

Change the View. Keep the Size.

Cell to atom / unit conversion, length ratios and a changing view width

LEARNER 1 / COMPARE ONE DIMENSION

Name: _____ Date: _____

Allow 30–40 minutes with a calculator. Adopt a cell diameter of 20 μm , mitochondrial length of 2 μm and atomic reference extent of 0.1 nm. These are chosen teaching lengths, not measurements of one specimen or universal biological sizes.

1 / Predict before converting

If a drawing is enlarged, does the cell gain atoms? Does its diameter-to-mitochondrion-length ratio change? Explain your prediction.

One physical view width, three length comparisons

Cell / 20 μm



Each full box = 50 μm

Mitochondrion / 2 μm



Each full box = 50 μm

Atomic ref / 0.1 nm



Each full box = 50 μm

Common scale in all boxes. The cell occupies 40% of the width; the mitochondrion occupies 4%. The atomic reference is below the lab’s display cutoff. Bars show one length only, not anatomy, microscope images or atom counts.

2 / Put all three lengths in nanometers

1 μm = 1,000 nm. Divide only after the units match.

Chosen reference	Length / nm	What is compared?
Cell diameter / 20 μm	_____	One diameter
Mitochondrial length / 2 μm	_____	One length
Atomic extent / 0.1 nm	_____	A characteristic reference extent

Find cell ÷ mitochondrion, cell ÷ atomic reference, and mitochondrion ÷ atomic reference. What can these three ratios tell you? What can they not tell you?

Zoom changes appearance.

The same adopted lengths remain fixed until you edit a dimension.

LEARNER 2 / CHANGE THE WINDOW

3 / Reproduce the worked ratio

$20\ \mu\text{m} = 20,000\ \text{nm}$

$20,000\ \text{nm} / 0.1\ \text{nm} = 200,000$

The chosen cell diameter spans 200,000 atomic reference lengths along one line. This is not a count of atoms contained in the cell.

Spreadsheet: $=20*1000/0.1$

Optional inch conversion: $20 \times 10^{-6}\ \text{m} / 0.0254\ \text{m per inch} \approx 0.000787402\ \text{inches}$. The international inch conversion is exact; the chosen biological dimension is illustrative.

4 / Predict what fits in each view

Each live panel has a width of 360 diagram units. Drawn width $w = 360 \times \text{object length} / \text{physical view width}$. Below 1 unit the shape is hidden as too small; above 720 it is hidden as larger than the view. These are display rules, not microscope resolution limits.

Case / nominal view width	Cell	Mitochondrion	Atomic reference
A / 50 μm , original lengths	_____	_____	_____
B / 5 μm , original lengths	_____	_____	_____
C / 0.5 nm, original lengths	_____	_____	_____
D / 50 μm , cell changed to 40 μm	_____	_____	_____

Use visible, below cutoff or larger than view. B’s cell has width $360 \times 20/5 = 1,440$ units. Changing the view from 50 μm to 5 μm enlarges every drawn width by what factor? Do the physical length ratios change?

5 / Separate zoom from an edited input

In case D only the adopted cell diameter changes, from 20 to 40 μm . Recalculate cell ÷ mitochondrion and cell ÷ atomic reference. Explain how this differs from zooming. Why can neither ratio reveal the number of organelles or atoms inside a real cell?

Online: darksciencedocs.com/exploration-guides/cell-to-atom/. Choose Cell scale, Mitochondrion scale and Atom scale. The logarithmic slider has finite steps, so live values may differ slightly from these nominal paper/CSV fields. Compare rounded readouts and the invariant ratios.

A length ratio is not a count.

Suggested ages 12+; unit ratios required, logarithms and coding optional.

EDUCATOR 1 / FACILITATE AND ASSESS

Learning goals and timing

Learners convert $\mu\text{m}/\text{nm}$, calculate dimensionless length ratios, preserve those ratios while zooming, and distinguish an edited model input from magnification. Print pages 1–2 for learners. Prediction 5 min; conversions/ratios 8; zoom cases 10; input change 5; claim and limits 7. Calculator; no account or submitted student information required.

Suggested answers

Lengths: cell 20,000 nm; mitochondrion 2,000 nm; atomic reference 0.1 nm = 100 pm. Ratios: cell/mitochondrion = 10; cell/atomic = 200,000; mitochondrion/atomic = 20,000. Equivalent inches: about 0.000787402, 0.0000787402 and 0.00000000393701. Changing units does not change physical length.

Case	Cell width / state	Mito width / state	Atomic width / state
A / 50 μm	144 / visible	14.4 / visible	0.00072 / below cutoff
B / 5 μm	1,440 / larger	144 / visible	0.0072 / below cutoff
C / 0.5 nm	14,400,000 / larger	1,440,000 / larger	72 / visible
D / cell 40 μm	288 / visible*	14.4 / visible	0.00072 / below cutoff

Widths are generated diagram units, not physical sizes. The view-width slider is rounded to 0.001 in $\log_{10}(\text{m})$, producing a small difference from nominal reference fields. *Case D is drawn but cropped vertically by the lab's rectangular panel. Visible means the model draws the shape; it does not promise the whole shape fits in both directions.

A $\rightarrow$ B: view width falls by factor 10, every drawn width increases by 10, and all physical ratios stay fixed. Across A/B/C, the chosen objects are unchanged. D: changing the cell input doubles its adopted diameter; ratios become 20 and 400,000, while mitochondrion/atomic stays 20,000.

Assess the explanation

Look for matched units, a dimensionless ratio, zoom invariance and a valid limitation. A real cell does not acquire atoms when the drawing enlarges. One cell diameter divided by one atomic extent is not a packing calculation. Shape, composition and three-dimensional structure would be needed for a meaningful particle-count estimate.

The 0.1-nm extent is a convenient reference, not a hard-edged universal atom. A displayed glow is not a measured electron probability map. The “Too small to resolve here” label refers only to this drawing's display cutoff, not an instrument's resolving power.

Check the scale. Keep the limits.

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EDUCATOR 2 / REPRODUCE AND CREDIT

Offline recipe

Extract the complete kit. Python 3.9+ requires only its standard library:

```
python3 verify_analysis.py --data-dir .
```

```
Windows: py -3 verify_analysis.py --data-dir .
```

Compare its JSON with worked-result.json. Seven pinned rows distinguish exact unit conversions from adopted teaching lengths. Four cases generate 12 object rows. Checks cover meters/inches, physical ratios, zoom, drawn widths and display states. No network request or input modification.

The original Scale Lab model/helper and an ES-module declaration are included for optional Node inspection; Python does not need Node. Convert μm with 10^{-6} , nm with 10^{-9} , and inches by dividing meters by 0.0254. Model field = 10^z meters; drawn width = $360 \times \text{length/field}$. Below 1 is small; above 720 is large; the endpoints remain drawn. Real rendering can crop vertically.

Interpretation and limits

The cell diameter, mitochondrial length and atomic reference extent compare different chosen linear dimensions. They are illustrative, not a measured population. Biology varies by cell type and context. The diagram has no calibrated microscope magnification, optical/electron resolution model or quantum probability calculation. Matching an arithmetic recipe does not validate a particular specimen.

Sources / checked October 25, 2026

BIPM / SI prefixes:

bipm.org/en/measurement-units/si-prefixes

NIST / international inch, length FAQ:

nist.gov/pml/owm/si-units-length

OpenStax Biology 2e / relative-size figure 4.6:

openstax.org/books/biology-2e/pages/4-2-prokaryotic-cells

Mourokh & Friedman (2024) / mitochondria size context:

pmc.ncbi.nlm.nih.gov/articles/PMC10932015/

These supply unit definitions and size context. The exact 20/2/0.1 teaching inputs and changed 40- μm case are adopted here, not specimen measurements transcribed from those sources.

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