

Halving to the Atom: How Many Cuts to the Bottom?

Investigation question: How many times would you have to cut a one-meter strip in half to reach the width of a single atom, and why can your scissors never get there?

Physical model

Groups of 3

1 session

Setup 5 · Activity 35 · Cleanup 5 min

MS-PS1-1 · practice

Name _____

Group _____

Date _____

Your role today

- ☐ **Cutter:** Folds the strip exactly in half, creases it, and cuts along the crease. Keeps one half and sets the other aside.
- ☐ **Measurer:** Measures the kept piece with the meter stick or mm ruler, calls out the value in centimeters and in millimeters.
- ☐ **Recorder and grapher:** Writes each measurement in the table, checks it against the predicted value, and plots the points on the graph.

Safety

- Scissors only: cut away from fingers, pass them handle first, and keep them closed on the desk when not in use.
- Tiny paper scraps are a slip hazard on hard floors; collect them in the envelope as you go.
- No hazards beyond ordinary classroom tools; no chemicals or heat are used.

Procedure

1. Measure your strip and record its length as halving number 0. It should be 100 cm. Before any cutting, fill in the predicted length column for halvings 1 through 10 by dividing the previous prediction by 2.
2. Fold the strip exactly in half so the ends line up, crease it, and cut along the crease. Keep one half; put the other half in the envelope with a small '1' written on it.
3. Measure the kept half in centimeters (and in millimeters once it is shorter than 10 cm). Record the measured length next to the prediction for halving 1.
4. Repeat: fold the kept piece in half, cut, keep one half, measure, record. Number each discarded piece and save it so the sequence can be lined up later.
5. Keep going until the group agrees the piece can no longer be folded and cut in half accurately. Record the halving number where you stopped and write one sentence about what went wrong.
6. Plot measured length (cm) on the vertical axis against halving number on the horizontal axis. Connect the points with a smooth curve, not straight segments.

7. Lay the saved pieces out in order from largest to smallest on the desk. Look at the pattern and compare it with the shape of your graph.
8. Now continue the pattern with arithmetic instead of scissors: use the fact that ten halvings divide a length by about 1,000 to work out how many halvings take 1 m down to 1 mm, then to 1 micrometer, then to 1 nanometer, and finally to about 200 picometers, the width of a typical atom.
9. Answer the analysis questions individually, then compare answers within the group.

Record your observations

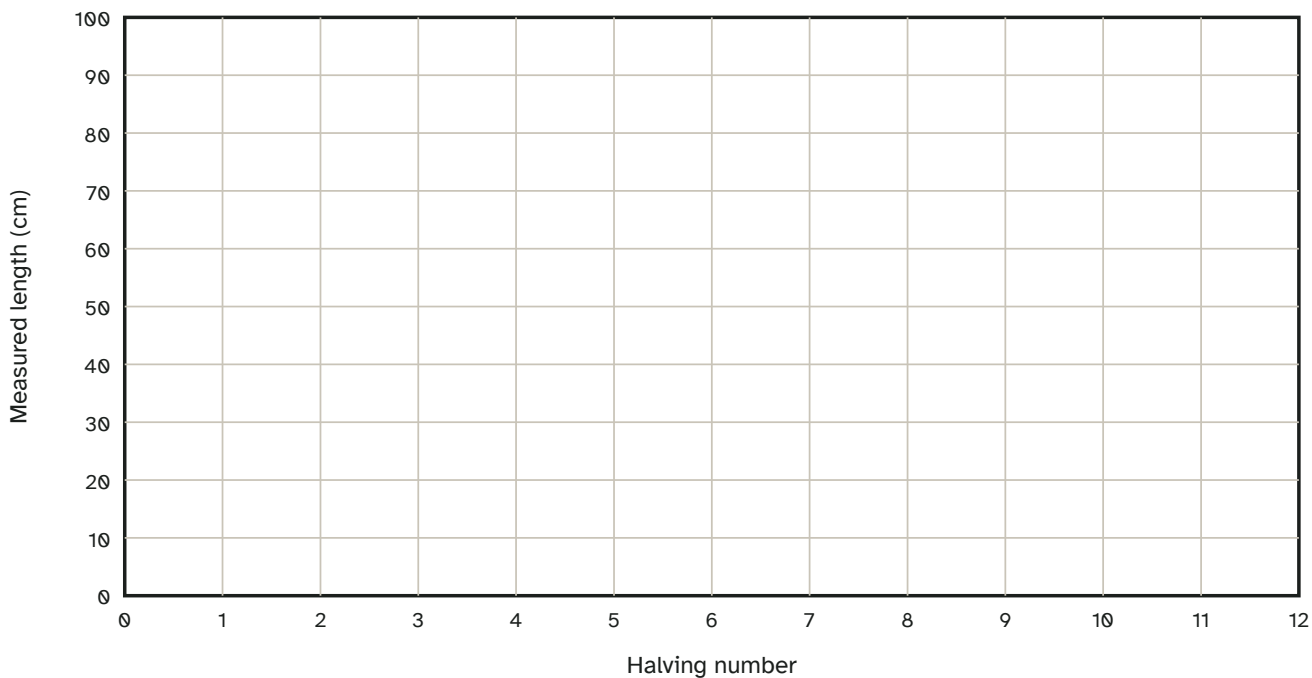
Lab 1 recording sheet: Halving to the atom

Fill in the predicted column before you cut. After each cut, record what you actually measured. Stop when your group cannot halve the piece accurately.

Halving data

Halving number	Predicted length (cm)	Measured length (cm)	Measured length (mm)	Could you still fold and cut it? (yes/no)
0	100			
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Length of the kept piece after each halving



Continuing the pattern with arithmetic

Target length	Same length in meters	Halvings needed from 1 m (estimate)	How you worked it out
1 mm			
1 micrometer (width of a bacterium)			
1 nanometer (1,000 pm)			
About 200 pm (one atom)			

1. At which halving did your group stop, and what exactly made the next cut impossible?
2. Describe the shape of your graph. Why does the curve flatten toward the horizontal axis even though every cut removes half?

Analysis questions

3. Ten halvings divide a length by 1,024, which is close to 1,000. Use that fact to estimate how many halvings take a 1 m strip down to 1 mm, and show the calculation.

4. Continue the pattern to a single atom about 200 pm wide. About how many halvings from 1 m does that take? Show your reasoning with the unit chain.

5. Your scissors failed after roughly ten halvings, but the arithmetic kept going. What is the difference between a limit of your tools and a limit of the matter itself? Where is each limit in this activity?

6. Why do scientists measure atoms in picometers instead of meters or millimeters? Use a number from your table in your answer.

7. Suppose you could keep halving a strip of pure iron and finally held one iron atom. If you split that atom in half, would you have two smaller pieces of iron? Explain what the halving model can and cannot show about this.

8. If you had started with a strip 1 kilometer long instead of 1 meter, how many more halvings would it take to reach an atom? Explain.
