DESIGNING EFFECTIVE FIGURES

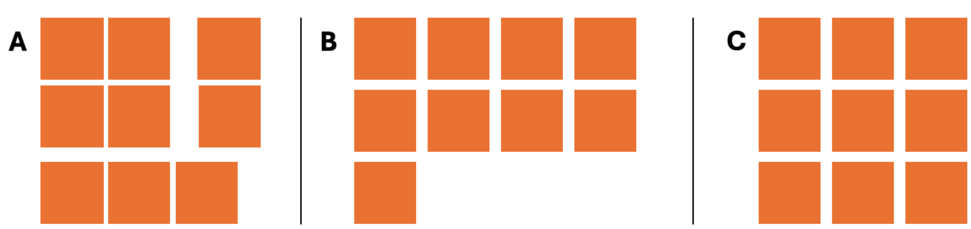
Figures are central to scientific communication whether you are writing a paper, presenting a poster, or giving a talk. The choices you make in the design of your figures influence how easily and accurately a viewer can interpret your data. This handout will explore some of the design considerations that help make figures more visually appealing, accessible to audiences, and efficient in conveying a message.

FIGURE LAYOUT MATTERS

Readers tend to approach figures the same way that they read text. This means that for English language texts, readers generally look from left to right and top to bottom. Going against the expected layout, or scattering material across the page can slow readers down and introduce opportunities for confusion. In addition, design choices can alter the flow of information within your figure by drawing attention toward specific objects. Objects gain this **visual weight** through characteristics such as bold warm colors, large size, texture or pattern, or higher contrast with their surroundings. **Your goal is to design and position each component of your figures so that the reader is drawn through the full image in the order you intend.**

Notice how your attention moves through this figure. In what order do you see each shape? Where do you spend the most time? What shapes do you interpret as related?

Objects that are grouped closely together are more easily interpreted as being related than those that are far apart. If your figure has multiple panels, try to cluster related content together in simple boxes; a panel left alone on a line can appear to not belong with the rest.

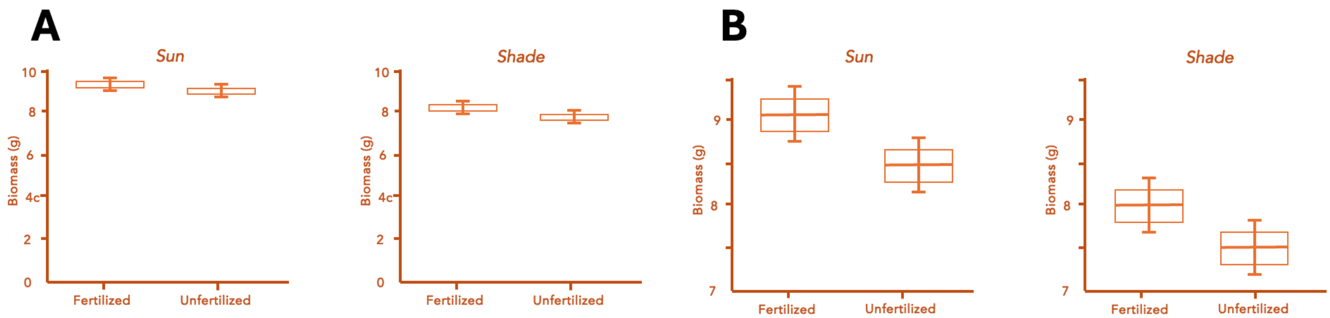


In **A**, the varying proximity of the boxes makes three groups visible. Note that in the irregular shape of **B,** the lone panel has more weight because it appears out of place. Figure **C** appears more balanced and unified.

A well-designed layout can convey more information than individual panels can do alone. For example, you might arrange content sequentially to reveal process or group by characteristic to help readers understand relationships between content in the figure. As you design a figure, consider how visual weight and organization interact: does the way the reader moves through the figure help them understand your message?

SCALE & ASPECT RATIO INFLUENCE INTERPRETATION

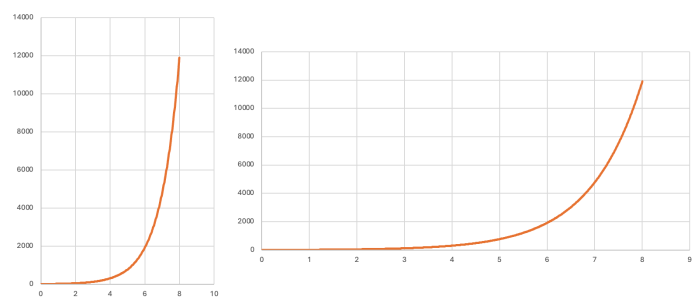
Size and scale influence how readers interpret figures. In the following figures about plant growth, a reader might assume at first glance that **(A)** shows that there are no differences between fertilized and unfertilized growth conditions, and only a slight difference between growth in sun and shade. In contrast, the zoomed-in version of the plot in **(B)** makes the variation between the growth conditions easier to see. **Be aware that changes in scale can have negative effects; avoid exaggerating differences that are statistically insignificant or hiding relevant information from your readers with a change of scale.**



Adapted from The Scientist's Guide to Writing *(Stephen B. Heard, 2016)*

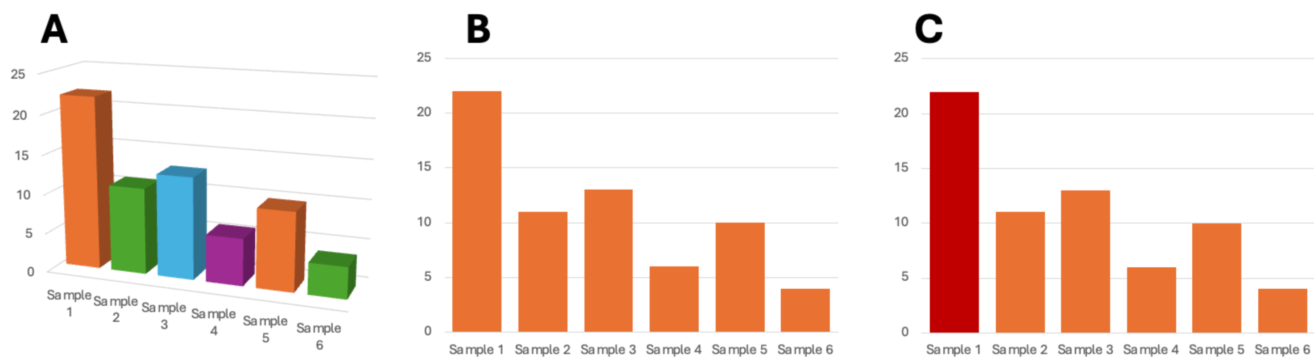
The **aspect ratio** of your figures also matters. The two figures below plot the same data, but at first glance, the plot on the left appears to have a steeper line, or faster rate of change, than the one on the right. While a careful reader will notice that the left plot is simply a compressed version of the right plot, an inaccurate first impression can interfere with later critical interpretation, especially for readers with limited time or expertise to evaluate your work.

When creating figures that are intended to be compared, be aware that differences in scale and aspect ratio force readers to translate between formats to separate out meaningful differences from artifacts. Keep the design of comparable figures identical so the only apparent differences come from the data.



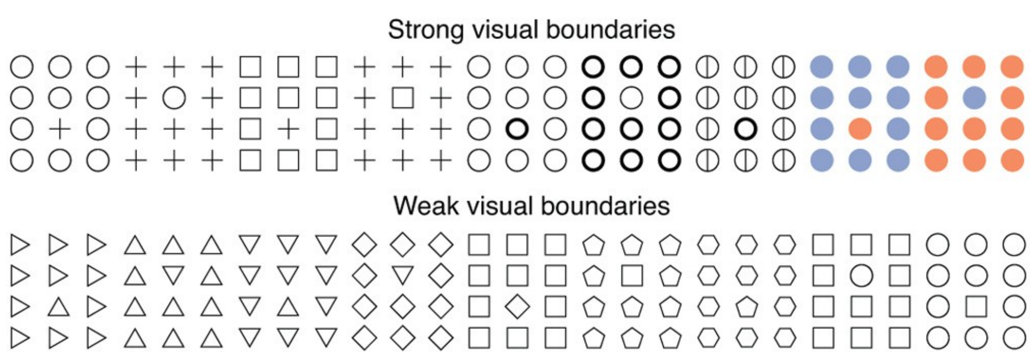
REDUCE NOISE, MAXIMIZE SIGNAL

Effective figures make their core message as salient as possible by minimizing distracting "noise" and enhancing visibility of important "signal". As you design your figure, ask yourself: does everything I'm including serve a purpose? Do all stylistic elements contribute meaning, or can some be removed? How quickly can I spot the most important information in this figure? For example, the colors in bar graph (**A)** look more meaningful than they are (are the two green and two orange bars related?), and the 3D effect makes differences between samples difficult to evaluate. A simpler version (**B**) removes these confusing elements, making it easier to focus on the real differences between samples. What if you want your reader to pay extra attention to a specific item? Figure **(C)** shows how reformatting just one bar on the graph can alert readers to focus on the sample of interest without introducing noise.



As the figure above shows, viewer attention is drawn to objects that differ significantly from others, so minimizing unimportant differences minimizes distraction. **Simple visual cues, such as proximity, orientation, shape, or color, can also be used to enhance the visibility of relationships within items in your figures.** Objects that appear close together appear more related than those that are far apart. Similar shapes and colors suggest objects are of the same kind. Bold, bright colors make data points appear important than translucency or desaturation do. Relatedly, cool colors tend to be interpreted as representing lower values than warm colors. Fuzzy or blurry outlines suggest uncertainty compared to sharp outlines. These and other cues can be used to increase contrast between objects in a figure and reinforce the main point of the image.

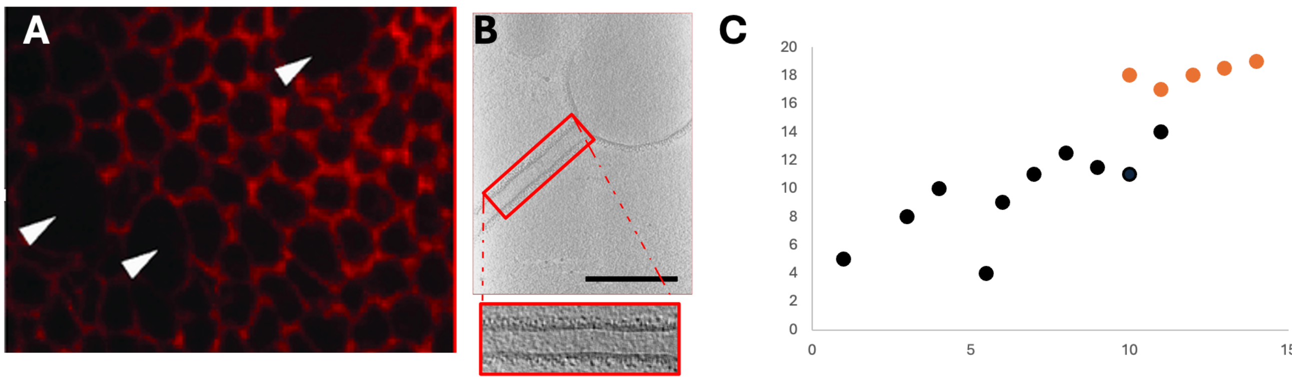
Be aware that not all representations are equally easy to tell apart. Aim for combinations of symbols with strong **visual boundaries**, and when in doubt about the ease of distinguishing data in your plots, include multiple avenues for interpretation, such as combining, shapes, patterns, and colors.



Notice how much easier it is to spot symbols that are different from their surroundings in the top row than in the bottom row. From: Krzywinski & Wong 2013 *DOI: 10.1038/nmeth.2490*

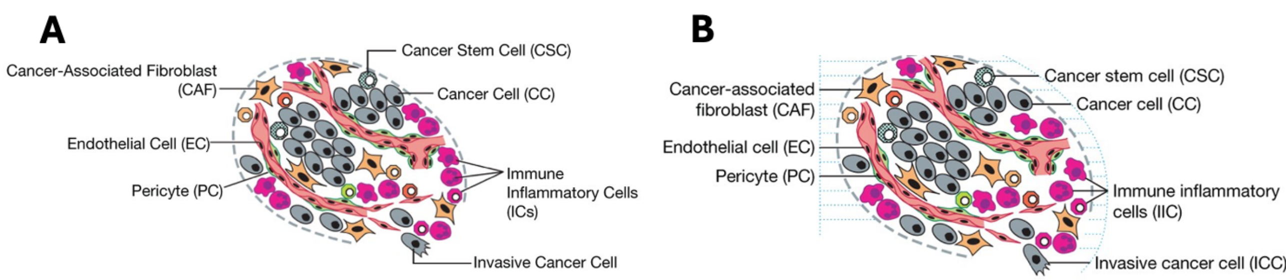
GUIDING THE READER THROUGH A FIGURE

Sometimes adding "signpost" features to your figures increases their clarity. Arrows, callout lines, and boxes guide readers through your figure by highlighting important details and making connections between images. In the examples below, a less expert reader might struggle to identify features in the microscopy image **(A)** without the arrows for guidance**.** Figure **(B)** uses boxes and lines to highlight important features and relate them to the zoomed-in view below. Sometimes visual cues, such as those described in the prior section, can be used to direct the audience to a region of interest on a plot **(C)**.



Left from Nematbakhsh et al. 2017 [DOI: 10.1371/journal.pcbi.1005533](). Middle from Coray & Castaño-Díetz 2025 [DOI: 10.1016/j.str.2025.06.009]().

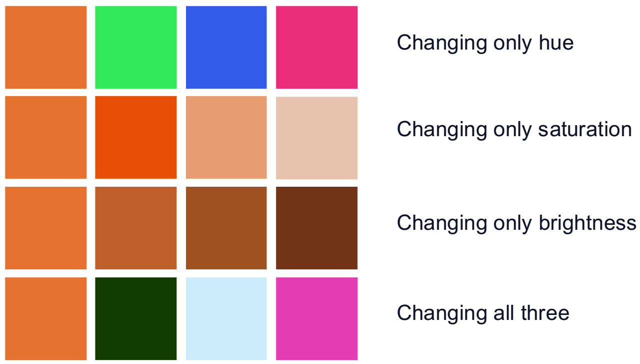
Make sure guiding elements are visible against the figure background and as simple as possible. If you have multiple labels, boxes, or callout lines, use similar formatting and try to keep lines parallel and even to avoid a cluttered look, as in the example below.



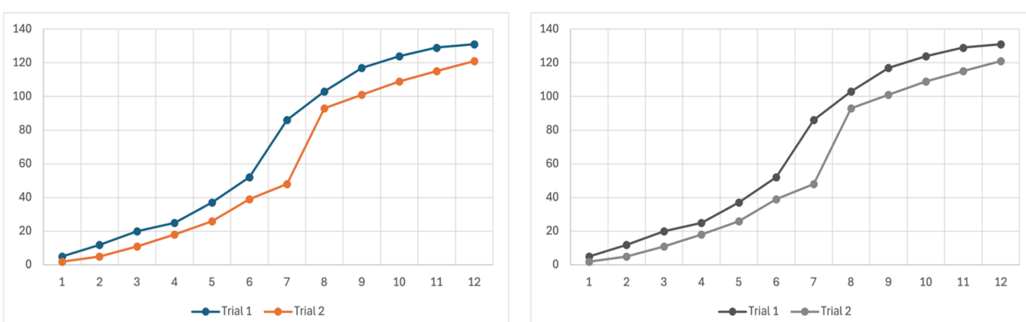
Left: original figure, with noisy callout lines. Right: revised figure. Krzywinski 2013 [DOI: 10.1038/nmeth.2405]()

ALL ABOUT COLOR

An interesting color palette can make your figures visually appealing and easy to read. However, colors must be chosen with care to ensure that your figures are accessible to all readers. When using color to distinguish elements of your data, make sure to **choose high-contrast, highly divergent colors**, especially for colors displayed side by side. Avoid monochrome palettes that rely on differences in brightness or saturation alone to distinguish values. Instead, change hues, or for the most diverse palette, change hue, saturation, and brightness at the same time.

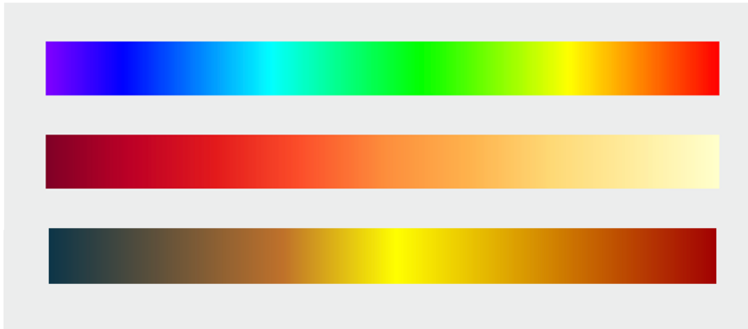


Be aware that **not all palettes will look the same to all readers**. Reading environment, medium, and reader vision together shape what colors are perceived. For example, colorblind readers may not be able to distinguish between certain colors such as red and green, and colors can change dramatically based on screen or printer settings. Whenever possible, **include multiple methods to distinguish data** such as combining grayscale-friendly colors with distinct shapes or patterns to ensure clarity for as many readers as possible.



In the color version of this graph, it's easy to distinguish Trial 1 (blue) from Trial 2 (orange). The difference between the two is more subtle when converted to grayscale. Would all readers be able to tell which trial is which?

Gradients require extra care. For accurate data visualization, a color gradient should appear uniformly smooth so differences between values can be easily assessed. In the top gradient below, the cyan and yellow regions appear to take up the least amount of space. As a result, two points on either side of one of these colors would appear more different from each other than two equally spaced points within the blue, green, and red regions. In contrast, the middle gradient shows a more consistent transition between red and yellow. Contrast can also be a problem with gradients when some values appear brighter or more intense than others. In the third gradient in the figure below, the bright middle values pop against the dark red and blues, which could distract a reader from noticing the highest and lowest values.



BUILD A DESIGN VOCABULARY FOR YOUR WORK

Using consistent symbols, colors, and other elements between panels, figures, or even related papers/presentations can help your readers quickly grasp the meaning of your work and highlights connections between different material, reinforcing the visual "story" your figures tell.

Take some time to plan ahead before making your figures. If you going to display data for the same sample in multiple figures, is there a design element that can be shared between each representation to indicate this to the reader? Maybe your first figures show each sample separately, but if you might need to compare them down the road, can you choose colors or symbols that will strongly contrast each other if present in the same figure? In the example at right, panels **b-f** use the same color scheme, making it easy to follow the results for each experimental condition. The reader only needs to learn the visual language of one plot to know how to interpret everything else.

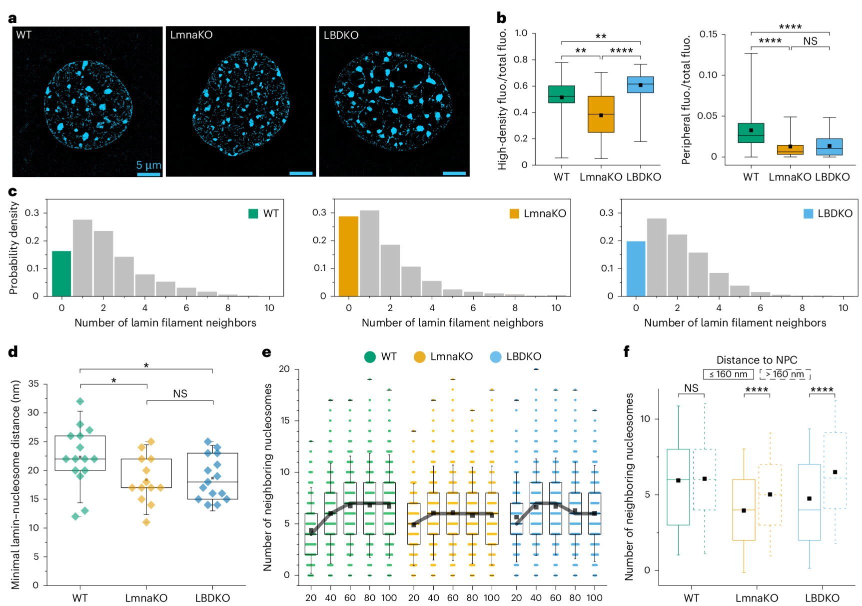


Figure from: Wang et al 2025 [DOI: 10.1038/s41594-025-01622-5]

ADAPTING FIGURES FOR POSTERS & SLIDES

So far, this handout has only included examples from research publications. While most of the design considerations discussed are relevant for other contexts, such as posters and slide decks, figures are more effective when adapted for the unique characteristics of the presentation medium.

Attending a poster session or talk is inherently more stimulating for an audience than reading a paper. Not only does the audience need to interpret the text and figures, but they need to do so while following the presenter's speech and tuning out distractions in a potentially noisy and crowded environment. Audiences also move through content differently than they do when reading a paper. On a poster, everything is visible at once, allowing the audience to roam freely through the figures and text, while in a presentation, audiences have a limited amount of time to view each slide and cannot go back to revisit past slides. As a result, it is critical that figures are easy to read and the flow of information is clear. Here are a few questions to consider when adapting figures for posters or presentations:

- What message am I trying to convey? How can I break it down into digestible pieces (individual slides on a presentation or sections on a poster)?
- Do my figures serve a single purpose? If not, do I have a good reason for this complexity?
- What can I do to give my audience the tools and time to understand my figures' messages?
- What information is *necessary* for readers to understand my point? What could be removed to avoid distraction?
- How can I take advantage of the format to make my message clearer? For example, you might use slide animations to reveal each sample on a plot only when you're ready to talk about it.
- If figures may need to be resized or reformatted to fit on a slide or poster, what other elements may need to be changed to make the figure appear balanced and organized?
- What formatting changes might improve my ability to hold the audience's attention in this particular context?

RESOURCES FOR FURTHER READING:

There are many excellent resources on design principles and making effective scientific figures. Here are just a few:

"Points of View" series from the *Nature Methods* Methagora blog:
https://blogs.nature.com/methagora/2013/07/data-visualization-points-of-view.html?

"Subtleties of Color" series, from the Nasa Earth Observatory Elegant Figures blog:
https://earthobservatory.nasa.gov/blogs/elegantfigures/2013/08/05/subtleties-of-color-part-1-of-6/

Fundamentals of Data Visualization – Claus O. Wilke. Online: https://clauswilke.com/dataviz/index.html

Powerful Charts – Koen Van den Eeckhouk.

Visual Strategies – Angela H. DePace and Felice Frankel.

EXAMPLE FIGURE REFERENCES:

Coray R. & Castaño-Díez D. (2025). Geometry-aware template matching for cryo-electron tomograms in Dynamo. *Structure*. DOI: 10.1016/j.str.2025.06.009

Heard S.B. (2016). *The Scientist's Guide to Writing*

Krzywinksi M. (2013). Labels and callouts. *Nature Methods* Points of View. DOI: 10.1038/nmeth.2405

Krzywinski M. & Wong B. (2013). Plotting symbols. *Nature Methods* Points of View. DOI: 10.1038/nmeth.2490

Nematbakhsh A., Sun W., Brodskiy P.A., et. al. (2017). Multi-scale computational study of the mechanical regulation of cell mitotic rounding in epithelia. *PLOS Computational Biology*. DOI: 10.1371/journal.pcbi.1005533