Creating Effective Scientific Figures

Peter Lawson, Ph.D.

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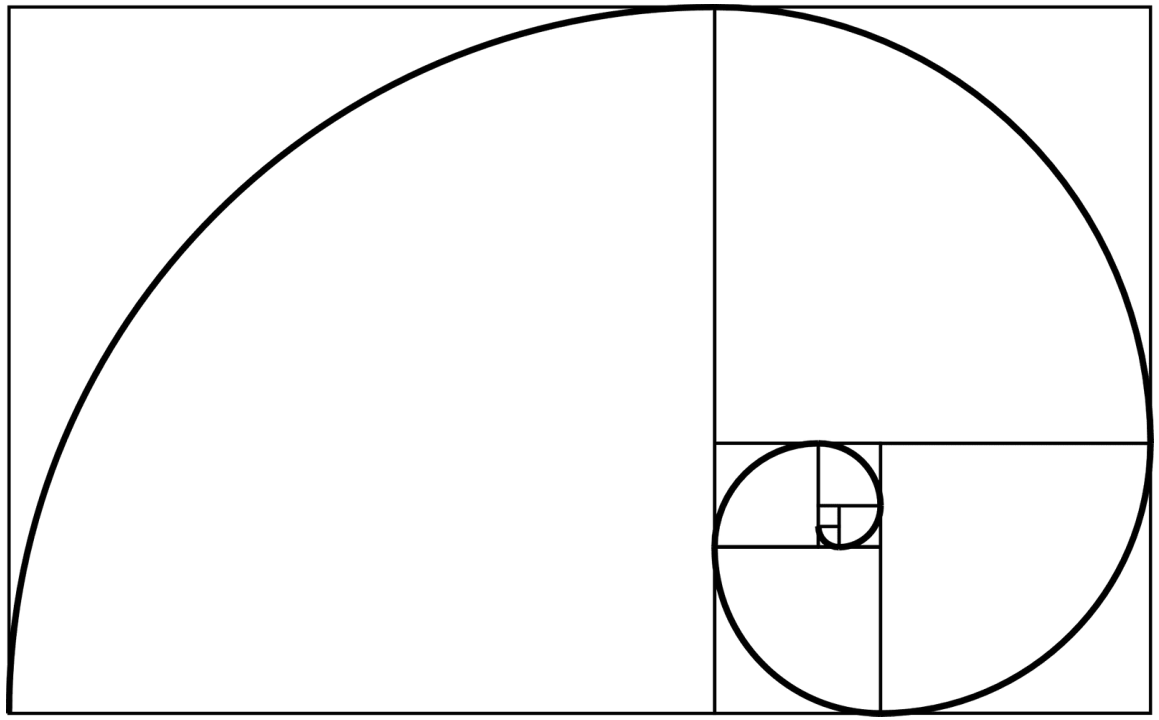

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What makes a good figure?

- It has a clear purpose and message
  - Complements and enhances the text

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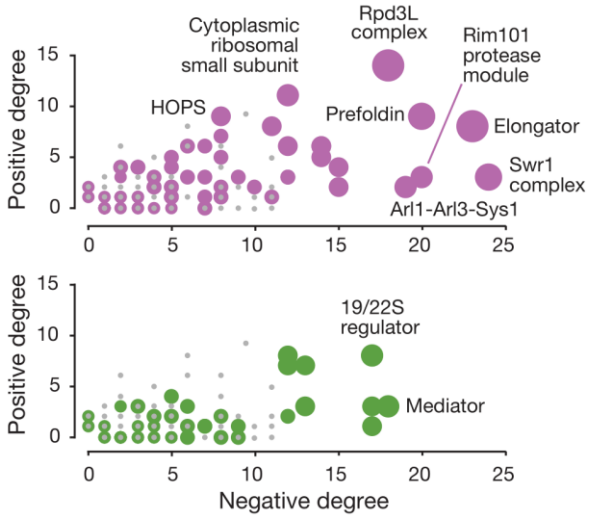
- It is easy to interpret
  - A good figure is like a joke, if you have to explain it, it’s not that good.

What makes a good figure?

- It has a clear purpose and message
  - Complements and enhances the text
- It is easy to interpret
  - A good visualization is like a joke, if you have to explain it, it’s not that good.
- It accurately reflects the data

Introduction

design of scientific figures



Information Design

Communicating information effectively
to facilitate comprehension

Figures adapted from B. Wong, "Layout," *Nat Methods*, vol. 8, no. 10, pp. 783–783, Oct. 2011, doi: 10.1038/nmeth.1711. and B. Wong, "Points of view: Points of review (part 2)," *Nat Methods*, vol. 8, no. 3, pp. 189–189, Mar. 2011, doi: 10.1038/nmeth0311-189.
Slide adapted from: Basics of Information Design for Scientific Figures, Kelly Krause

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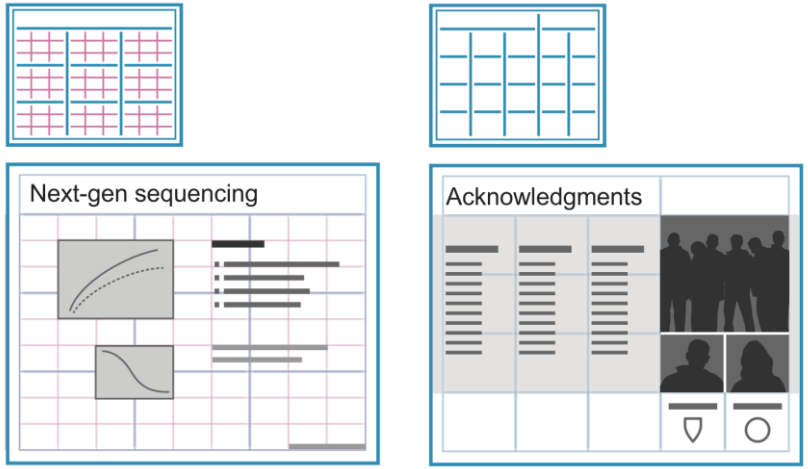

Graphic design

Communicating ideas in an engaging and appealing way

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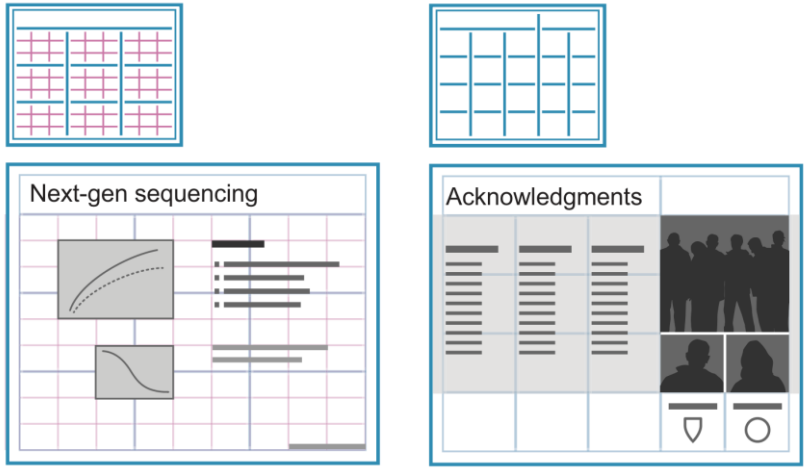

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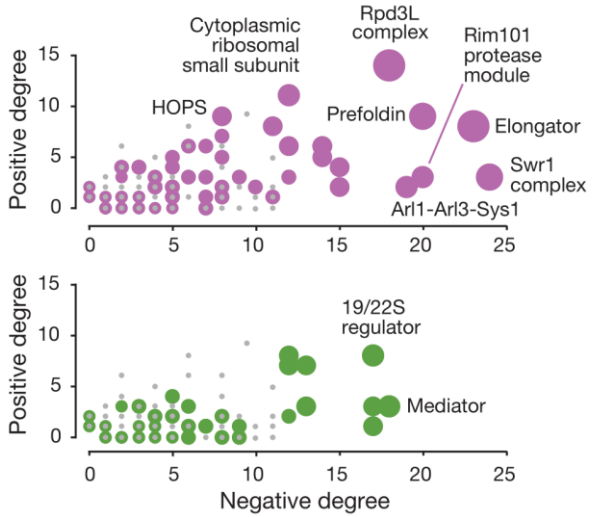

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The process

creating effective scientific figures

clarify the message

restructure the composition

simplify the components

use intentional color palettes

refine the text style

The process

creating effective scientific figures

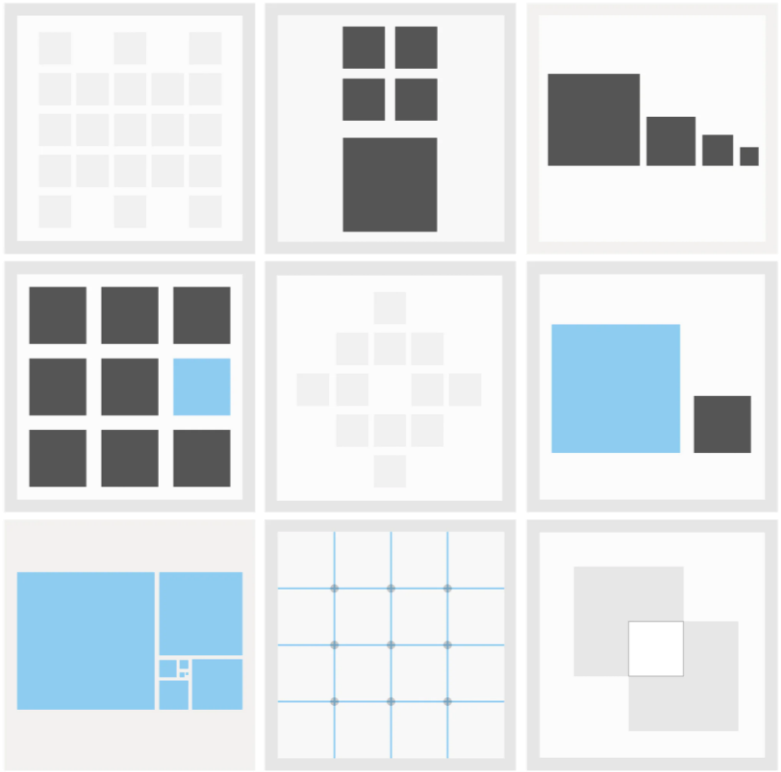

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Image Source: https://99designs-blog.imgix.net/blog/wp-content/uploads/2017/10/design-composition-layout.png

The process

creating effective scientific figures

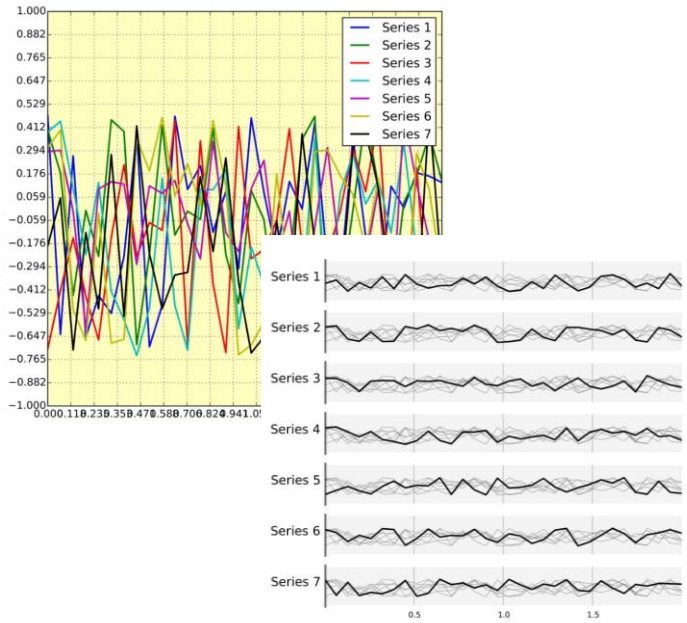

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Figure adapted from: N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

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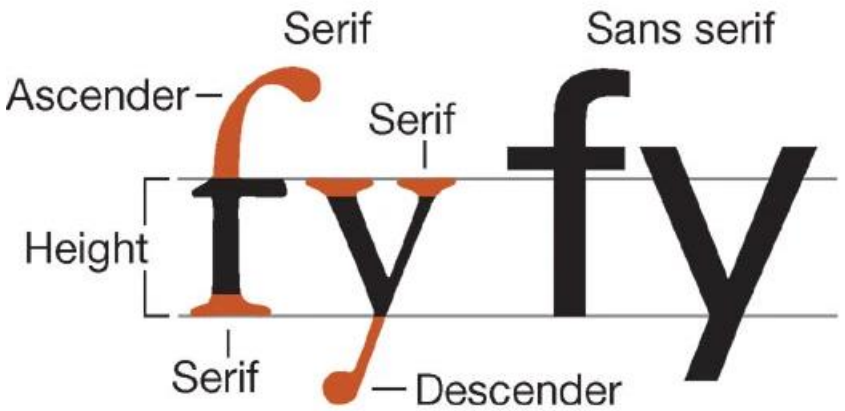

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Image adapted from: Wong, Bang. 2011. “Points of View: Typography.” *Nature Methods* 8 (4): 277–277. https://doi.org/10.1038/nmeth0411-277.

Clarify the Message

Clarify the message

establish an information hierarchy

Purpose
example: *show immune response to intestinal antigens*

Key elements
example: *animal, intestines, lymphatics*

Useful context
example: *intact vs. leaky lymphatics*

Details
example: *dendritic cell, inflamed node, leaky vessel*

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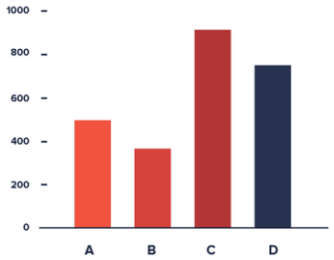
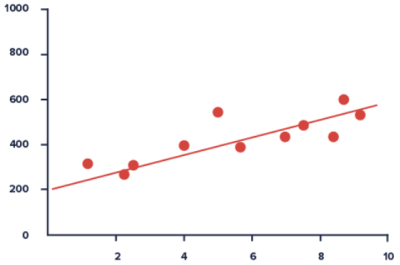
Clarify the message

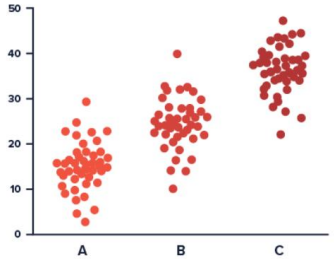
match the purpose to the design



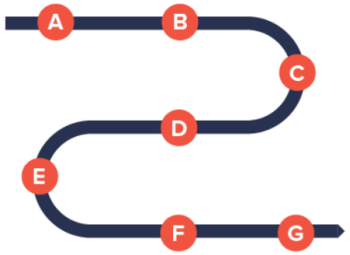
Compare and contrast



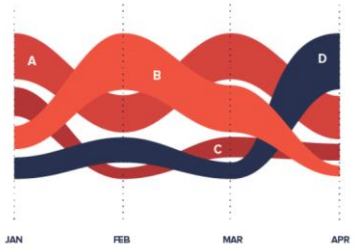
To show a pattern in



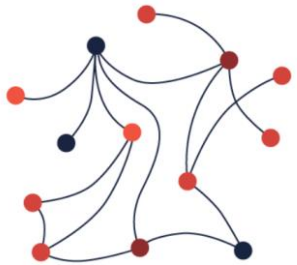
To show the variability of



To show the process of



To show the change in



To show connections

Clarify the message

sketch it out

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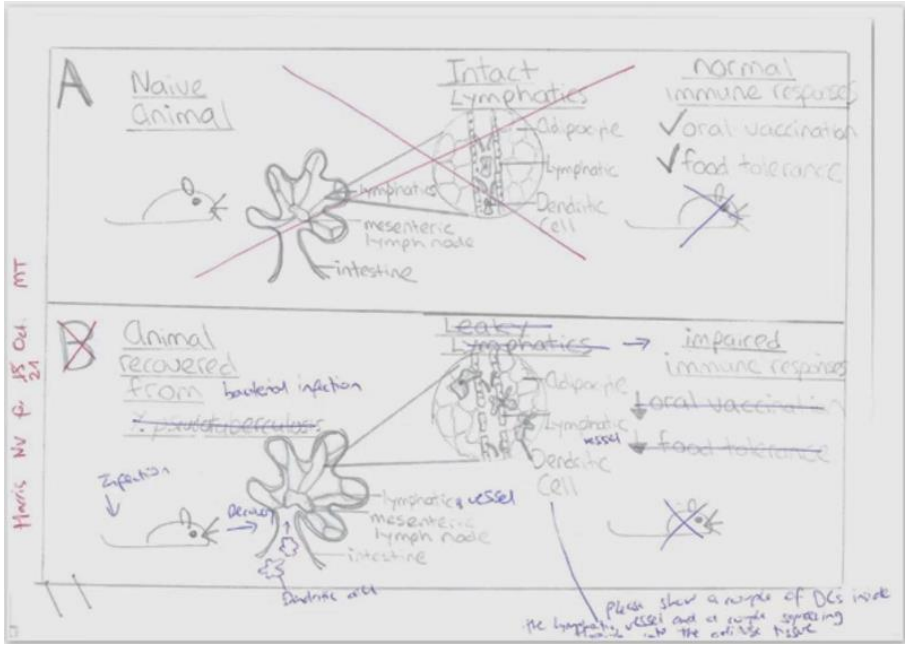
Useful context
example: *intact vs. leaky lymphatics*

Details
example: *dendritic cell, inflamed node, leaky vessel*



Sketch your figure or diagram

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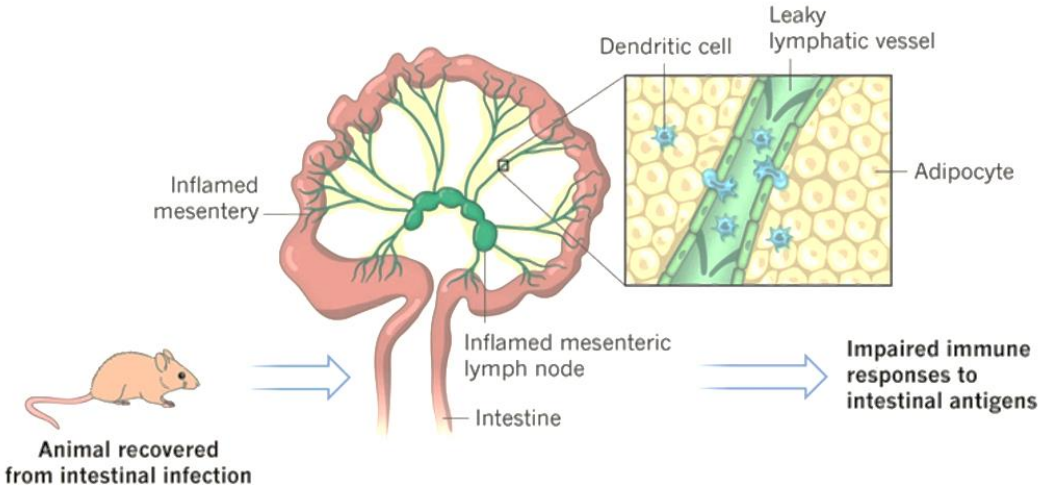

Sketch your figure or diagram

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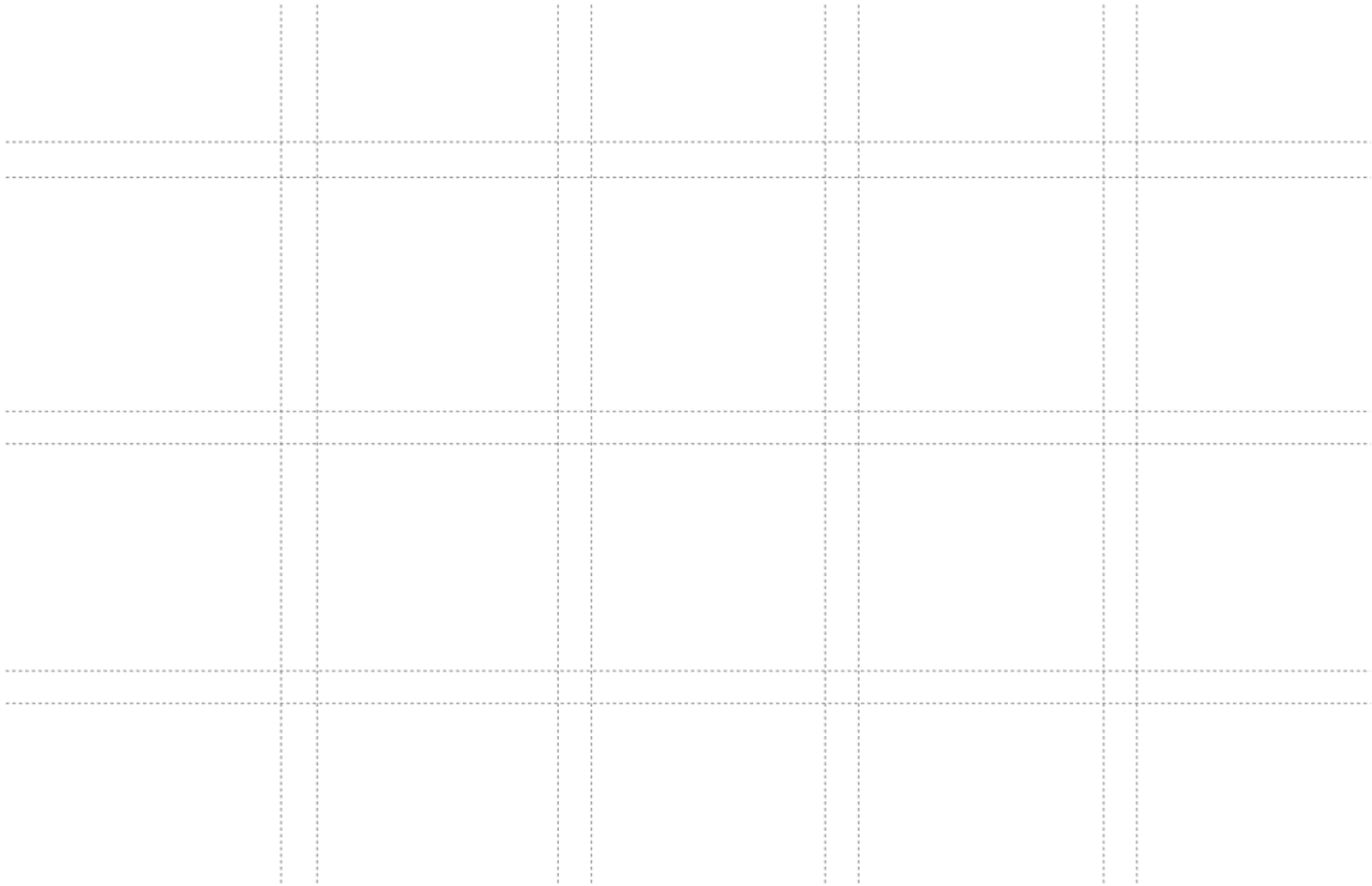
Restructure the Composition

Composition

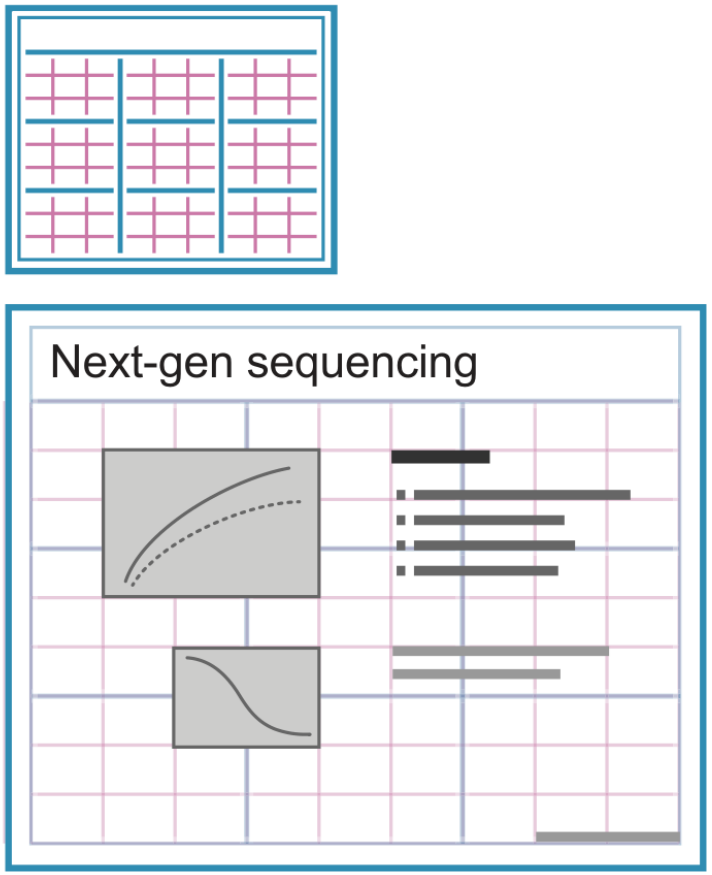
design using gridlines

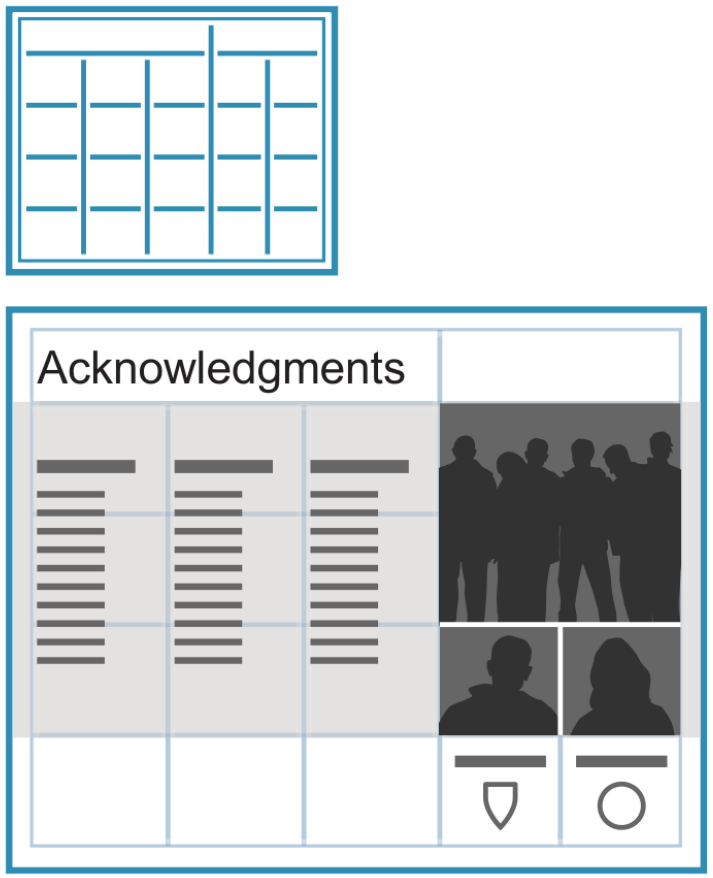


https://bioinformatics-core-shared-training.github.io/effective-figure-design/DesigningEffectiveScientificFigures_Zabala_afternoon_v00.pdf

Composition

design using gridlines





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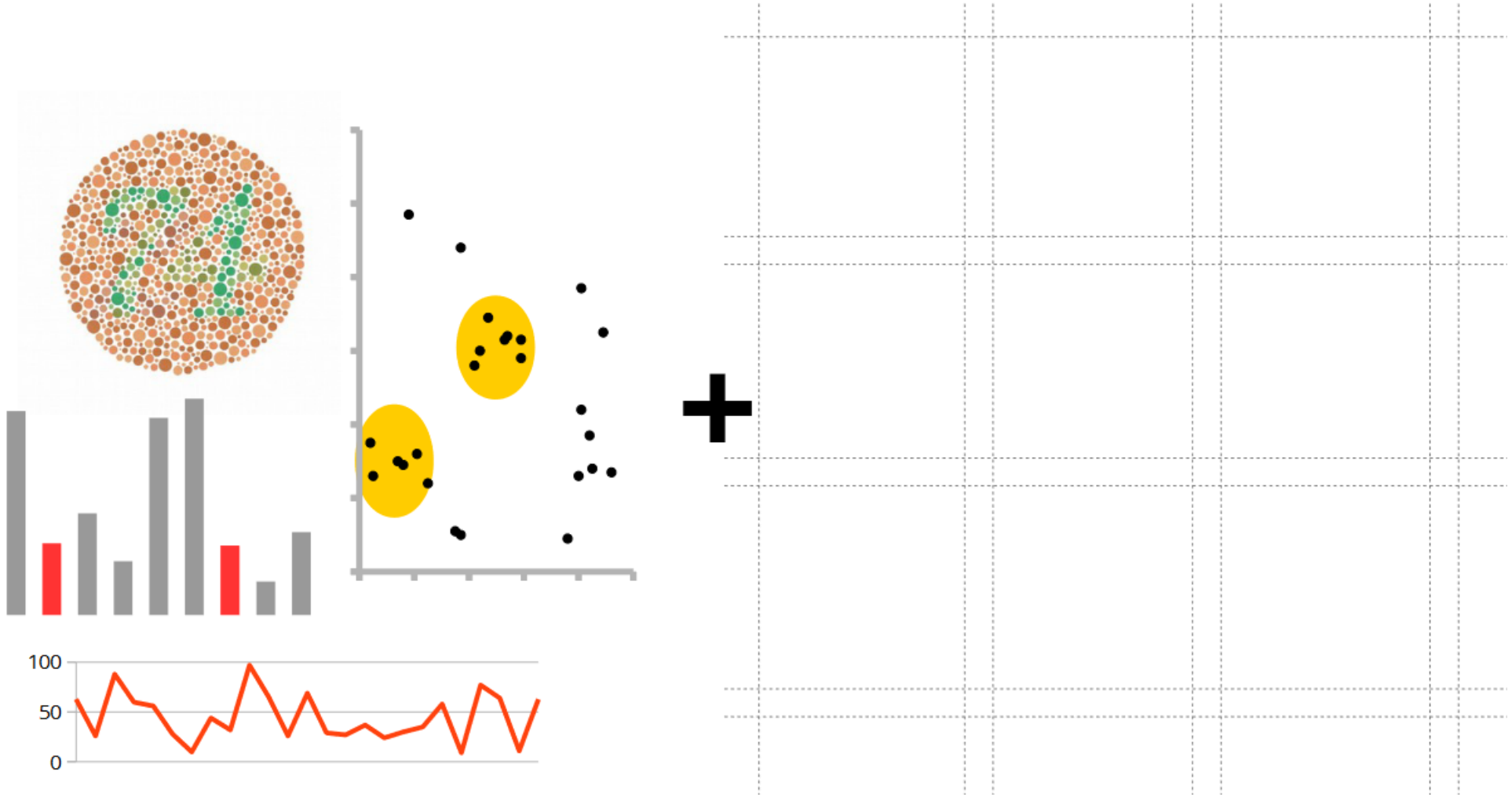

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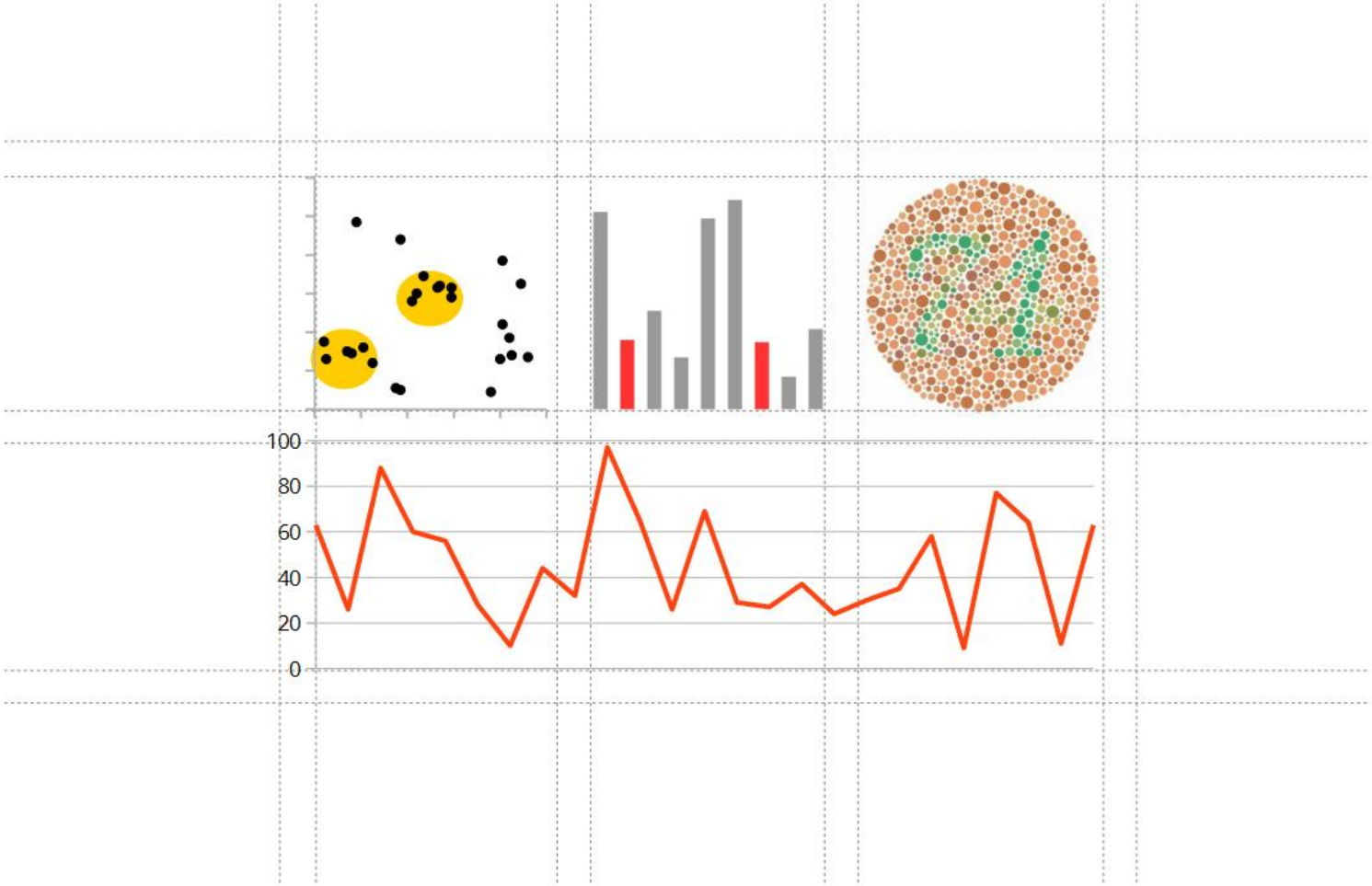

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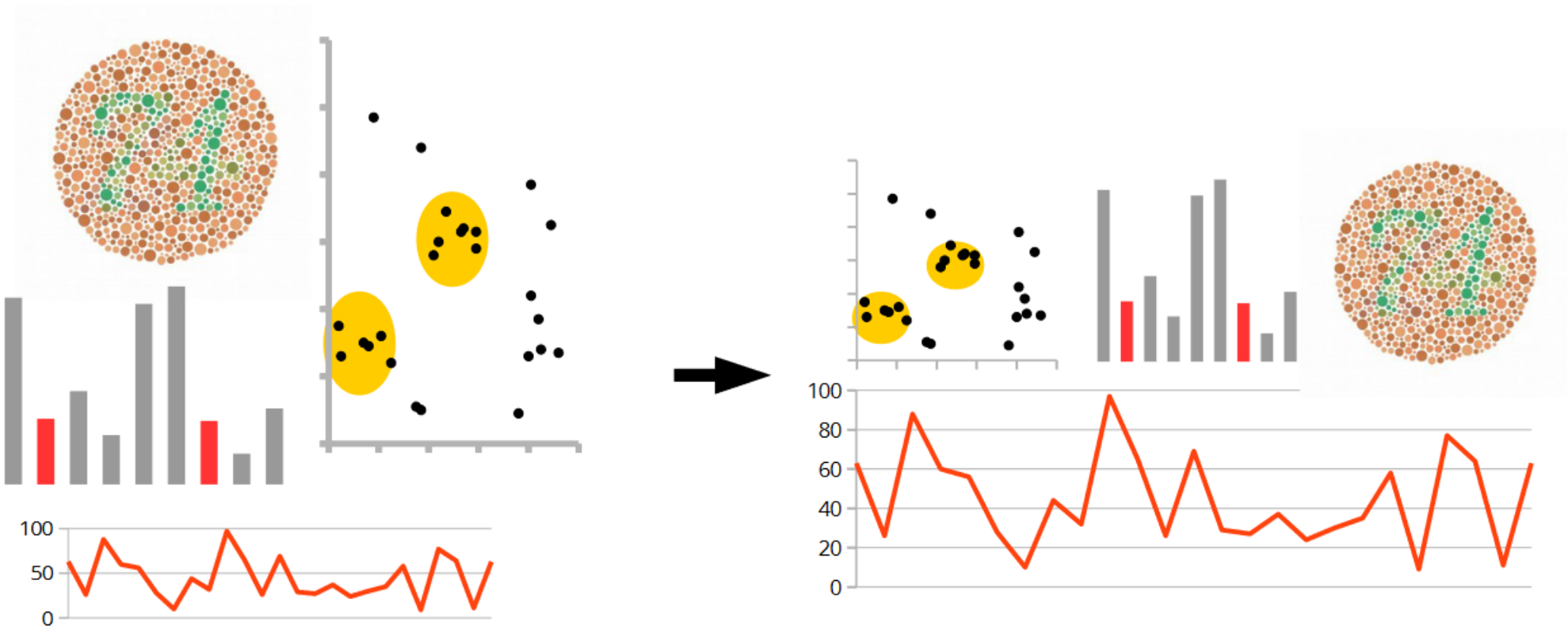
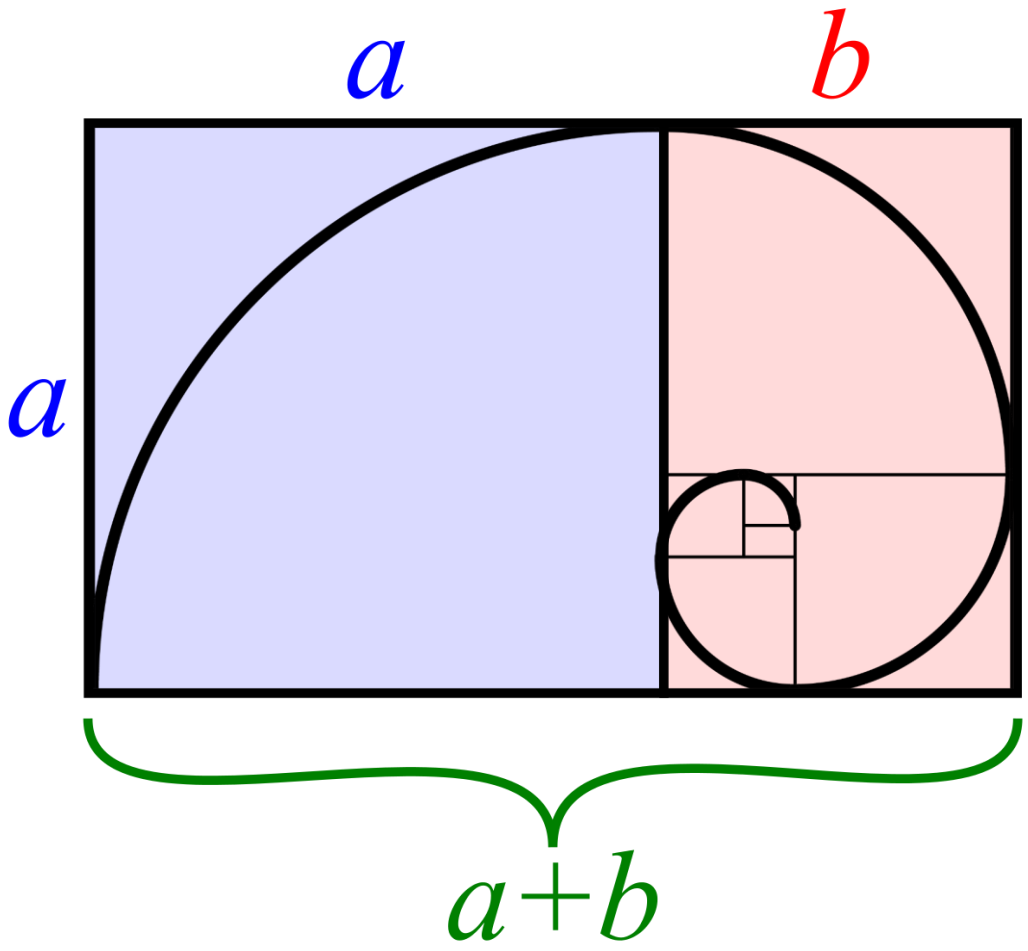


Composition

the golden ratio: an aesthetically pleasing ratio



$$\varphi = 1.618034... = \frac{a}{b}$$

Composition

the rule of thirds

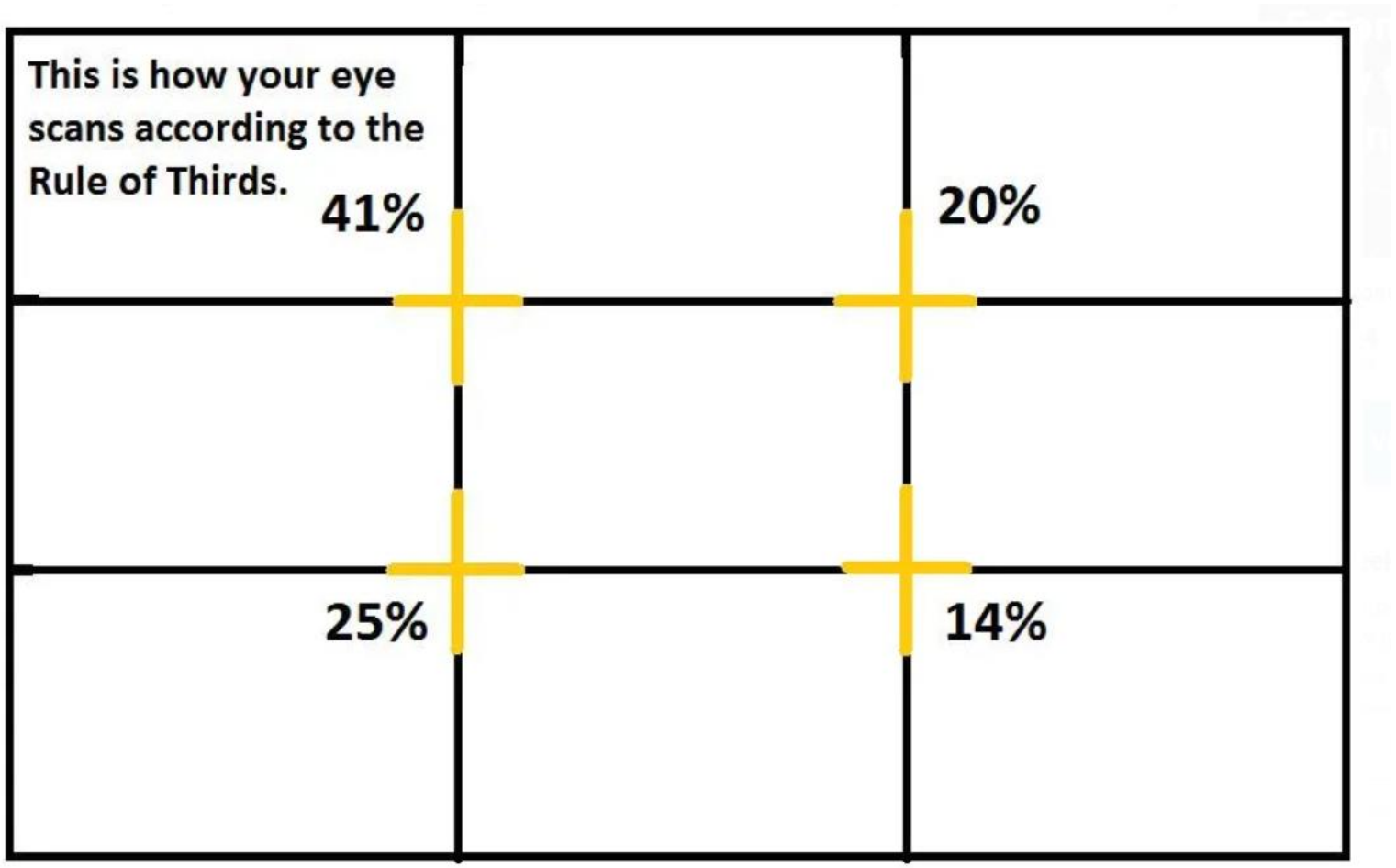


Image source: https://www.interaction-design.org/literature/article/the-rule-of-thirds-know-your-layout-sweet-spots

Composition

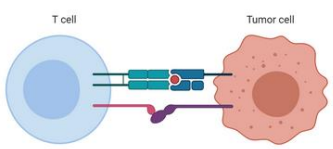
applying the golden ratio

Teach people something cool you learned in 5 seconds as they walk by (or scroll by).

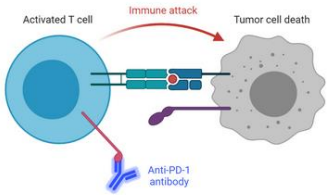
(illustrate your takeaway point)

Method

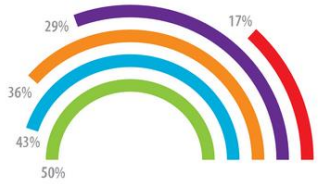
Immune checkpoint inhibits T-cell activation.



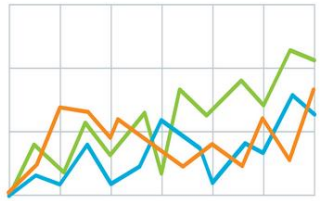
Anti-PDF-1 antibodies permit T cell activation.



Explain what the graph shows. Like, **spoilers are good.**



Quickly explain what the graph shows. **Help people think.**

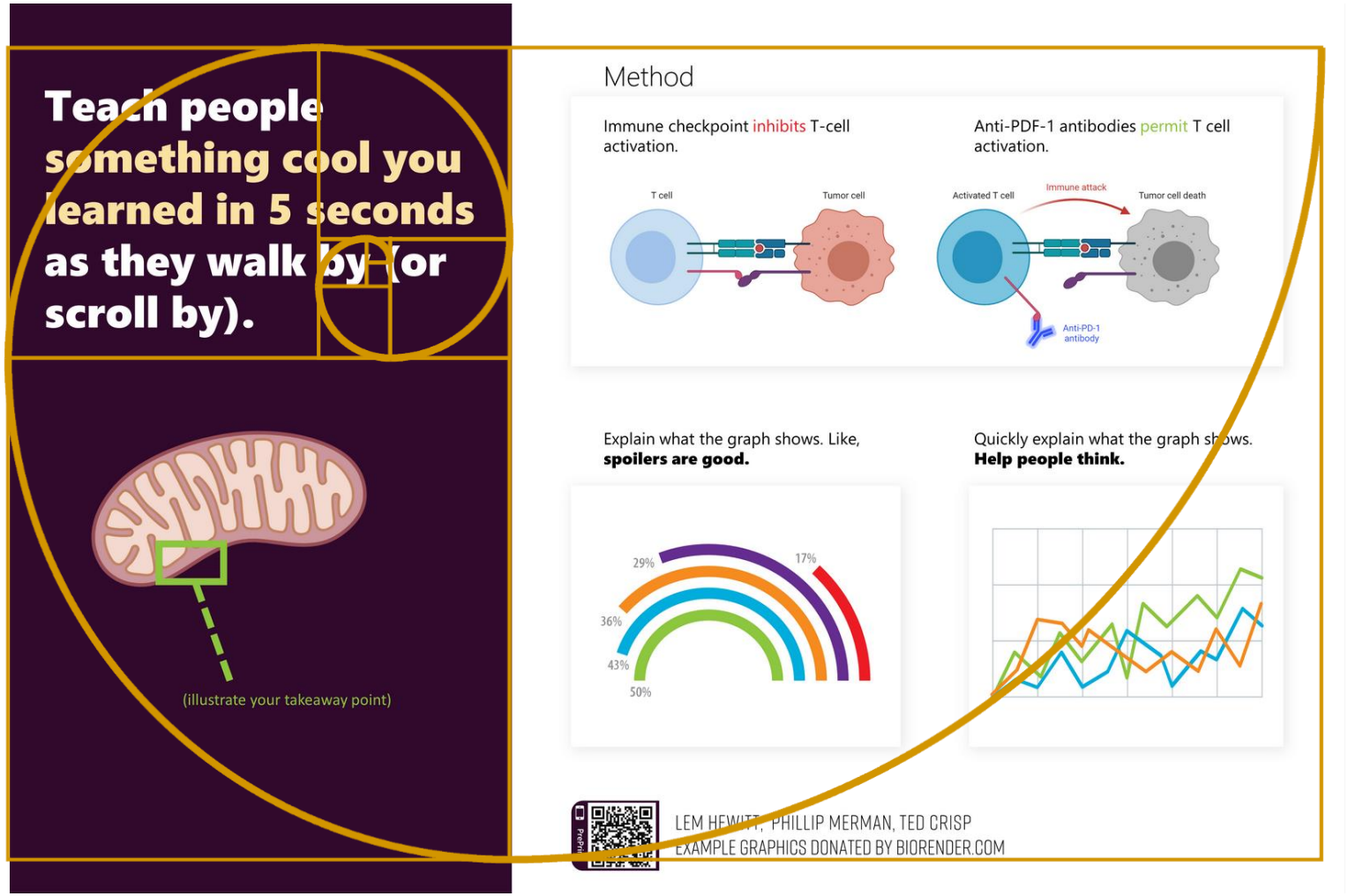


LEM HEWITT, PHILLIP MERMAN, TED CRISP

EXAMPLE GRAPHICS DONATED BY BIORENDER.COM

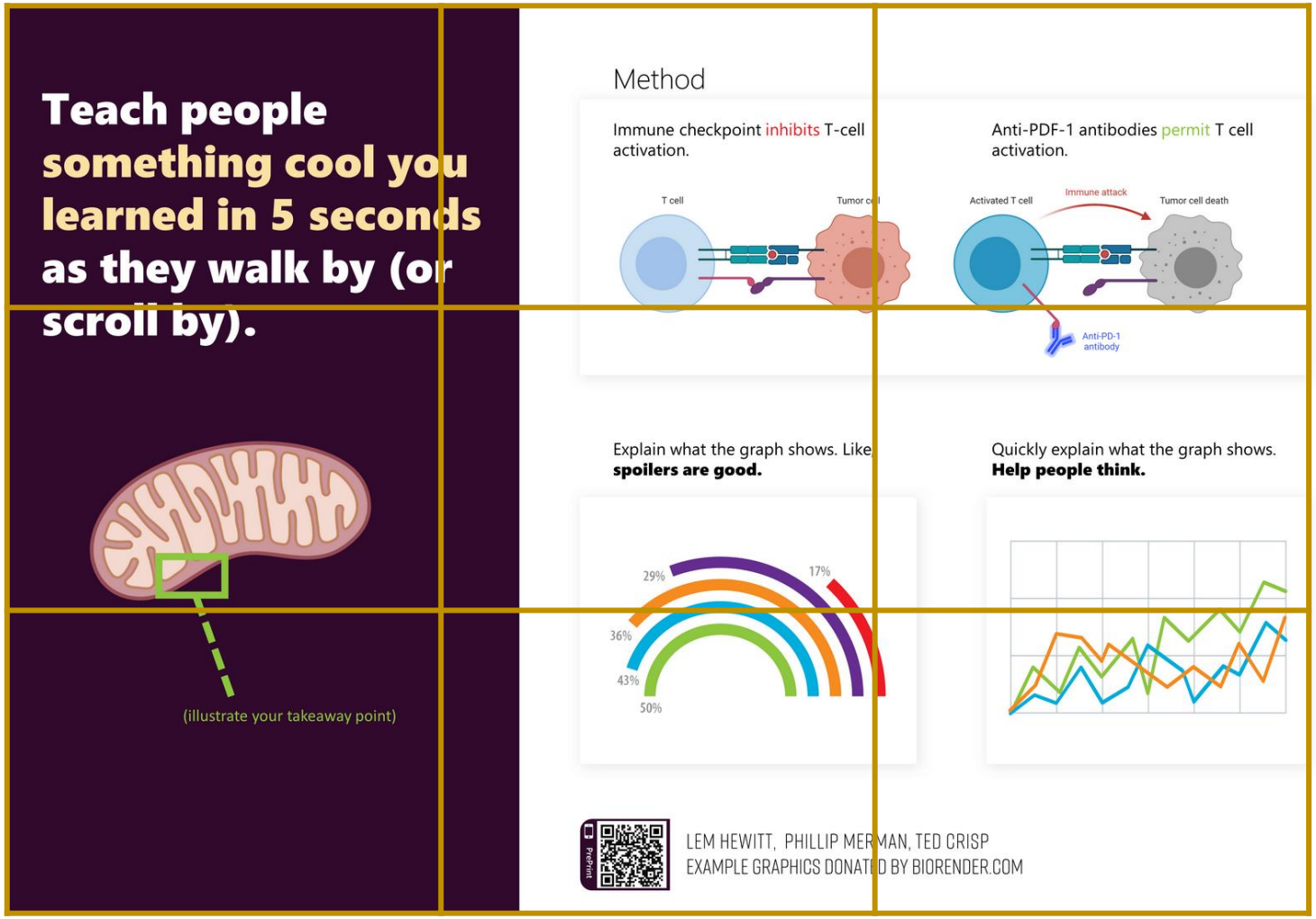
Composition

applying the golden ratio



Composition

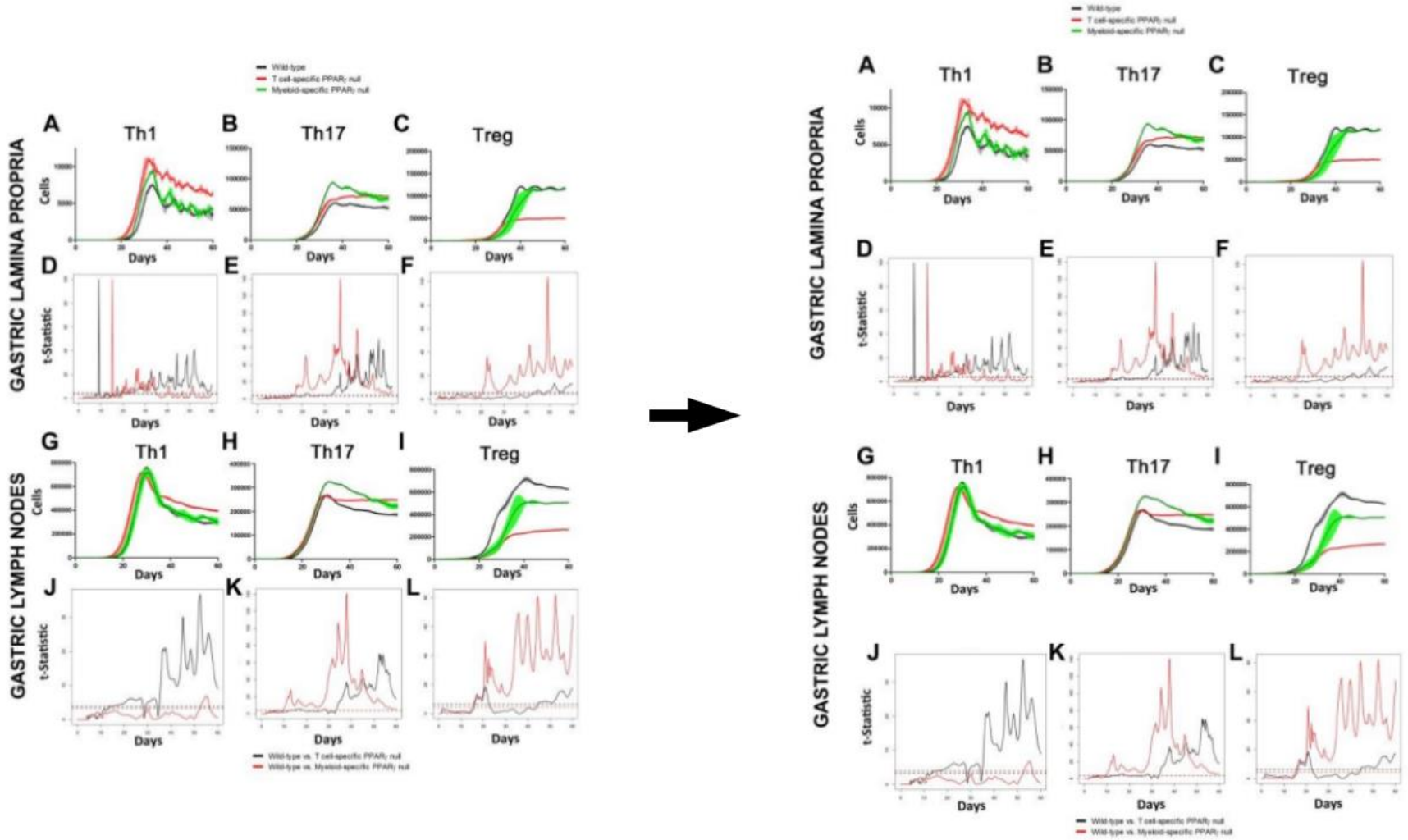
the rule of thirds



Better Scientific Poster Template: https://osf.io/ef53g/

Composition

create natural groupings with whitespace



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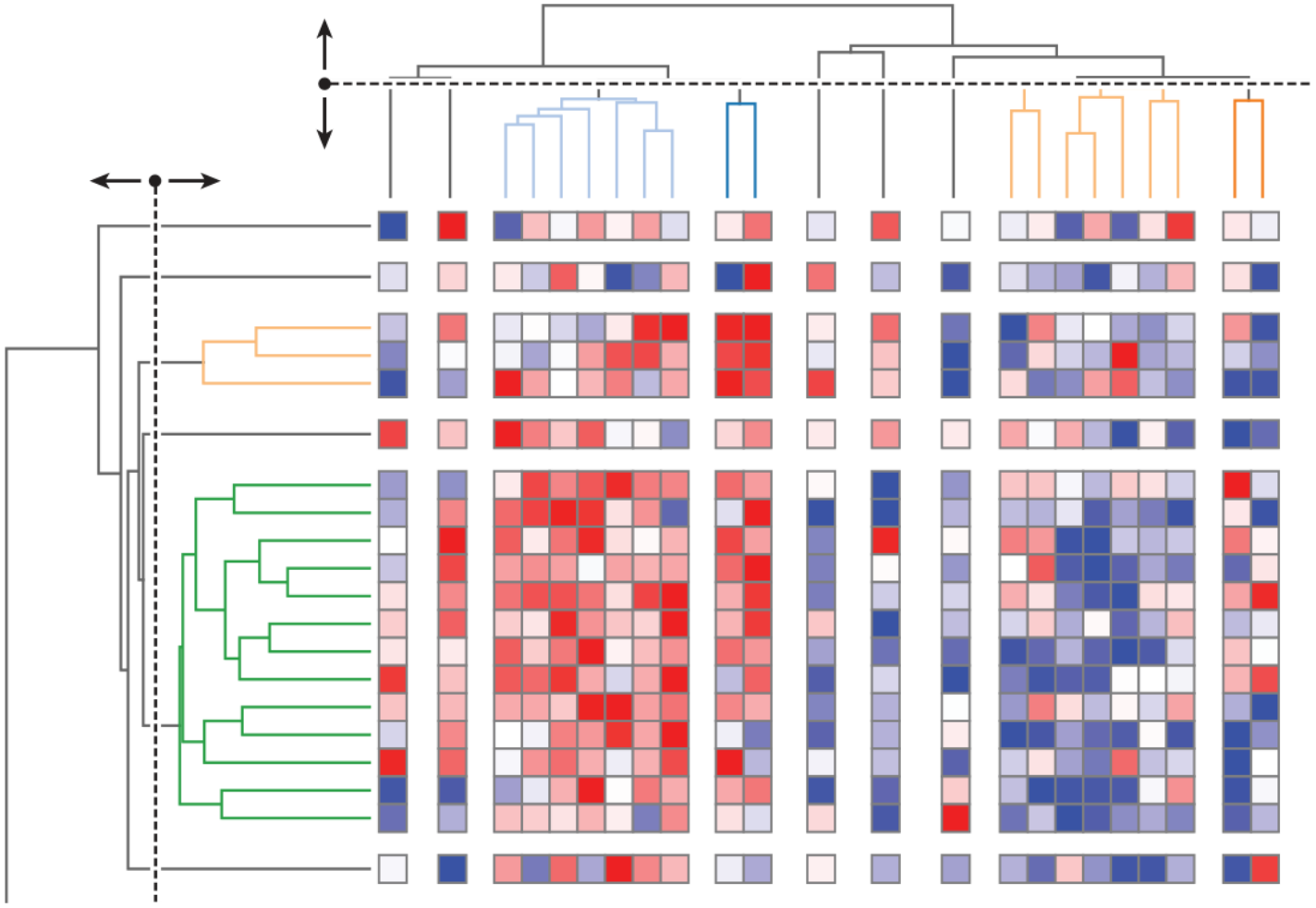

N. Gehlenborg and B. Wong, “Heat maps,” *Nat Methods*, vol. 9, no. 3, pp. 213–213, Mar. 2012, doi: 10.1038/nmeth.1902.

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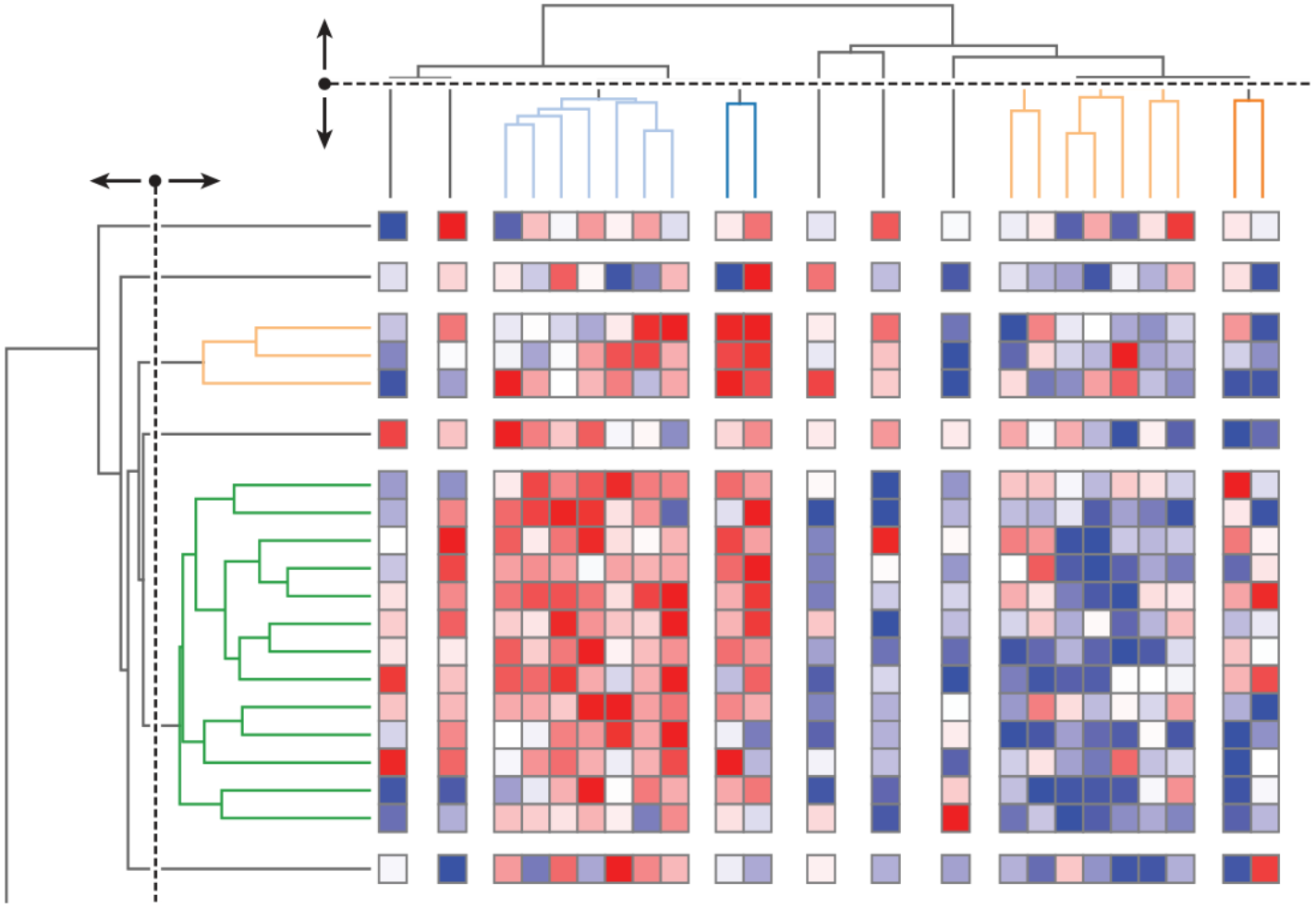
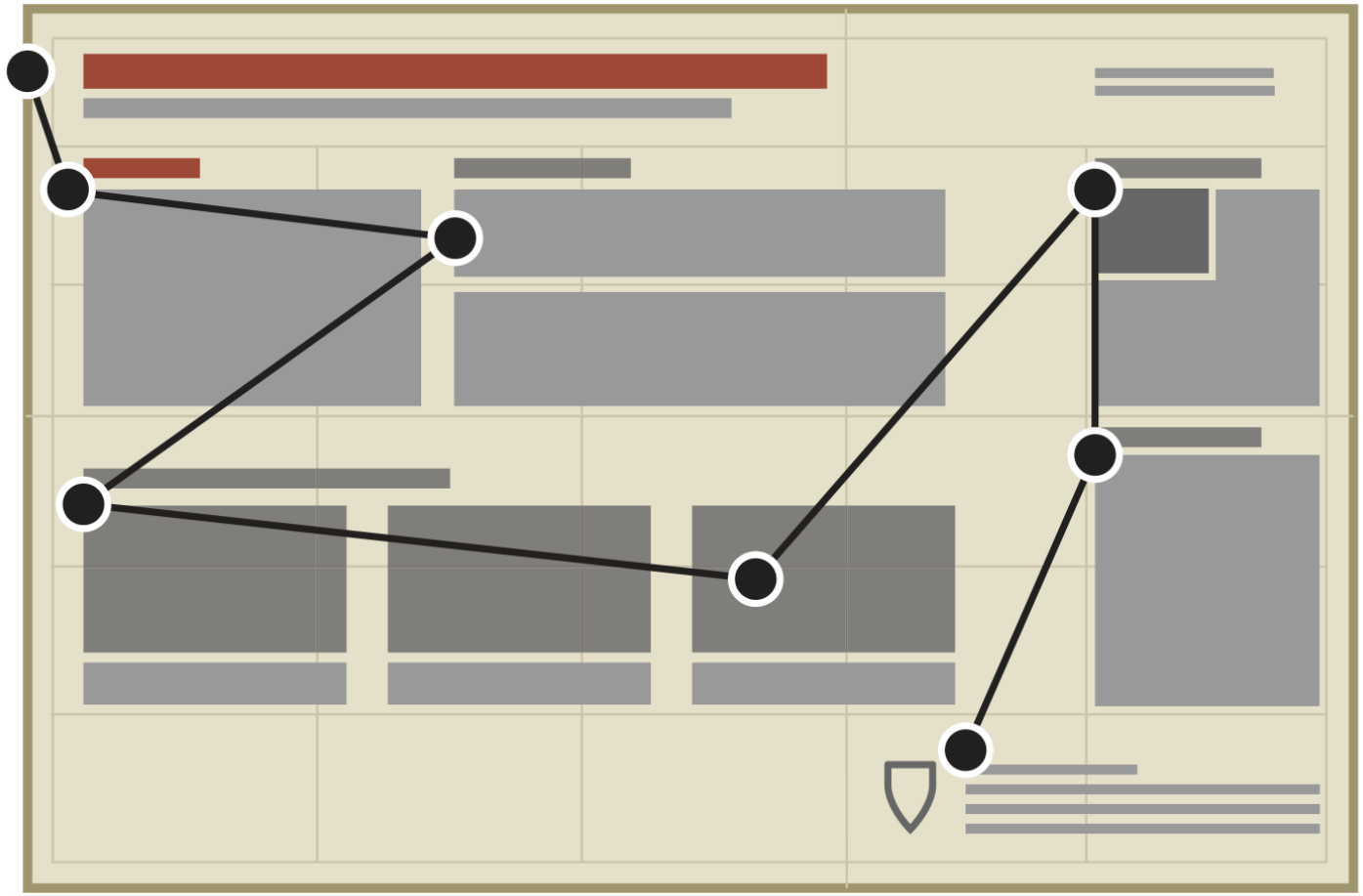


N. Gehlenborg and B. Wong, “Heat maps,” *Nat Methods*, vol. 9, no. 3, pp. 213–213, Mar. 2012, doi: 10.1038/nmeth.1902.

Composition

arrange elements in the order they should be read



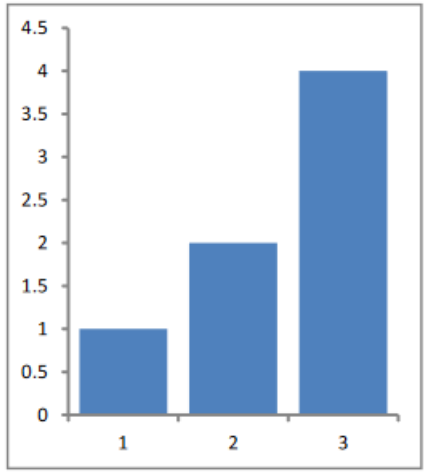
B. Wong, “Layout,” *Nat Methods*, vol. 8, no. 10, pp. 783–783, Oct. 2011, doi: 10.1038/nmeth.1711.

Simplify the Components

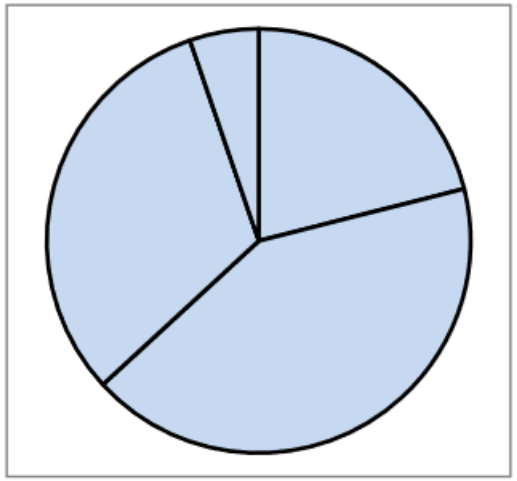
Simplify

principles of visual encoding

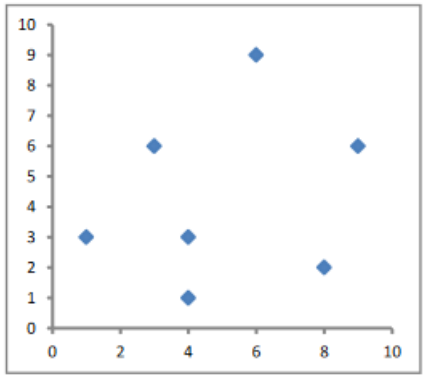
1 Mark = Rectangle
1 Channel = Length of longest side



1 Mark = Circle segment
1 Channel = Angle

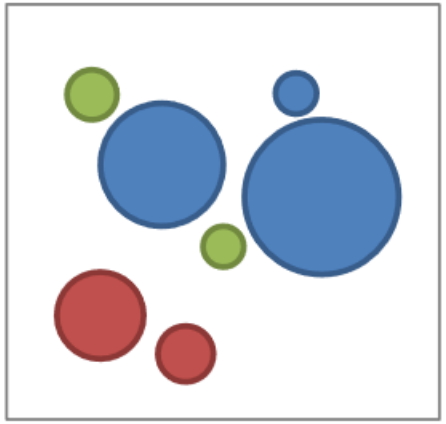


1 Mark = Diamond shape
2 Channels = X position, Y position



1 Mark = Circle
4 Channels:

X position
Y position
Area
Colour

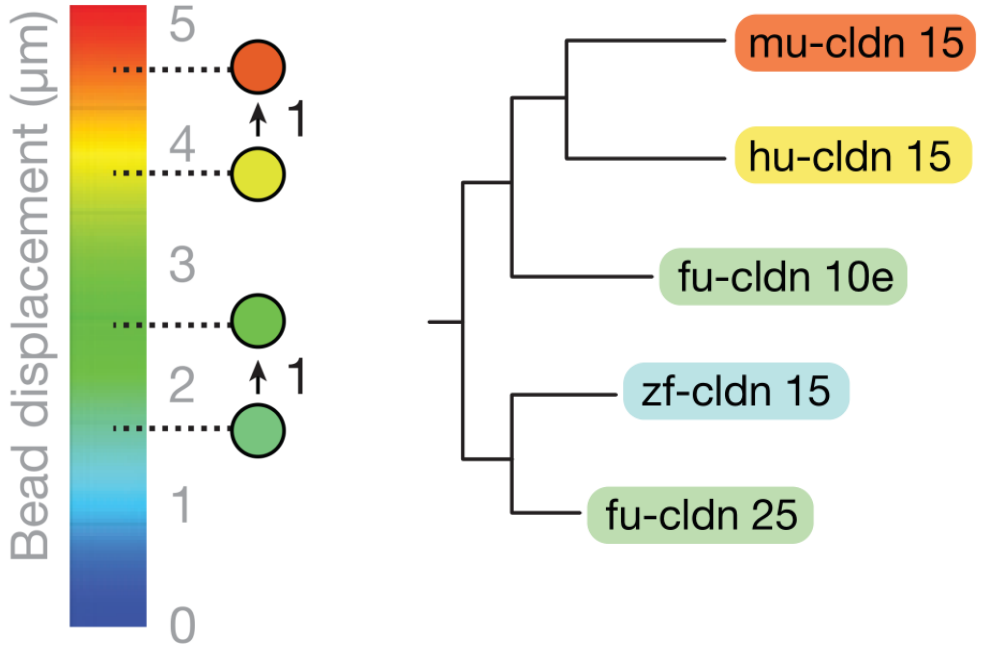


Adapted from: https://www.bioinformatics.babraham.ac.uk/training/Figure_Design_Course/Figure%20Design%20Slides.pdf

Simplify
principles of visual encoding

Expressiveness principle
Visual encodings should express all of, and only, the information in the dataset attributes.

Effectiveness principle
The importance of the attribute should match the salience of the channel.



M. Krzywinski, “Labels and callouts,” *Nat Methods*, vol. 10, no. 4, pp. 275–275, Apr. 2013, doi: 10.1038/nmeth.2405.

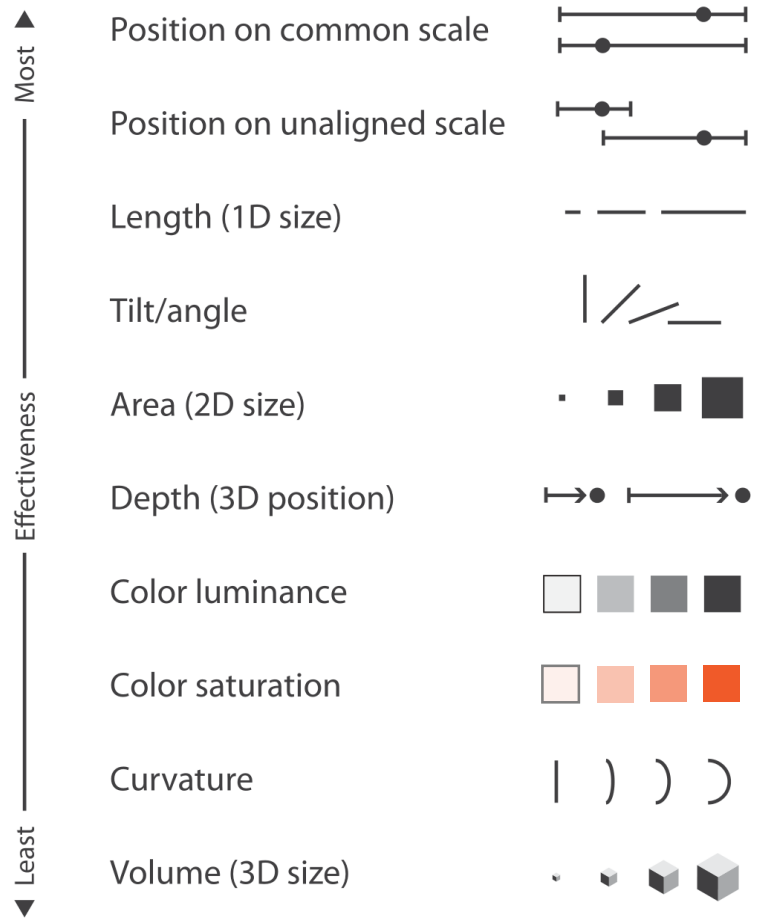
What is encoded

must be decoded

Simplify

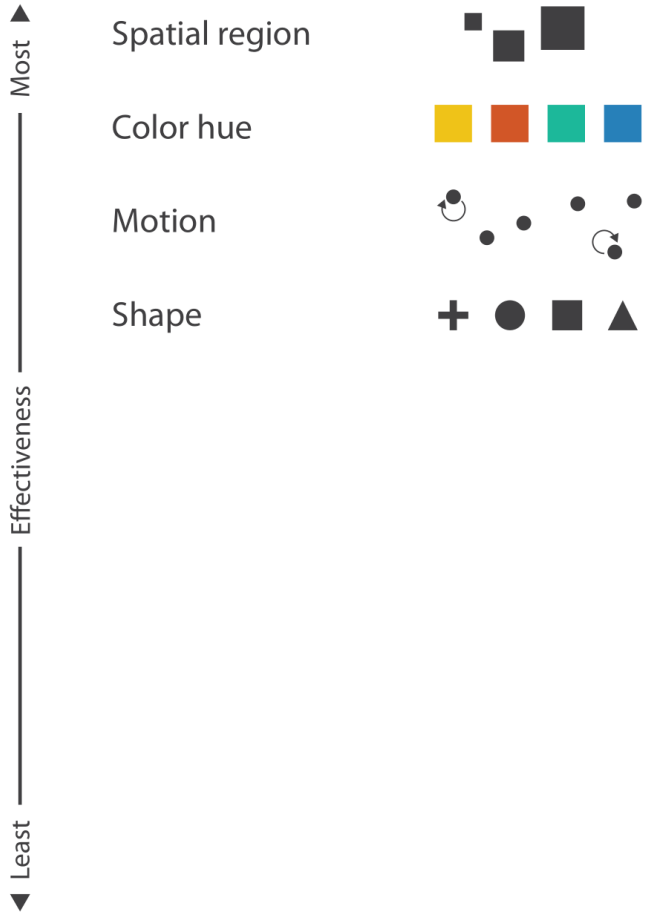
visual encoding

Magnitude Channels



Magnitude channels encode ordered attributes

Identity Channels

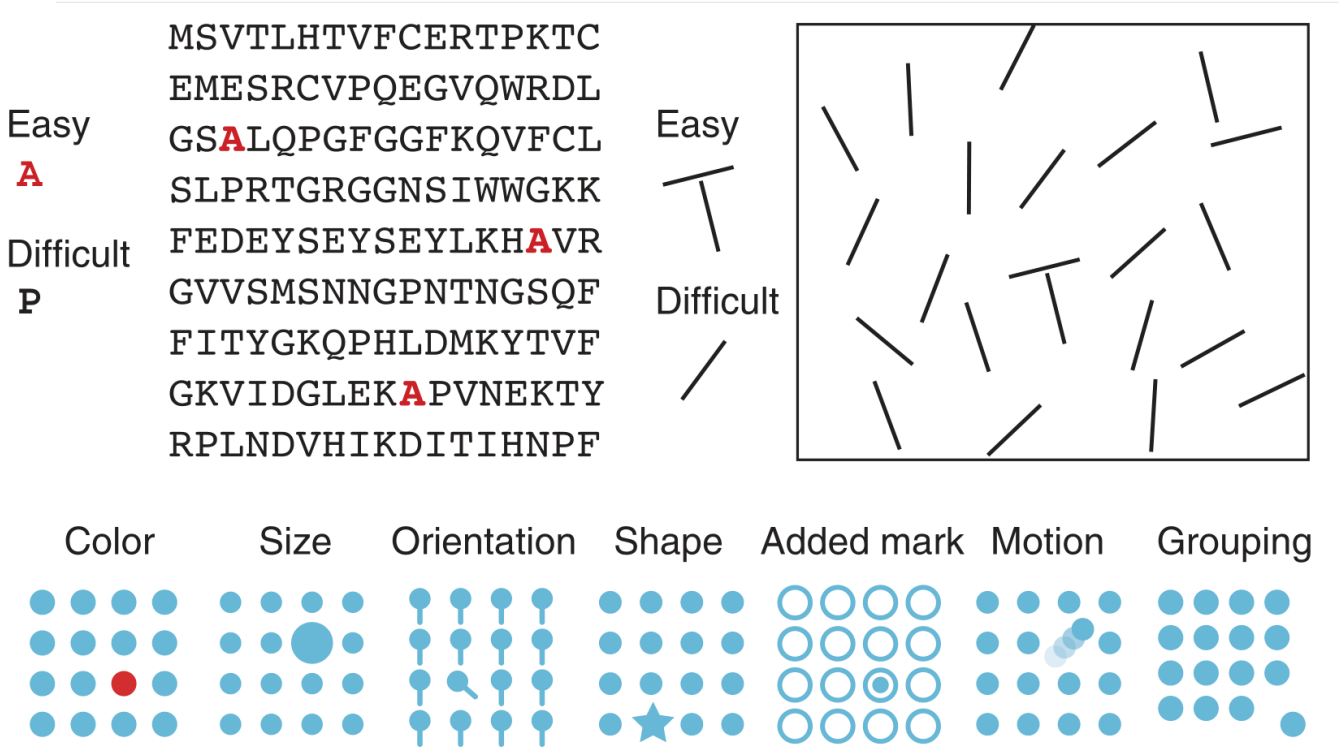


Identity channels encode categorical attributes

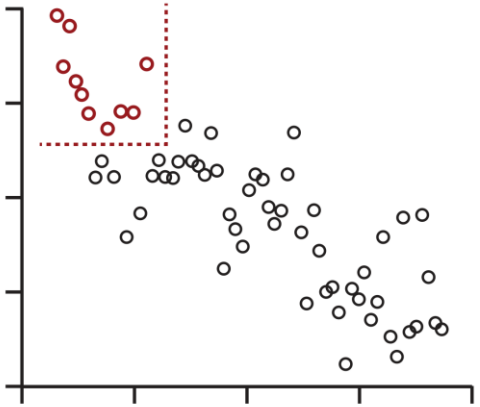
Adapted From: T. Munzner, *Visualization analysis and design.* Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2015.

Salience

Set an object apart from its surroundings to create contrast



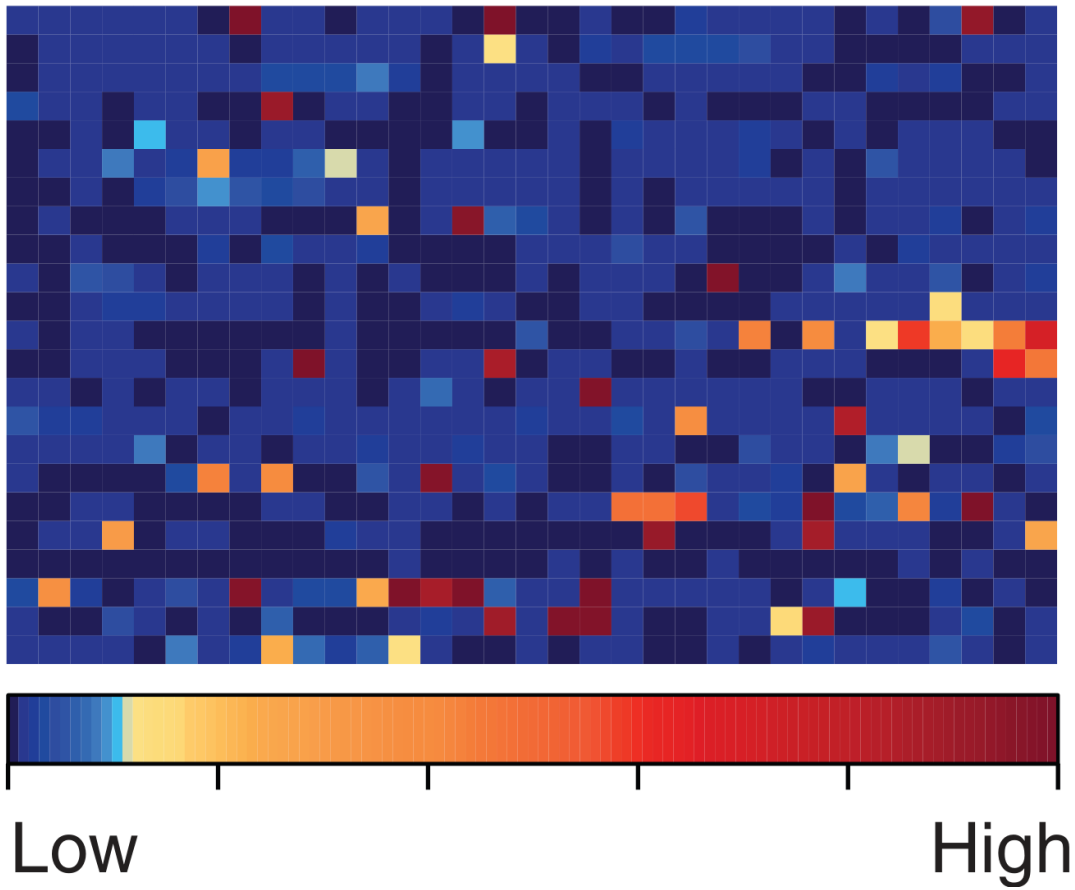
Color name	RGB (1–255)
Black	0, 0, 0
Orange	230, 159, 0
Sky blue	86, 180, 233
Bluish green	0, 158, 115
Blue	0, 114, 178
Vermillion	213, 94, 0



B. Wong, “Salience,” Nat Methods, vol. 8, no. 2, pp. 184–184, Feb. 2011, doi: 10.1038/nmeth0211-184c.
B. Wong, “Salience to relevance,” Nat Methods, vol. 8, no. 11, pp. 889–889, Nov. 2011, doi: 10.1038/nmeth.1762.

Salience

match salience to relevance



B. Wong, “Salience to relevance,” Nat Methods, vol. 8, no. 11, pp. 889–889, Nov. 2011, doi: 10.1038/nmeth.1762.

Salience

exploit natural visual hierarchies

bigger > smaller

thicker > thinner

brighter > darker

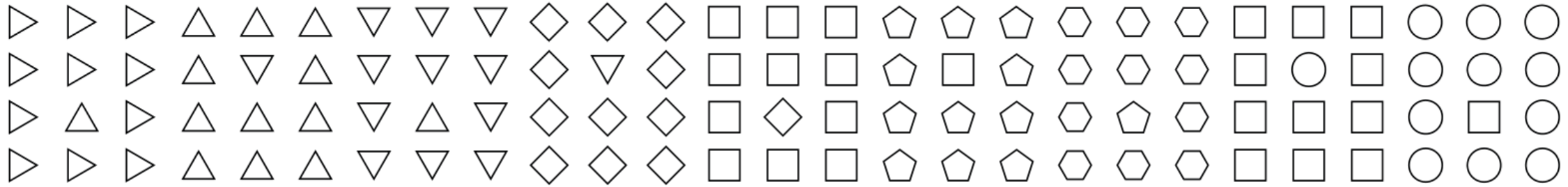
bold > light

ALL CAPS > Sentence Case

Salience

with dense data, use visually distinctive shapes

Weak visual boundaries



Strong visual boundaries

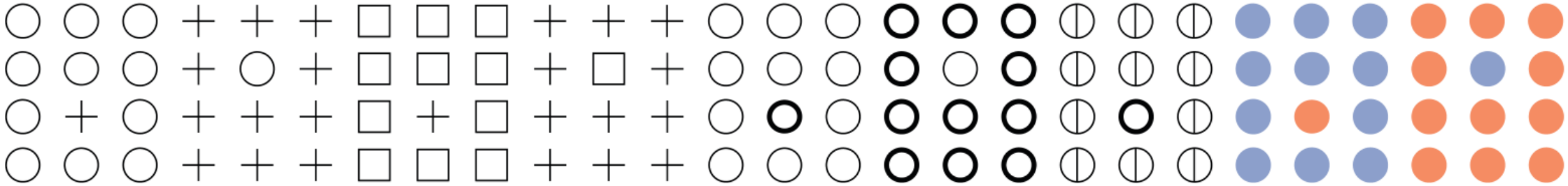
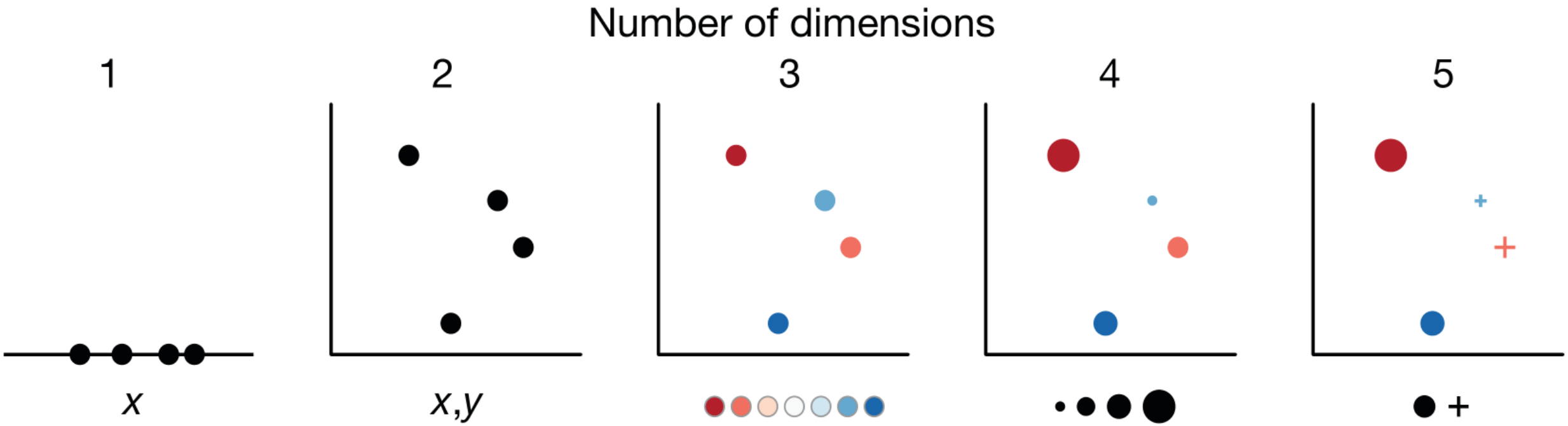


Figure source: N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

Salience

Encoding multivariate data



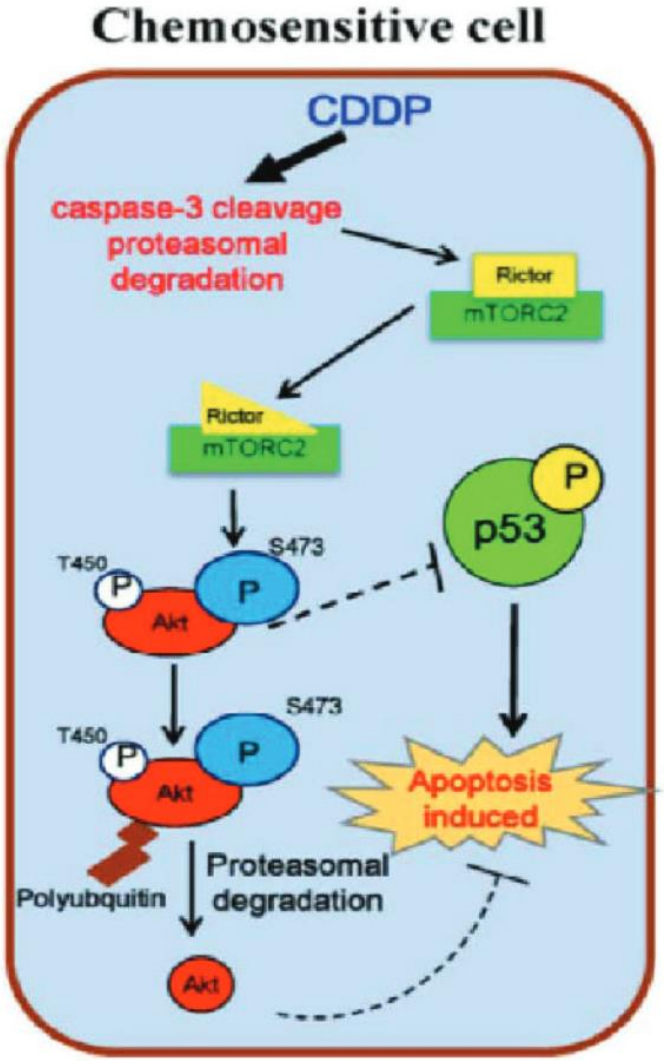
Effectiveness principle

The importance of the attribute should match the salience of the channel.

M. Krzywinski and E. Savig, “Multidimensional data,” Nat Methods, vol. 10, no. 7, pp. 595–595, Jul. 2013, doi: 10.1038/nmeth.2531.

Simplify to clarify

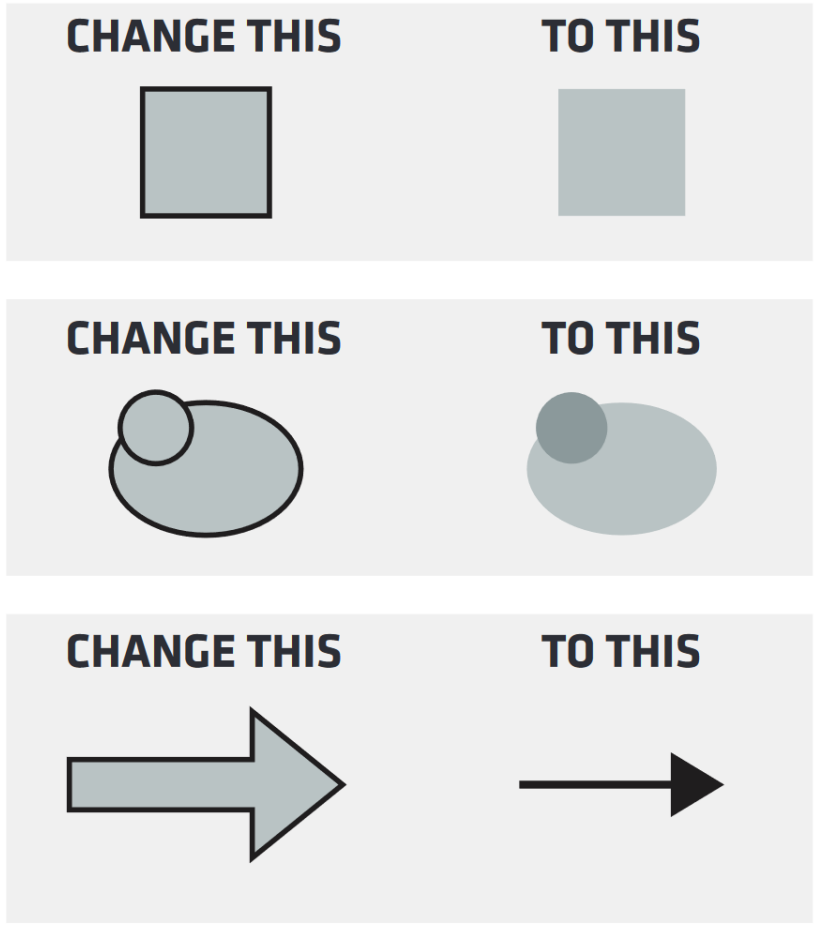
resist decoration

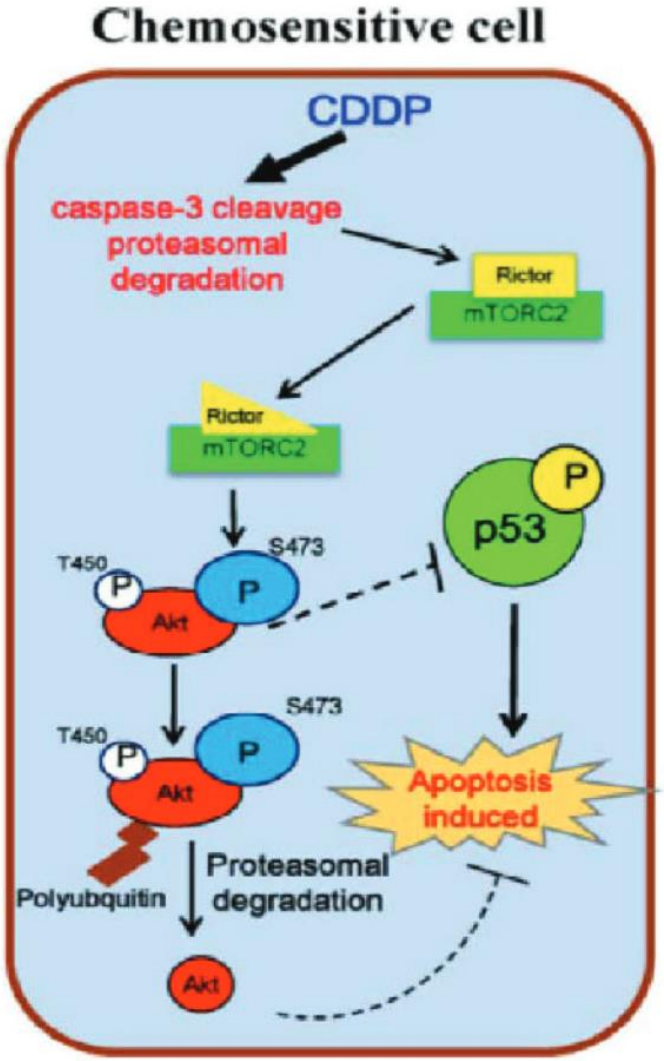


https://cns.utexas.edu/images/CNS/Deans_Office/Communications/Files/design-tips-for-scientists_GUIDE.pdf

Simplify

resist decoration





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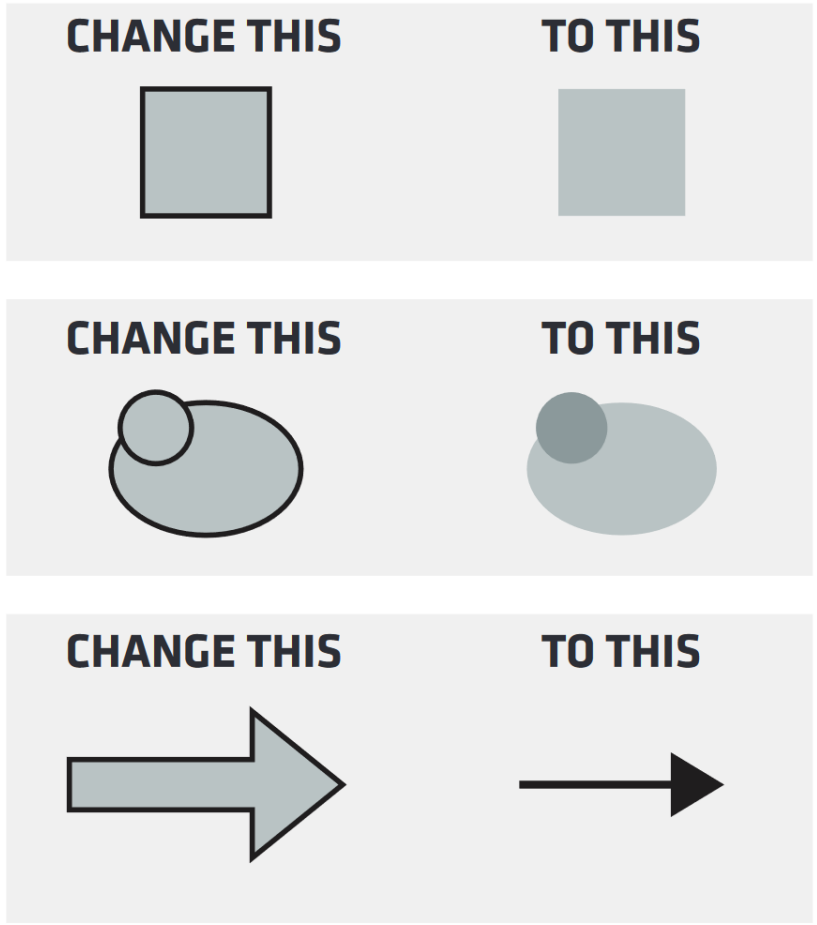
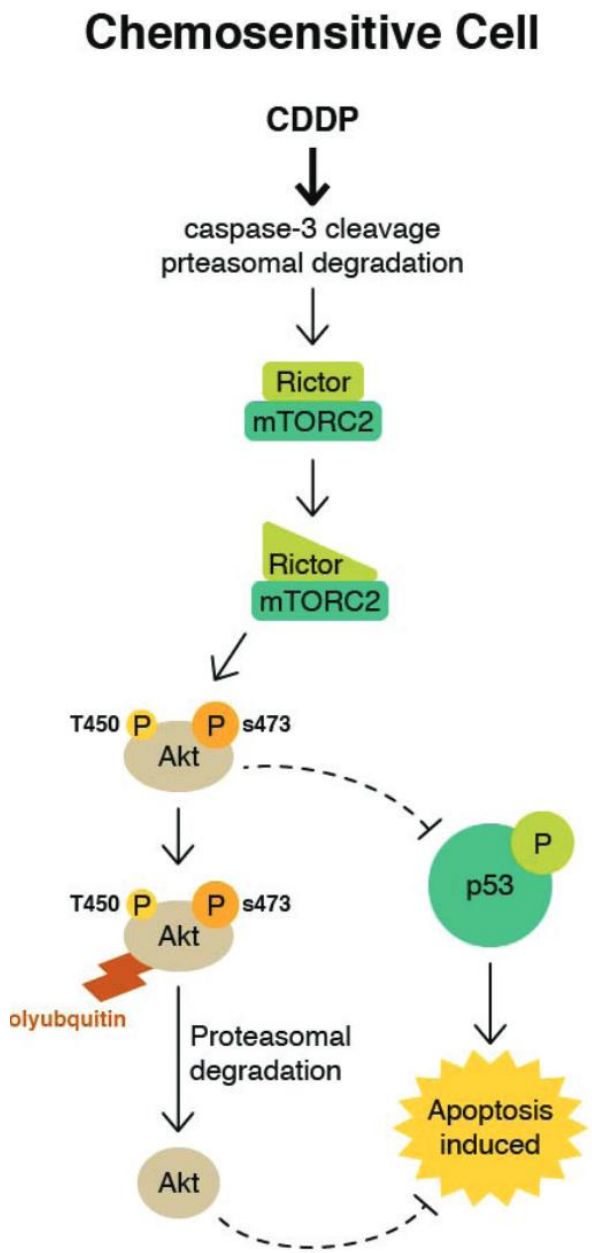
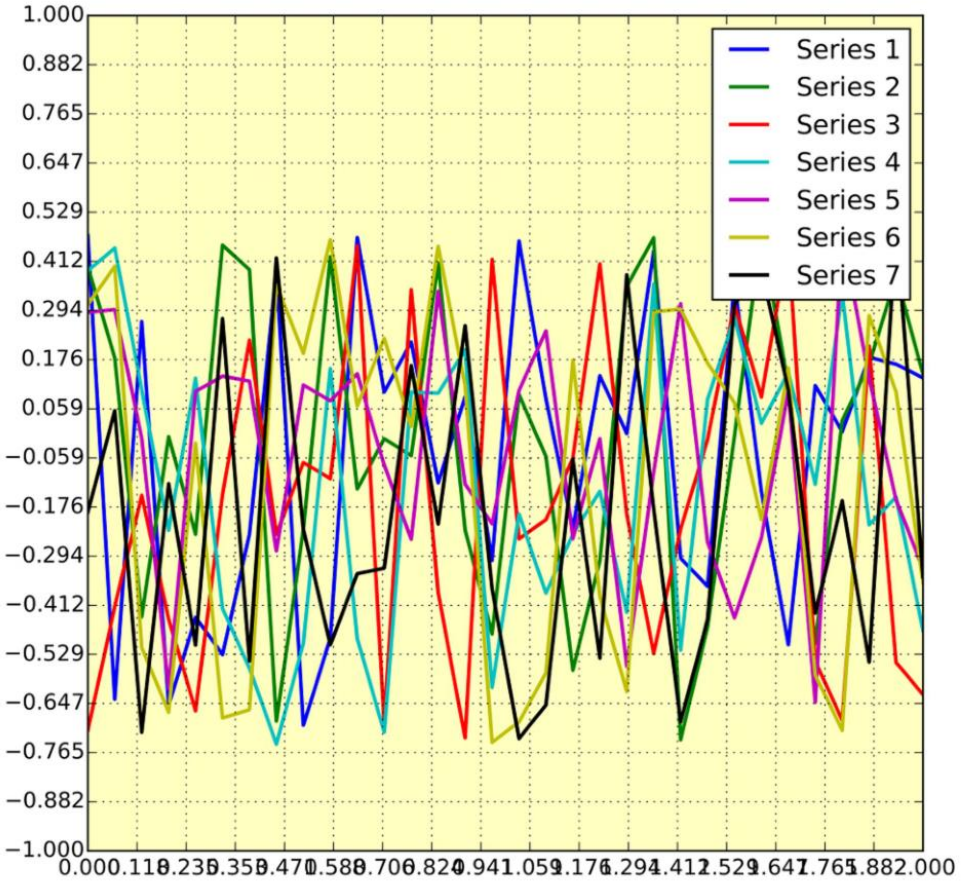




https://cns.utexas.edu/images/CNS/Deans_Office/Communications/Files/design-tips-for-scientists_GUIDE.pdf

Simplify

simplify to clarify



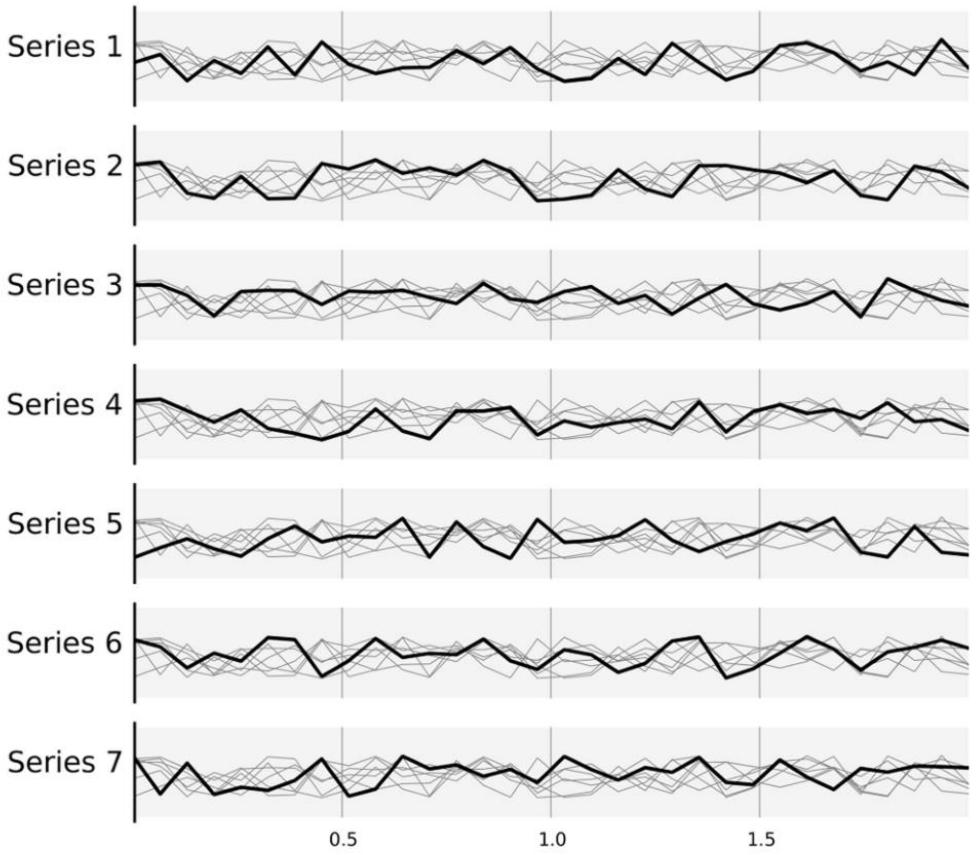


Figure source: N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

Simplify

remove chartjunk

Expressiveness principle

Visual encodings should express all of, and only, the information in the dataset attributes.

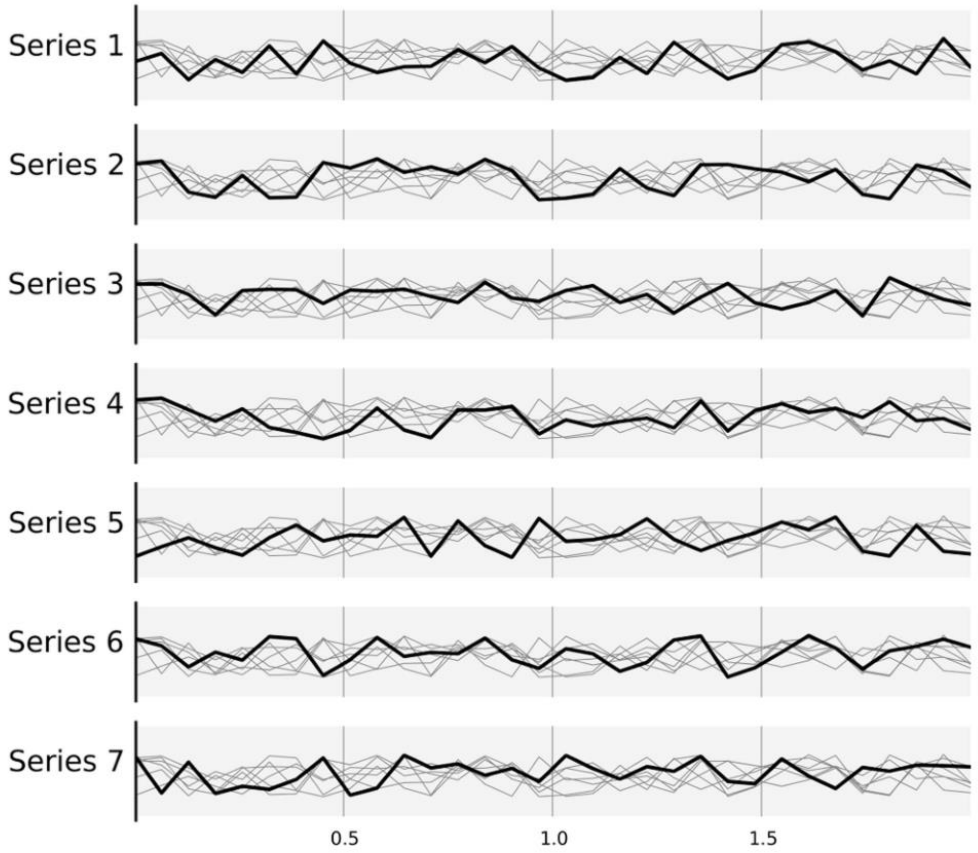


Figure source: N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

Axes

Borders
Avoid bounding figures with axes on all sides.

Arrows
Axes do not need arrows to indicate their orientation. This is almost never in doubt.

Axis Ticks
Axis ticks should not be densely labeled.

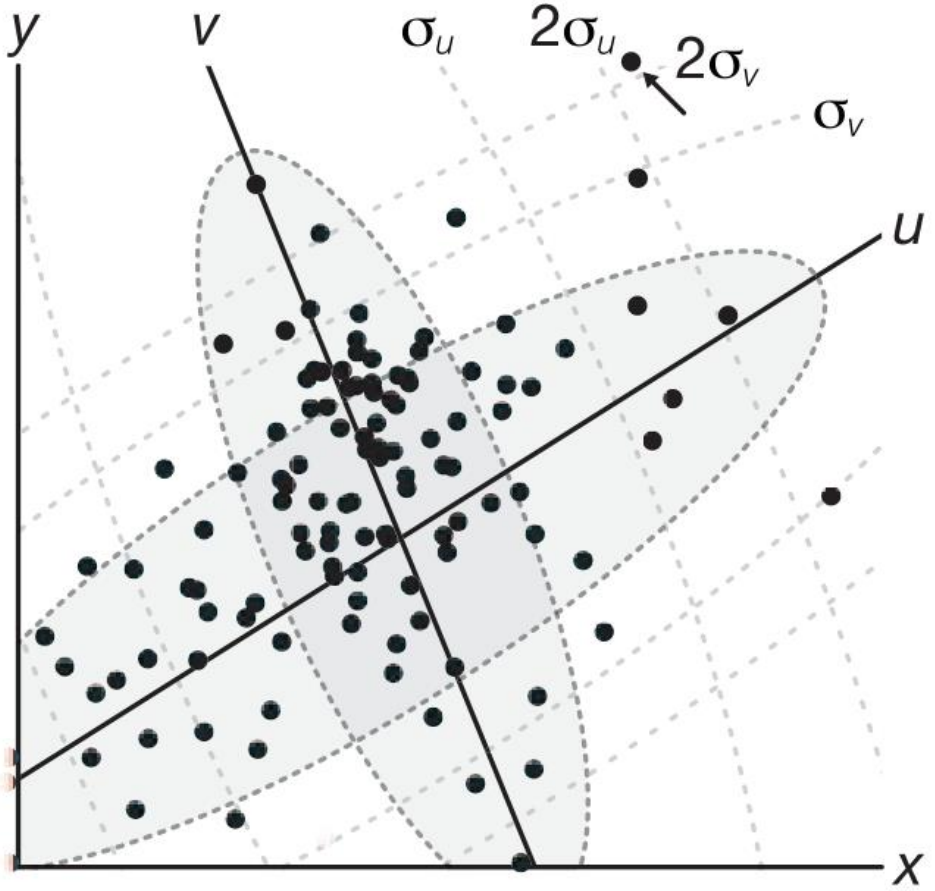
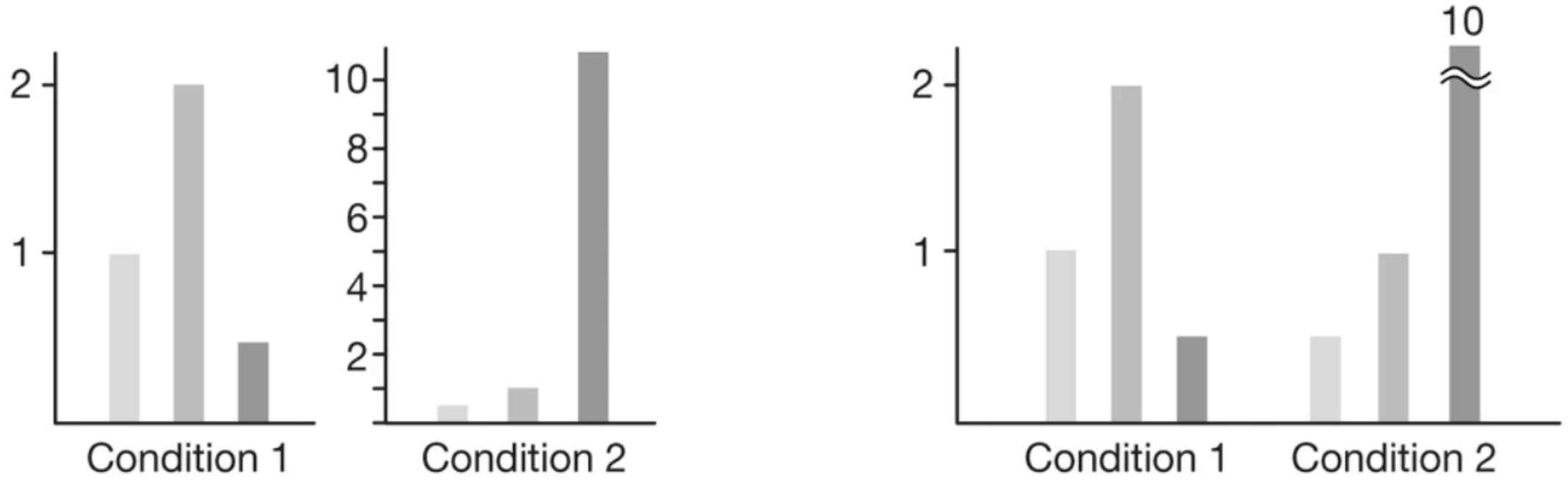


Figure source: N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

Axes

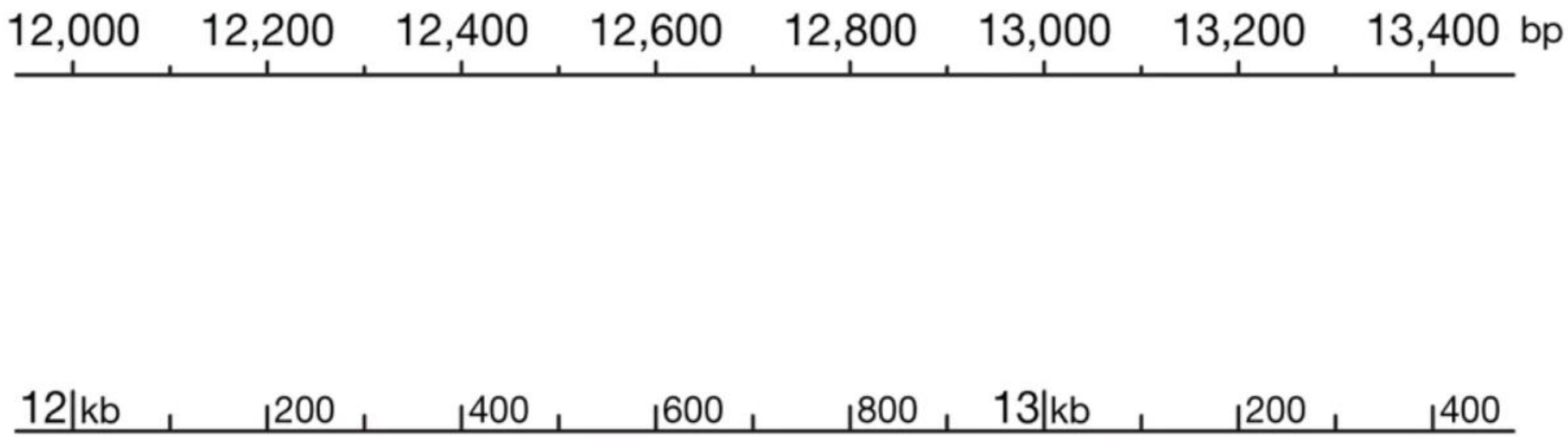
if absolute differences are important, **maintain scaling**



M. Krzywinski, “Axes, ticks and grids,” Nat Methods, vol. 10, no. 3, pp. 183–183, Mar. 2013, doi: 10.1038/nmeth.2337.

Axes

use the appropriate unit in your labels



M. Krzywinski, “Axes, ticks and grids,” Nat Methods, vol. 10, no. 3, pp. 183–183, Mar. 2013, doi: 10.1038/nmeth.2337.

Gridlines

gridlines should enhance readability

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Gridlines

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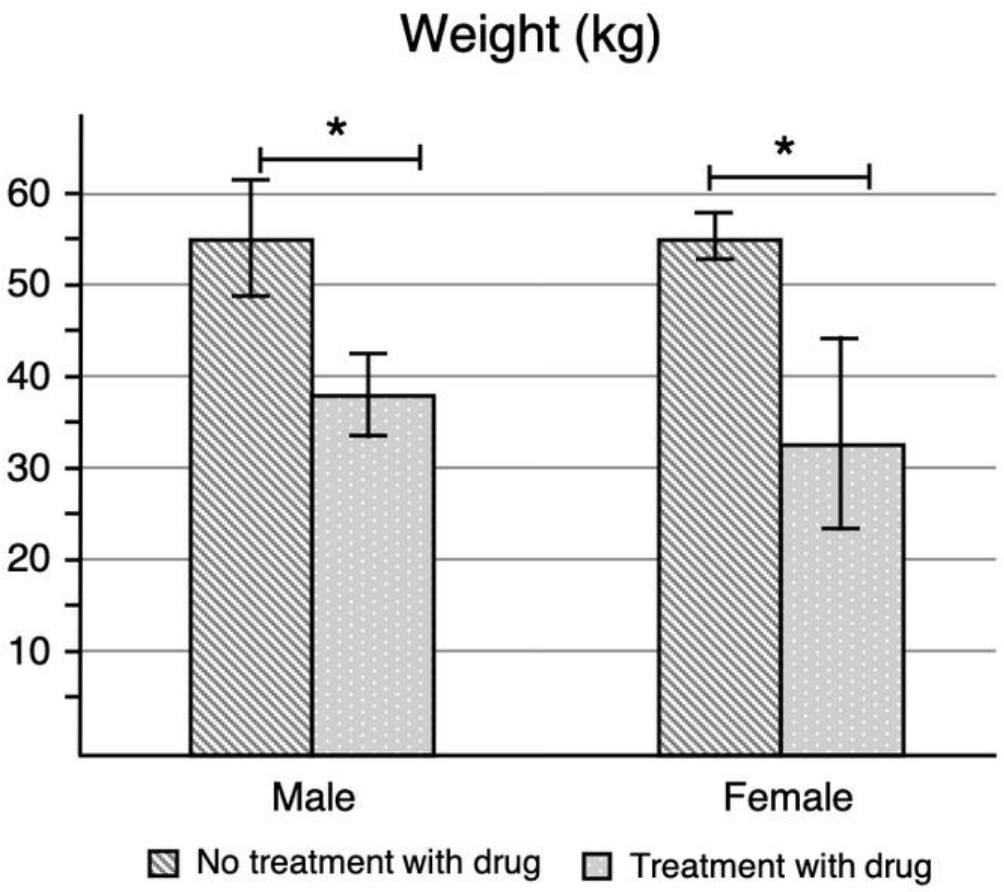
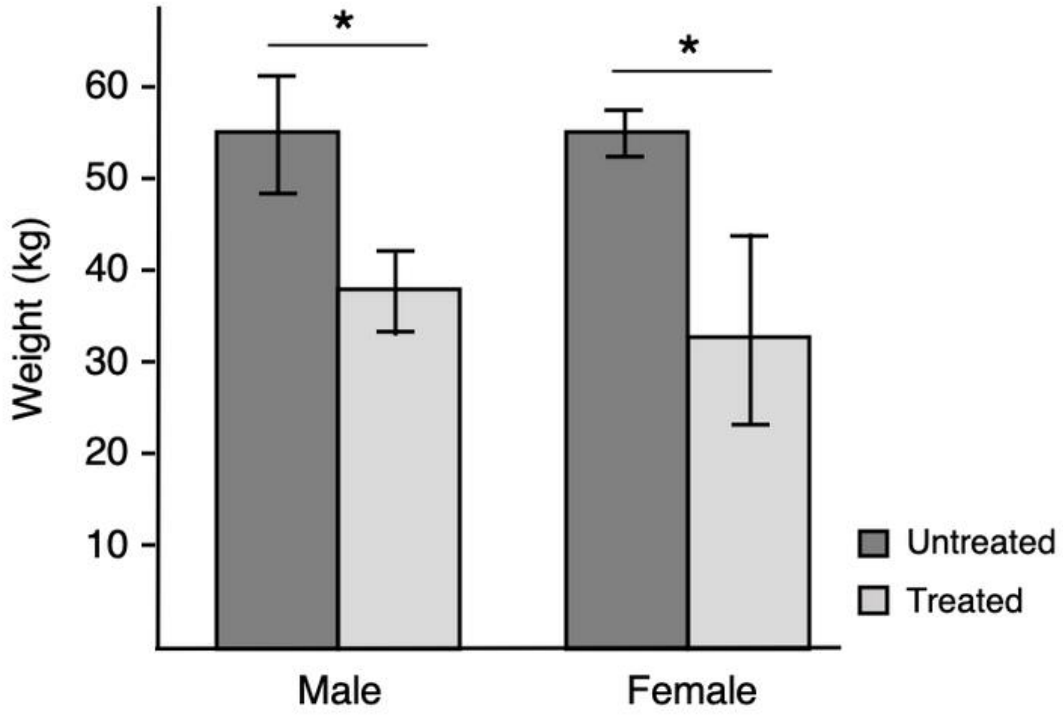
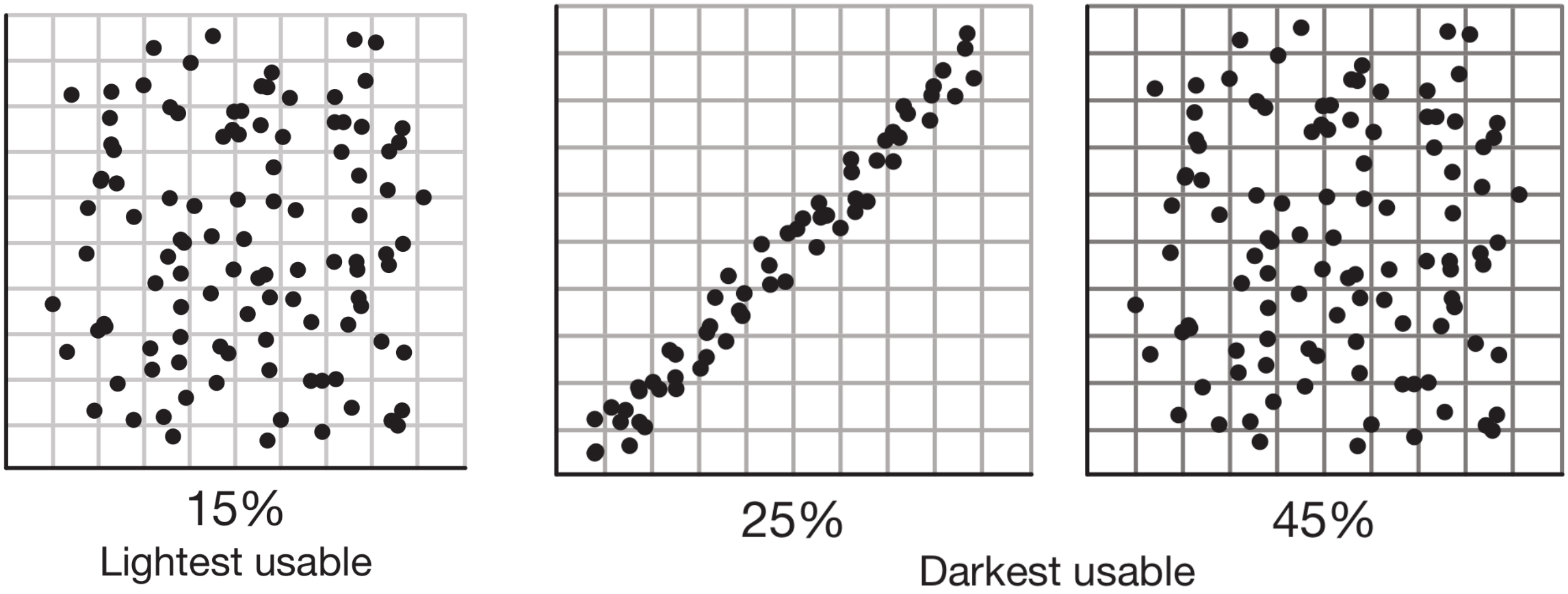




https://redwoodink.com/resources/how-to-improve-the-quality-of-your-scientific-figures

Gridlines

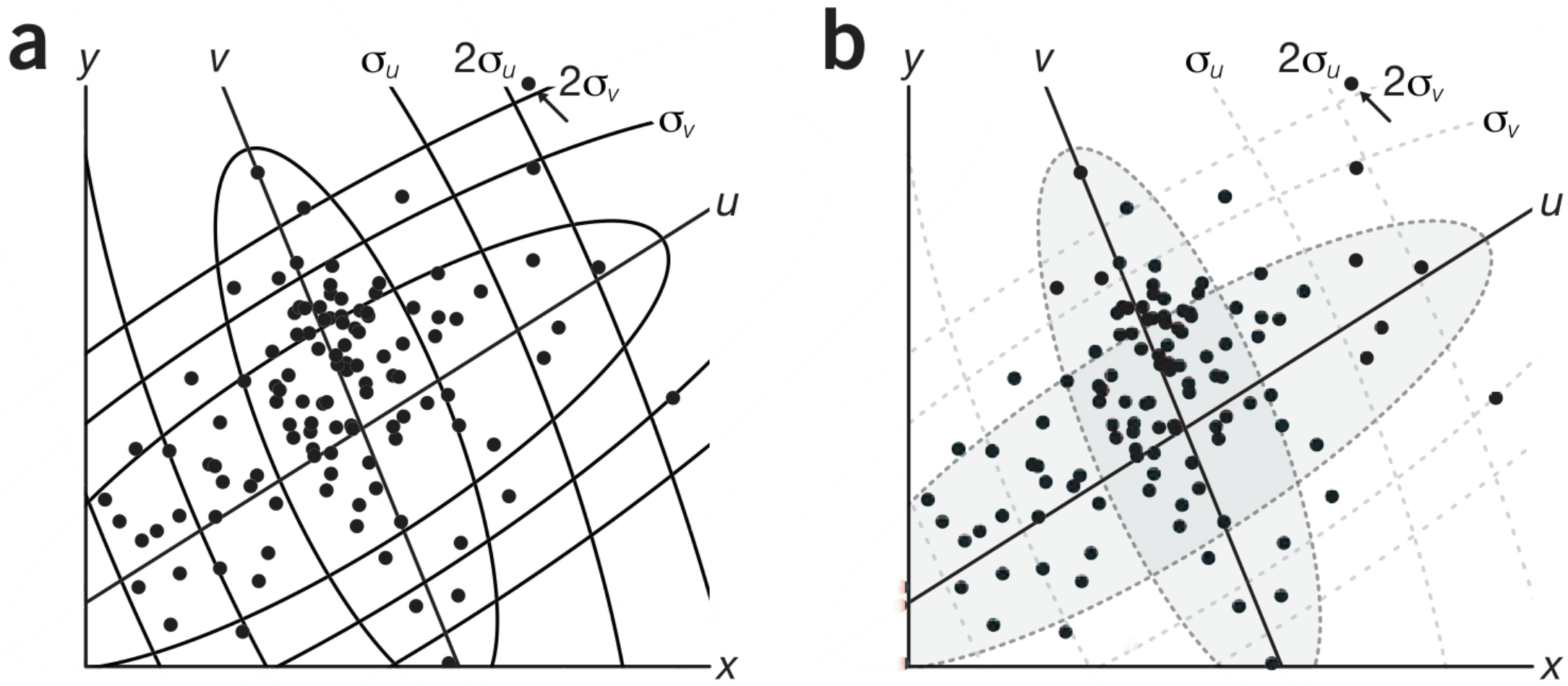
scale grid opacity to data density



M. Krzywinski, “Axes, ticks and grids,” Nat Methods, vol. 10, no. 3, pp. 183–183, Mar. 2013, doi: 10.1038/nmeth.2337.

Gridlines

make navigational elements distinct



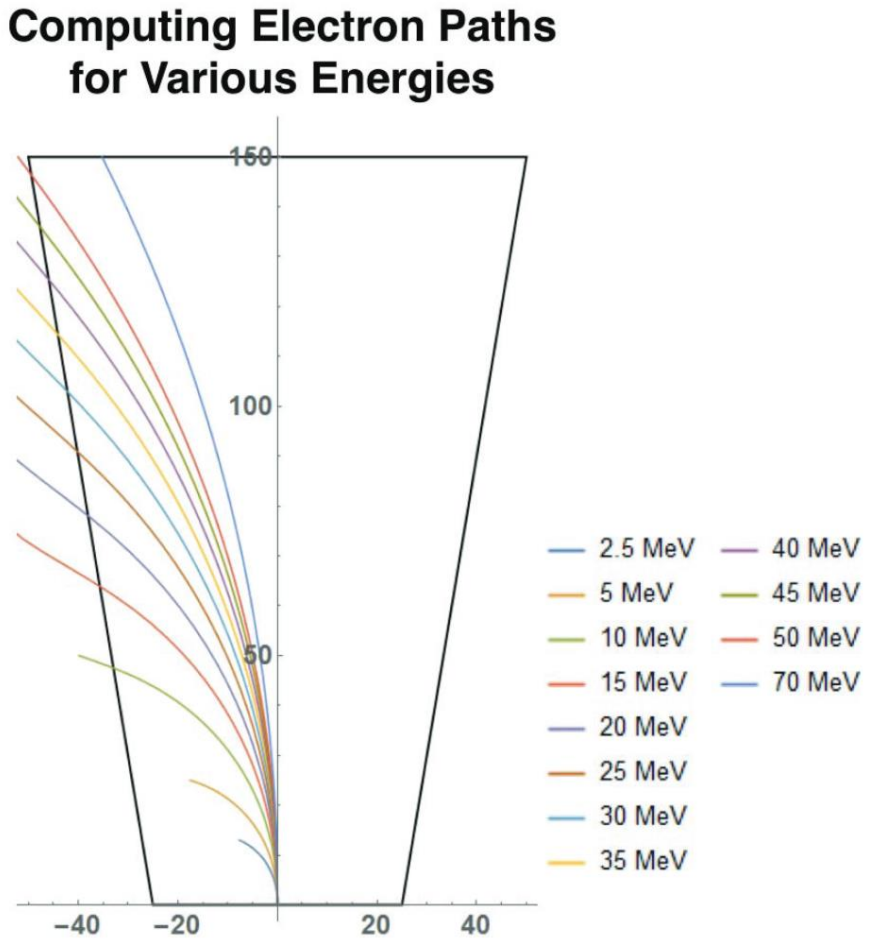
M. Krzywinski, “Axes, ticks and grids,” Nat Methods, vol. 10, no. 3, pp. 183–183, Mar. 2013, doi: 10.1038/nmeth.2337.

Legends

legends should refer to more than one element

Expressiveness principle

Visual encodings should express all of, and only, the information in the dataset attributes.



https://cns.utexas.edu/images/CNS/Deans_Office/Communications/Files/design-tips-for-scientists_GUIDE.pdf

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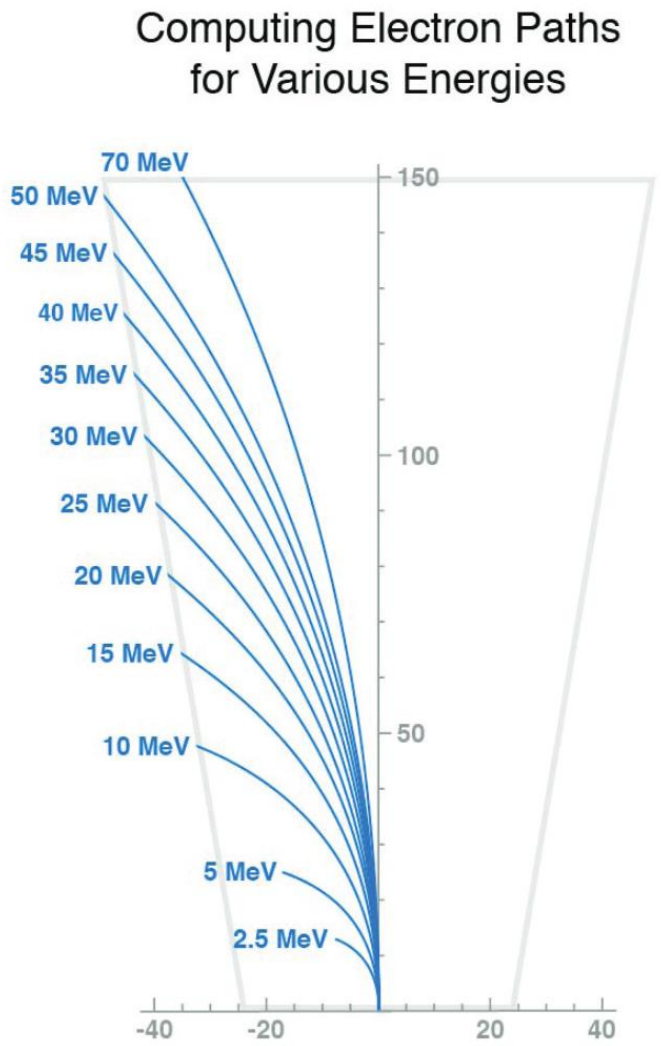
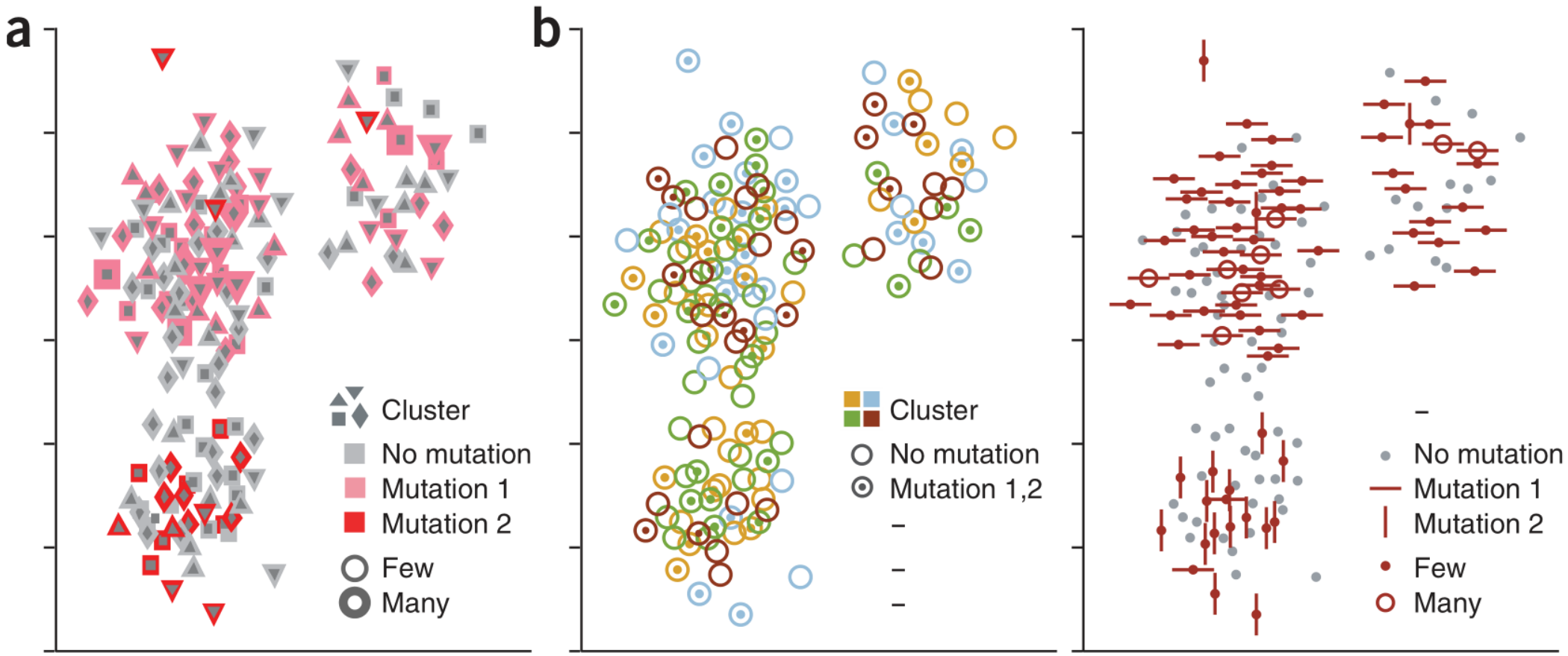


https://cns.utexas.edu/images/CNS/Deans_Office/Communications/Files/design-tips-for-scientists_GUIDE.pdf

Simplify

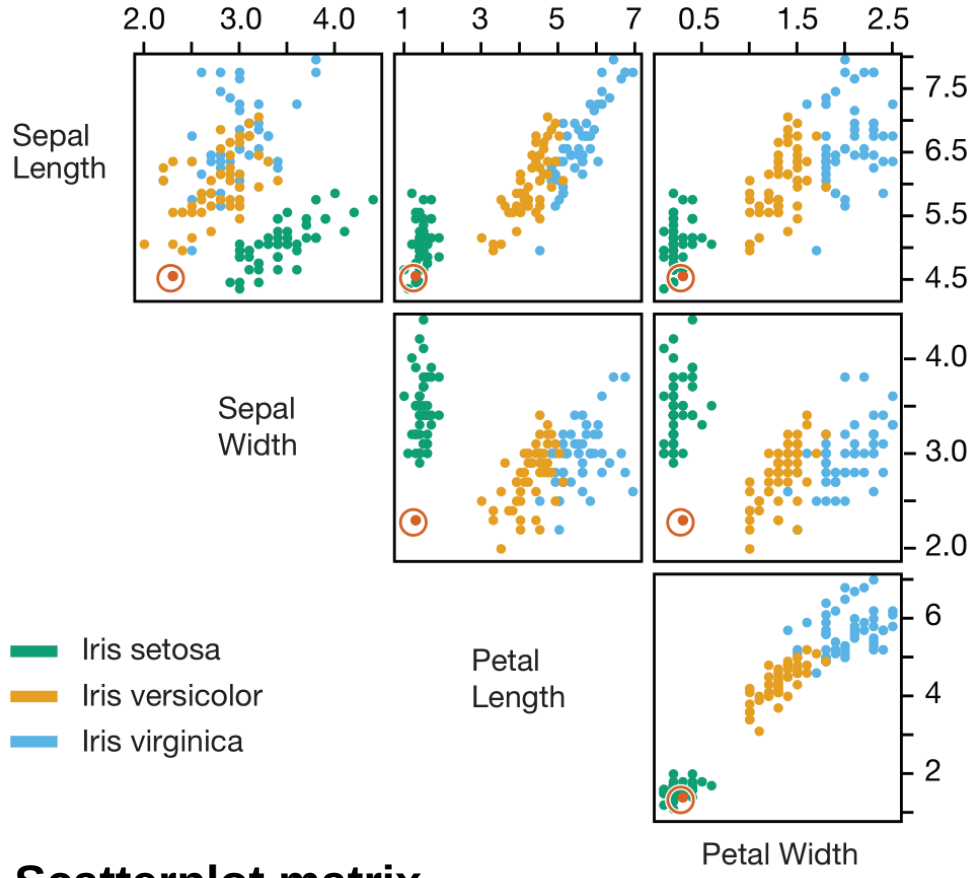
Encoding multivariate data



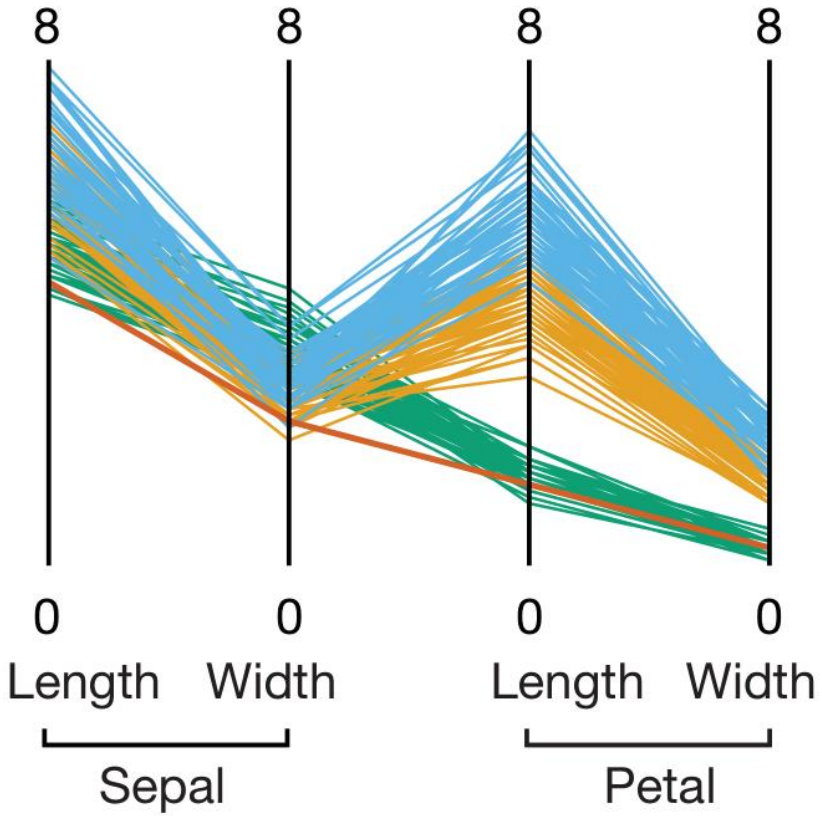
B. Wong, “Salience,” Nat Methods, vol. 8, no. 2, pp. 184–184, Feb. 2011, doi: 10.1038/nmeth0211-184c.

Simplify

Encoding multivariate data



Scatterplot matrix
(facet)

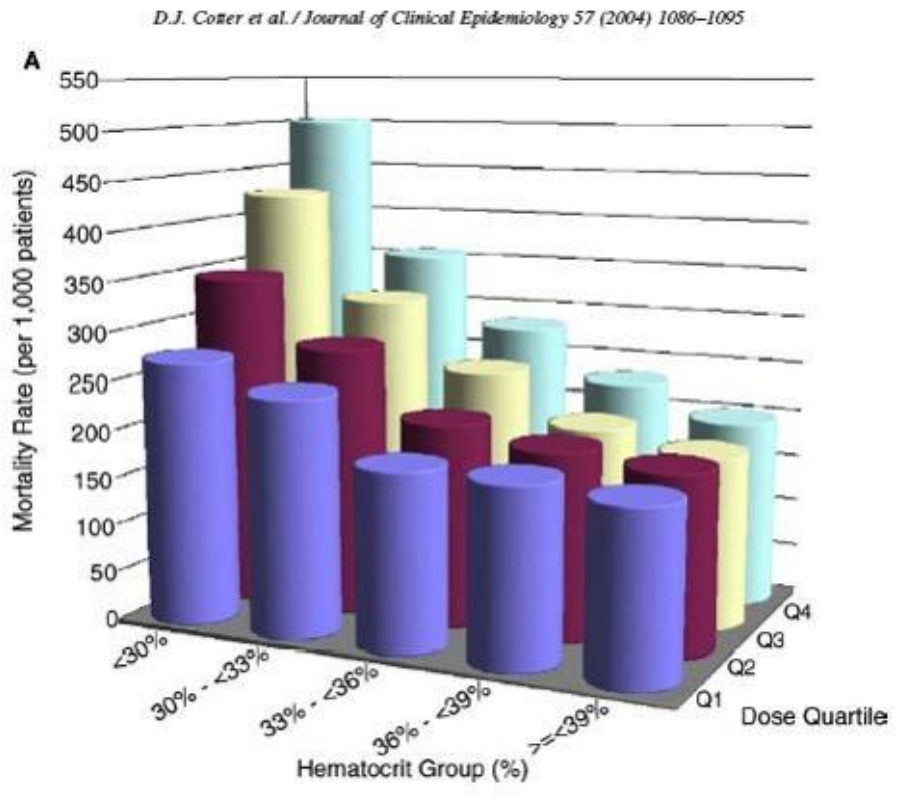


Parallel coordinate plot

N. Gehlenborg and B. Wong, “Power of the plane,” Nat Methods, vol. 9, no. 10, pp. 935–935, Oct. 2012, doi: 10.1038/nmeth.2186.

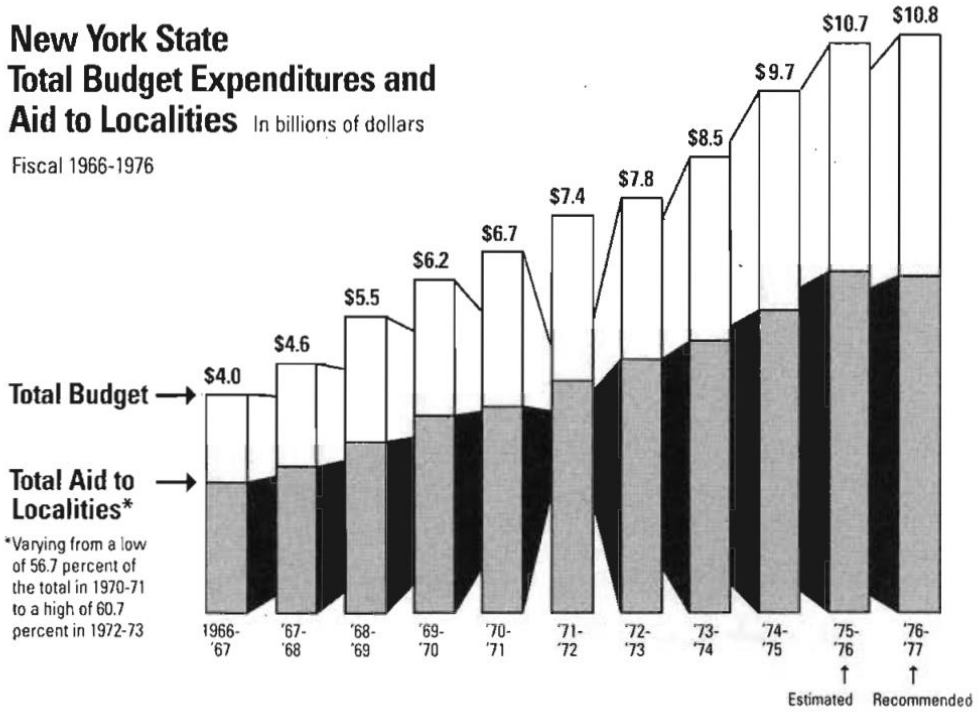
Simplify

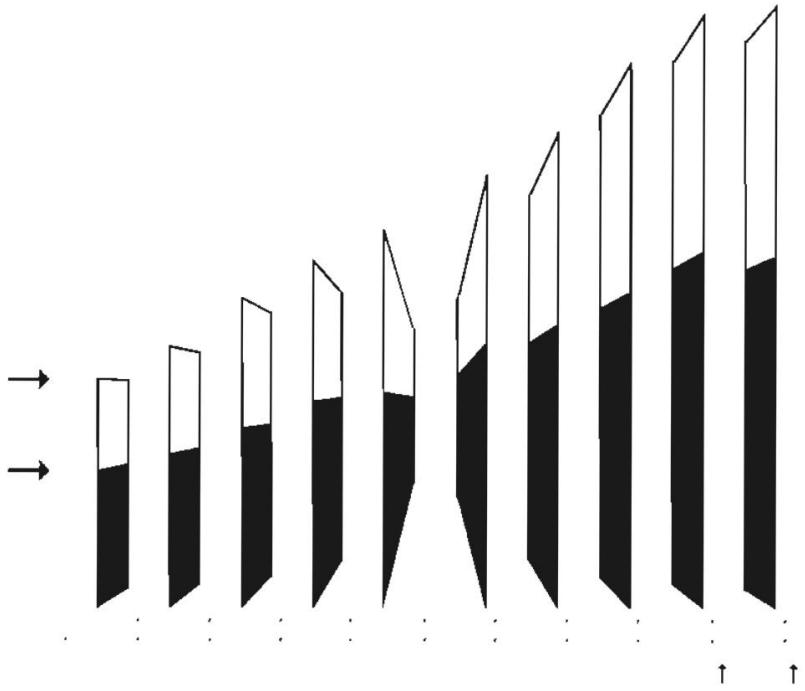
no unjustified 3D



Simplify

no unjustified 3D

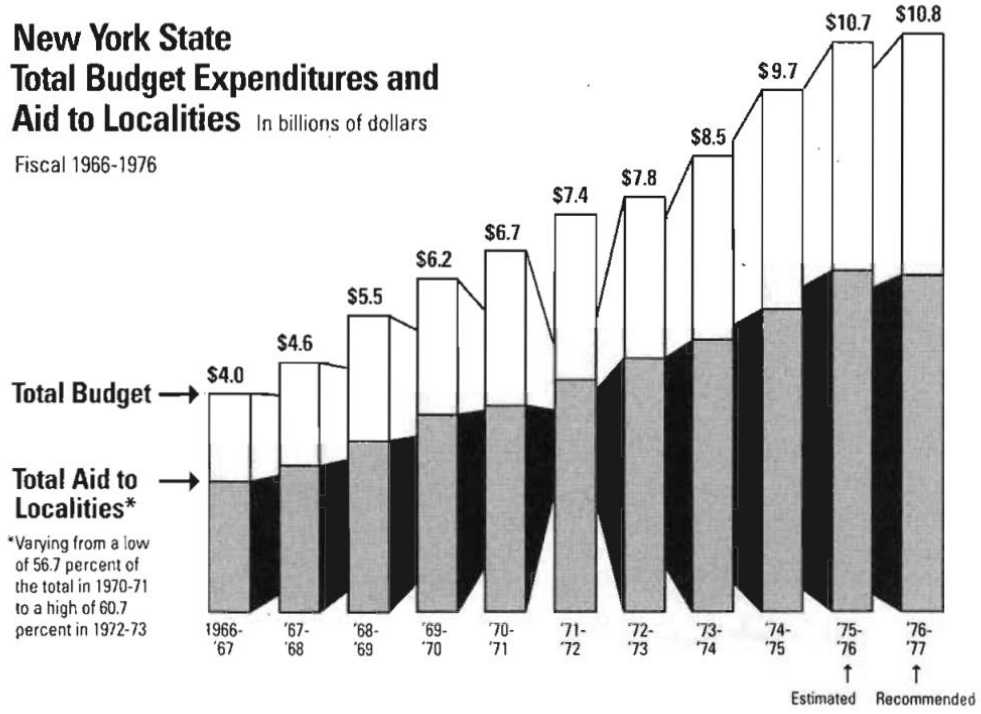


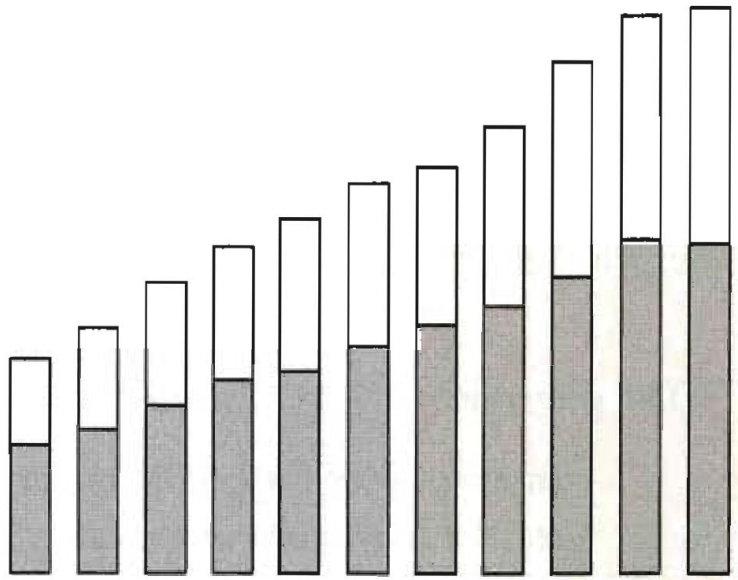


Tufte, Edward R., 1942-. The Visual Display of Quantitative Information. Cheshire, Conn. :Graphics Press, 2001.

Simplify

no unjustified 3D

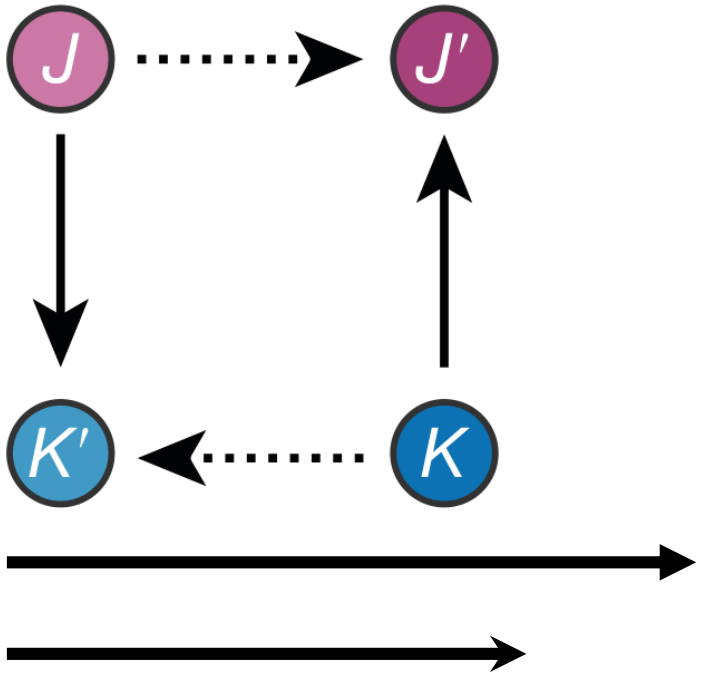




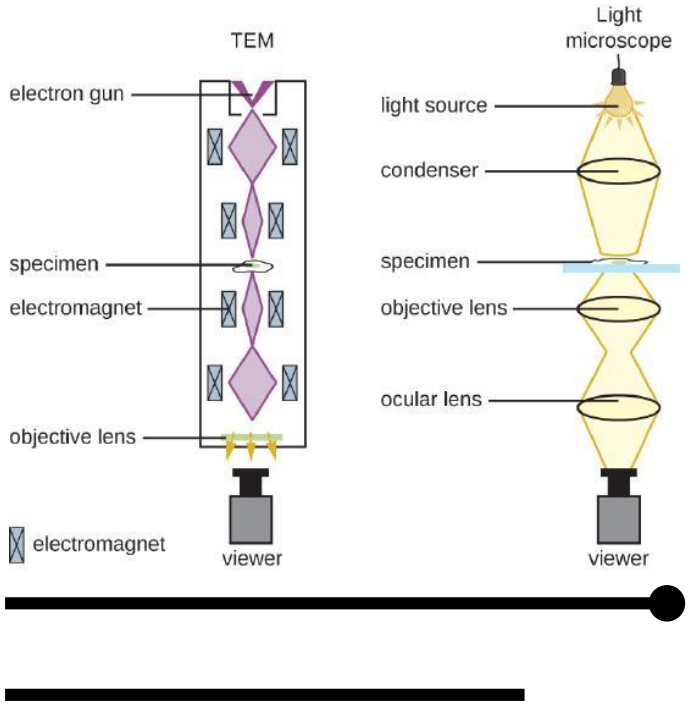
Tufte, Edward R., 1942-. The Visual Display of Quantitative Information. Cheshire, Conn. :Graphics Press, 2001.

Arrows and Labels

use arrows sparingly and effectively



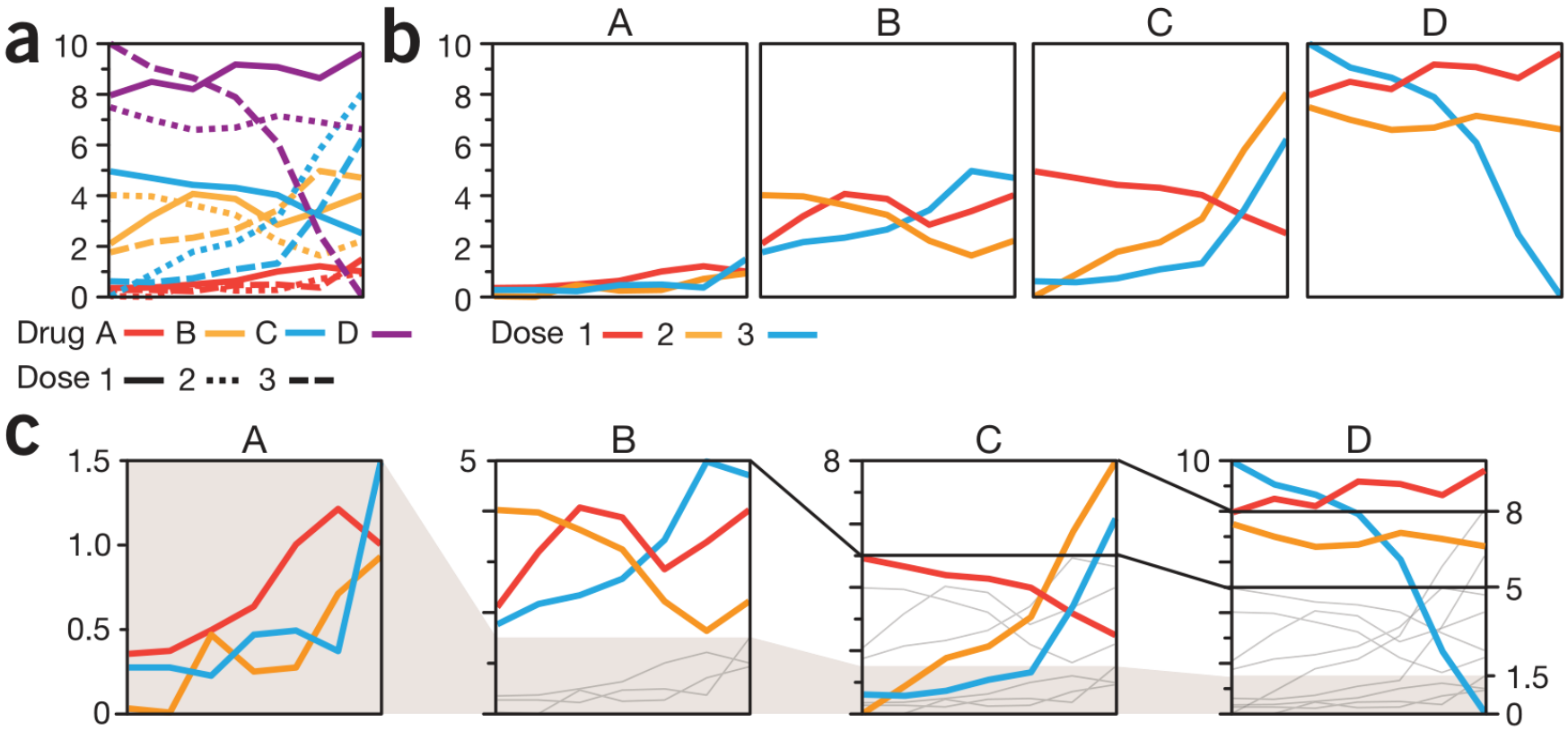
Use arrows for the functional inter-relatedness of parts



Use lines for the spatial inter-relatedness of parts

Simplify

use small multiples for complex plots



G. McInerny and M. Krzywinski, "Unentangling complex plots," *Nature Methods*, vol. 12, no. 7, pp. 591–591, Jul. 2015, doi: 10.1038/nmeth.3451.

Use Intentional Color Palettes

Color

not perceptually uniform

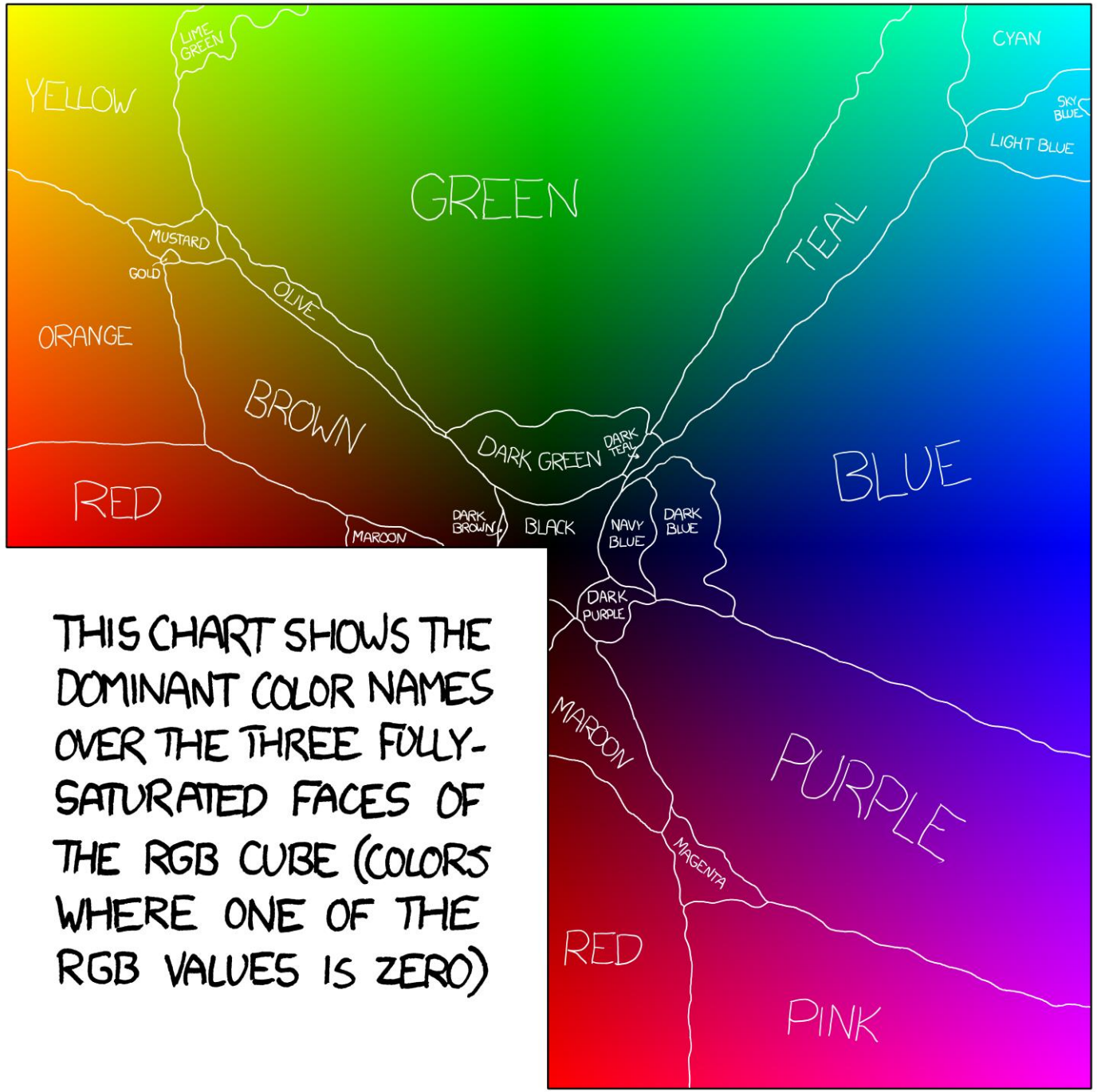
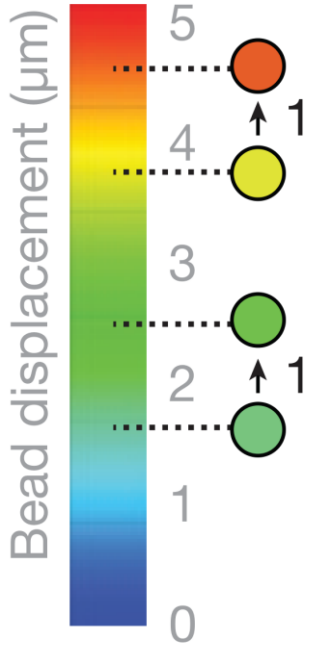


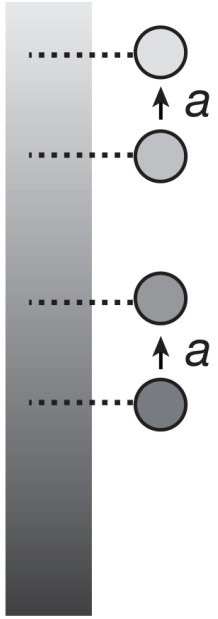
Image source: https://blog.xkcd.com/2010/05/03/color-survey-results/

Color
can misrepresent data



Avoid the rainbow

Shifts in color hue do not match unit changes in value



Gradation from 10- 90% black produces even transitions

Images adapted from: B. Wong, “Points of view: Points of review (part 2),” *Nat Methods*, vol. 8, no. 3, pp. 189–189, Mar. 2011, doi: 10.1038/nmeth0311-189.
Slide adapted from: Basics of Information Design for Scientific Figures, Kelly Krause

Get it Right in Black and White

Color

use the appropriate colormap

Image source: http://mkweb.bcgsc.ca/brewer/

Color

use the appropriate colormap

Image source: http://mkweb.bcgsc.ca/brewer/

Color

use the appropriate colormap

Image source: http://mkweb.bcgsc.ca/brewer/

Color

what makes an effective colormap?

- Perceptually Uniform
- High Discrimination
- Implicit Order
- 3D Shading Friendly
- Color-blind Friendly

Non-Uniform

Uniform

Adapted From: VIS2020 ParaView Tutorial: Effective Use of Color, Kenneth Moreland, Sandia National Laboratories, October 25th, 2020.

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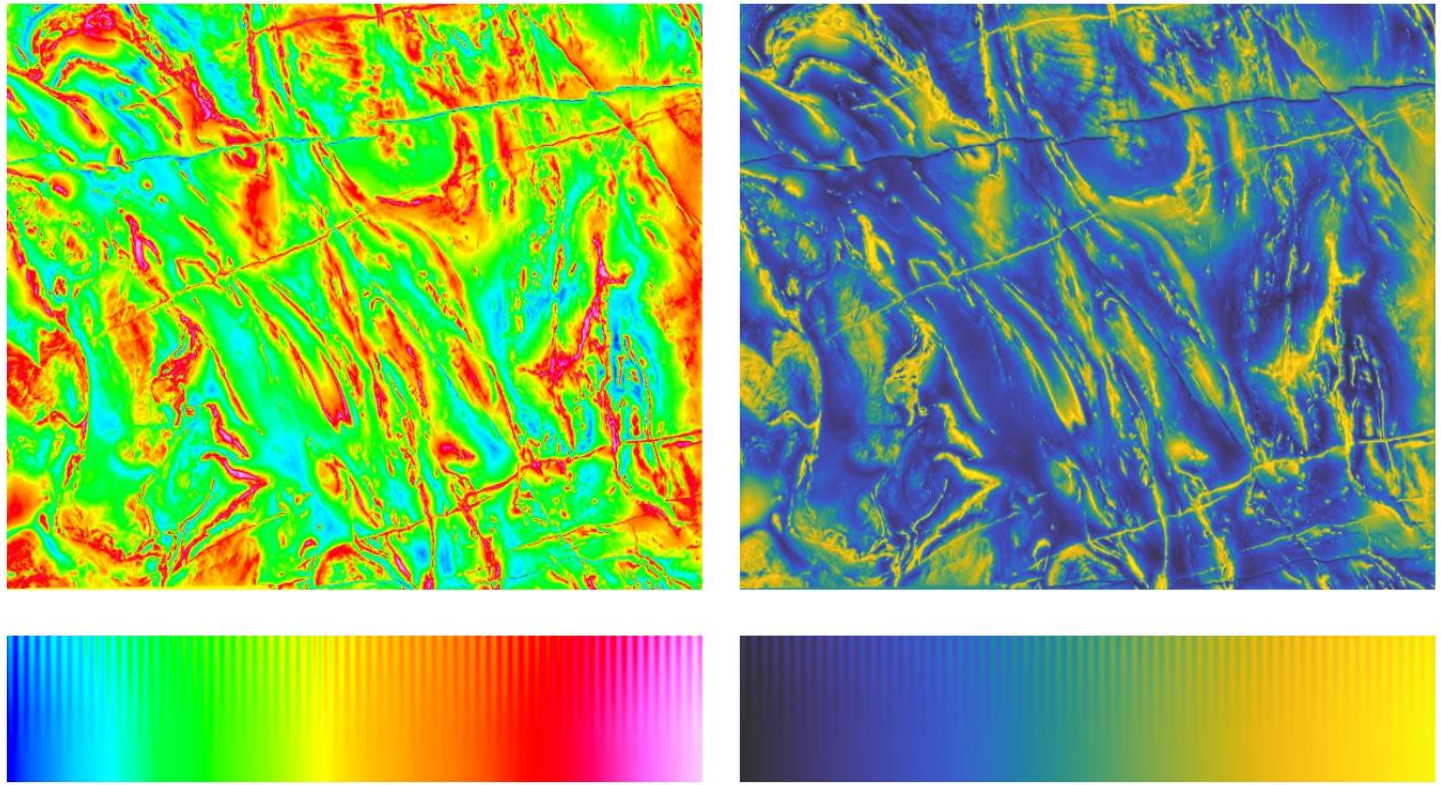

Image Source: P. Kovesi, “Good Colour Maps: How to Design Them,” *arXiv:1509.03700 [cs]*, Sep. 2015, Accessed: Nov. 08, 2021. [Online]. Available: http://arxiv.org/abs/1509.03700
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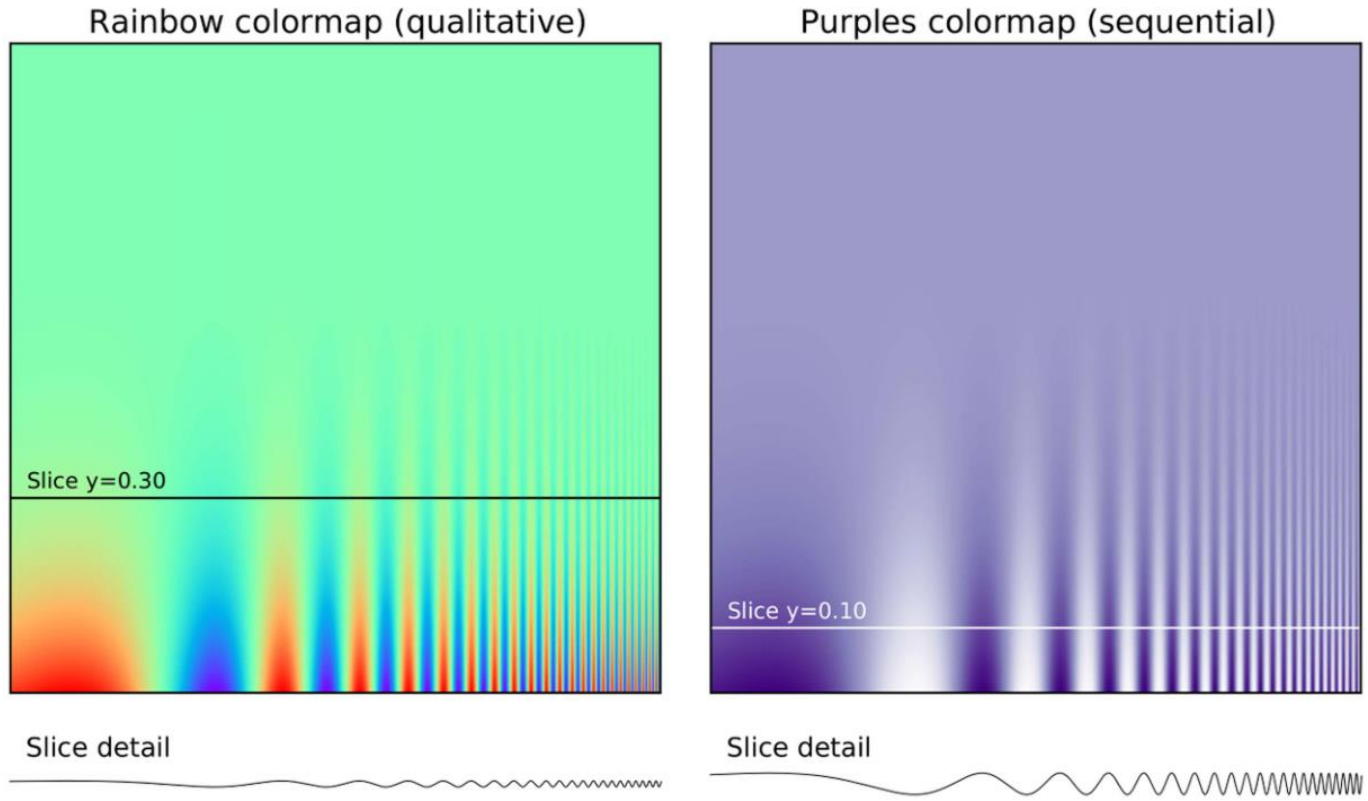

Figure adapted from: N. P. Rougier, M. Droettboom, and P. E. Bourne, "Ten Simple Rules for Better Figures," *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.
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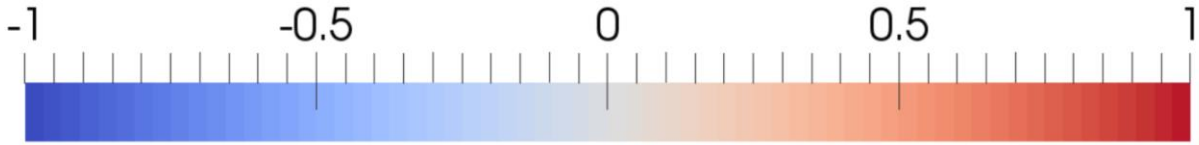

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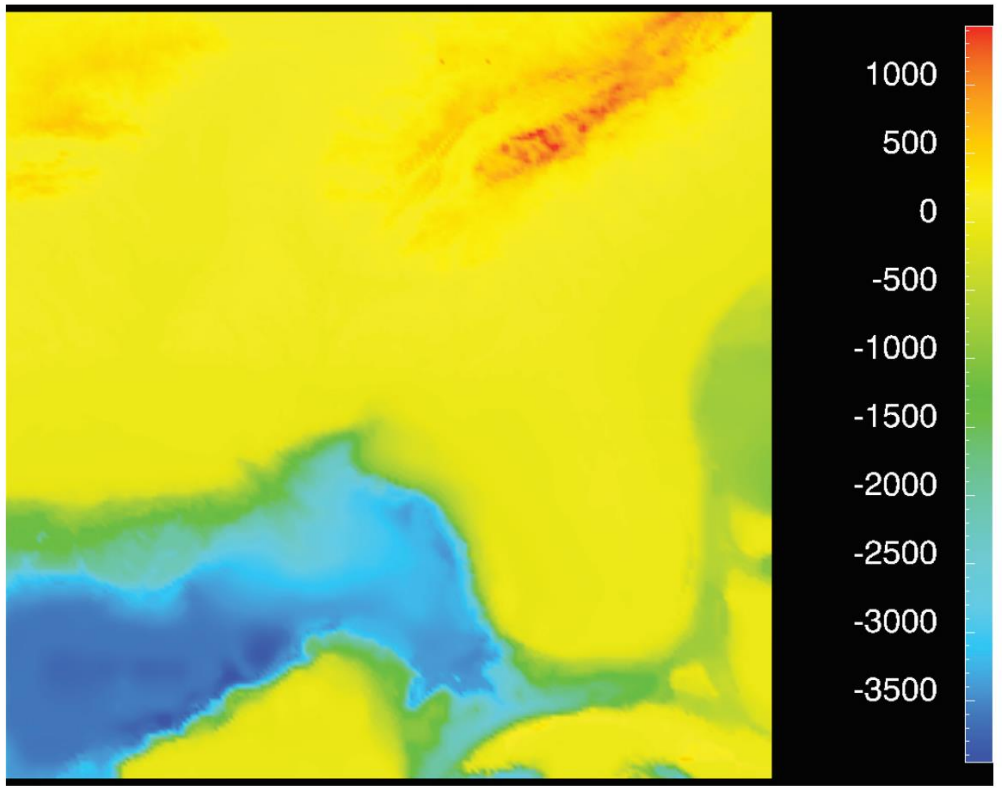

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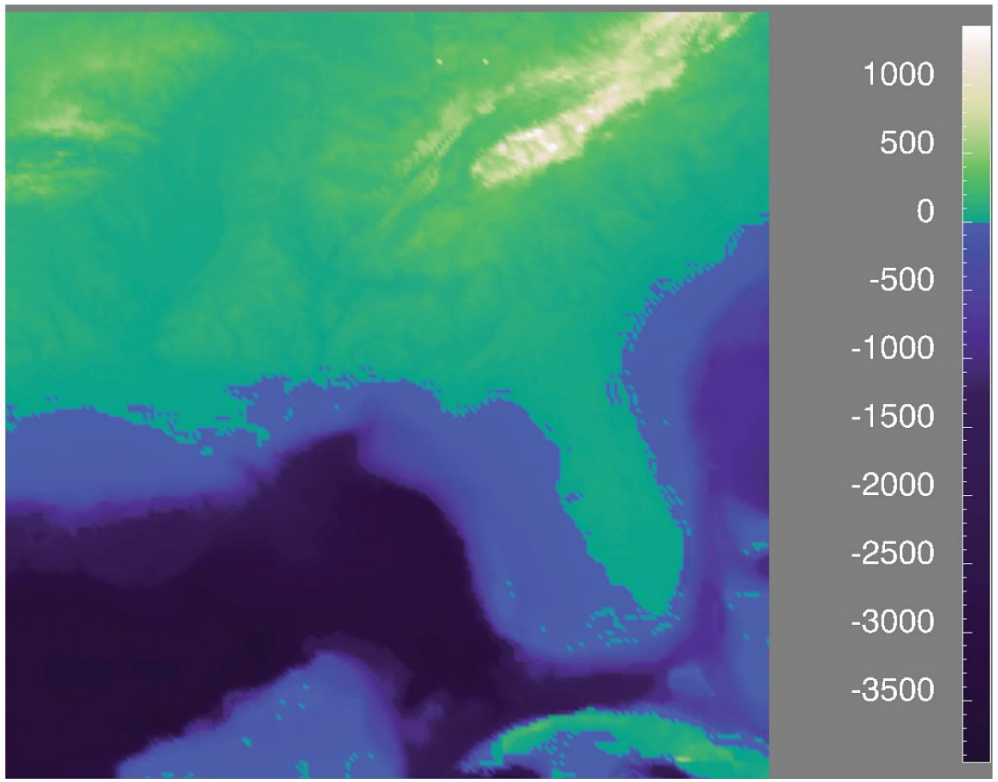

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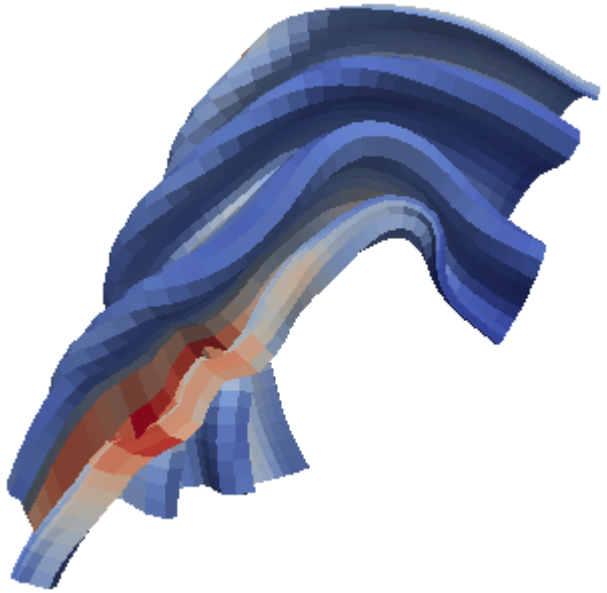
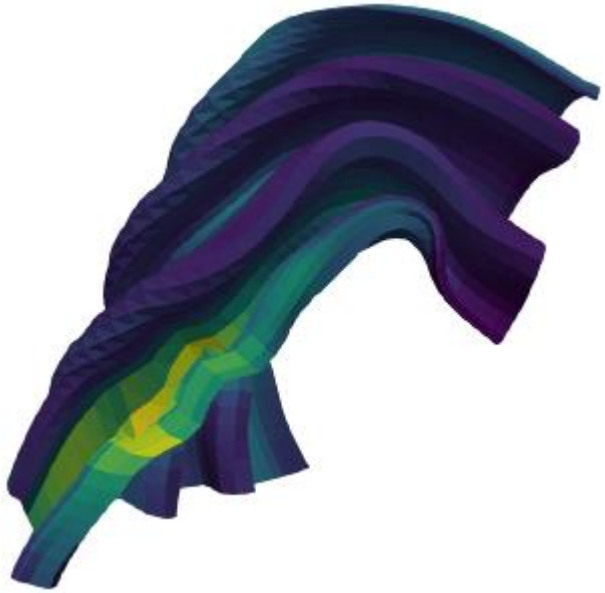
- Color-blind Friendly



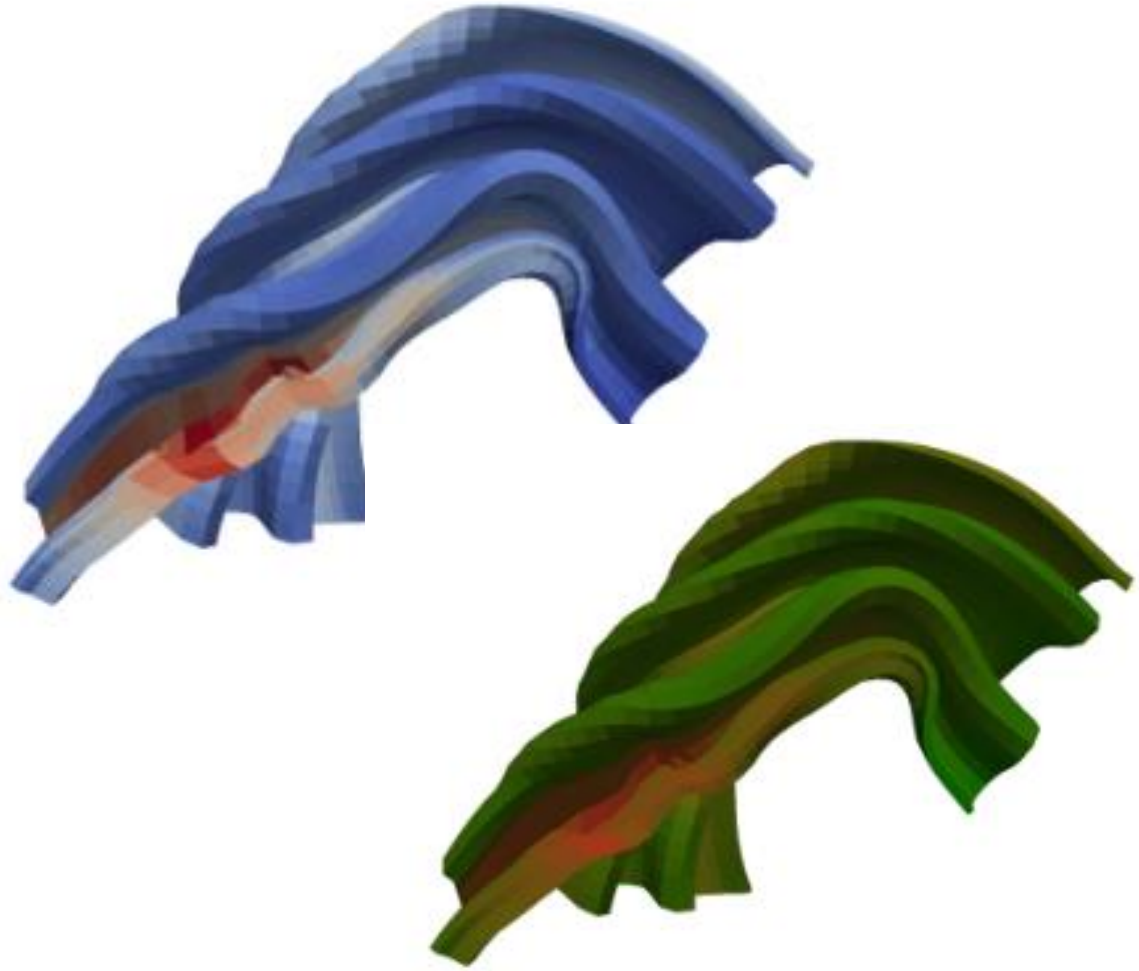


Adapted From: VIS2020 ParaView Tutorial: Effective Use of Color, Kenneth Moreland, Sandia National Laboratories, October 25th, 2020.

Color

what makes an effective colormap?

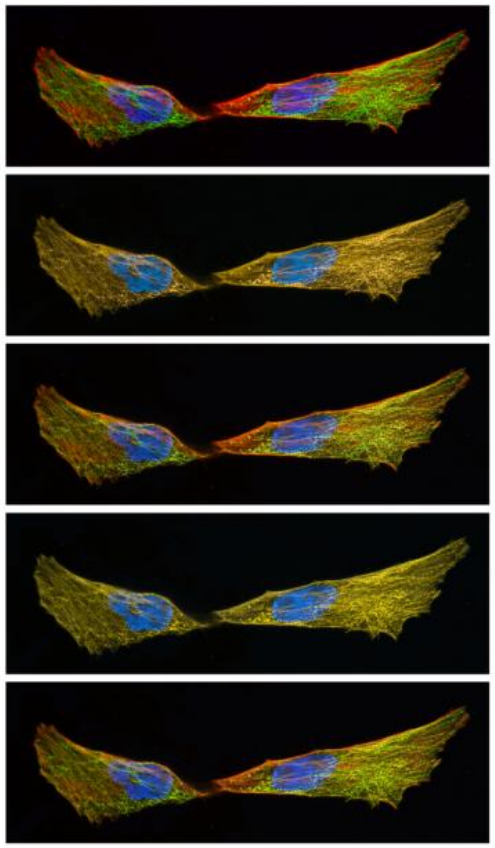
- Perceptually Uniform
- High Discrimination
- Implicit Order
- 3D Shading Friendly
- Color-blind Friendly



Adapted From: VIS2020 ParaView Tutorial: Effective Use of Color, Kenneth Moreland, Sandia National Laboratories, October 25th, 2020.

Color

be considerate of colorblindness



Wild-type photoreceptors

Deuteranopia (no green)

Deuteranomaly (reduced green)

Protanopia (no red)

Protanomaly (reduced red)

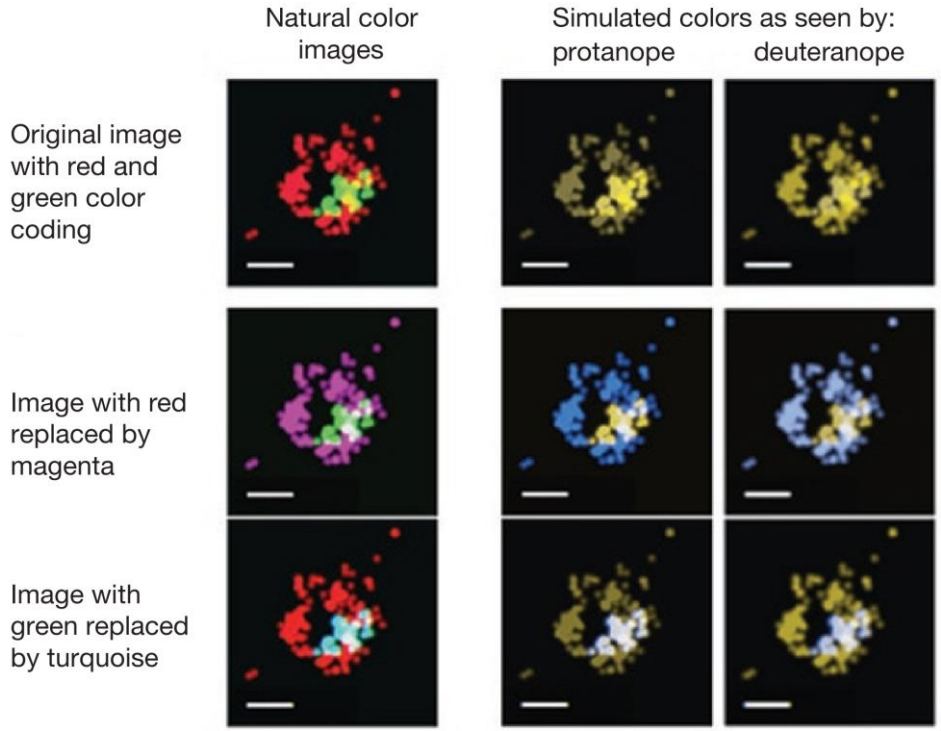
Your next reviewer may be colorblind

Up to **8%** of males and **.5%** of females have some form of color blindness

For three reviewers you have (at worst) an over **22%** chance of being assigned a colorblind reviewer.

Color

choose a colorblind friendly palette



Avoid red and green color combinations

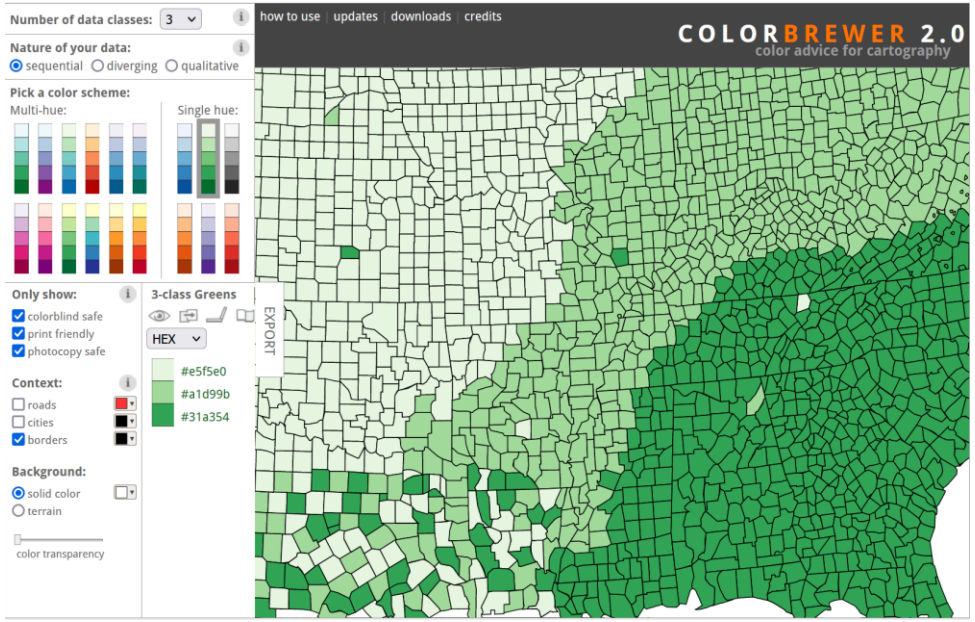
Color	Color name	RGB (1–255)	CMYK (%)	P	D
	Black	0, 0, 0	0, 0, 0, 100		
	Orange	230, 159, 0	0, 50, 100, 0		
	Sky blue	86, 180, 233	80, 0, 0, 0		
	Bluish green	0, 158, 115	97, 0, 75, 0		
	Yellow	240, 228, 66	10, 5, 90, 0		
	Blue	0, 114, 178	100, 50, 0, 0		
	Vermillion	213, 94, 0	0, 80, 100, 0		
	Reddish purple	204, 121, 167	10, 70, 0, 0		

Use a colorblind friendly color palette

Figures adapted from: B. Wong, “Points of view: Color blindness,” *Nat Methods*, vol. 8, no. 6, pp. 441–441, Jun. 2011, doi: 10.1038/nmeth.1618.

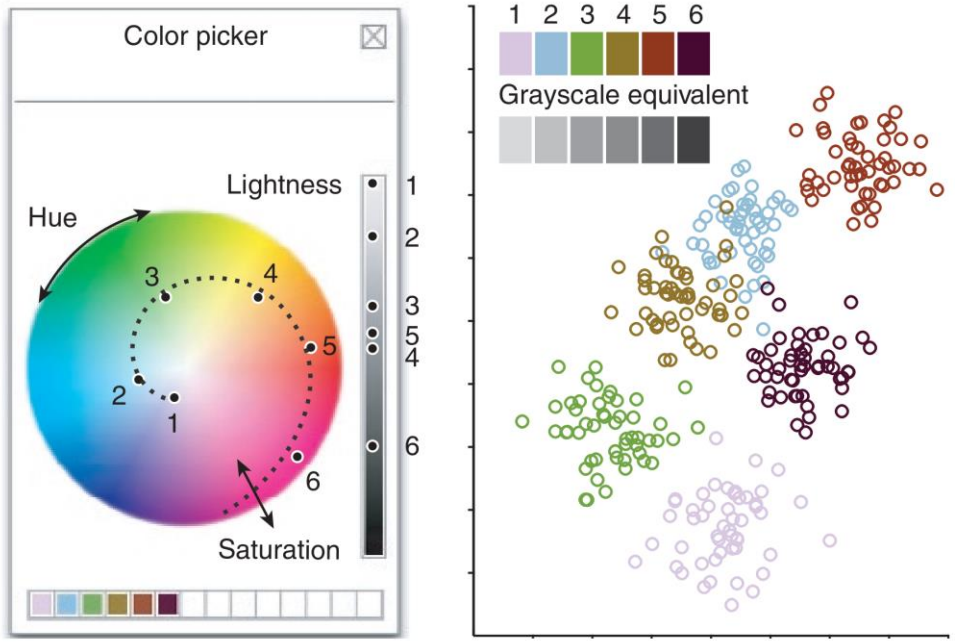
Color

choosing a color palette



Mapping color to quantitative data

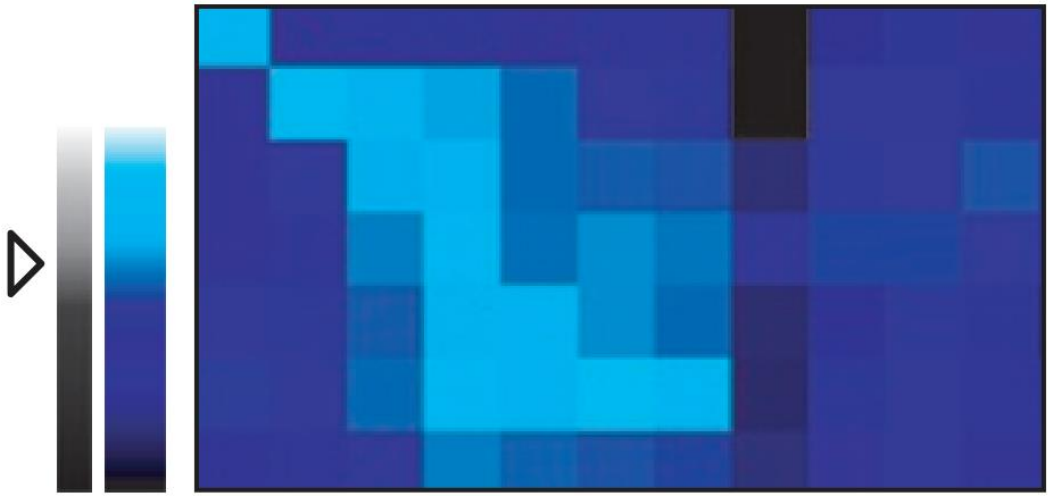
When selecting a sequential or diverging color scheme.



When colors have uneven saturation, data can be underrepresented

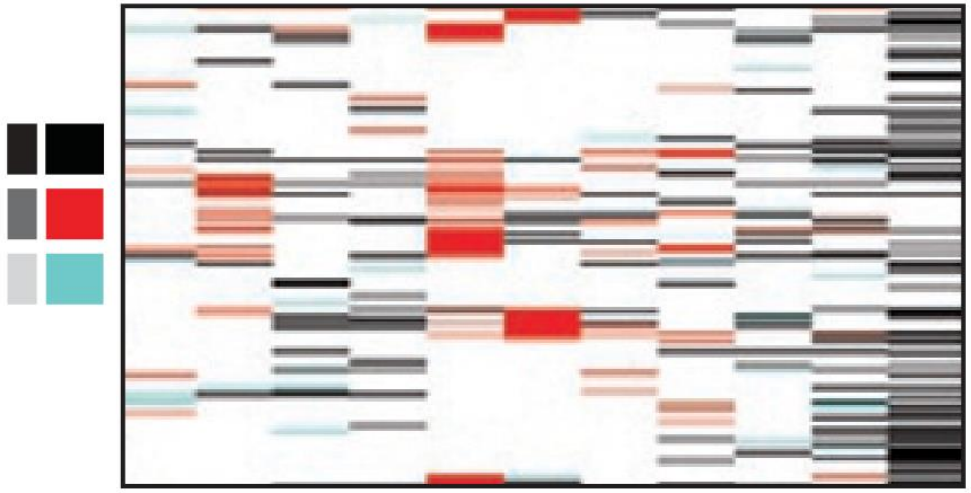
Images adapted from: B. Wong, “Points of view: Points of review (part 2),” *Nat Methods*, vol. 8, no. 3, pp. 189–189, Mar. 2011, doi: 10.1038/nmeth0311-189.
Slide adapted from: Basics of Information Design for Scientific Figures, Kelly Krause

Color
can misrepresent data



Use uniform colormaps

Color scales with sharp transitions can exaggerate data ranges

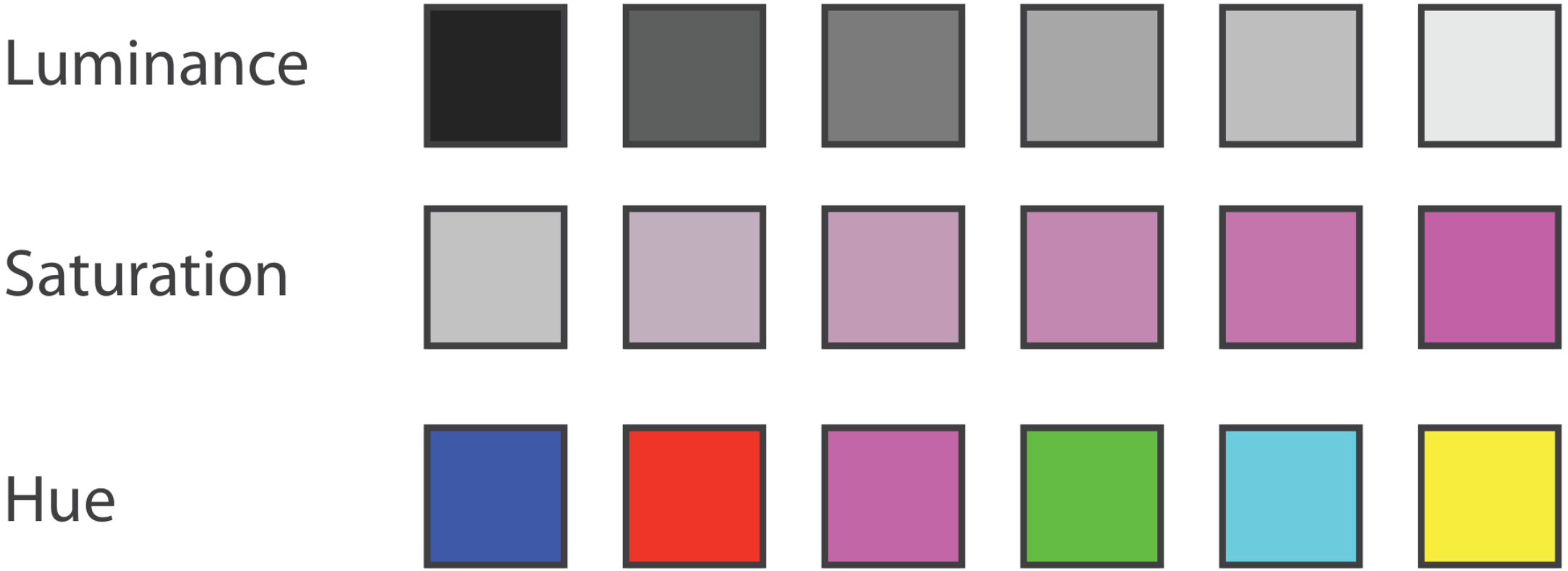


When colors have uneven saturation, data can be underrepresented

Images adapted from: B. Wong, “Points of view: Points of review (part 2),” *Nat Methods*, vol. 8, no. 3, pp. 189–189, Mar. 2011, doi: 10.1038/nmeth0311-189.
Slide adapted from: Basics of Information Design for Scientific Figures, Kelly Krause

Color

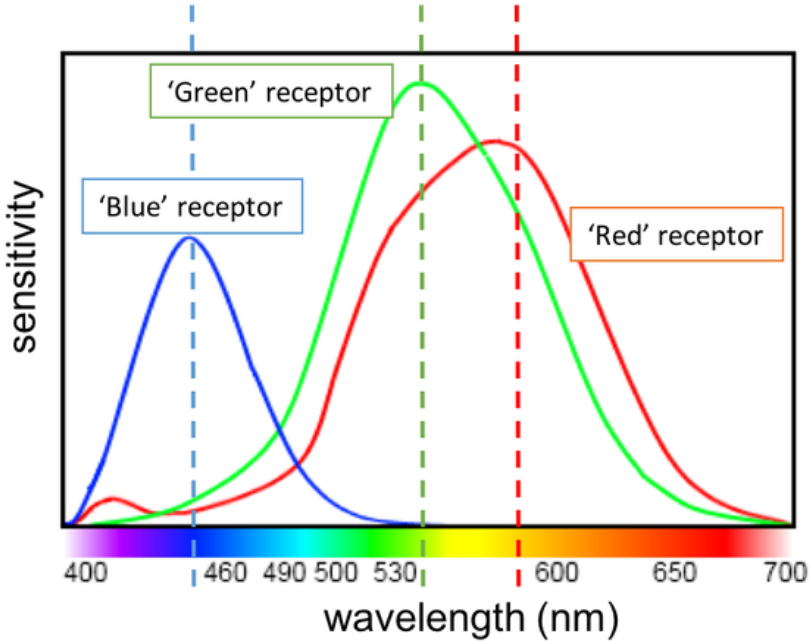
use all elements of color

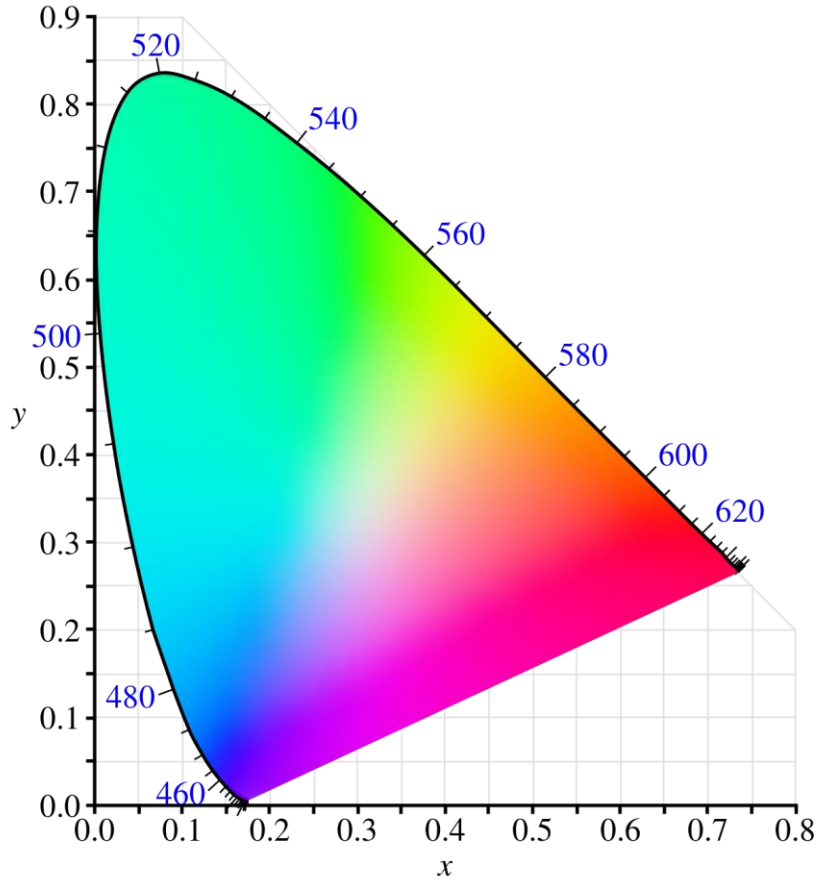


Adpated From: T. Munzner, *Visualization analysis and design.* Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2015.

Color

use the CIE L*a*b* color space where human perception is involved

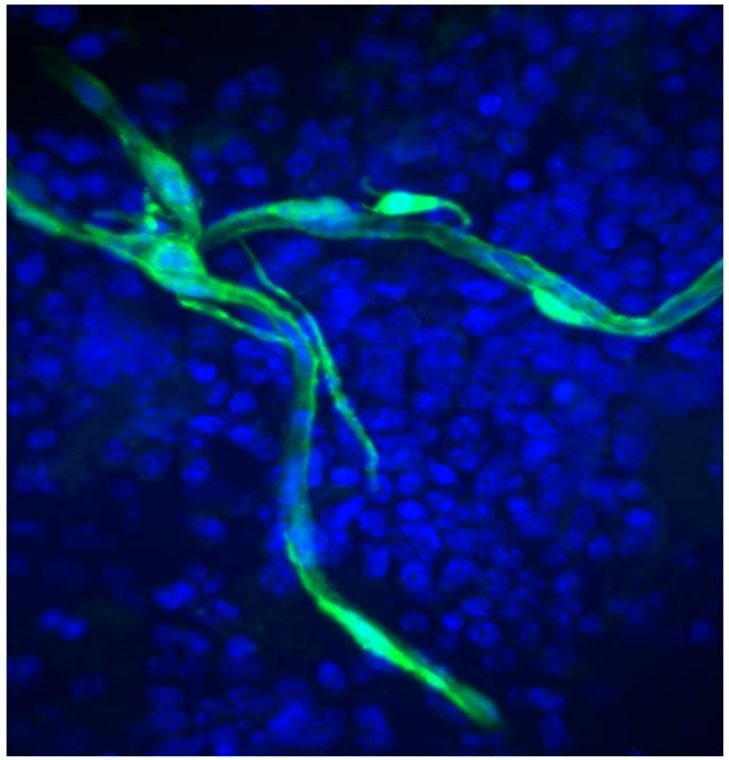




Adapted From: VIS2020 ParaView Tutorial: Effective Use of Color, Kenneth Moreland, Sandia National Laboratories, October 25th, 2020.

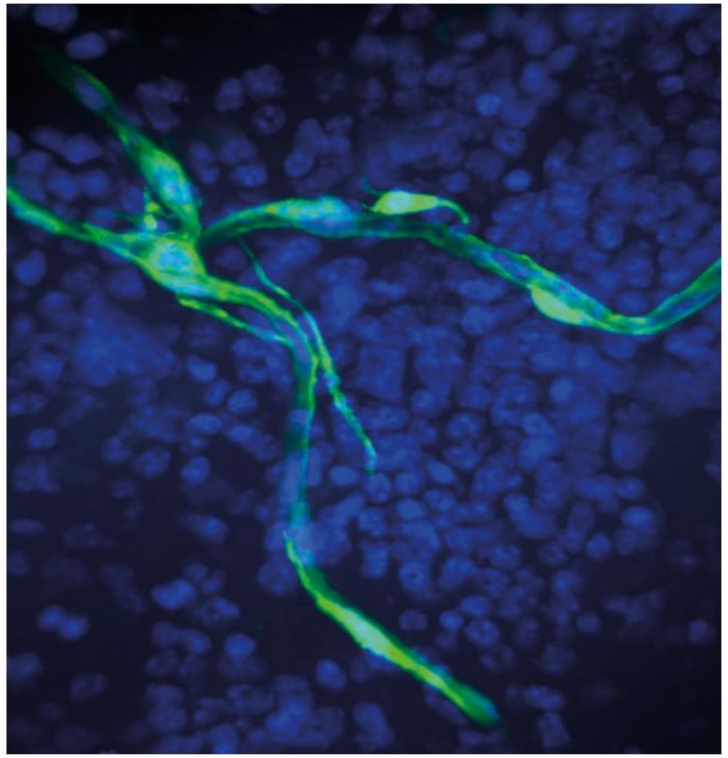
Color

use an RGB color space for digital display



RGB (Red, Green, Blue)

Additive colors, used for digital.
Greater dynamic range.



CMYK (Cyan, Magenta, Yellow, and Key)

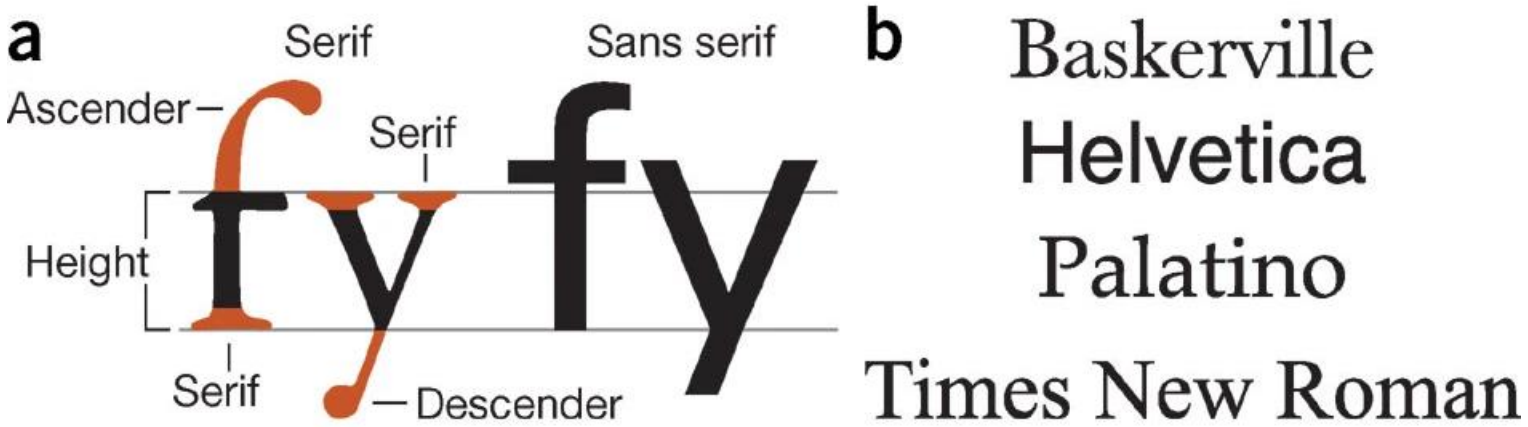
Subtractive colors, used for print.
Lower dynamic range.

Adpated From: T. Munzner, *Visualization analysis and design.* Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2015.

Refine the Text Style

Typography

Use one font-family

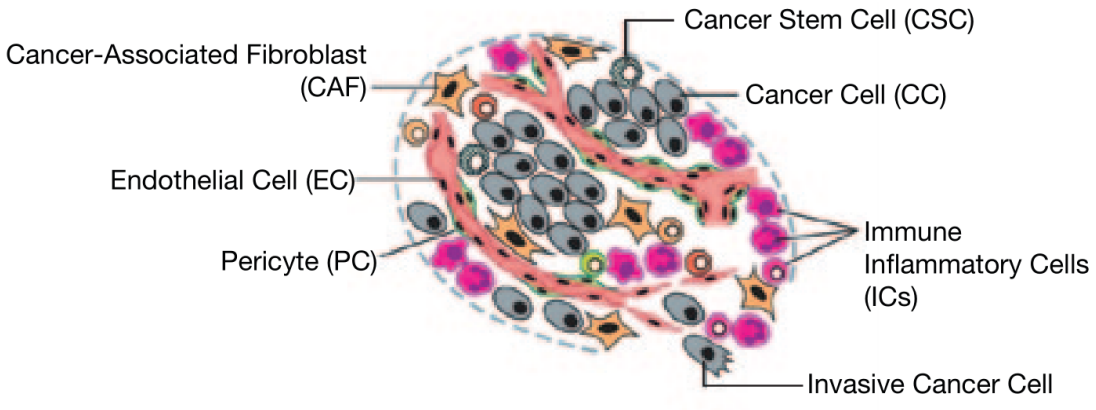


Use Serif for text, Sans serif for figures

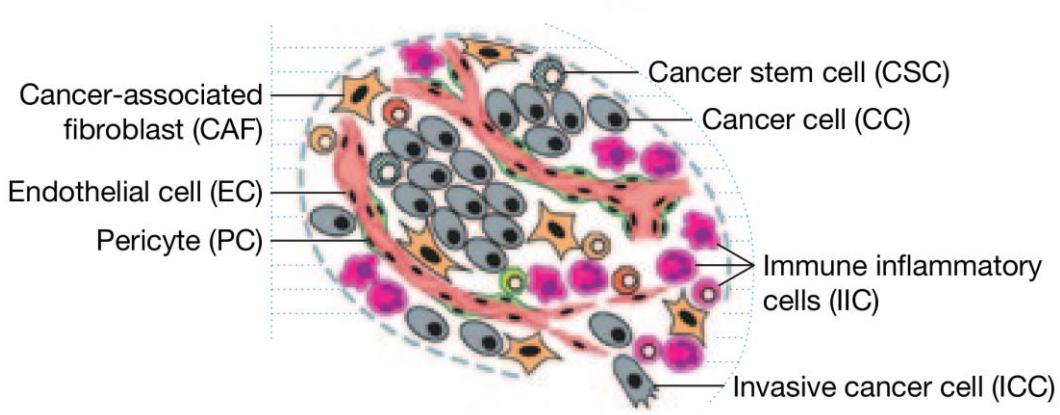
Wong, Bang. 2011. “Points of View: Typography.” *Nature Methods* 8 (4): 277–277. https://doi.org/10.1038/nmeth0411-277.

Arrows and Labels

align figure callout lines and labels



Unaligned figure



Callout labels are aligned when feasible

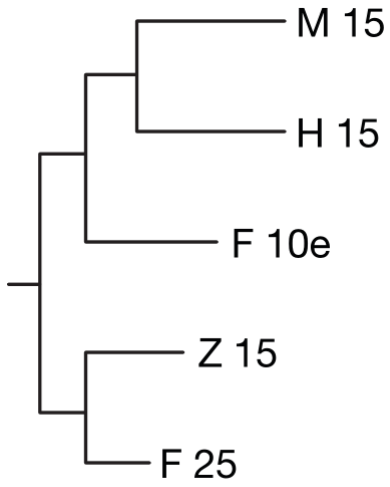
Use horizontal callout lines or fixed angle lines (30 or 45°) when not possible.

Align labels when necessary, otherwise follow the curve of the schematic.

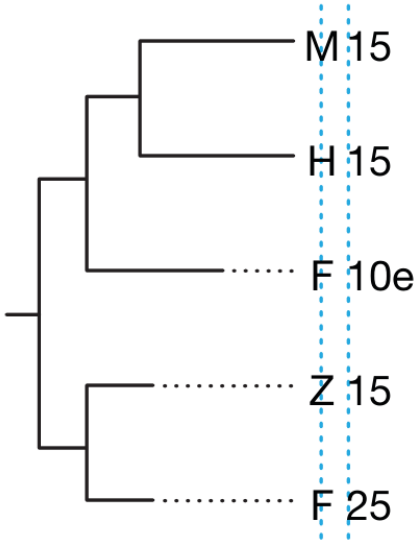
M. Krzywinski, “Labels and callouts,” *Nat Methods*, vol. 10, no. 4, pp. 275–275, Apr. 2013, doi: 10.1038/nmeth.2405.

Arrows and Labels

align figure callout lines and labels



Unaligned figure



Callout labels are aligned when feasible

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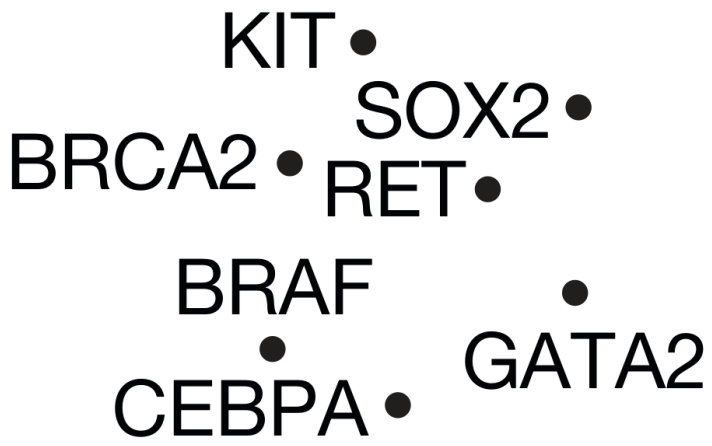
Align labels when necessary, otherwise follow the curve of the schematic.

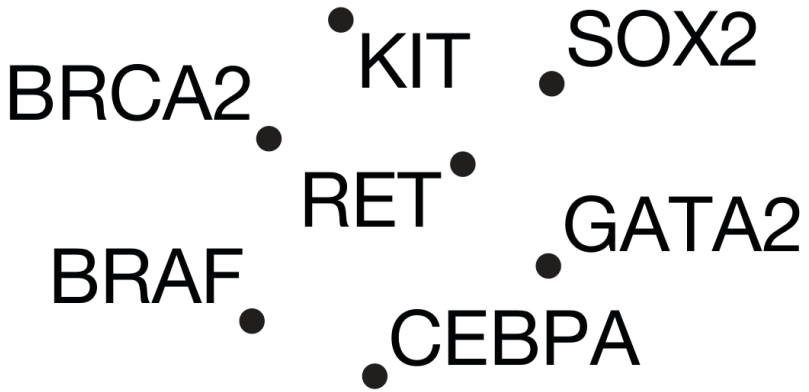
M. Krzywinski, “Labels and callouts,” *Nat Methods*, vol. 10, no. 4, pp. 275–275, Apr. 2013, doi: 10.1038/nmeth.2405.

Arrows and Labels

position labels consistently



Ambiguous label placement



Good label placement

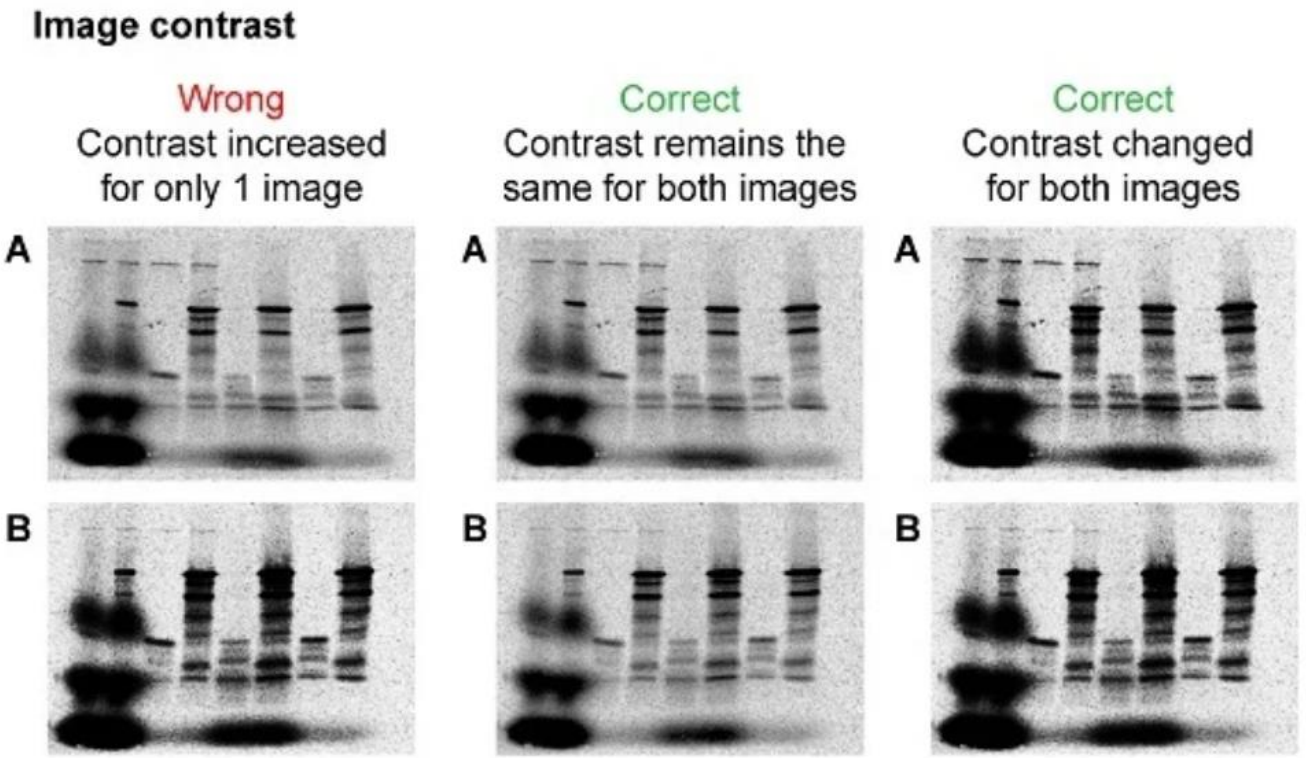
Distance and alignment of labels should be fixed

M. Krzywinski, “Labels and callouts,” *Nat Methods*, vol. 10, no. 4, pp. 275–275, Apr. 2013, doi: 10.1038/nmeth.2405.

Recommended Practices

Recommended practices
avoid image manipulation

Scientific digital images **are data** that can be compromised by inappropriate manipulations



Source: http://microscopy.arizona.edu/learn/digital-image-ethics

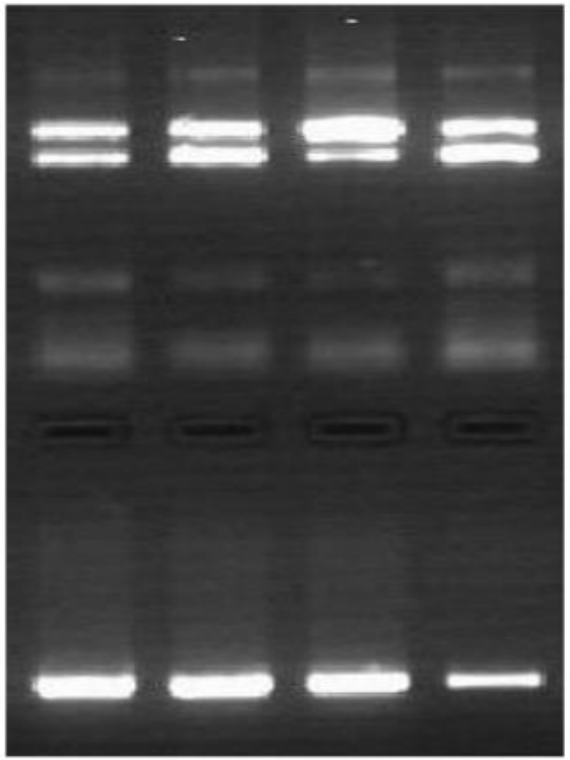
Recommended practices
avoid image manipulation

Scientific digital images **are data** that can be compromised by inappropriate manipulations

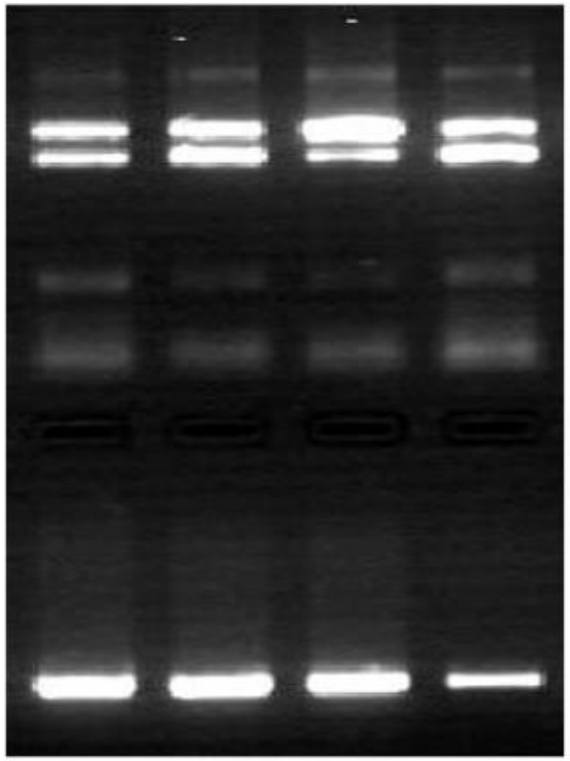
1. Only make changes to a copy
2. Only make global changes
3. Cropping is (usually) acceptable
4. Digital images should be acquired under comparable conditions if being compared
5. Local manipulations are generally NOT acceptable
6. Use of software filters to improve image quality is not recommended
7. Cloning or copying objects into a digital image is NEVER acceptable
8. Intensity measurements should be performed on uniformly processed image data, and the data should be calibrated to a known standard
9. Avoid the use of lossy compression;
10. Magnification and resolution are important;
11. Be careful when changing the size (in pixels) of a digital image.

Source: http://microscopy.arizona.edu/learn/digital-image-ethics

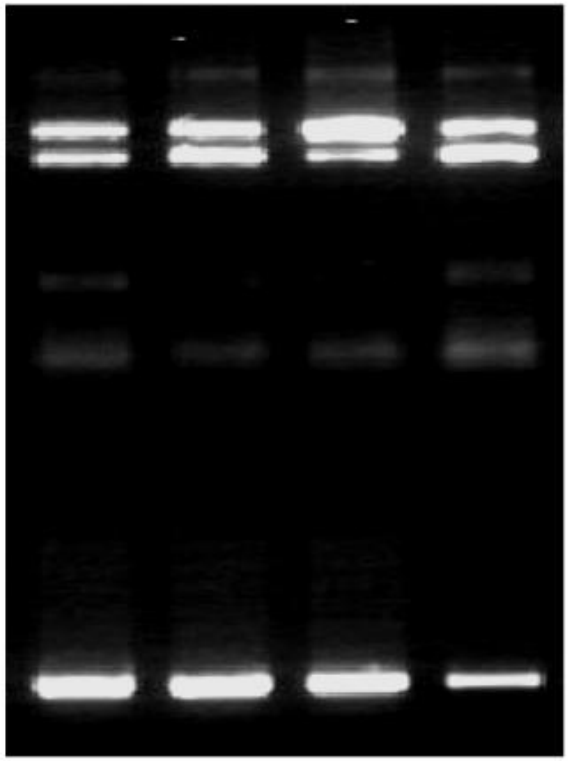
Recommended practices
don’t be misleading



Original



Brightness and Contrast Adjusted



Brightness and Contrast Adjusted Too Much: Oversaturation

Adapted From: https://www.bioinformatics.babraham.ac.uk/training/Figure_Design_Course/Figure%20Design%20Slides.pdf

Recommended practices
image compression considerations

Three levels of JPG compression. The left-most image is the original. The middle image offers a medium compression, which may not be immediately obvious to the naked eye without closer inspection. The right-most image is maximally compressed.

Image source: https://www.lifewire.com/the-effect-of-compression-on-photographs-493726

Recommended practices

be aware of differences in downsampling

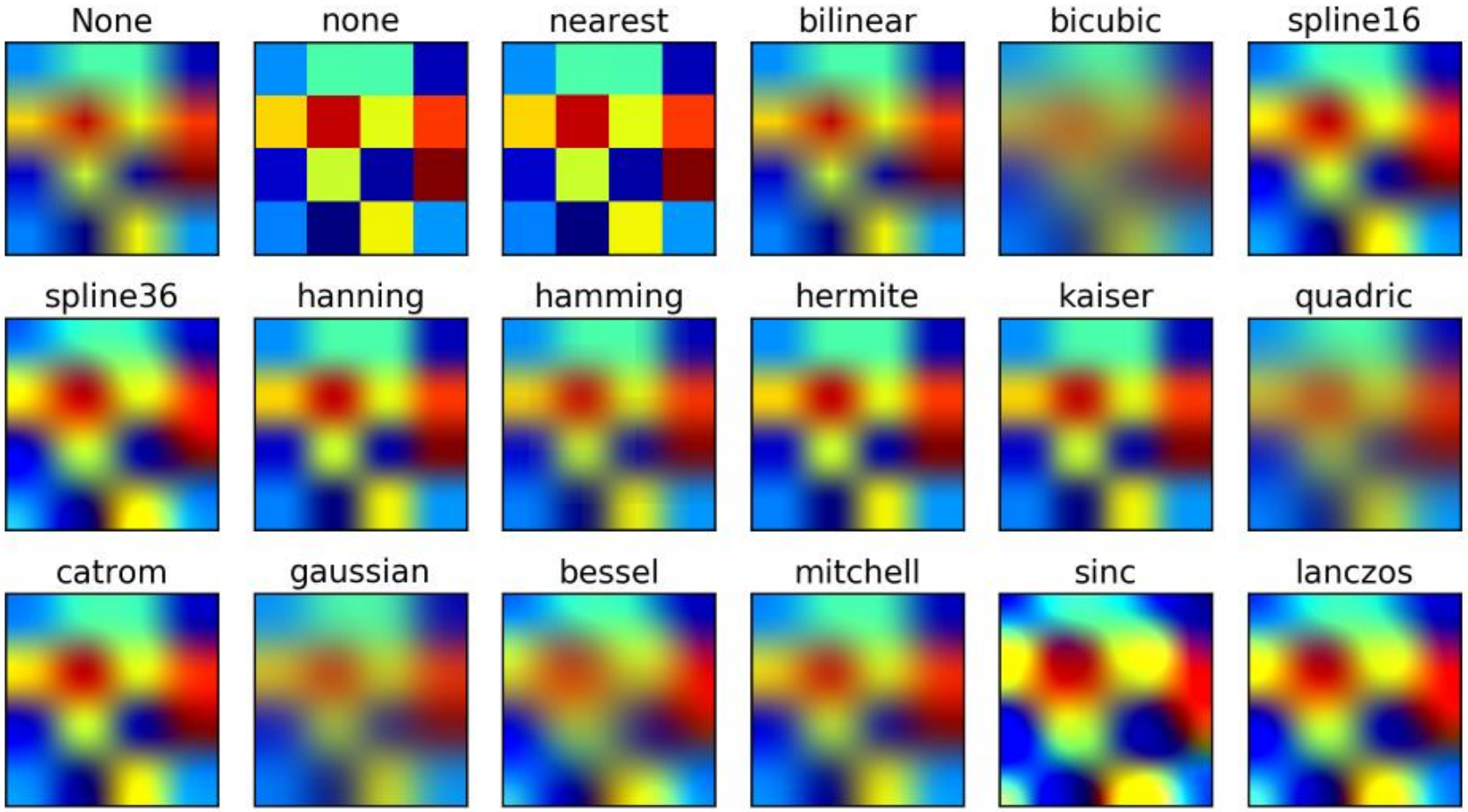
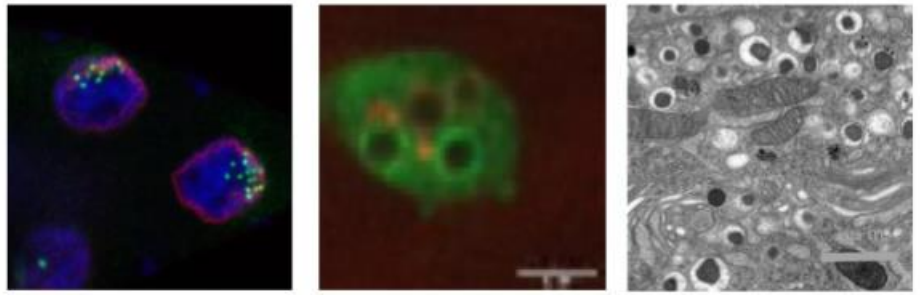


Image source: https://matplotlib.org/mpl_examples/images_contours_and_fields/interpolation_methods.hires.png

Recommended practices

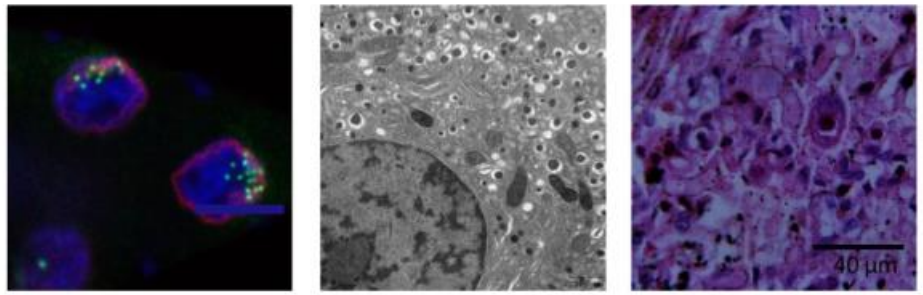
Use scale bars to annotate image size



1. No scale bar

2. Scale bar illegible, poor compression

3. Scale bar blends into the background

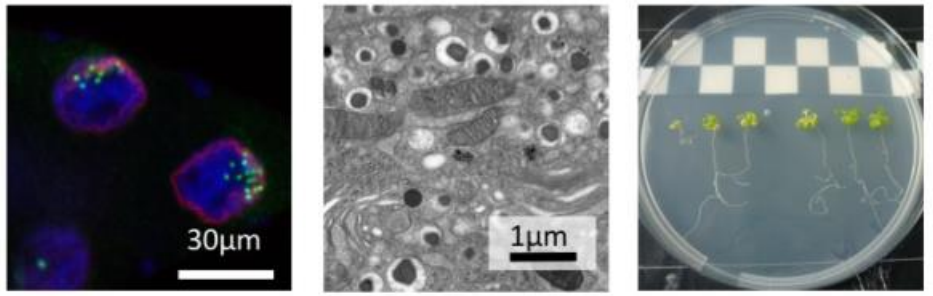


4. Scale bar in color

5. Scale bar too small

6. Scale bar blends into the background

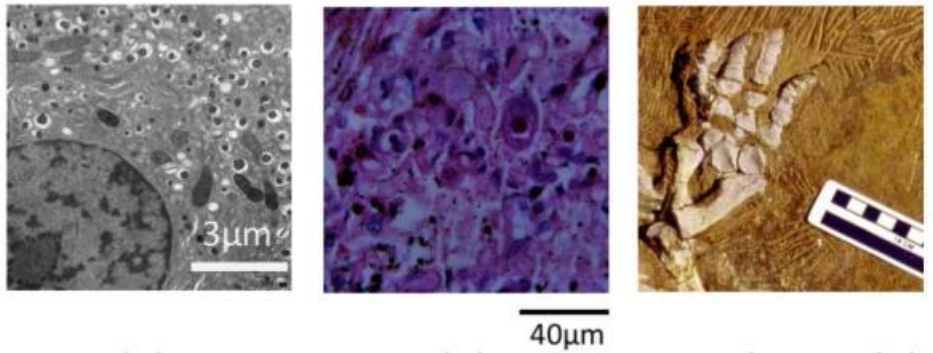
Poor use of scale bars



7. Scale bar, good contrast

8. White background enhances contrast

9. Ruler as scale bar, Square edge: 1cm



10. Scale bar, good contrast

11. Scale bar below image

12. Ruler as scale bar, Square edge: 1cm

Effective use of scale bars

Jambor, H. *et al.* Creating clear and informative image-based figures for scientific publications. *PLOS Biology* **19**, e3001161 (2021).

Recommended practices

know your journal requirements

GUIDE TO PREPARING FINAL ARTWORK

When preparing figures, authors are advised to refer to printed copies of *Nature* to get a sense of general size and style points. The aim of this guide is to show you the main things to look out for when submitting final production-quality artwork.

FIGURE SIZING

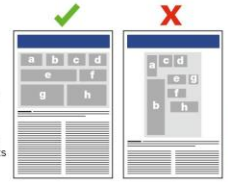
- Provide files at about the size they are to be printed. *Nature*'s standard figure sizes are 89 mm (single column) and 183 mm (double column). The full depth of the page is 247 mm.
- Figures can also be 1.5 columns where necessary – 120 mm or 136 mm.

89 mm width (1 column)

183 mm width (2 column)

ARRANGEMENT

- Try to keep white space to a minimum where possible.
- *Nature* will be guided by your suggested layout of parts within figures, but may rearrange parts if necessary.
- Essential layout features should be indicated when submitting — for example, particular alignments of panels within a figure.



FILE FORMATS

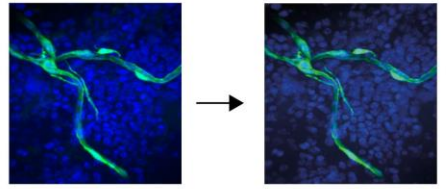
- Acceptable formats include: AI, Vector EPS, layered PSD, postscript, PDF, PowerPoint, Word, Excel and CorelDraw (up to version 8).
- We cannot use the following formats: JPEG, TIFF, png, DeltaGraph, Tex, ChemDraw, Canvas, SigmaPlot - convert these files to PDF, EPS or postscript formats before submission.

FONTS AND LABELS

- All text should be in a sans-serif typeface, preferably Helvetica or Arial.
- Amino acid sequences should be presented in one-letter code in Courier.
- Do not rasterize or convert text to outlines, this will mean that the text isn't editable (see below).
- Separate panels in multi-part figures should be labelled with 8 pt bold, upright (not italic) **a, b, c's...**
- Maximum text size for all other text: 7pt.
- Minimum text size: 5pt.

COLOURS

- We recommend supplying your artwork in the RGB colour spectrum. This provides a wider gamut than the CMYK print format and allows more faithful reproduction of fluorescent colours when viewed digitally.
- Your artwork will be automatically converted to CMYK to be printed in the journal but the online PDF will retain the RGB colour space.
- You can supply your artwork in CMYK instead, if you wish to ensure the printed figures are replicated faithfully.
- The example below shows the shift in colour between RGB and the equivalent colour shown in CMYK-subtle details are often lost during the conversion.

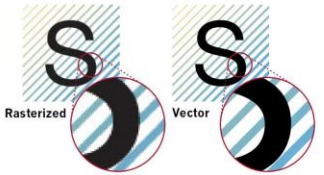


RGB CMYK

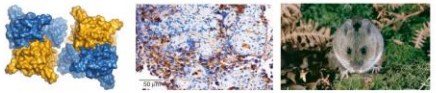
IMAGE TYPES

The best format for any particular figure depends partly on what sort of imagesit contains. Images fall into two basic categories: rasterized images (flattened image) and line (or vector) art which is in a layered format.

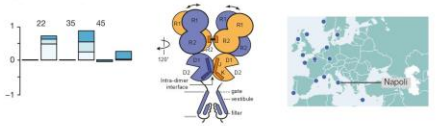
- Do not rasterize line art or text in submitted figures.
- Wherever possible please supply editable, unflattened vector artwork.
- The example below shows the difference in quality between text and lines that have been rasterized and text and lines that are still editable.



Typical examples of raster artwork



Typical examples of vector artwork



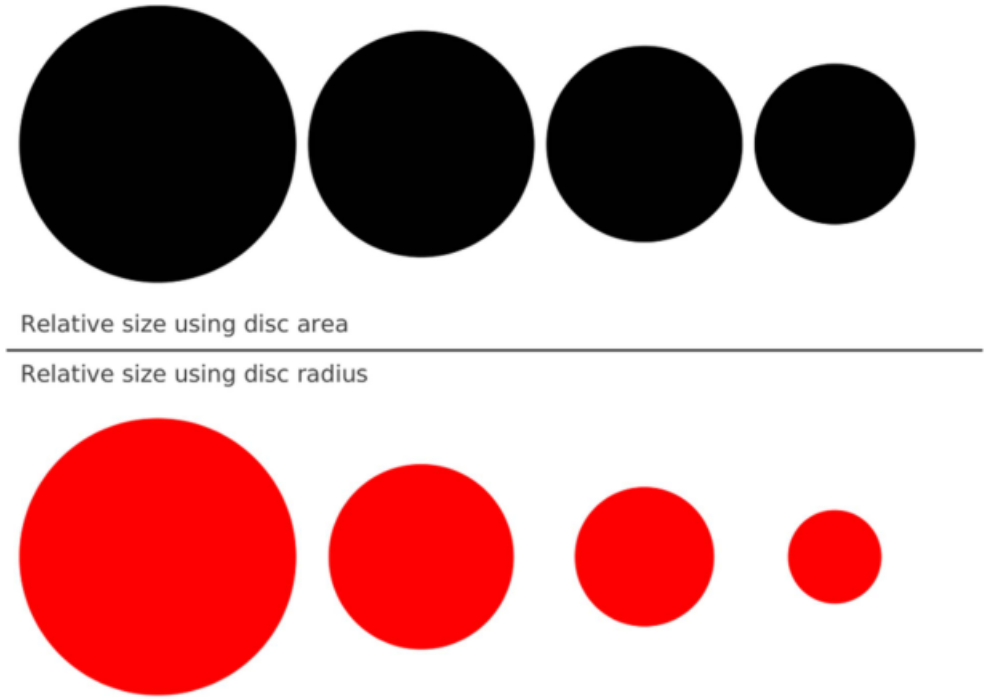
RESOLUTION

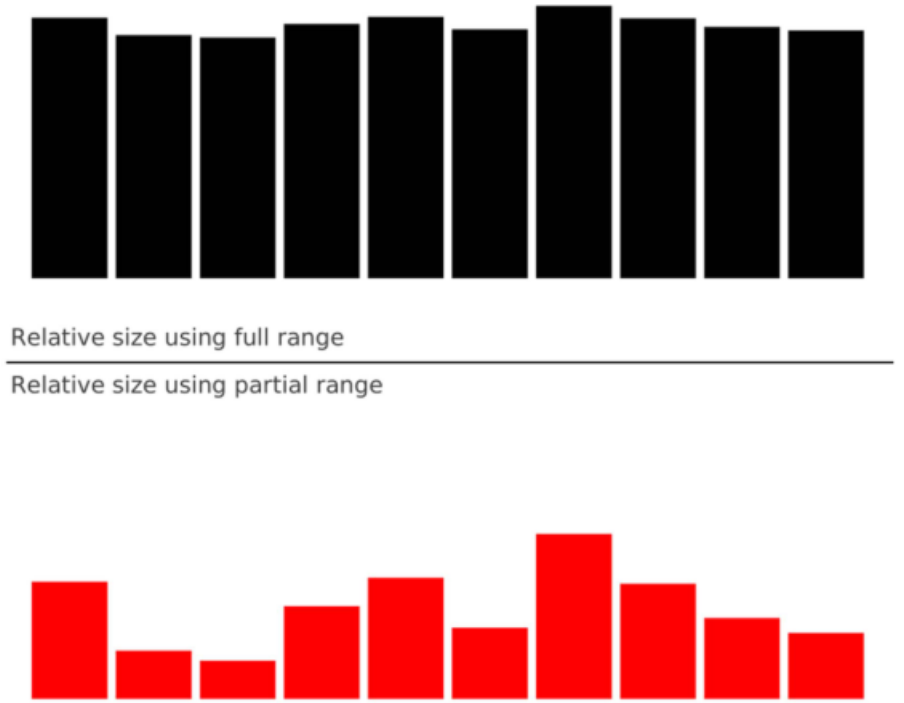
- All photographic images must be supplied at a minimum of 300 dpi at the maximum size they can be used.
- Artificially increasing an image's resolution in an artwork program will not improve its quality.
- The example below shows the difference between a low-resolution image and the same image at 300 dpi (the differences are more apparent the further you zoom in).

72 dpi 300 dpi

For further help and advice, e-mail our art editors at art@nature.com

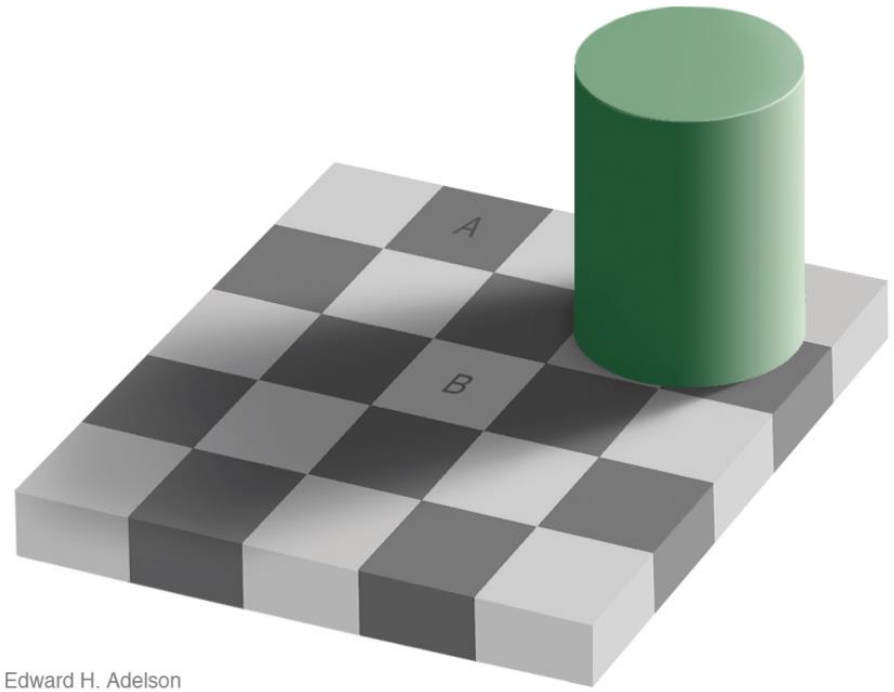
Recommended practices
don’t be misleading

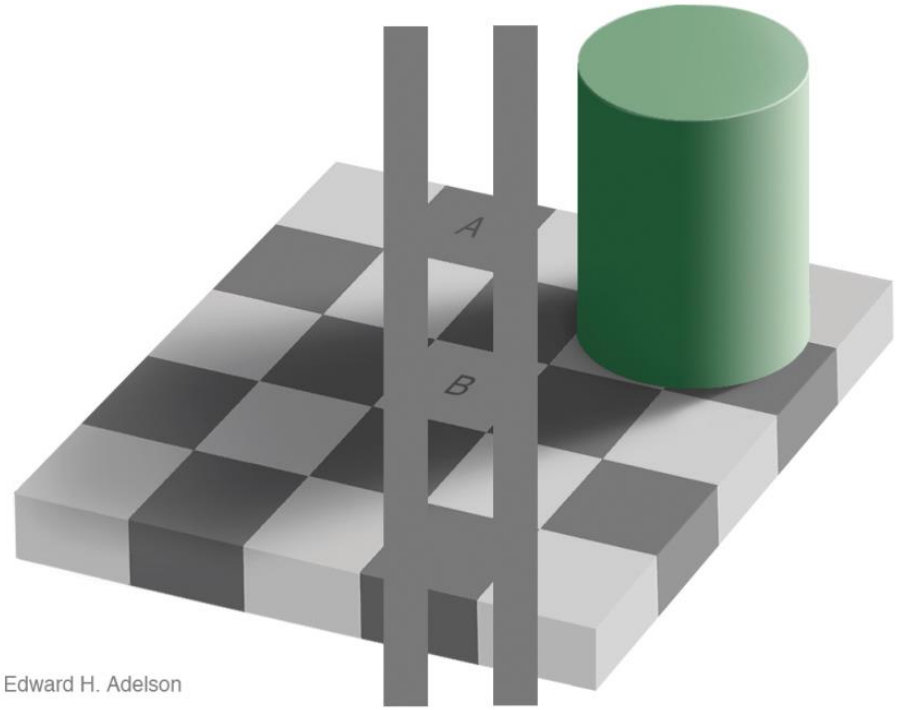




N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

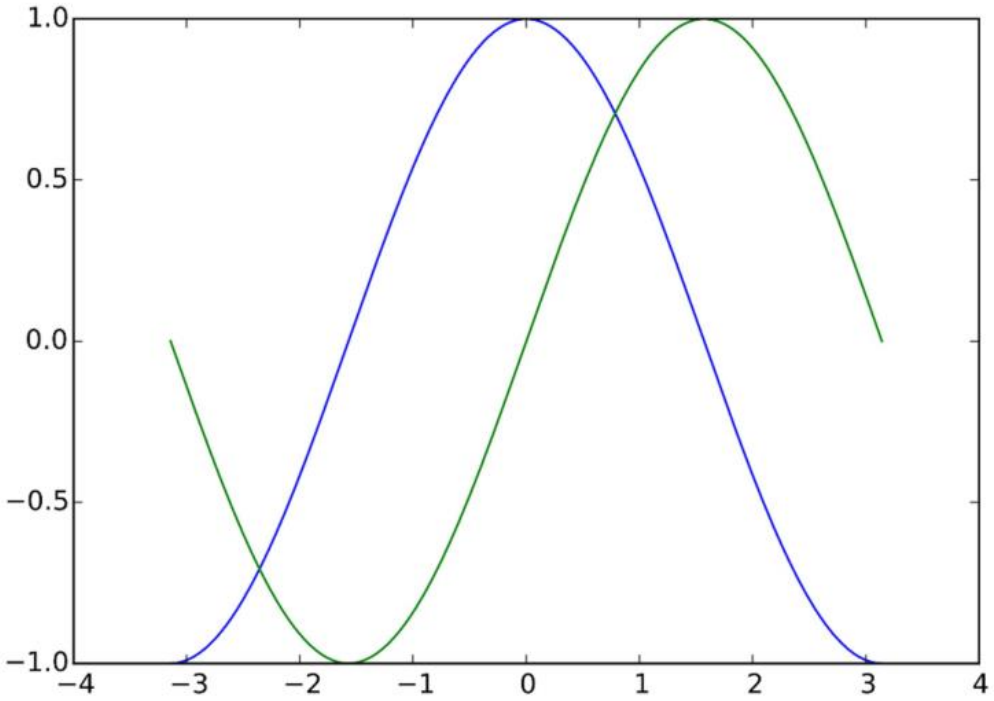
Recommended practices
don’t be misleading



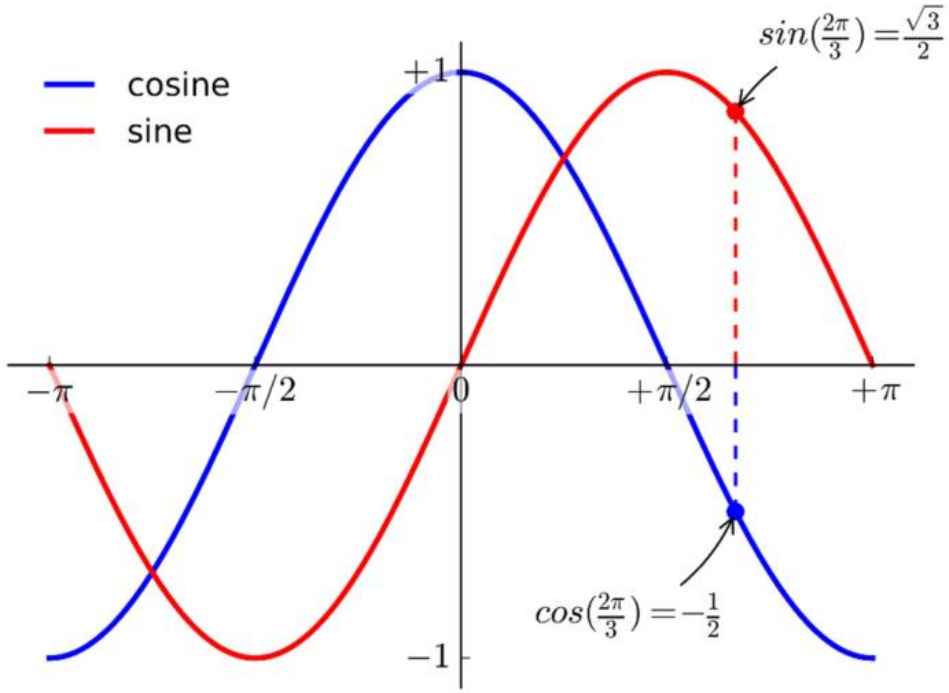


Adapted From: T. Munzner, *Visualization analysis and design.* Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2015.

Recommended practices
don’t trust the defaults



matplotlib defaults



Visually improved plot

N. P. Rougier, M. Droettboom, and P. E. Bourne, “Ten Simple Rules for Better Figures,” *PLOS Computational Biology*, vol. 10, no. 9, p. e1003833, Sep. 2014, doi: 10.1371/journal.pcbi.1003833.

Colormaps in Matlab

dangerous defaults

Jet

R2014a and prior

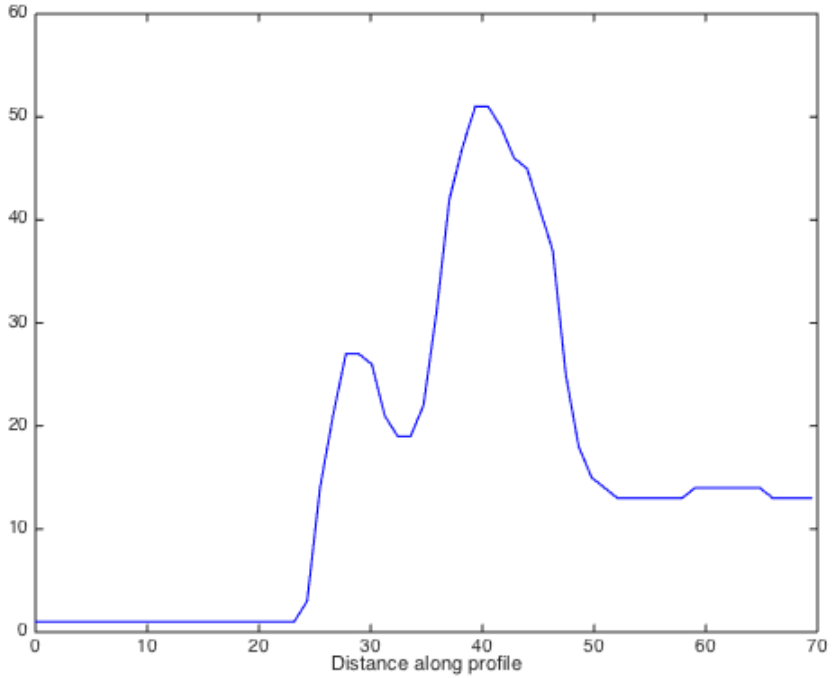
Parula

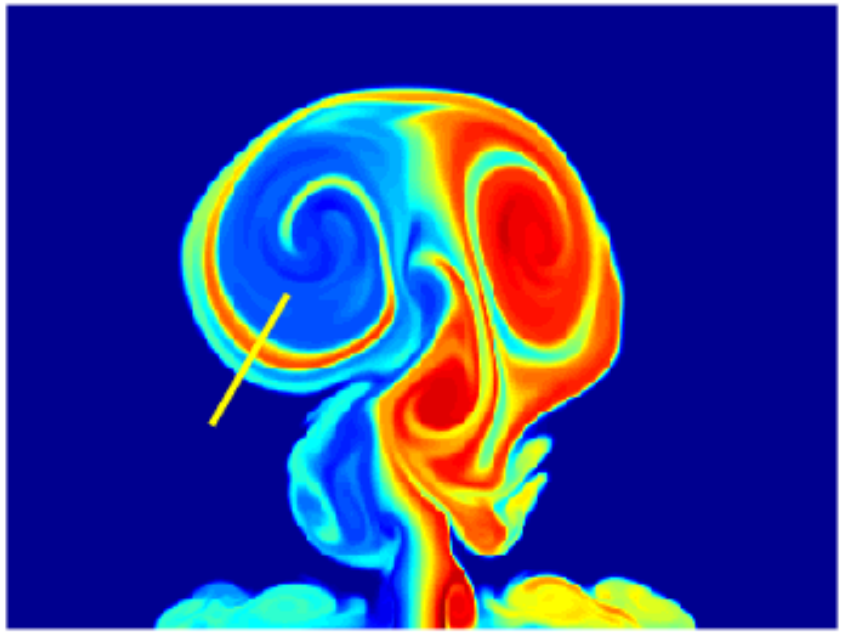
Since R2014b

https://www.mathworks.com/help/matlab/ref/colormap.html

Colormaps in Matlab

dangerous defaults



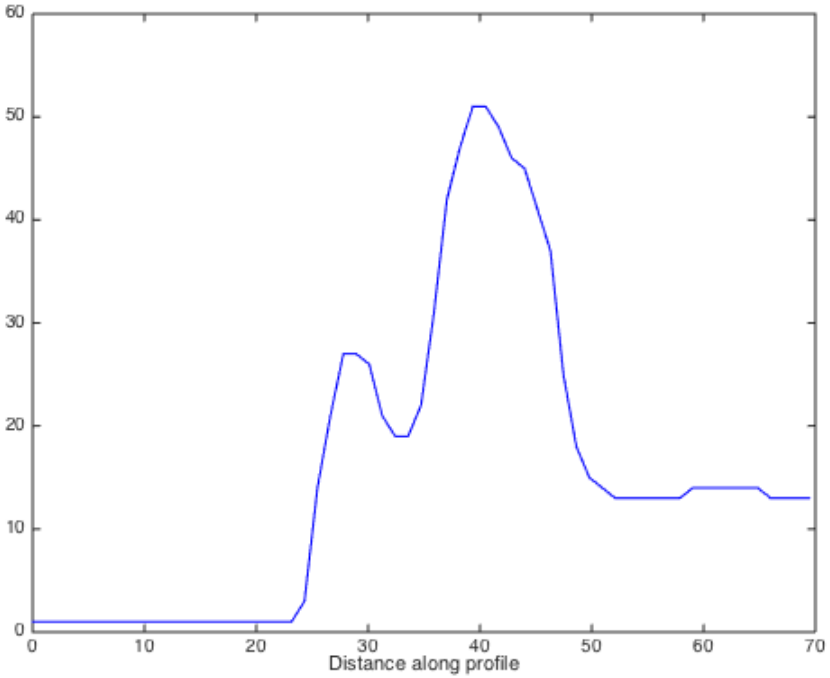


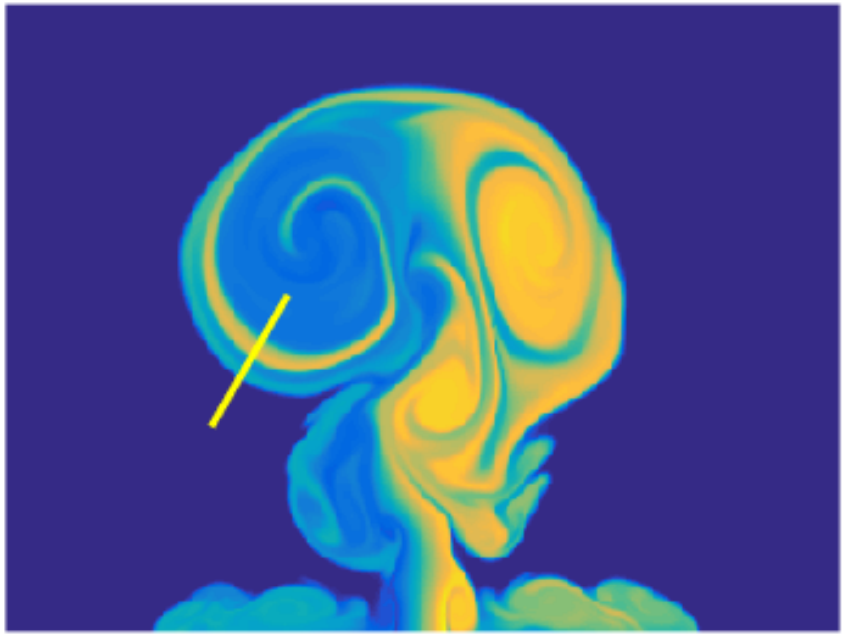
Jet

https://blogs.mathworks.com/steve/2014/10/20/a-new-colormap-for-matlab-part-2-troubles-with-rainbows/

Colormaps in Matlab

dangerous defaults





Parula

https://blogs.mathworks.com/steve/2014/10/20/a-new-colormap-for-matlab-part-2-troubles-with-rainbows/

Recommended practices

vector vs. raster graphics

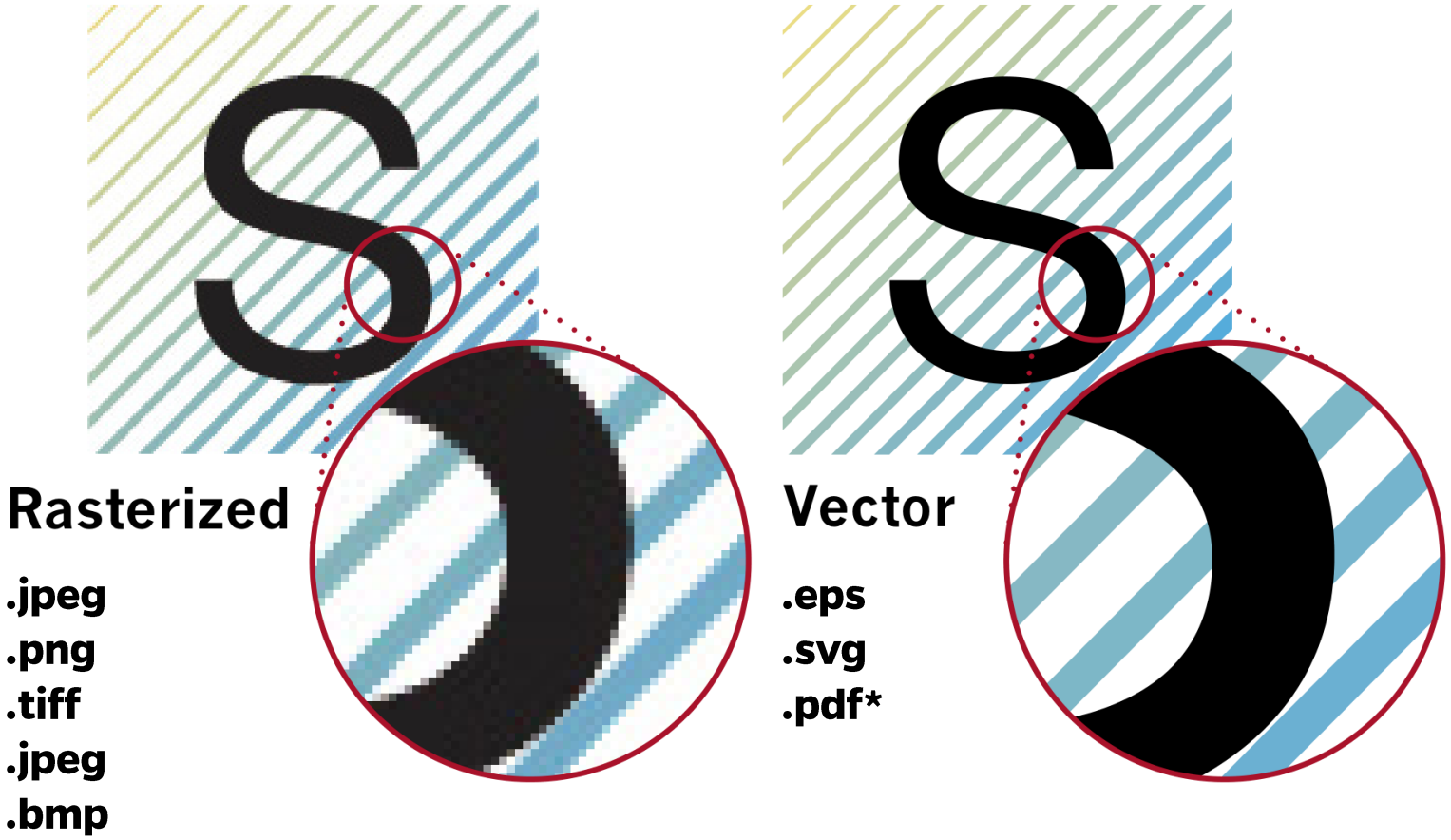


Image source: https://www.nature.com/documents/nature-final-artwork.pdf

Recommended practices

vector vs. raster graphics

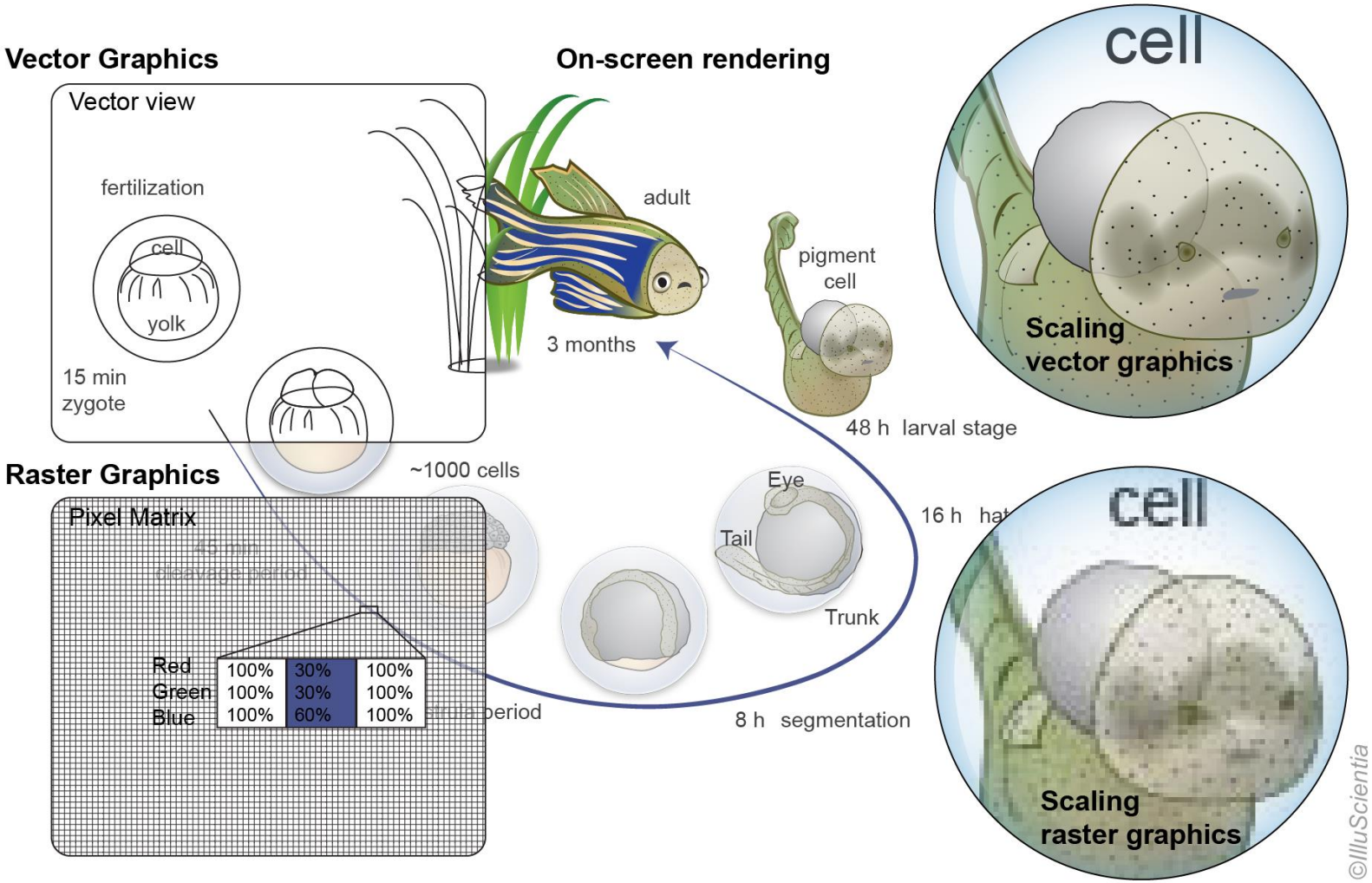


Image soure: http://www.illuscientia.com/resources/vector-vs-raster-graphics/

Checklist

is your figure effective?

- ☐ The figure is **self contained**: understandable without additional information
- ☐ Every element is **labelled** or explained in the caption, including x and y units
- ☐ x and y axis: **scales** show appropriate variation of the data, or are comparable
- ☐ **Readability** and **contrast** are appropriate
- ☐ Every use of **colour** has a reason
- ☐ The figure works in **grayscale** (except for very complex figures)
- ☐ If there are **groupings**, they help understand the message without manipulating
- ☐ There are no channel **inconsistencies** within the figure
- ☐ It is as **simple** as possible: i.e. no decorations, every piece that could be eliminated without losing information has been eliminated
- ☐ Has been **validated** with other people...

https://bioinformatics-core-shared-training.github.io/effective-figure-design/DesigningEffectiveScientificFigures_Zabala_afternoon_v00.pdf

Resources

Resources
recommended software

Inkscape
Vector graphics editor
Alternative: Adobe Illustrator

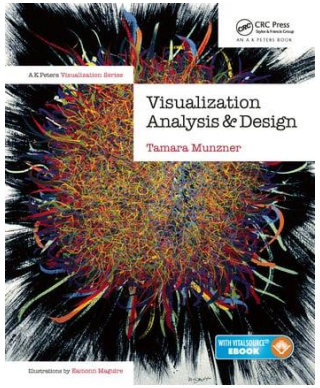
GIMP
Raster graphic image manipulation
Alternative: Adobe Photoshop

ImageMagick
Command line utilities for image manipulation

Fiji/ImageJ
Image processing program
Alternative: NIS-Elements

Resources

recommended reading



Visualization Analysis and Design

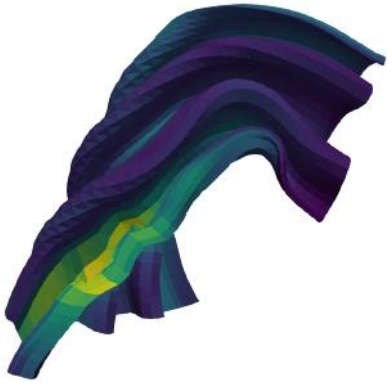
Tamara Munzner

methagora

a blog from *Nature Methods*

Points of View

Bang Wong and Martin Krywinksi



Color Map Advice for Scientific Visualization

Kenneth Moreland

Thank you!

any questions?

Please Complete Our Survey:

https://bit.ly/sci-fig