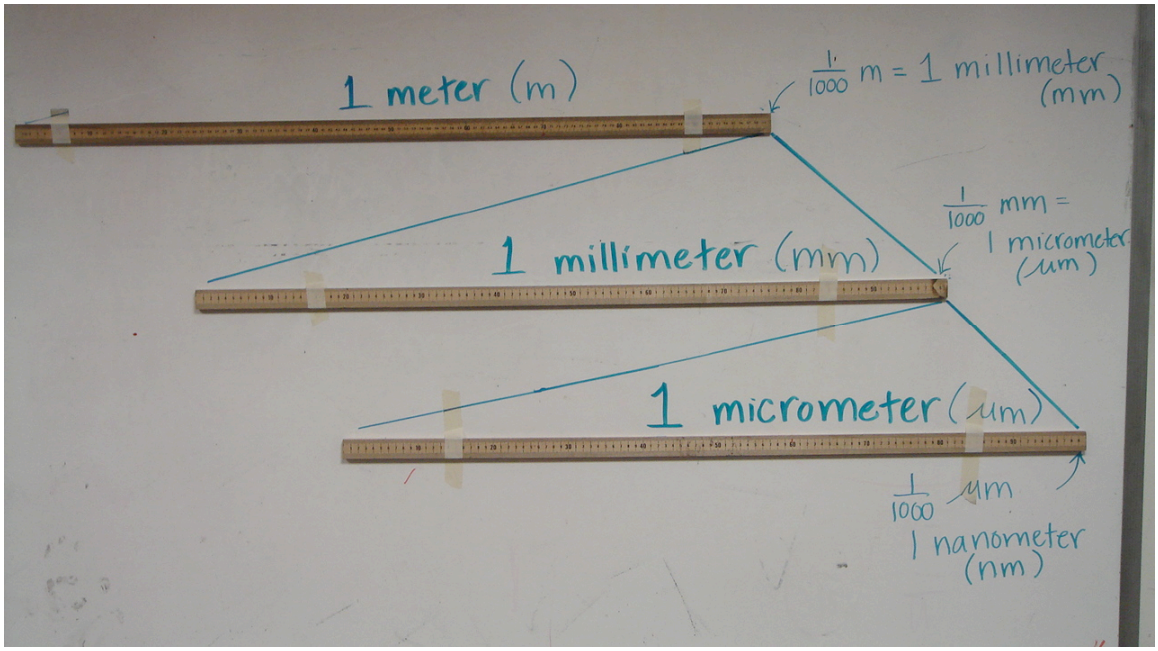
Metric Measurements

Background: When we use measurements such as millimeters, micrometers, and nanometers, students don't necessarily have a good idea about how small these measurements are, nor do they realize the relative sizes of these different units.

Materials:
Several meter sticks or paper meter tapes
Tape
White board or wall
Appropriate markers

To Do and Notice:

1. Tape 1 meter stick to the board in the upper left-hand corner.
2. Label it "1 meter (m)".
3. Discuss the other units on the meter stick – centimeters and millimeters. Explain the fractional relationships with centimeters and millimeters to 1 meter. Identify and label the 1000th millimeter.
4. Tape a second meter stick to the board below and slightly to the right of the first.
5. Explain that this meter stick represents an expanded version of the 1000th mm from the meter stick above.



At this scale, we have our millimeter divided into thousandths. One 1000th of a millimeter is a micrometer, or μm. Notice that the micrometer is three orders of magnitude smaller than the millimeter, which is three orders of magnitude

smaller than the meter. Therefore, one micrometer is 1/1,000,000 of a meter. Identify and label the 1000th μm.

A micrometer is a millionth of a meter. How small is a micrometer? A human hair is approximately 100 micrometers in width. A red blood cell is approximately 10 micrometers in diameter, while your average bacterium is approximately 1 micrometer in diameter.

6. Tape the third meter stick to the board. This meter stick represents a scaled up version of a micrometer. At this scale, we have our micrometer divided into thousandths. One 1000th of a micrometer is a nanometer, or nm. Notice that the nanometer is three orders of magnitude smaller than the micrometer, which is three orders of magnitude smaller than the millimeter, which is three orders of magnitude smaller than the meter. Therefore, one nanometer is 1/1,000,000,000 of a meter. Identify and label the nm.

We have changed our scale again, and now each one thousandth of our scaled up micrometer is equal to one nanometer (nm). One nanometer is about 10 atoms lined up, diameter to diameter, it is also how much your fingernails grow in one second.

Math Interlude:
Let's assume that your fingernails grow 1 mm per week.

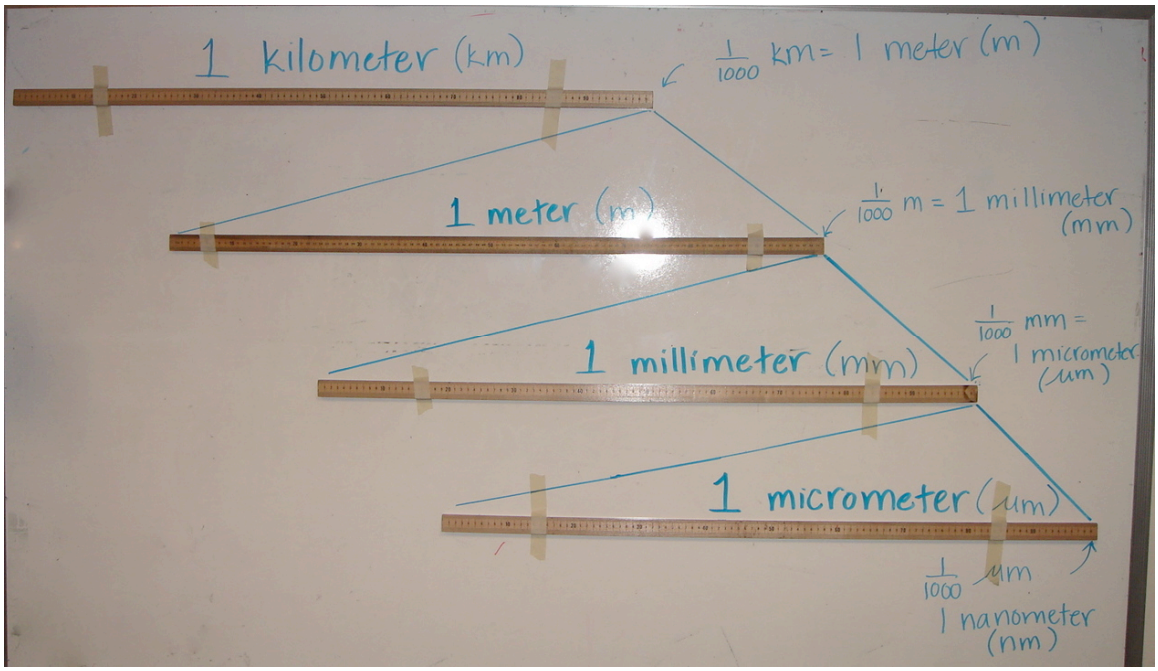
$$\frac{1\ mm}{1\ week} \times \frac{10^6\ nm}{1\ mm} = \frac{10^6\ nm}{1\ week}$$

$$\frac{10^6\ nm}{1\ week} \times \frac{5.2 \times 10^1\ weeks}{1\ year} = \frac{5.2 \times 10^7\ nm}{1\ year}$$

$$\frac{5.2 \times 10^7\ nm}{1\ year} \times \frac{1\ year}{3.14 \times 10^7\ sec} = \frac{1.65\ nm}{1\ sec} \sim 1\ nm/s$$

One human hair is about 100,000 nanometers in diameter.
The diameter of the head of a pin is about 1,000,000 nanometers.

7. Using the same technique, we can use the meter sticks to represent scaled down versions of measurements larger than 1 m. For example, the meter is one 1000th of a kilometer.



What's Going On?
Most of the metric measurements we use have exponents that are divisible by three. A kilometer is 10^3 meters, a meter is 10^0 meters, a millimeter is 10^{-3} meters, a micrometer is 10^{-6} meters, and a nanometer is 10^{-9} meters.
Here is a chart of metric prefixes and their powers of 10:
http://www.metricconversion.us/prefixes.htm

Prefix	Meaning	Exponent	Unit	Abbreviation
		10^0	meter	m
centi-	hundredth	10^{-2}	centimeter	cm
milli-	thousandth	10^{-3}	millimeter	mm
micro-	millionth	10^{-6}	micrometer, micron	μm
nano-	billionth	10^{-9}	nanometer	nm

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