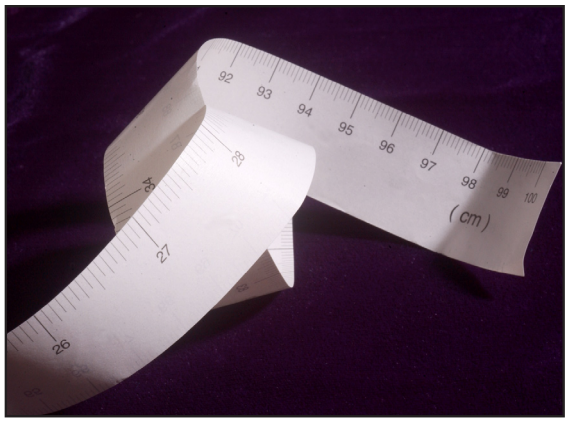
Making the Cut: A Nanoscale Investigation

How small is the nanoscale? Can ordinary tools be used at this scale?



Materials

- paper tape measure (available at IKEA)
- scissors
- calculator (optional)

To Do and Notice

1. Notice that your tape measure is 1 meter long. A nanometer is 1/1,000,000,000 (0.000,000,001) of a meter. Could you cut the tape measure in half, over and over, to end up with a piece only 1 nanometer long?

2. Cut your tape measure in half as many times as possible, keeping track of how many cuts you make.

3. How many times were you able to cut the tape measure? How close did you come to 1 nanometer?

4. Can macroscale tools such as scissors be used at the nanoscale?

What's Going On?

You probably were able to cut the tape measure about ten times. Ten cuts leaves you with a piece that's approximately 1 millimeter long, which is 1/1,000 of a meter. (See the table below.) That's not even close to a nanometer! Using scissors to try to cut something 1 nanometer long is clearly an impossible task.

To reach the width of a nanometer, you'd have to cut the tape measure 30 times. (You can prove this using the table. Another way is to divide 1 meter by 2, then divide the answer by 2 until you get an answer that's approximately 1 nanometer, keeping count of how many times you divide.)

Number of cuts	Fraction of a meter remaining
1	1/2
2	1/4
3	1/8
4	1/16
5	1/32
6	1/64
7	1/128
8	1/256
9	1/512
10	1/1,024 = ~1 millimeter

Note: You could extend the table until you get approximately 1 nanometer. Or you could use this shortcut: If 10 cuts leaves approximately 1/1,000 of a meter, then another 10 cuts will leave 1/1,000 of 1/1,000, or 1/1,000,000 of a meter. Another 10 cuts (for a total of 30) will leave 1/1,000 of 1/1,000,000, or 1/1,000,000,000 of a meter.

So What?

Scientists and engineers weren't able to work at the nanoscale until near the end of the twentieth century because they didn't have the proper tools. The invention of the scanning tunneling microscope in the 1980s enabled scientists to observe the surfaces of materials atom by atom, and then to manipulate individual atoms. (Atoms are 0.1 to 0.5 nanometers in diameter.) The ability to manipulate atoms meant that materials could be constructed at the atomic level, and the nanotechnology revolution was begun.

This activity is based on an activity by MRSEC: http://mrsec.wisc.edu/Edetc/IPSE/educators/activities/cuttingNano.html

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