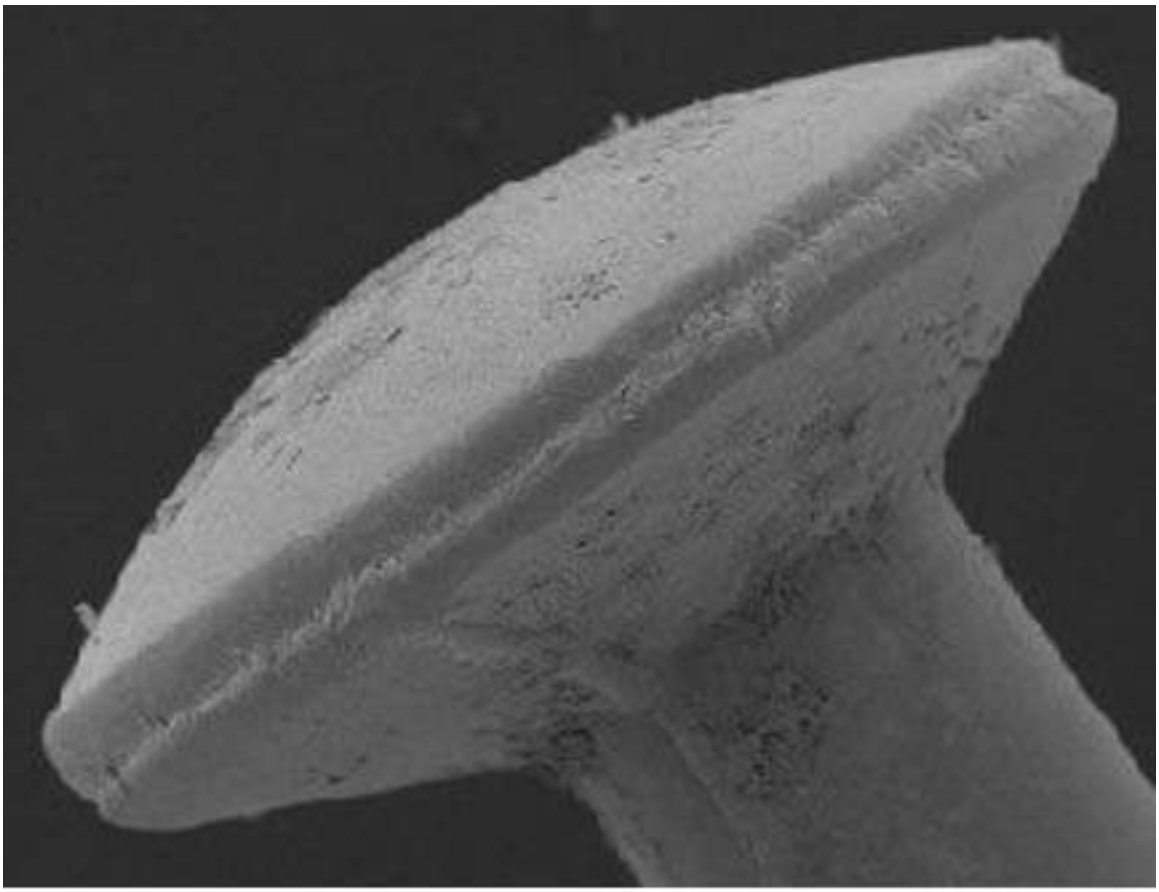
Football Field



Grain of Sand

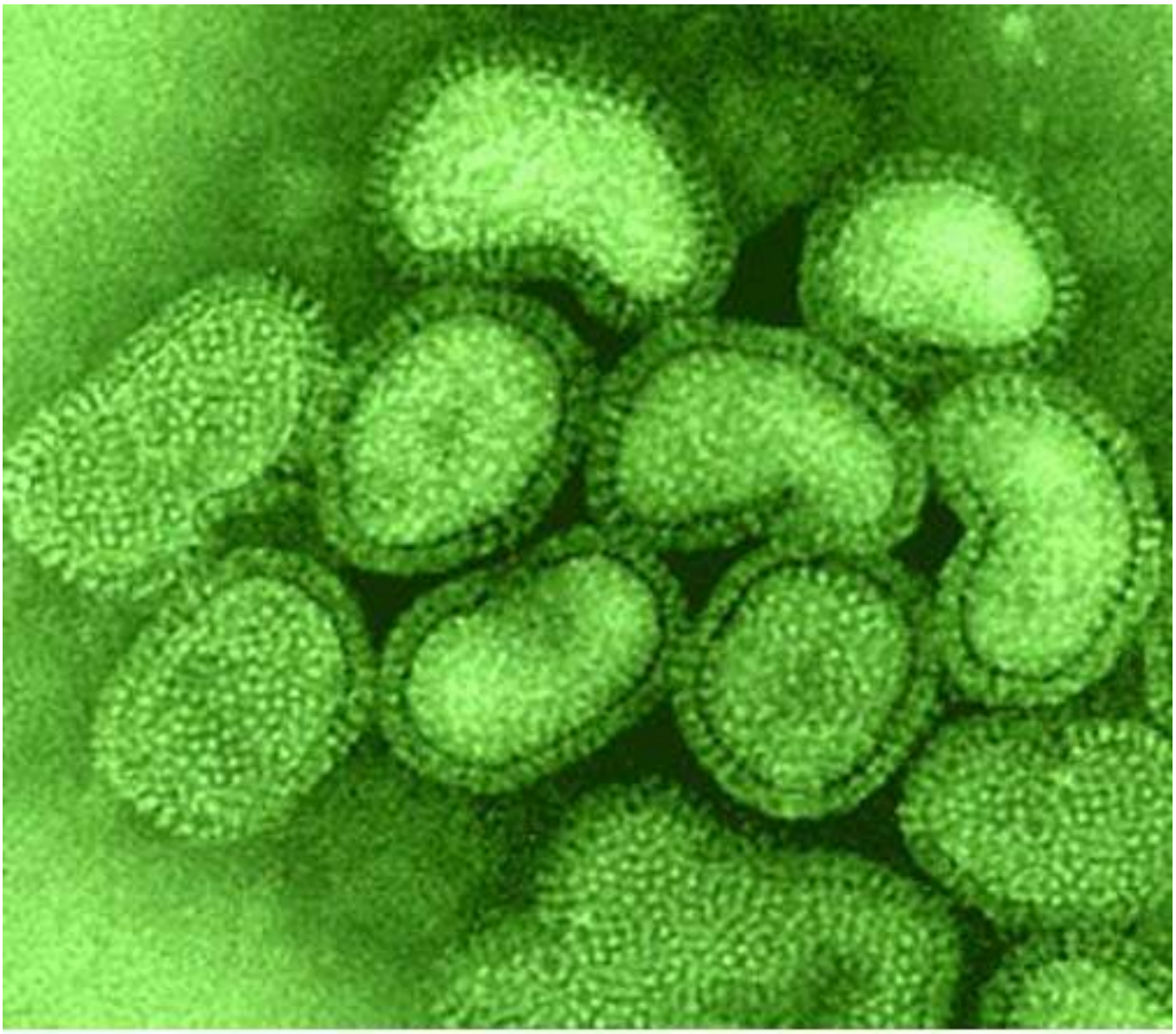


Hair Strand



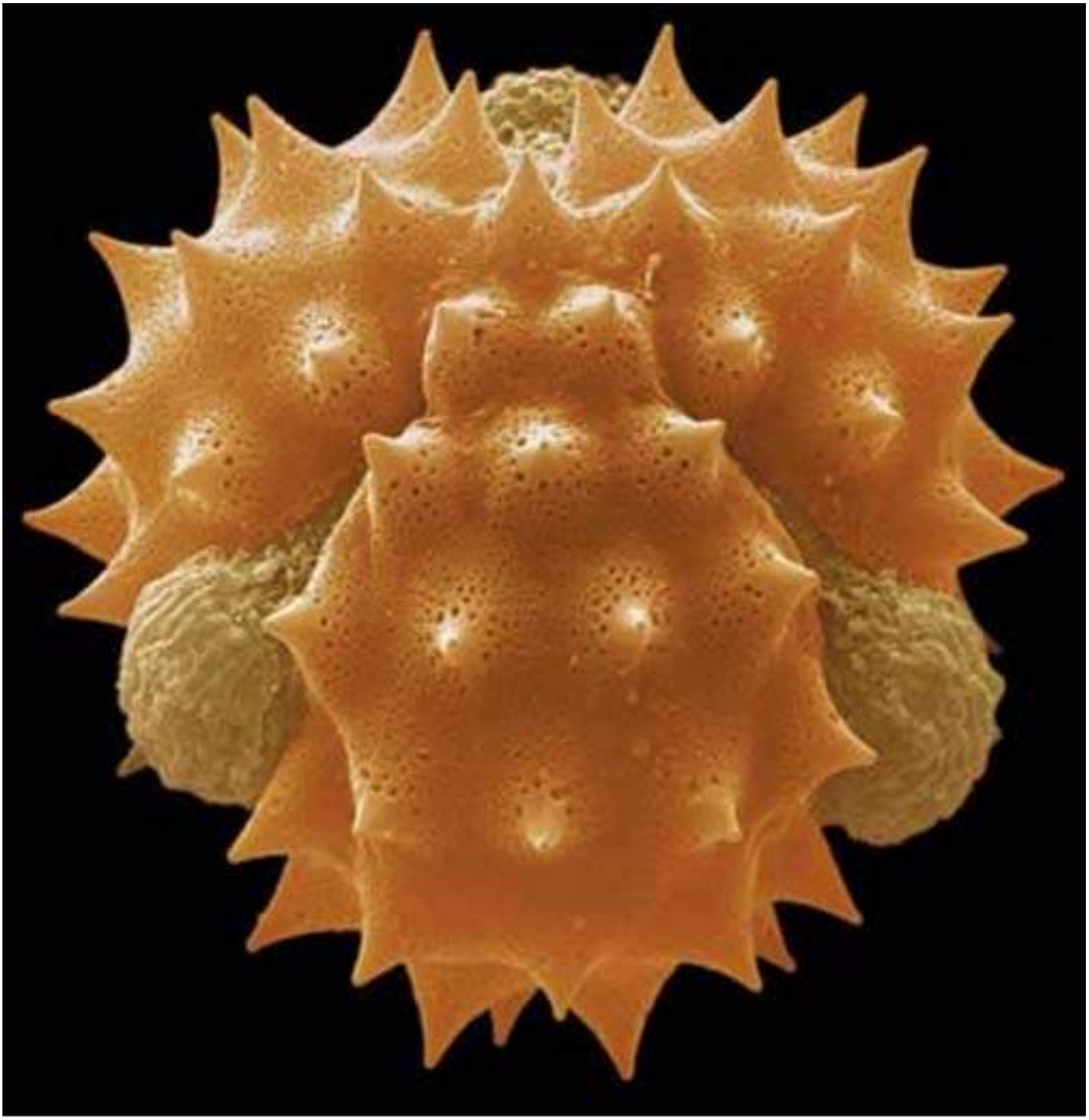
Head of a Pin

Hummer H1



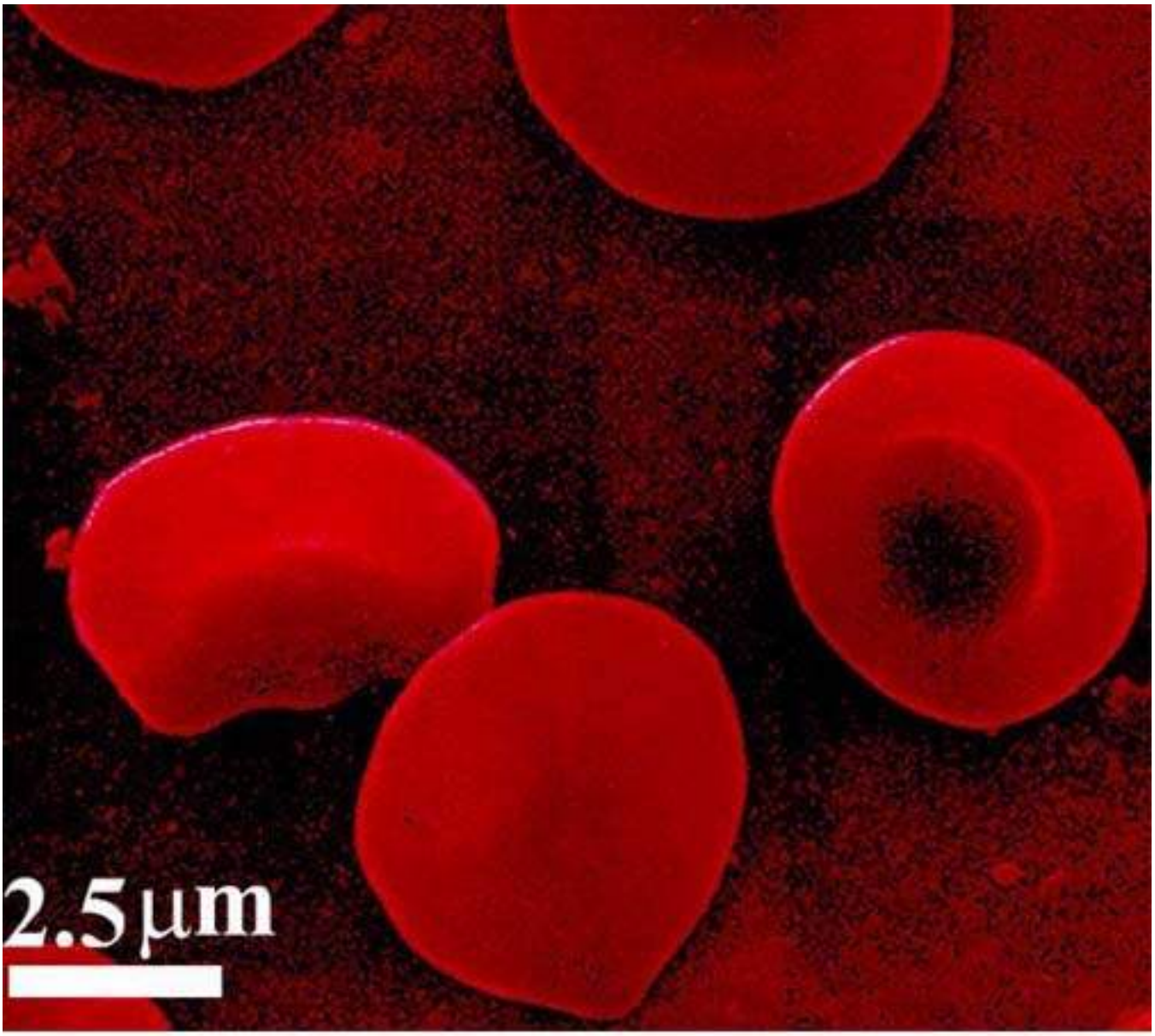
Influenza Virus

iPod Nano



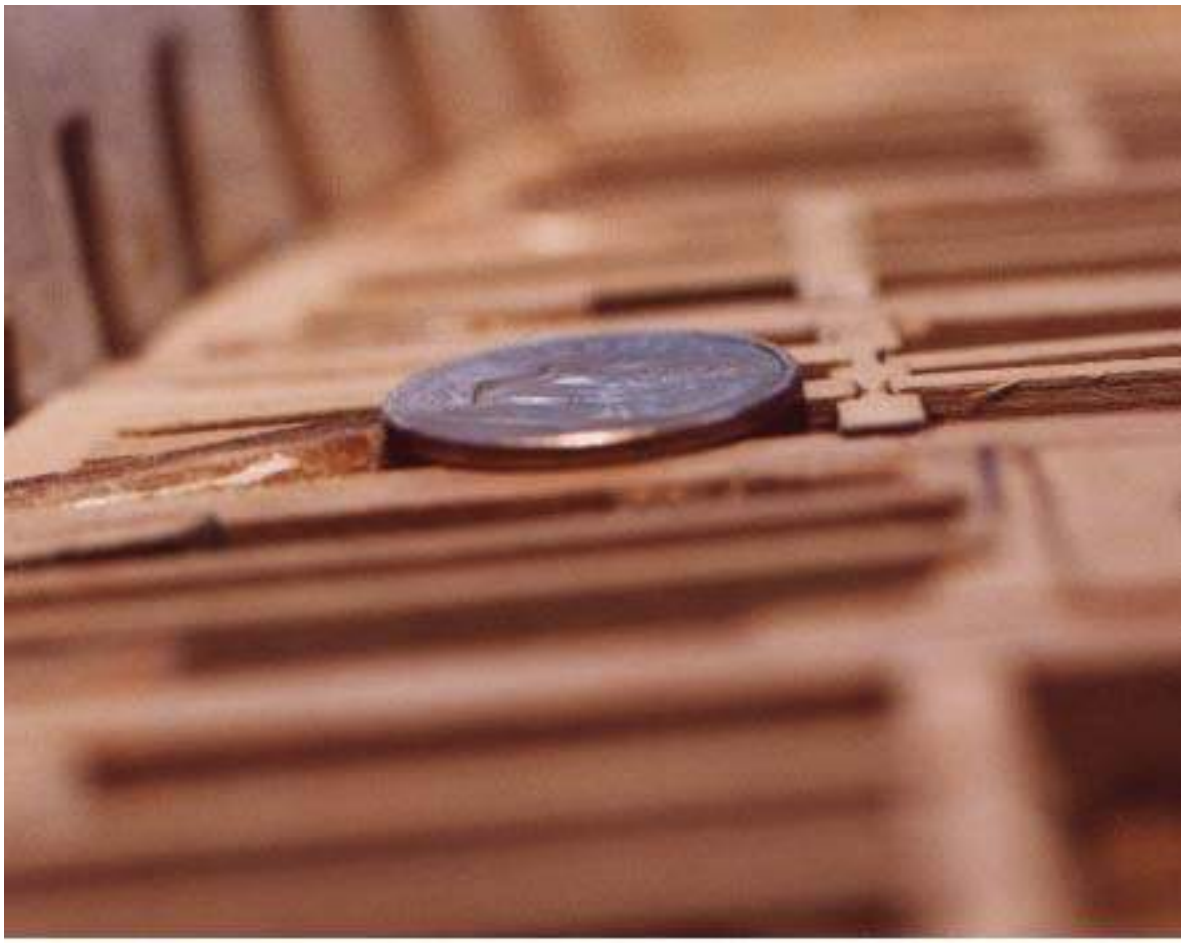
Pollen

Queen Mary II



Red Blood Cells

Soccer Ball



Dime Thickness

Yellow Jacket