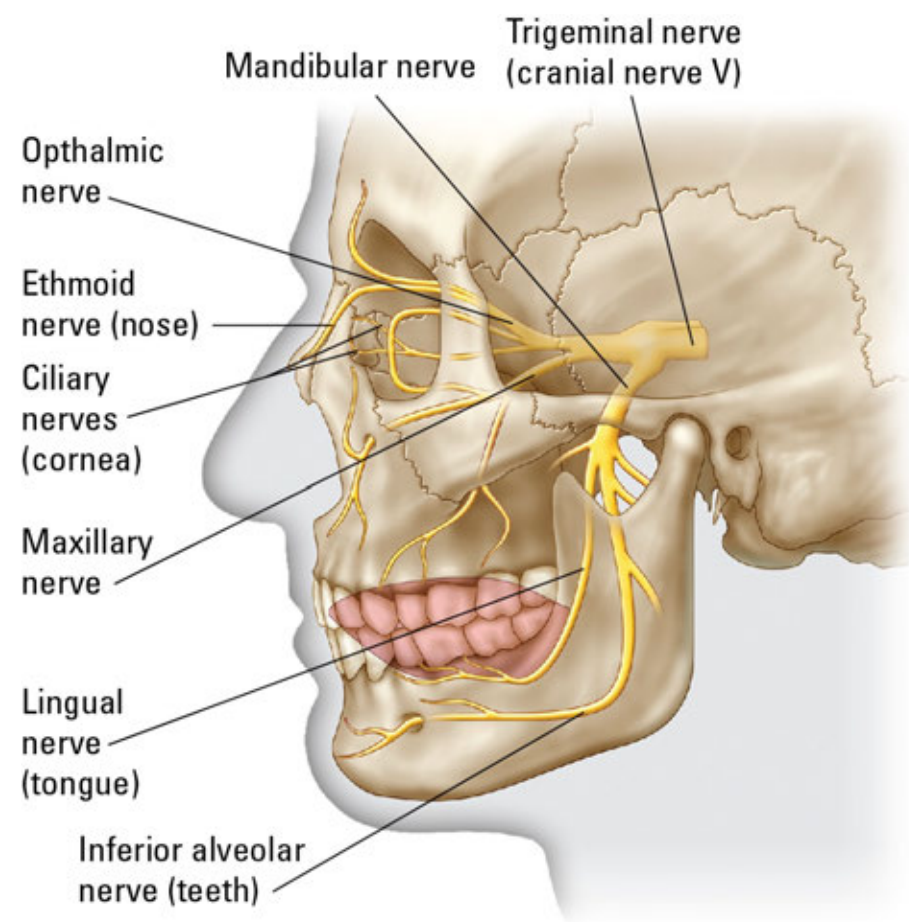
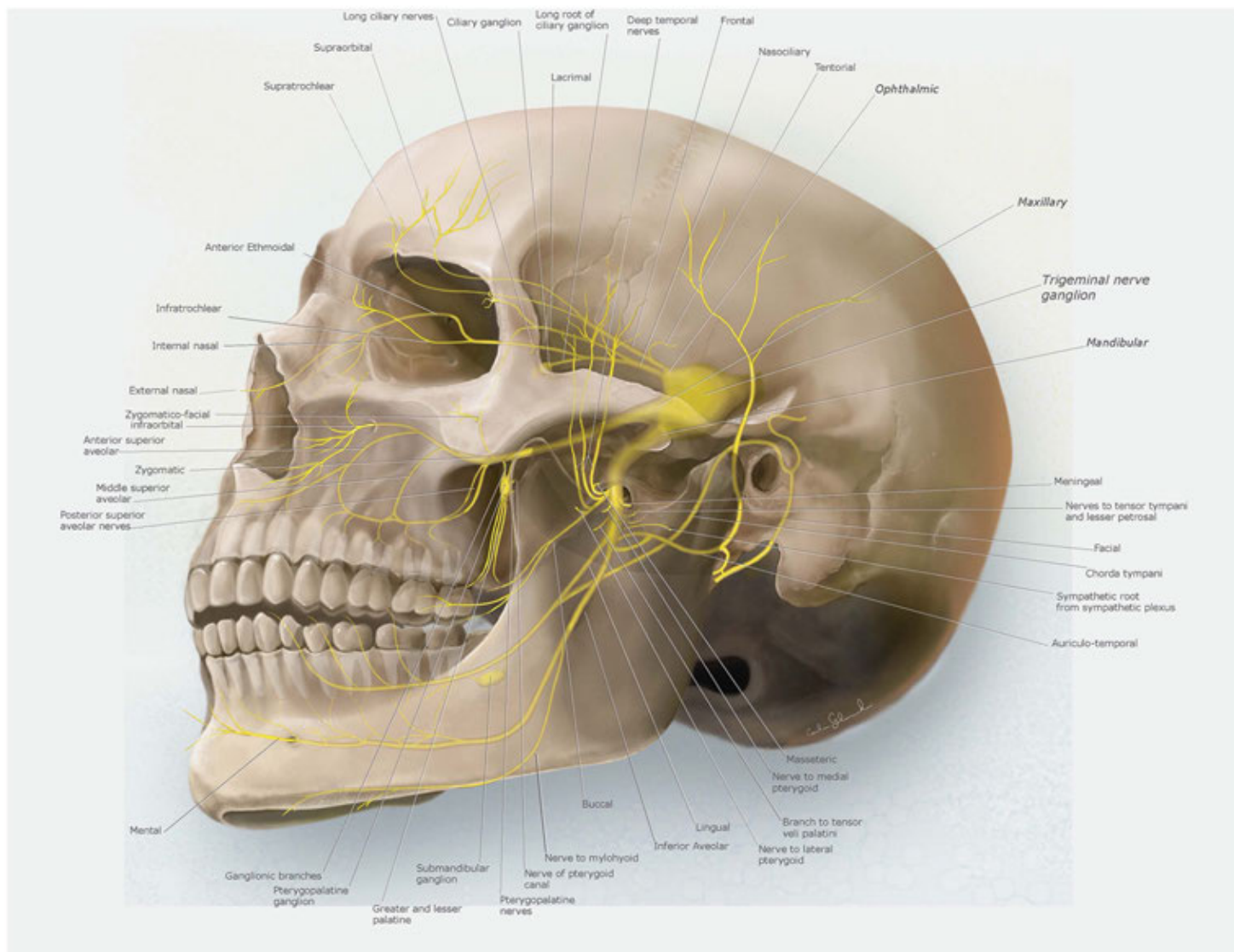




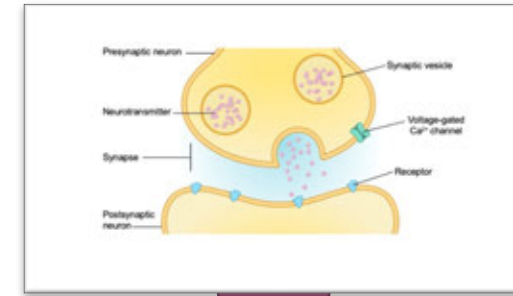
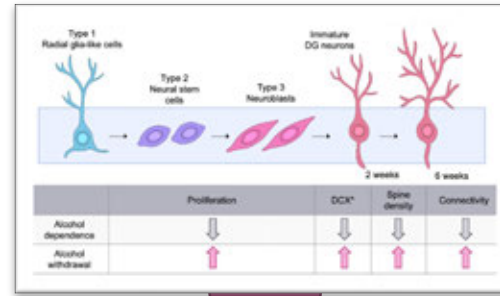
Science Visualization for Research Scientists

Carolina Hrejsa, MS, CMI

Kansas State University 2022



Agenda



Visual Storytelling
for scientific audiences

Best Practice for Publication
vector graphics
print vs web

Principles of Design
creating hierarchy and focus

Image Use
Licenses, "free" images

A decorative graphic on the right side of the slide consists of several overlapping diamond and rectangular shapes in teal, yellow, and green. On the left side, there are partial shapes in teal, yellow, and green.

“

Visualization is the art of turning scientific data into imagery.

To facilitate learning, record scientific discovery, and stimulate imagination.



**Scientists can be
artists.**

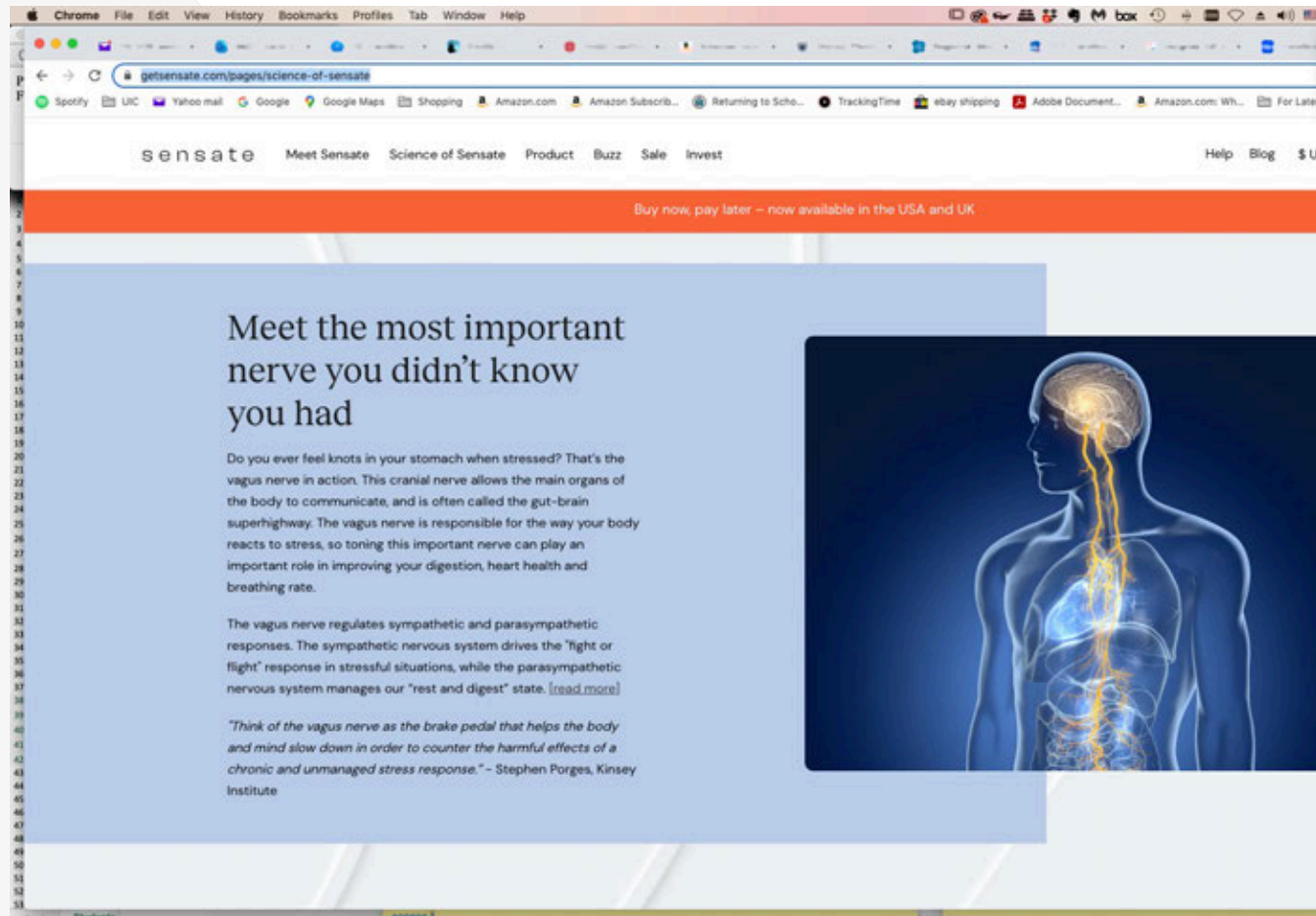


**Artists cannot be
scientists.**

What is wrong here?



What is wrong here?



Chrome File Edit View History Bookmarks Profiles Tab Window Help

getsensate.com/pages/science-of-sensate

Sensate Meet Sensate Science of Sensate Product Buzz Sale Invest Help Blog \$ US


Buy now, pay later – now available in the USA and UK

Meet the most important nerve you didn't know you had

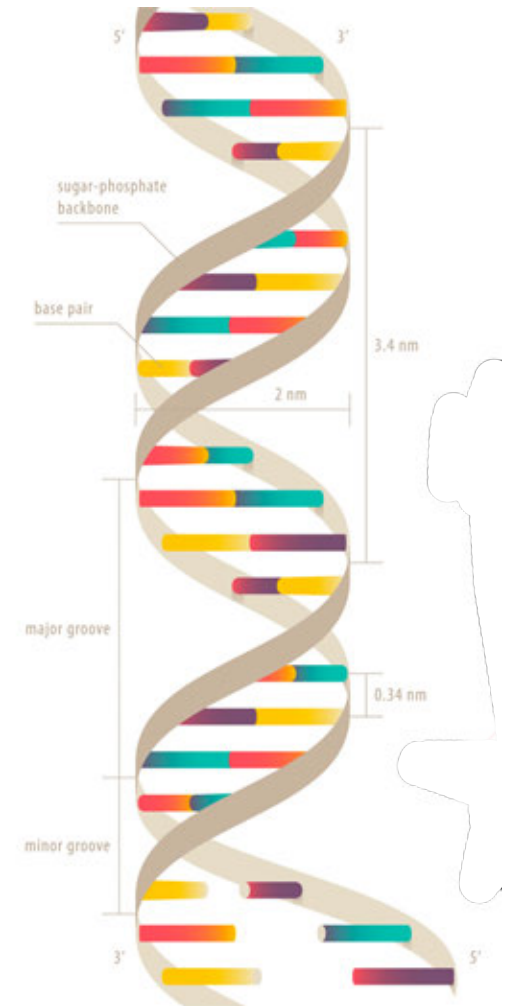
Do you ever feel knots in your stomach when stressed? That's the vagus nerve in action. This cranial nerve allows the main organs of the body to communicate, and is often called the gut-brain superhighway. The vagus nerve is responsible for the way your body reacts to stress, so toning this important nerve can play an important role in improving your digestion, heart health and breathing rate.

The vagus nerve regulates sympathetic and parasympathetic responses. The sympathetic nervous system drives the "fight or flight" response in stressful situations, while the parasympathetic nervous system manages our "rest and digest" state. [\[read more\]](#)

"Think of the vagus nerve as the brake pedal that helps the body and mind slow down in order to counter the harmful effects of a chronic and unmanaged stress response." – Stephen Porges, Kinsey Institute



What is wrong here?





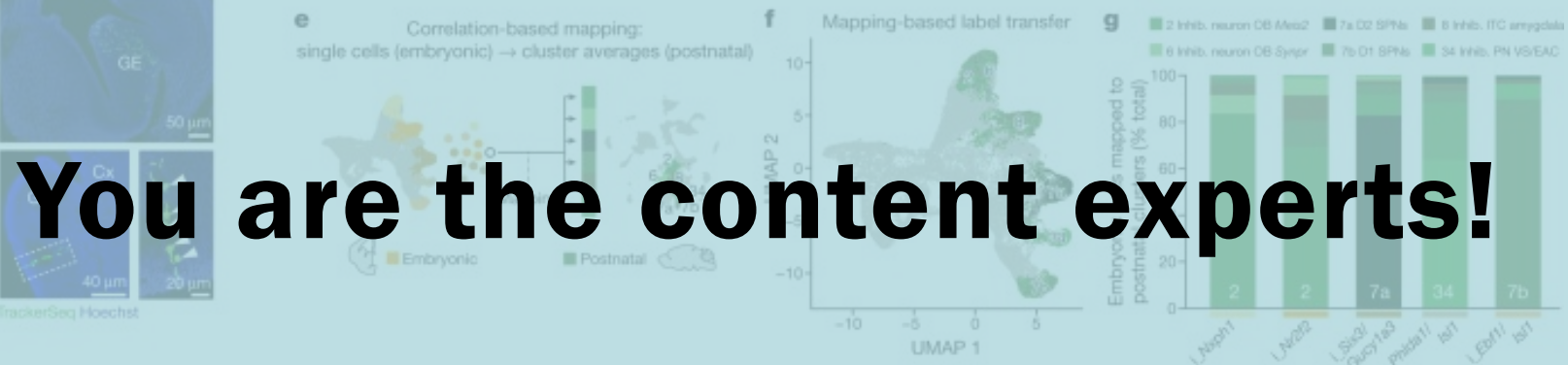
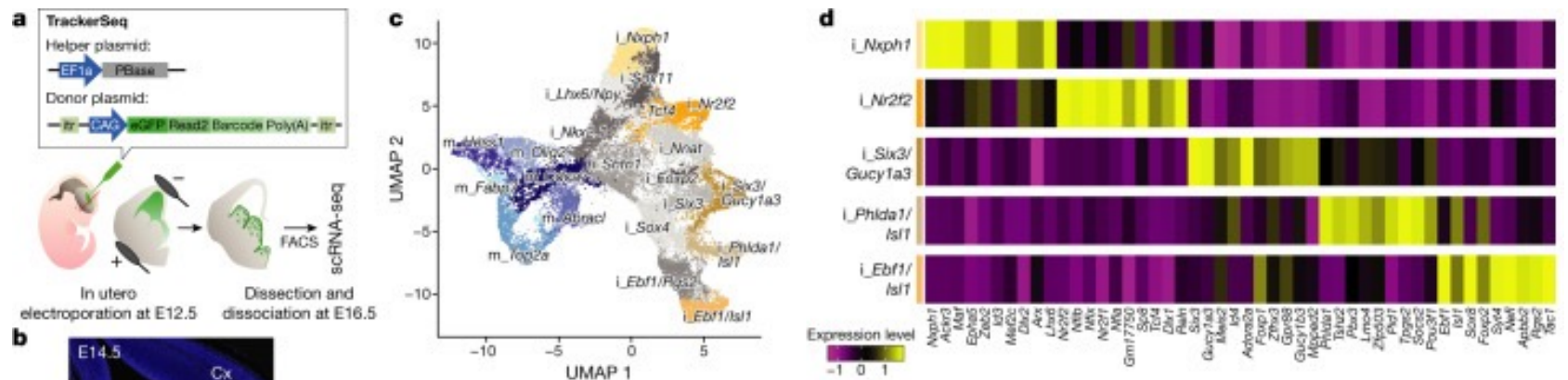
**Artists cannot be
scientists.**

Science Storytelling

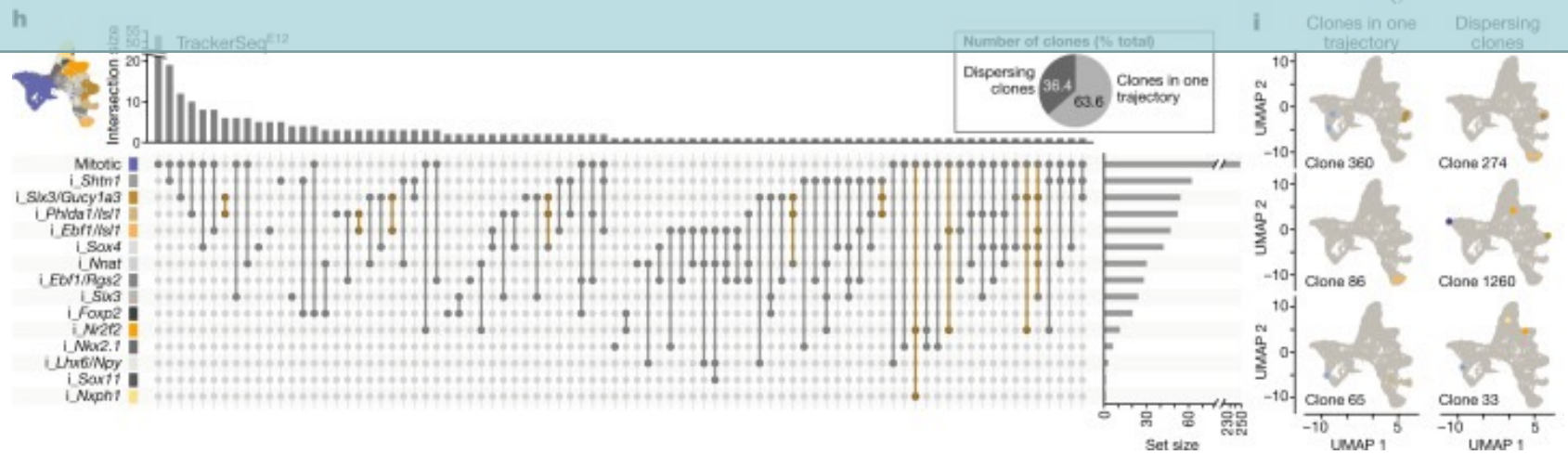
- Science narratives
- What makes a good story?



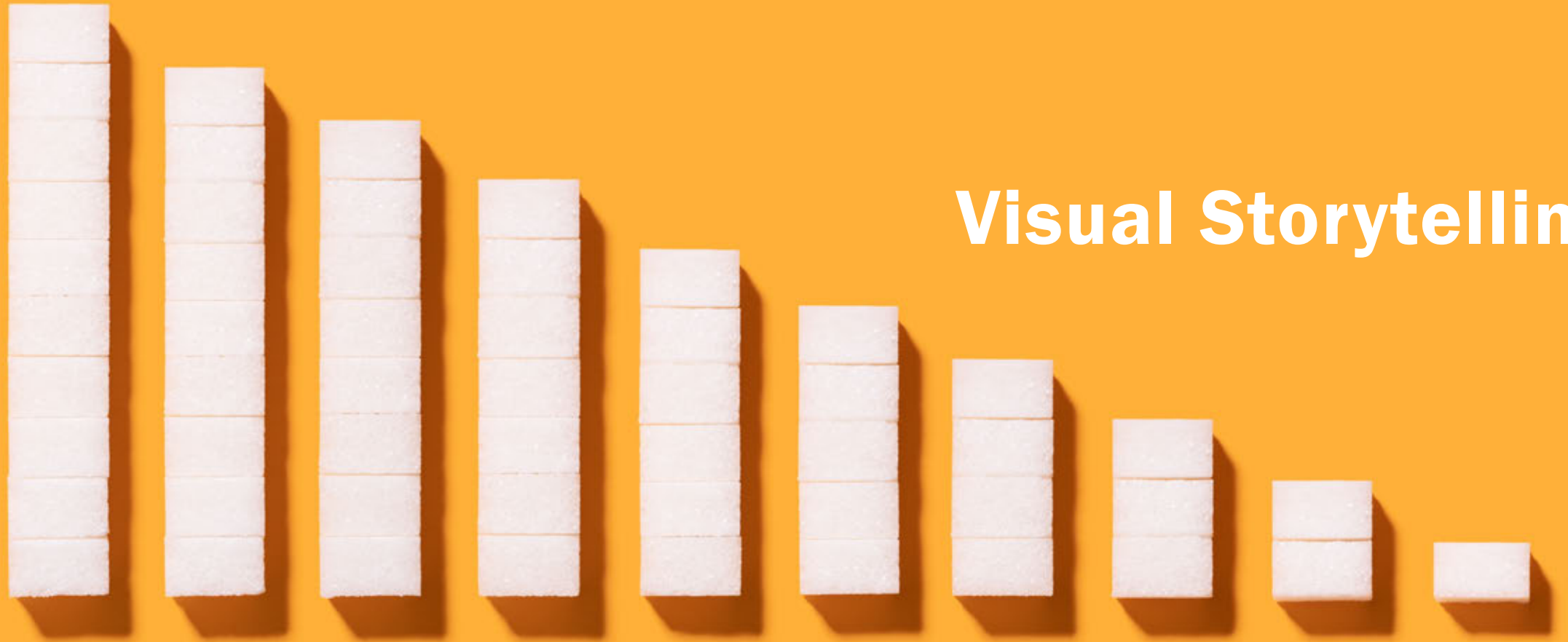
<https://www.americanscientist.org/article/the-tensions-of-scientific-storytelling>



You are the content experts!



Visual Storytelling





“

The smallest effective difference.

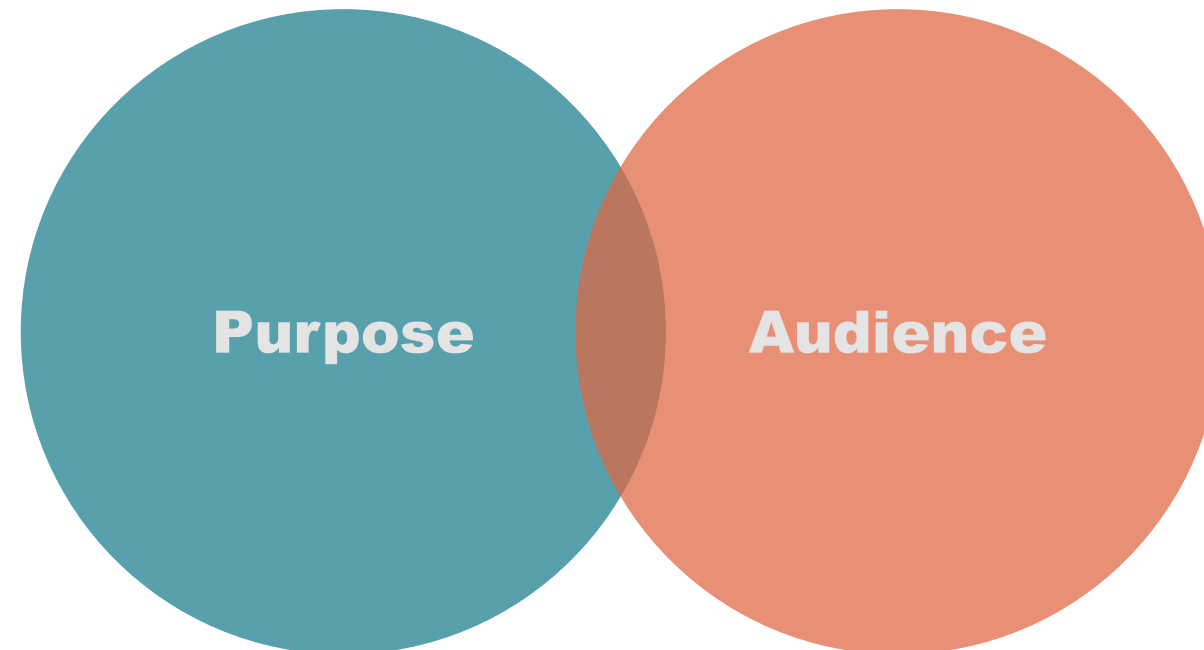
– Edward R. Tufte

Author of **Visual Explanations**

Effective Science Storytelling

What makes a good story?

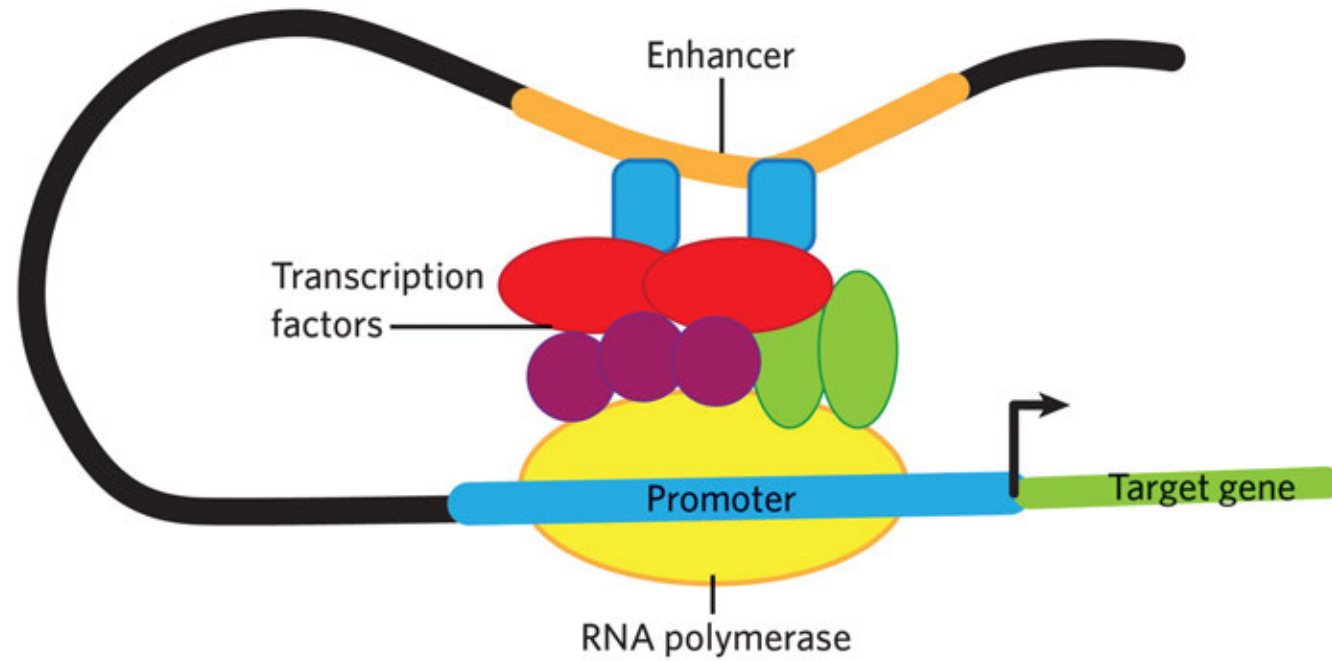
- Know your purpose, know your audience
 - What are objective are you trying to achieve?
 - What does the audience need to know?



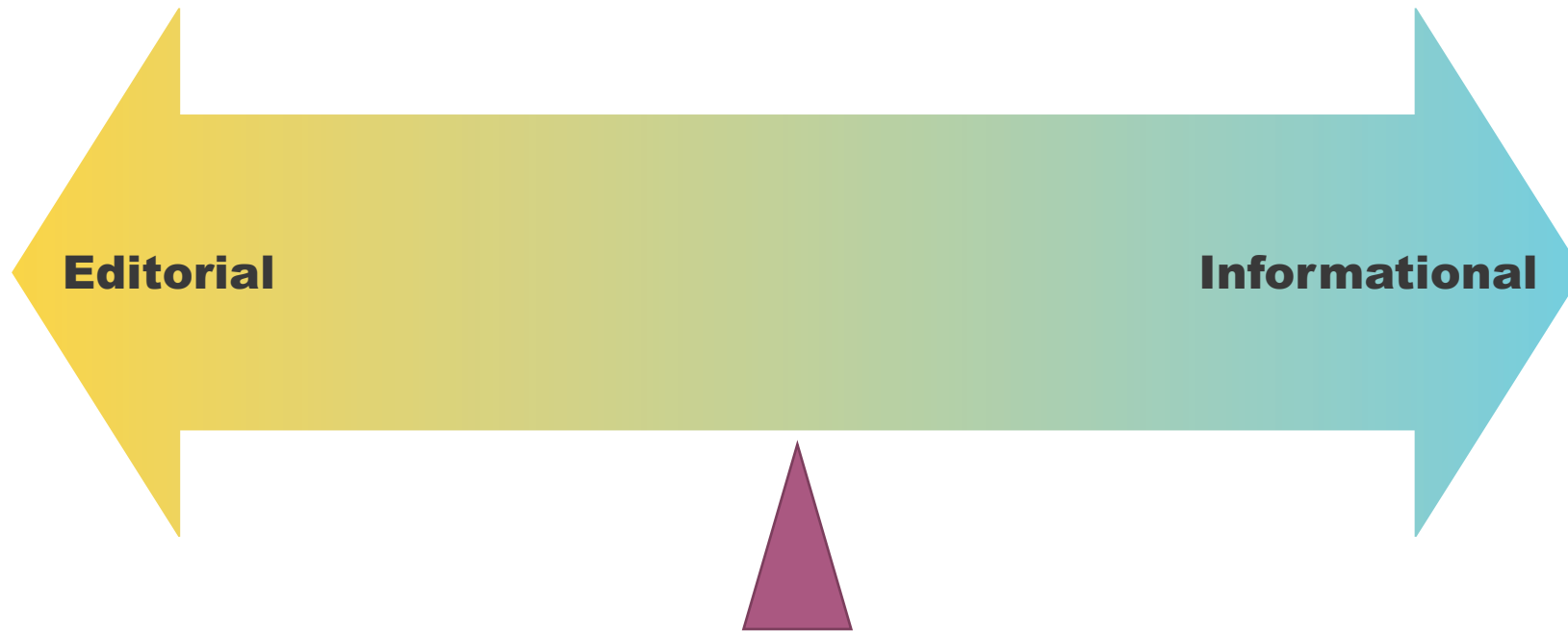
Science Storytelling

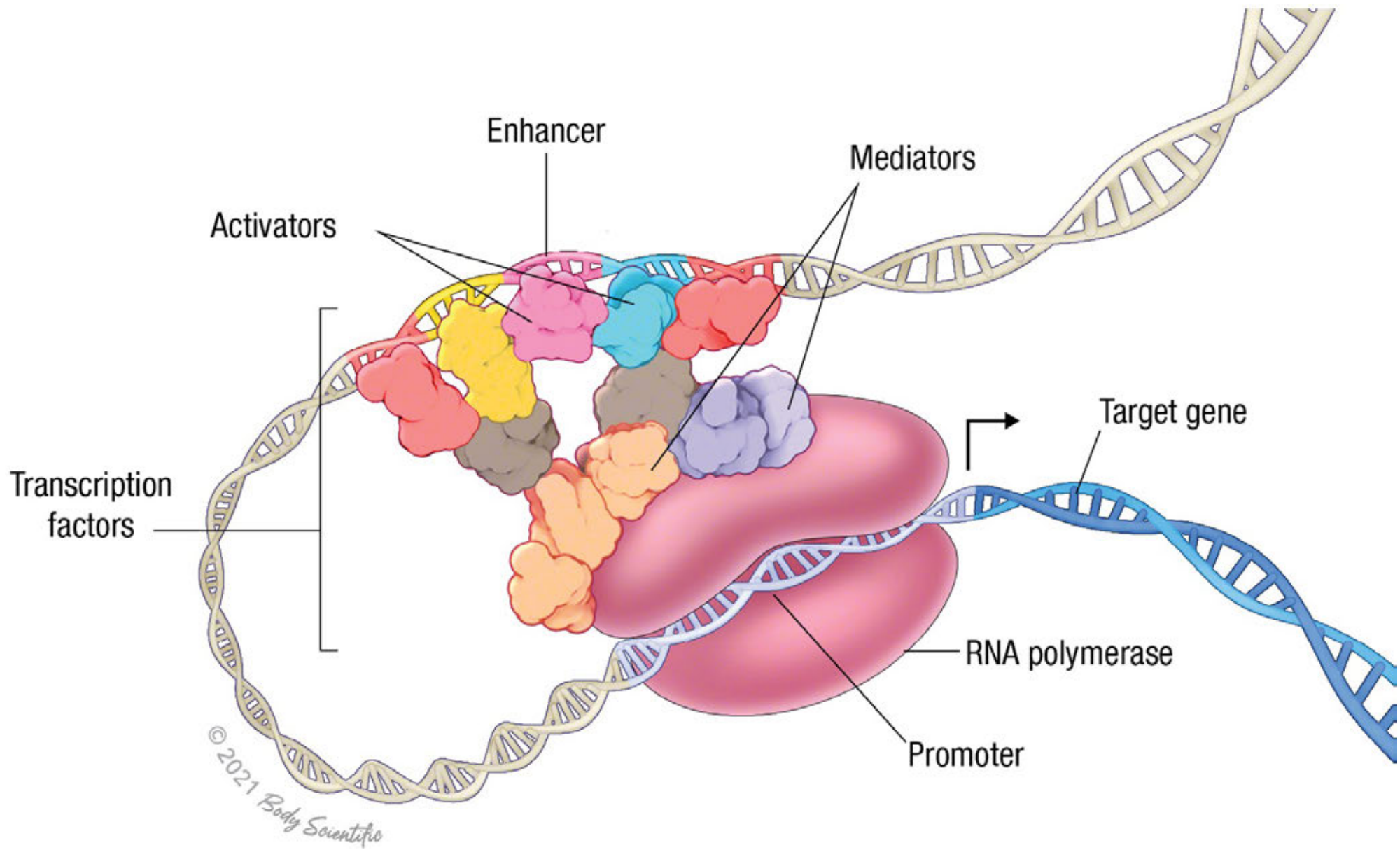


Example



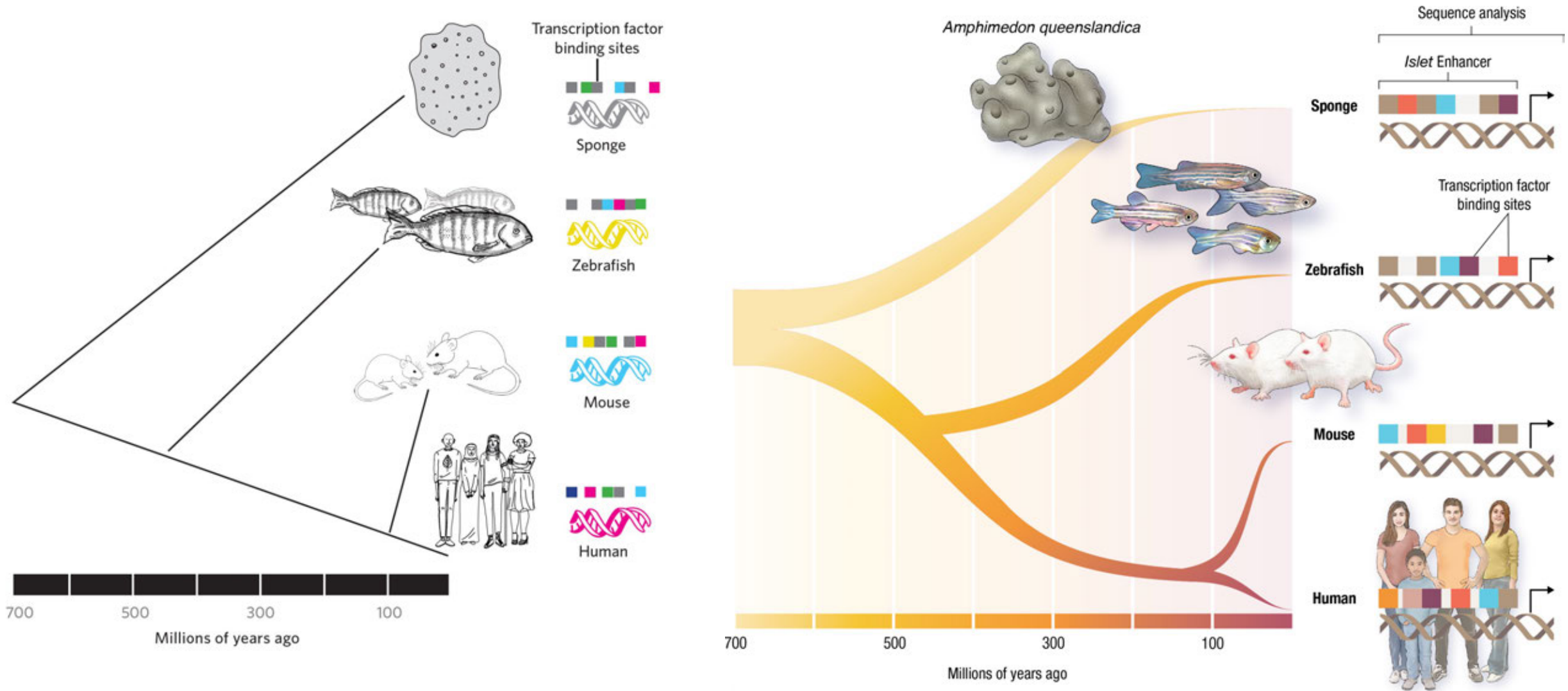
Science Storytelling





Lee, J., 2022. Infographic: Enhancer Activity Across the Tree of Life. [online] The Scientist Magazine. Available at: <<https://www.the-scientist.com/infographics/infographic-enhancer-activity-across-the-tree-of-life-69347>> [Accessed 29 September 2022].

Example



Lee, J., 2022. Infographic: Enhancer Activity Across the Tree of Life. [online] The Scientist Magazine. Available at: <<https://www.the-scientist.com/infographics/infographic-enhancer-activity-across-the-tree-of-life-69347>> [Accessed 29 September 2022].

Step up your cell sorting capabilities with the Sony SH800 Cell Sorter

[Schedule a Virtual Product Tour](#)





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Infographic: Enhancer Activity Across the Tree of Life

Scientists are still trying to paint a complete picture, but it's clear that these gene expression regulators have an unusual evolutionary history.

 **Jack J. Lee**
Nov 1, 2021

[PDF VERSION](#)

[f](#) [t](#) [v](#) [+](#) [18](#)

Enancers are stretches of DNA that regulate where and when a gene is expressed. While the sequences of enhancers can vary among species, their function is highly conserved across hundreds of millions of years of evolution. For example, a recent [study](#) found that an enhancer from the sponge *Amphimedon queenslandica* can drive transcription in specific cell types in mice and zebrafish. While enhancers in the more complex organisms didn't match the sequence of the sponge enhancer, the regions contained different arrangements of shared transcription factor binding motifs. The same was also true in the human region that most closely matched the sponge enhancer.

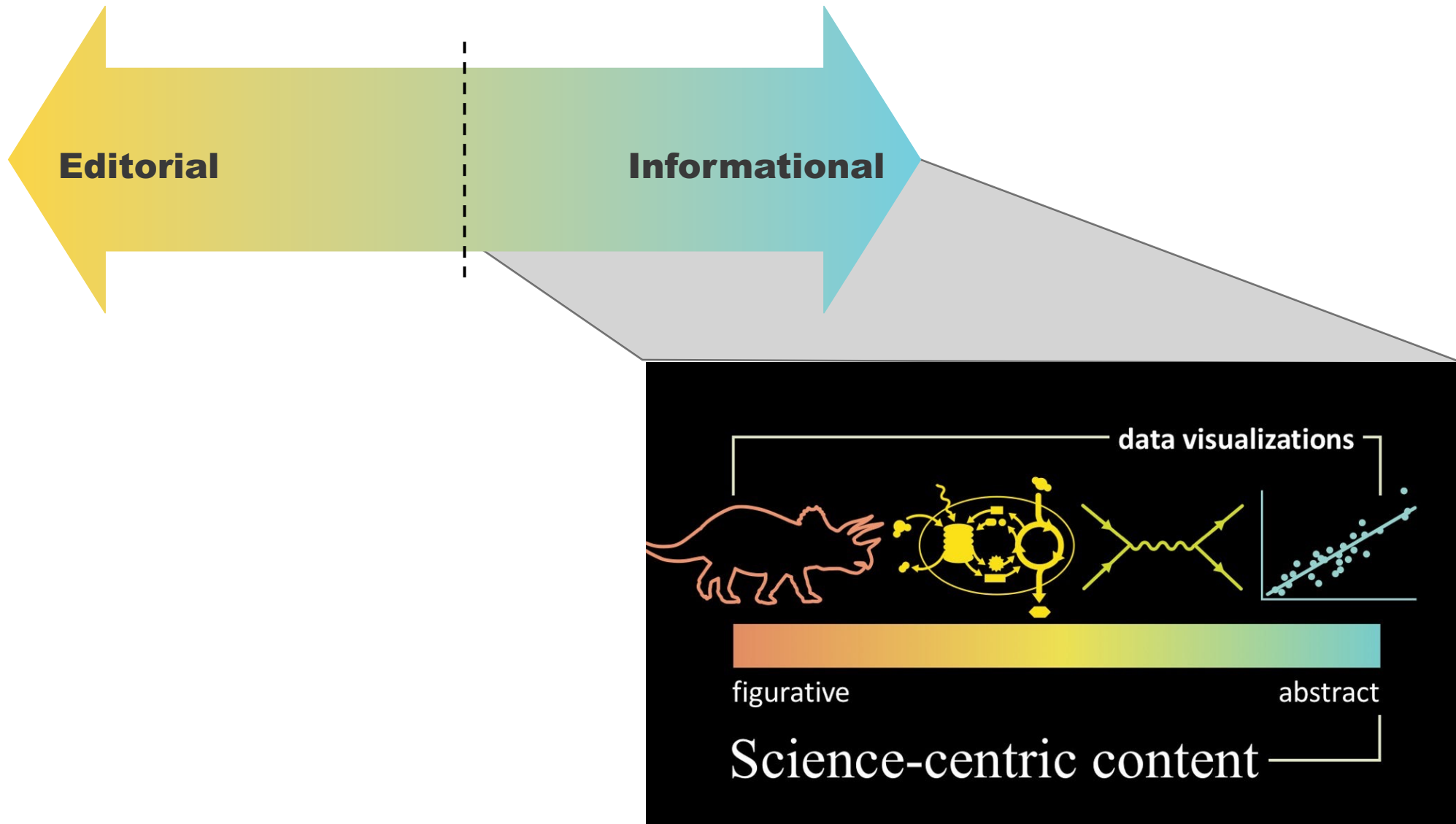
ABOVE: ©
BODY SCIENTIFIC
INTERNATIONAL

The proteomics platform that leads to pioneering discoveries

[Discover more](#)

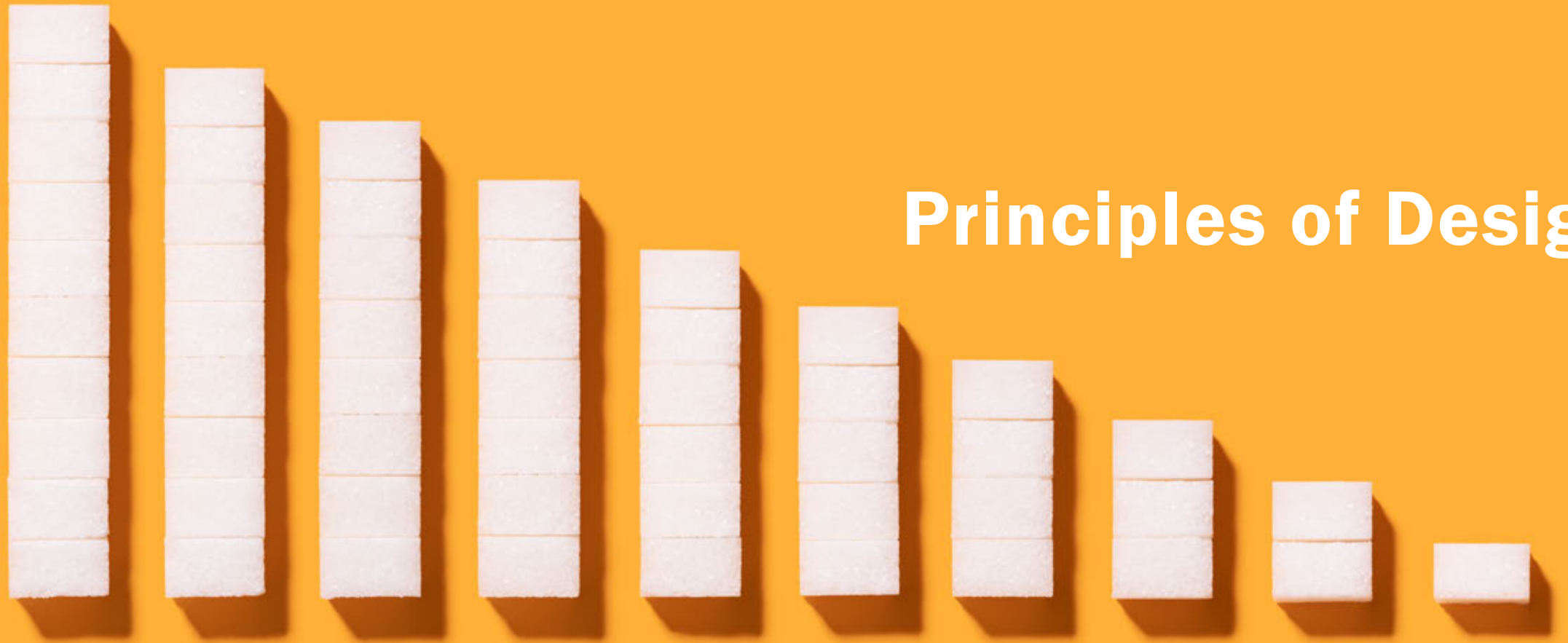
somalogic

ADVERTISEMENT



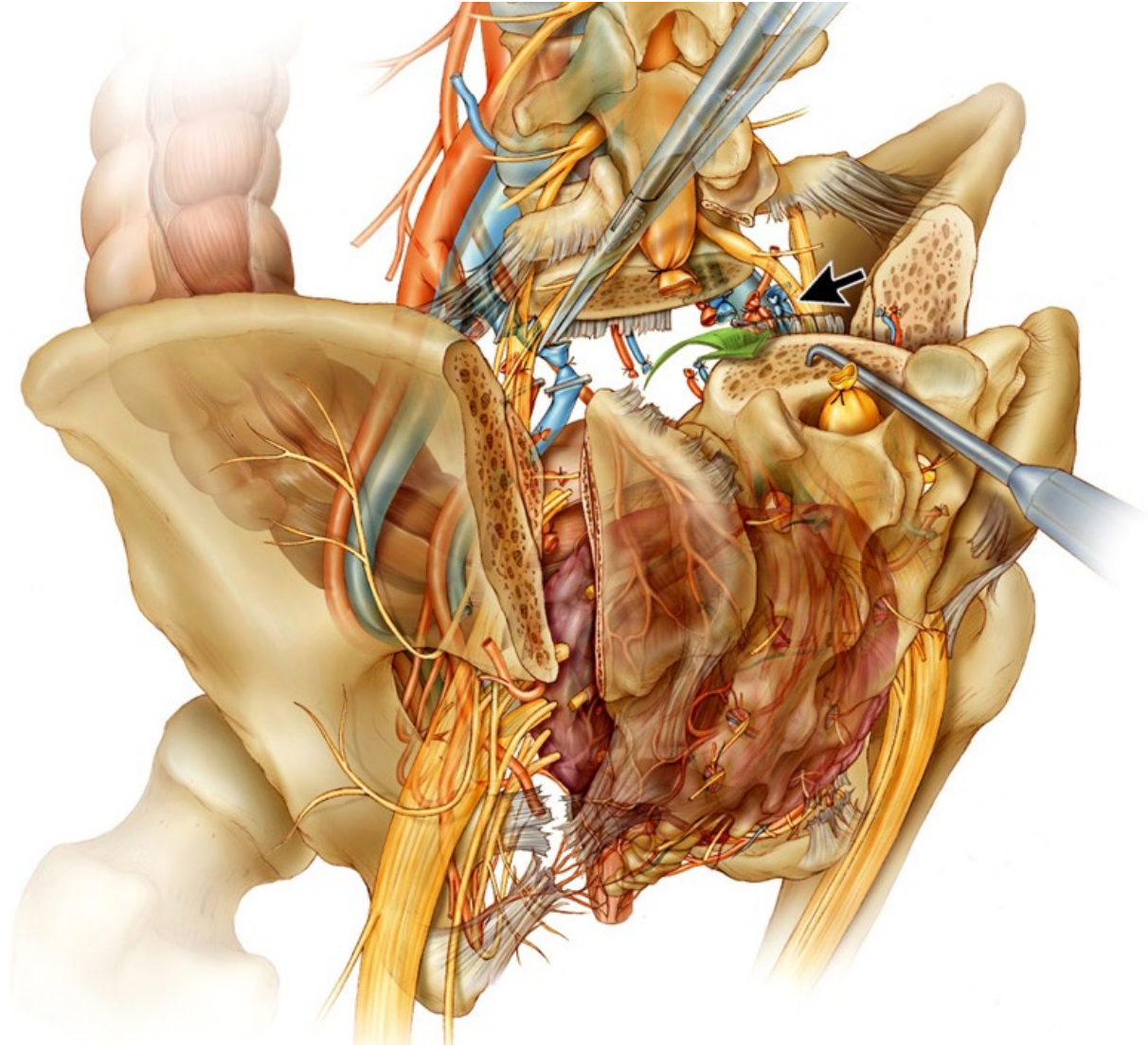
Christiansen J. Visualizing Science: Illustration and Beyond. Scientific American Blog Network. <https://blogs.scientificamerican.com/sa-visual/visualizing-science-illustration-and-beyond/>. Published 2018. Accessed September 9, 2022.

Principles of Design



Principles of Design

How to create emphasis?





Most important

More important

Important

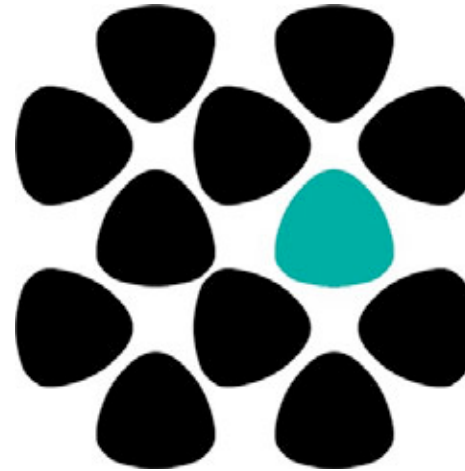
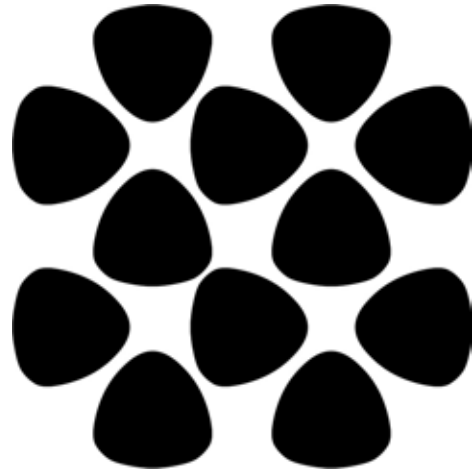
Less important

Design is information hierarchy

Principles of Design

Why Create Emphasis?

Helps readers determine the important information and understand faster



Emphasis

“Easy 3”

Size

Color

Position

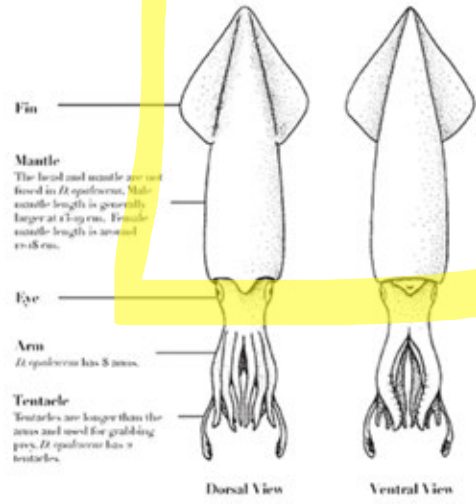
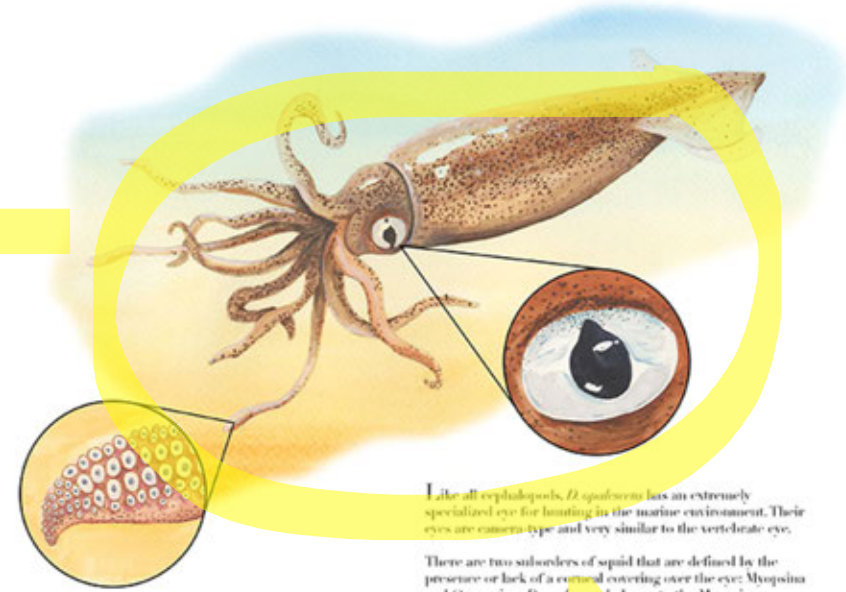
Emphasis

“Easy 3”
Size
Color
Position

Common Market Squid *Doryteuthis opalescens*

The opalescent inshore squid, also known as the common market squid, resides in the Pacific Ocean in a range reaching from California's Baja peninsula up to Alaska. As an inshore squid, they often stay within a distance of 200 miles from the shore. The life span of *D. opalescens* is only about 6-9 months and consists of four stages: egg, hatching, juvenile & adult. During sexual maturity, giant shoals of squid, reaching up to millions of individuals, move to shore to spawn.

D. opalescens feeds on smaller prey such as fish, shrimp, crabs & even other juvenile squid. The squid itself is an important part of the food chain, serving as a staple in the diets of California sea lions, Chinook salmon, cormorants & even humans. The common market squid fishery began in Monterey Bay, California in 1860 and has grown significantly in the past few decades with a record year in 2014 of 60,000 tons of harvested squid. In 2003, the Department of Fish and Wildlife put in place the Market Squid Fishery Management Plan to ensure responsible harvesting of the species.



Fin
Mantle
Eye
Arm
Tentacle

The head and mantle are not fused in *D. opalescens*. Male mantle length is generally larger at 23-29 cm. Female mantle length is around 20-25 cm.
D. opalescens has 5 arms.
Tentacles are longer than the arms and used for grabbing prey. *D. opalescens* has 2 tentacles.

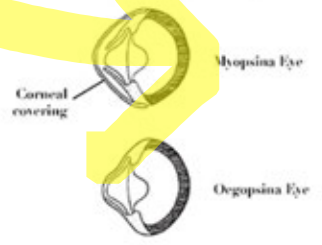
Dorsal View Ventral View

While they are very small, suckers can be found on all ten limbs of *D. opalescens*. The two longer tentacles end in tentacular clubs clustered with suckers. This small club has four rows of suckers and is used to reach out and grip prey. The other eight arms are lined with two alternating rows of suckers down their entire length.



Tentacle
Arm

Like all cephalopods, *D. opalescens* has an extremely specialized eye for hunting in the marine environment. Their eyes are camera-type and very similar to the vertebrate eye.
There are two suborders of squid that are defined by the presence or lack of a corneal covering over the eye. *Myopsina* and *Oegopsina*. *D. opalescens* belongs to the *Myopsina* suborder and has a corneal covering over its eye.



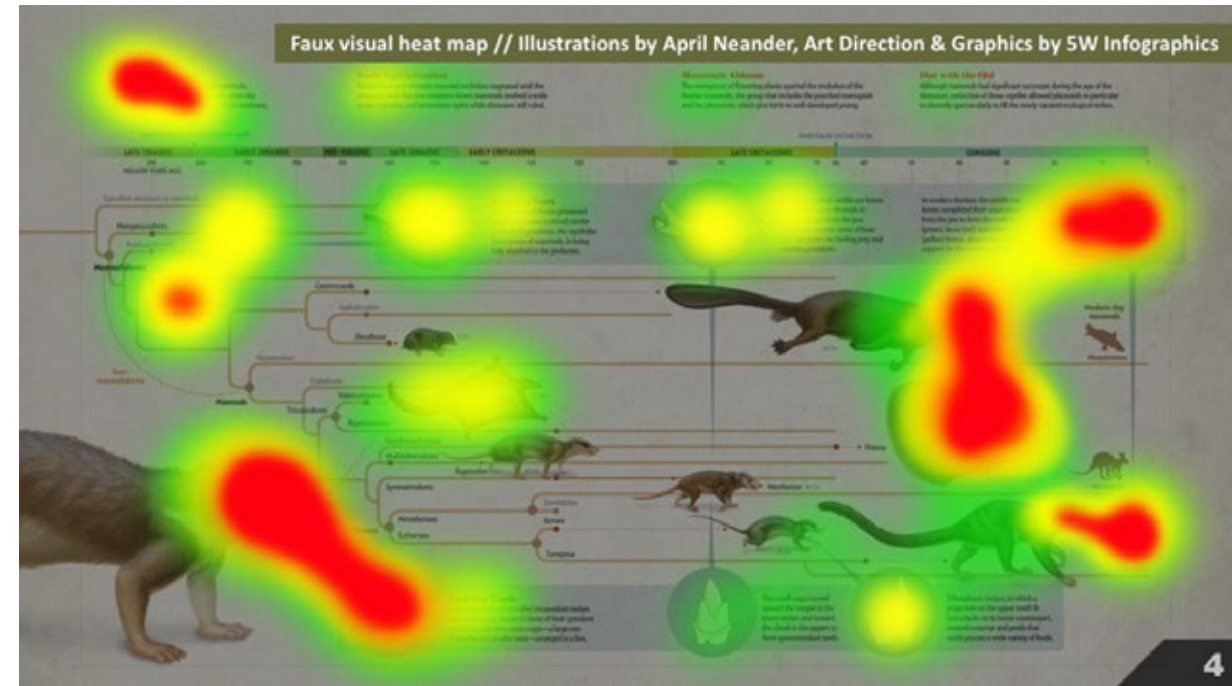
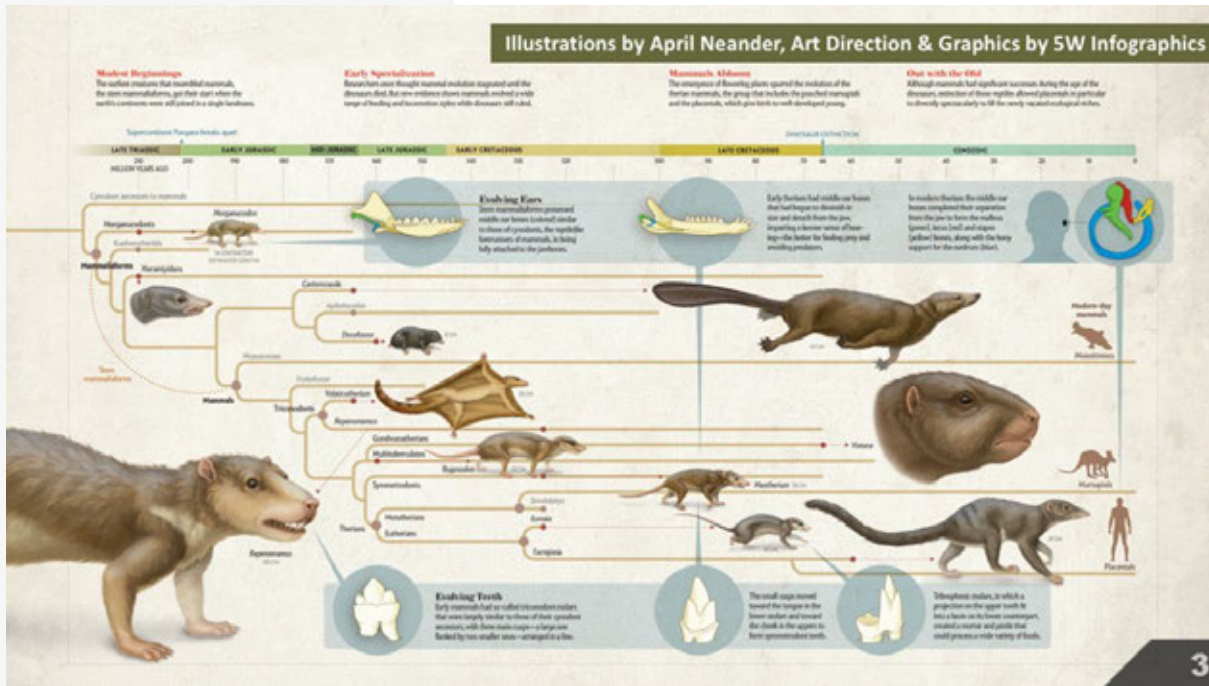
Myopsina Eye
Oegopsina Eye
Corneal covering

Created by Madison Myfield

Principles of Design

Methods to Create Emphasis

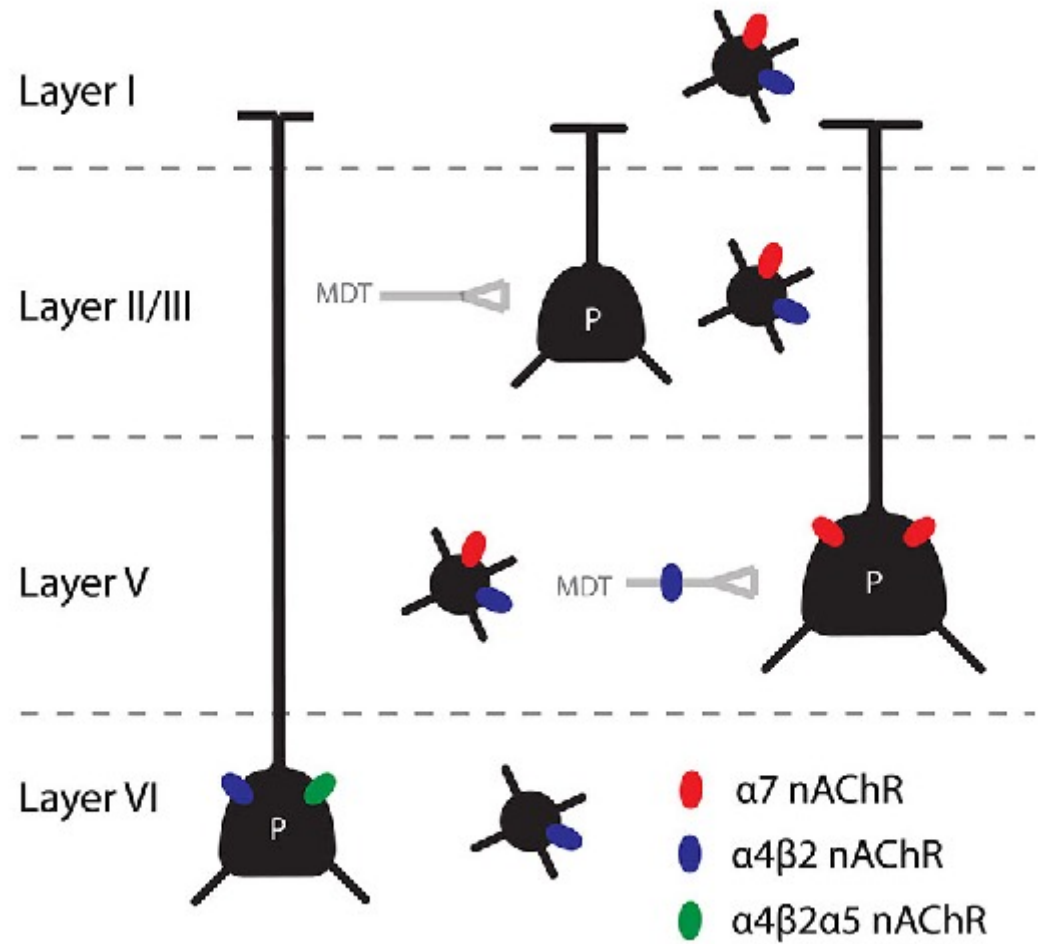
- Where does the viewer focus and why?





High Contrast





High Contrast

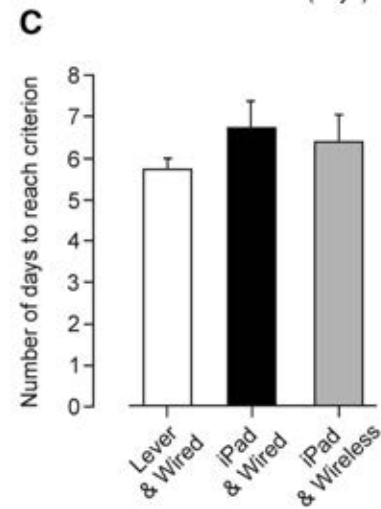
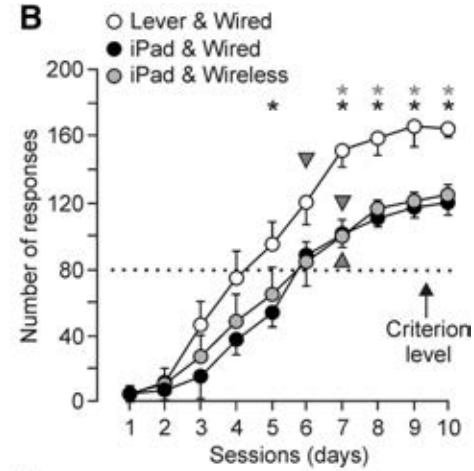
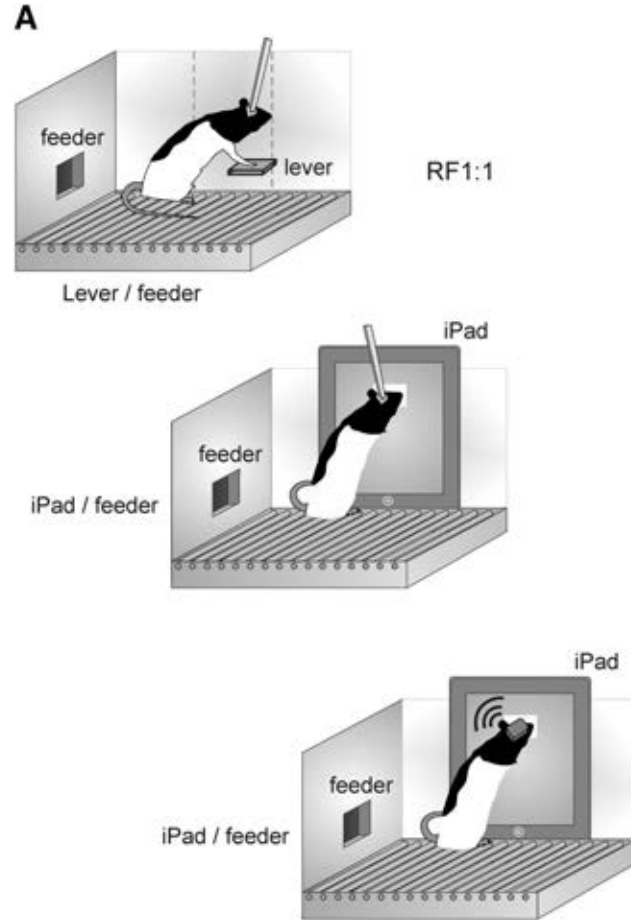
DON'T

- Don't use high contrast colors/areas when it is not the focus

High Contrast

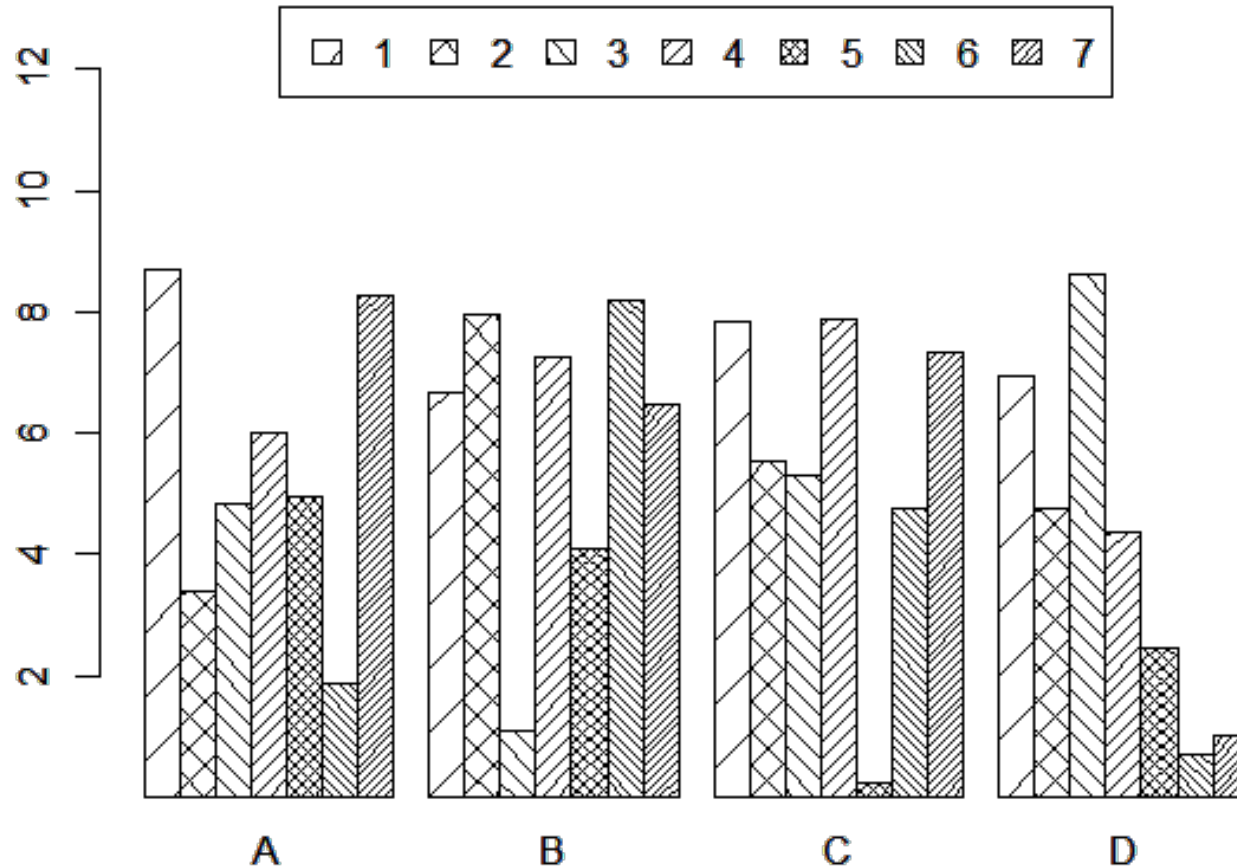
DO

- Be consistent

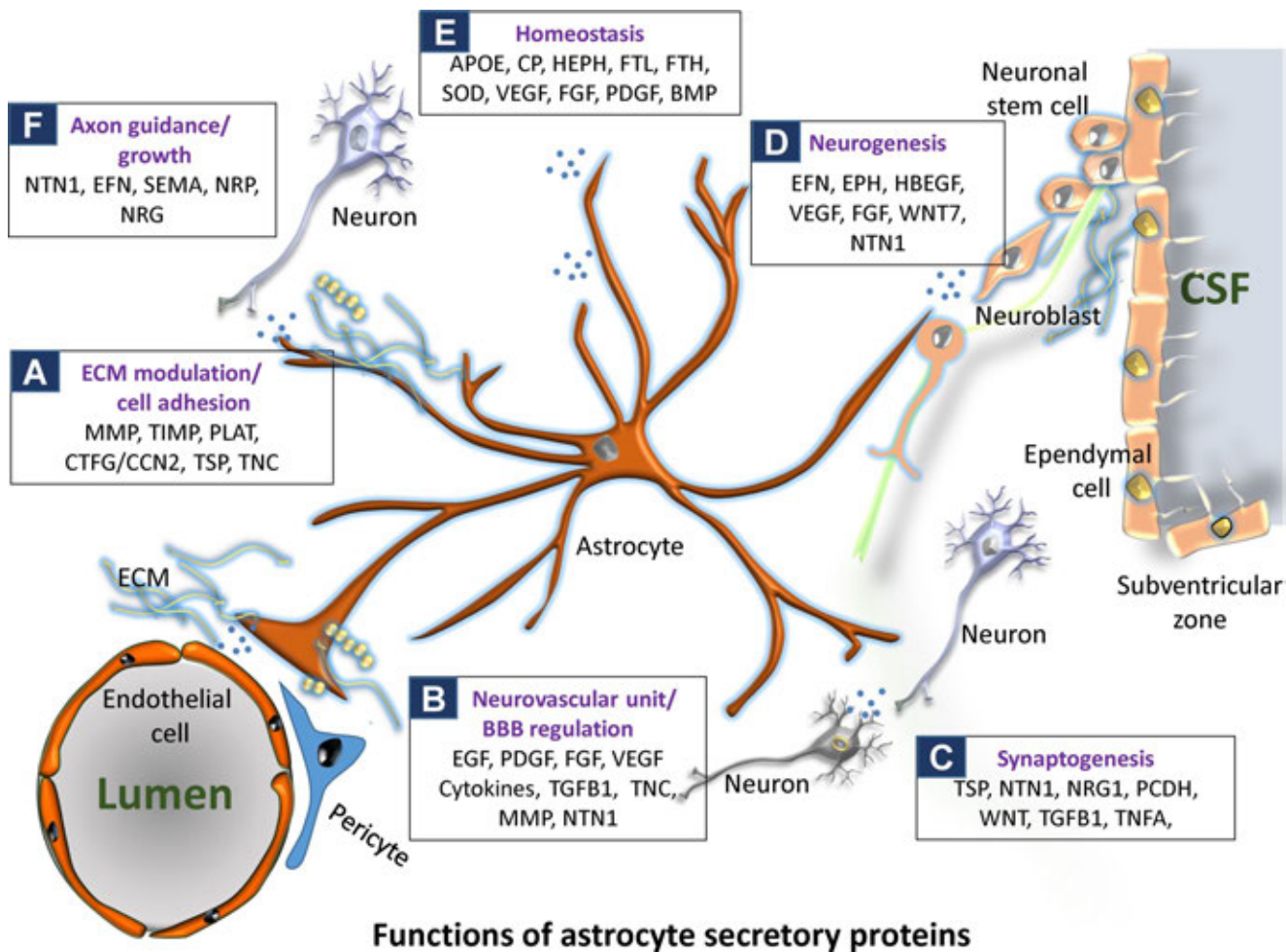


Overstylize

DON'T



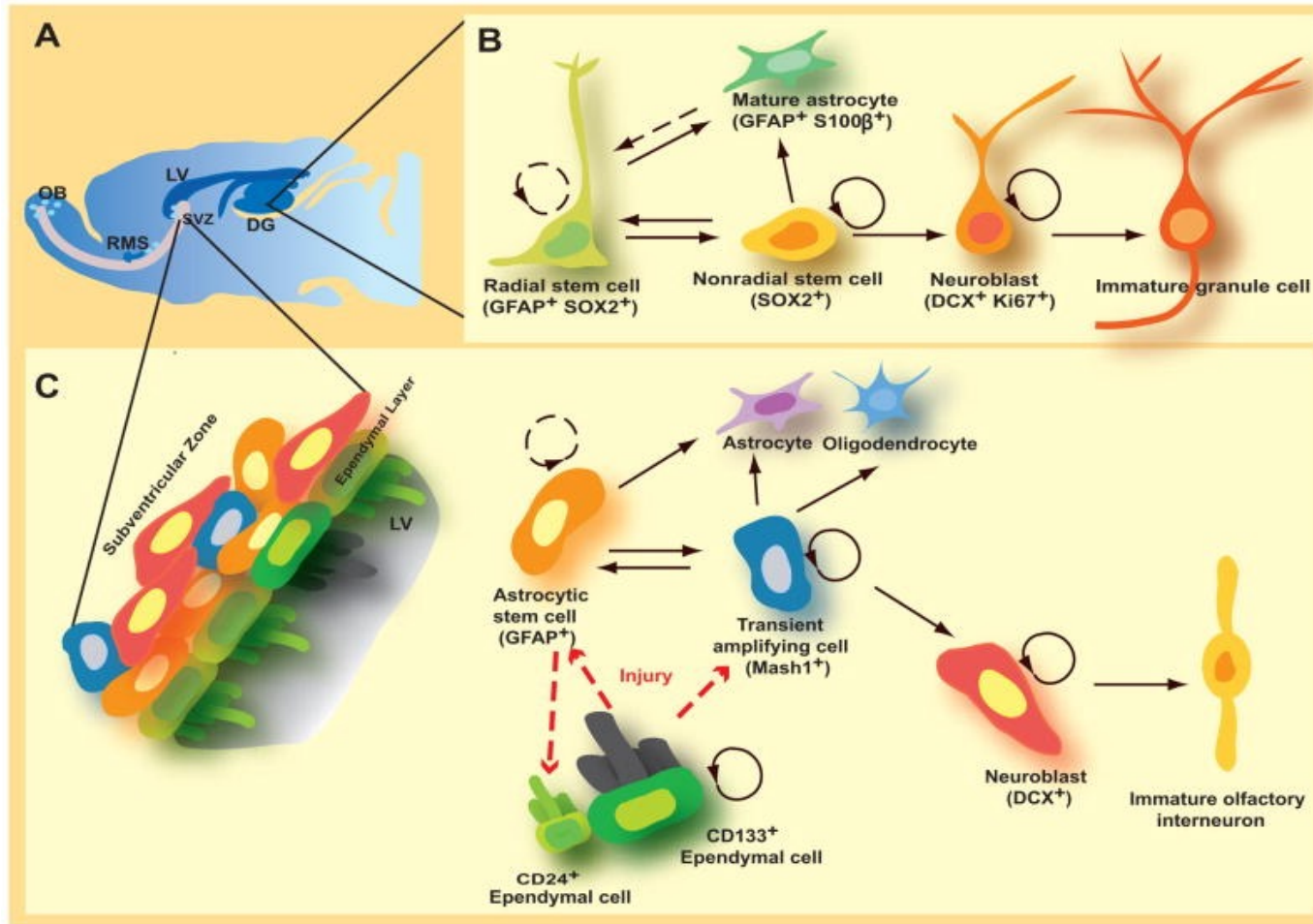
- Don't use patterns. All print and digital work can show a wide tonal range.



Overstylize

DON'T

- Don't add drop shadows, outer glows, if not needed



Overstylize

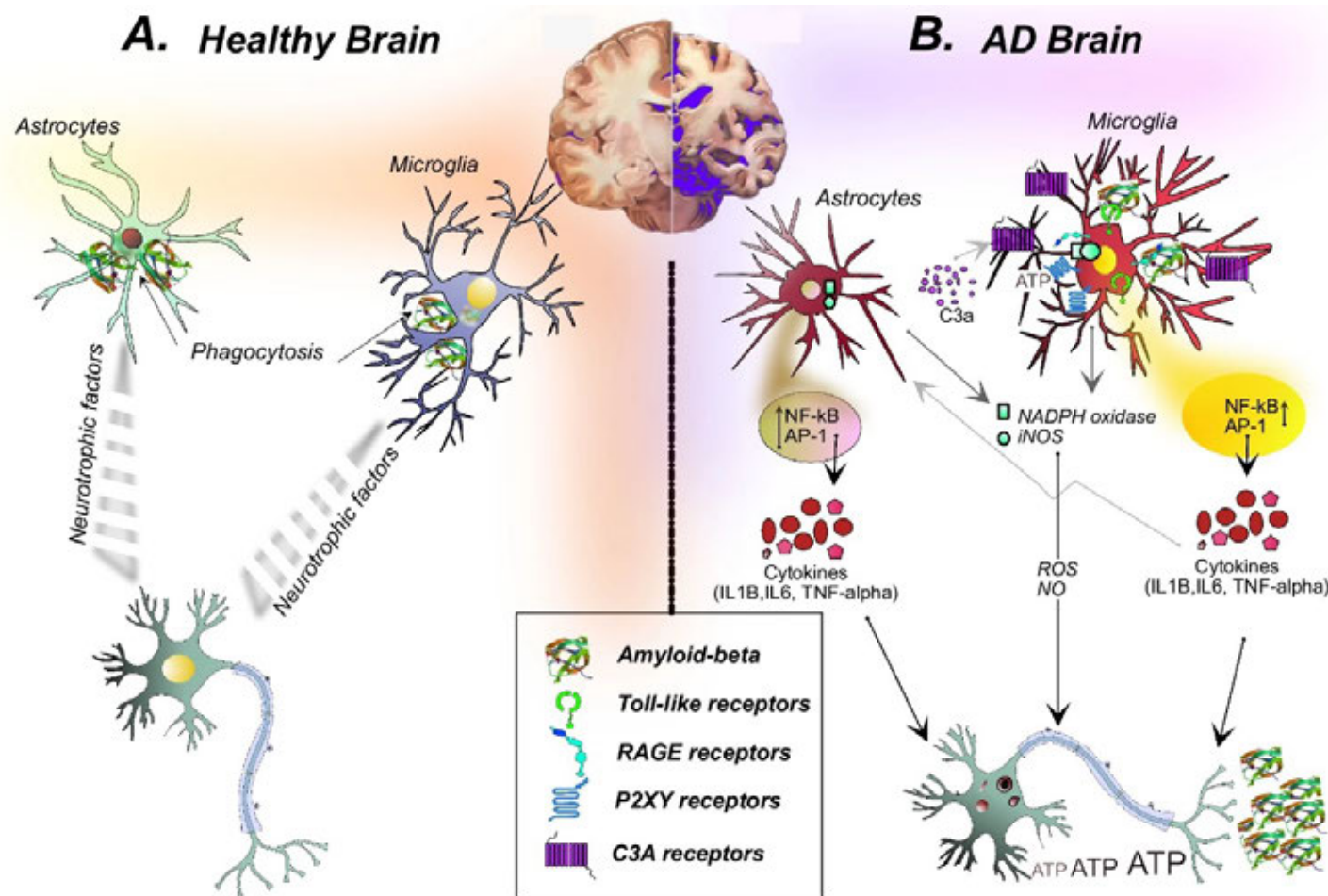
DON'T

- Don't add drop shadows, outer glows, if not needed

Mismatch styles

DON'T

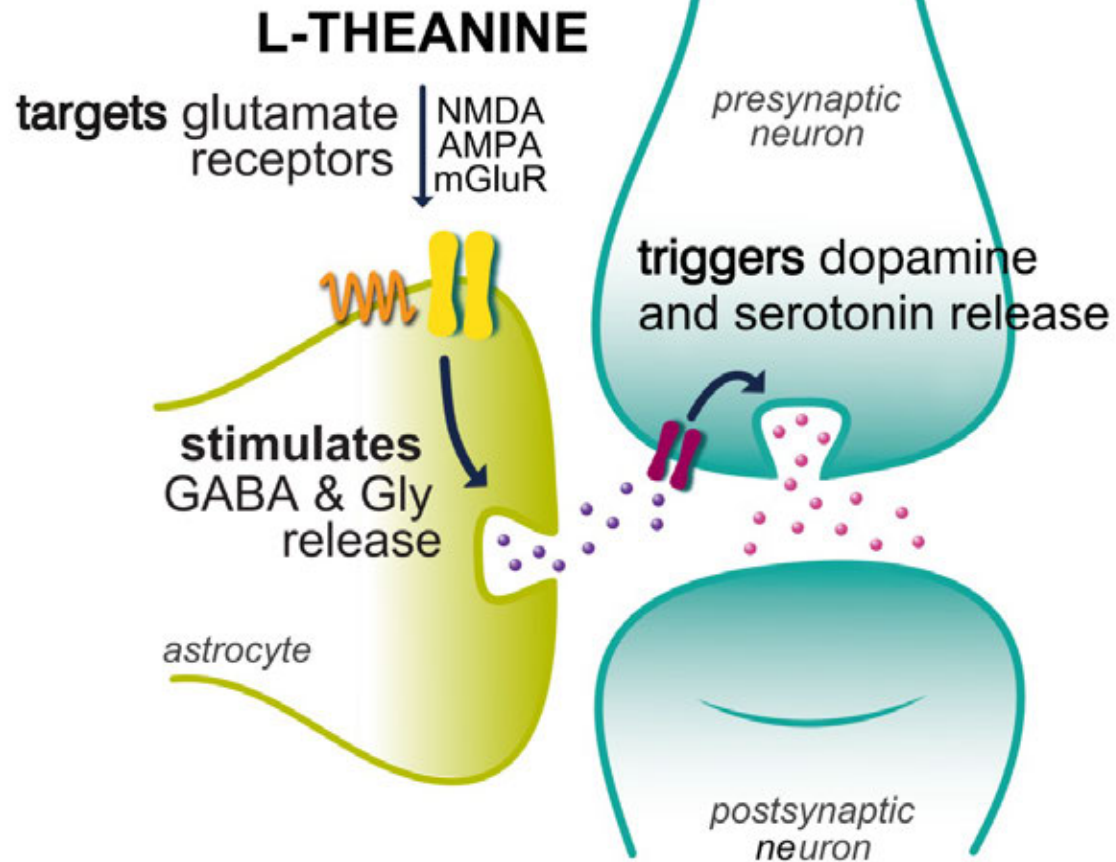
- Don't mix styles
- If you start vector, stay vector!

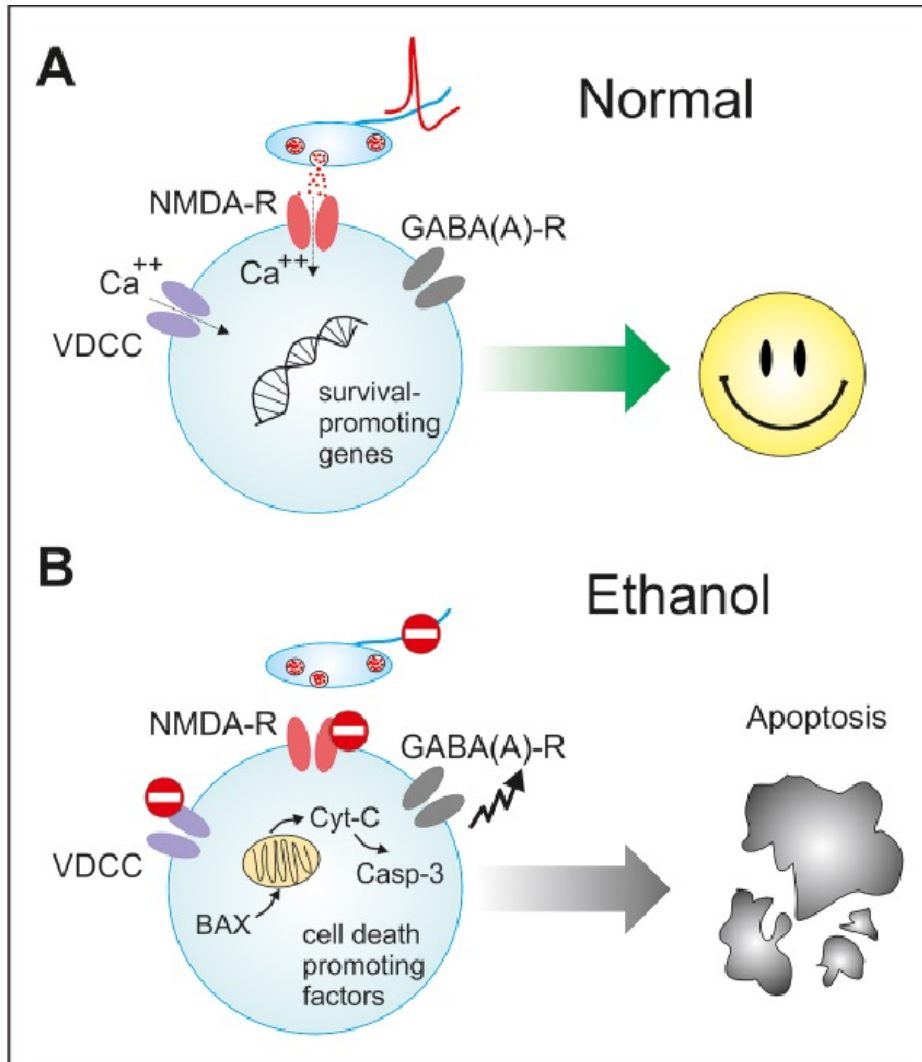


Gradients

DO

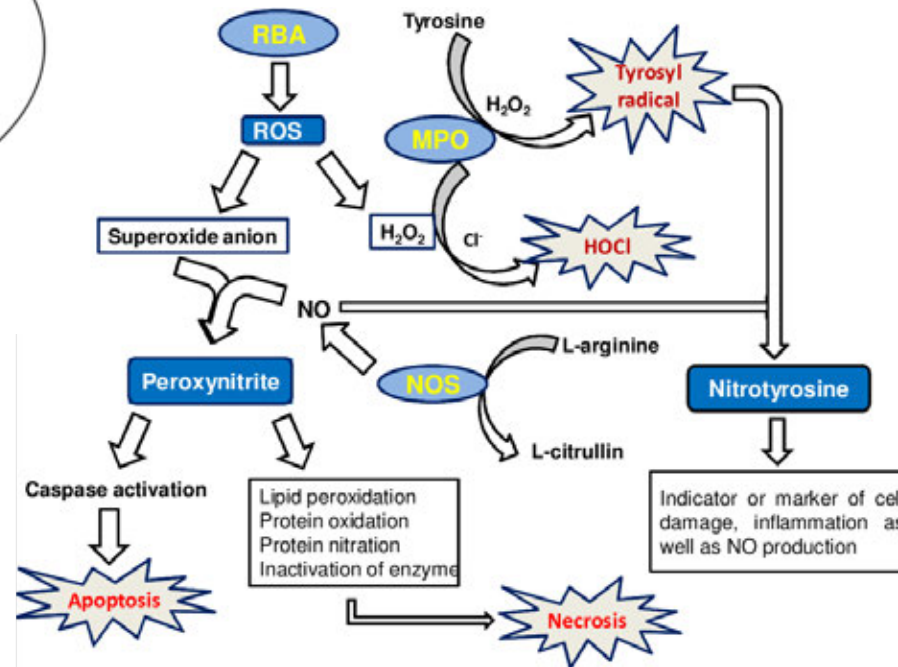
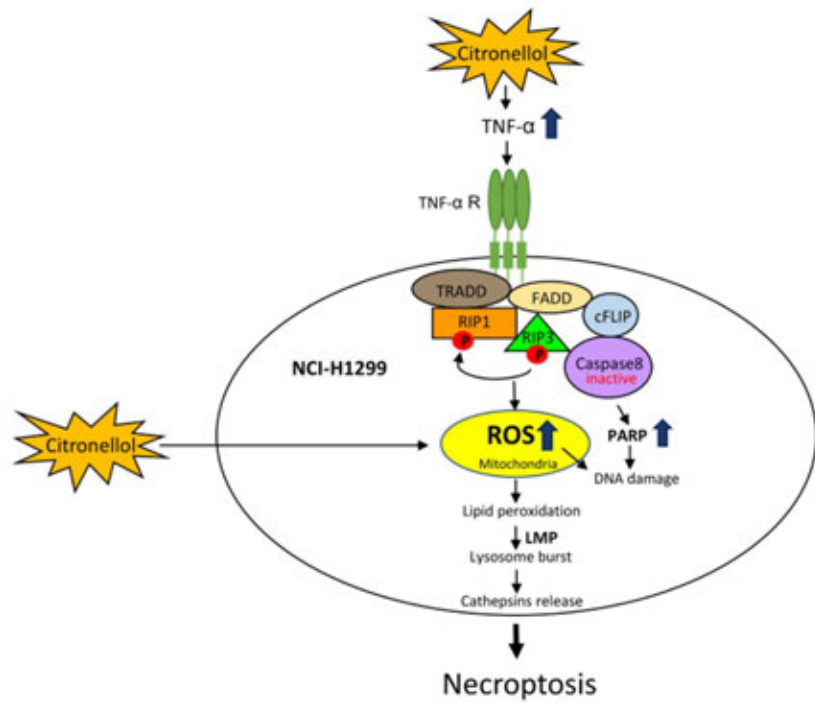
- Gradients are ok if done correctly!





Nonprofessional **DON'T**

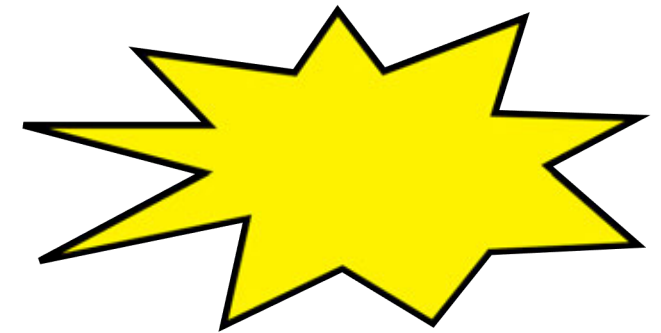
- Don't use non-scientific/non-professional icons



Burst

DON'T

- Avoid the burst!



Citronellol Induces Necroptosis of Human Lung Cancer Cells via TNF-α Pathway and Reactive Oxygen Species Accumulation
In Vivo July 2019, 33 (4) 1193-1201; DOI: <https://doi.org/10.21873/invivo.11590>

Srivastava, Praveen & Pandey, A.K.. (2015). Role of immunostimulants in immune responses of fish and shellfish. *Biochem. Cell. Arch.* 15. 47-73.



Color Rules

MEDIUM BLUE 453

SKY BLUE 451

ICE BLUE 450

MAGENTA 465

BUBBLE GUM 469

MIDNIGHT BLUE 459

DARK BLUE 458

LINE TREE 454

MINT 432

ISLAND BEACH 457

PURPLE 468

LIGHT GREEN 467

GREEN 466

ORANGE 464

YELLOW 463

CORAL 462

WHITE BLUE 455

ORANGE 461

YELLOW 460

INDIGO 464

PURPLE 463

RED 462

RED 461

ORANGE 460

YELLOW 459

Color definitions

HUE



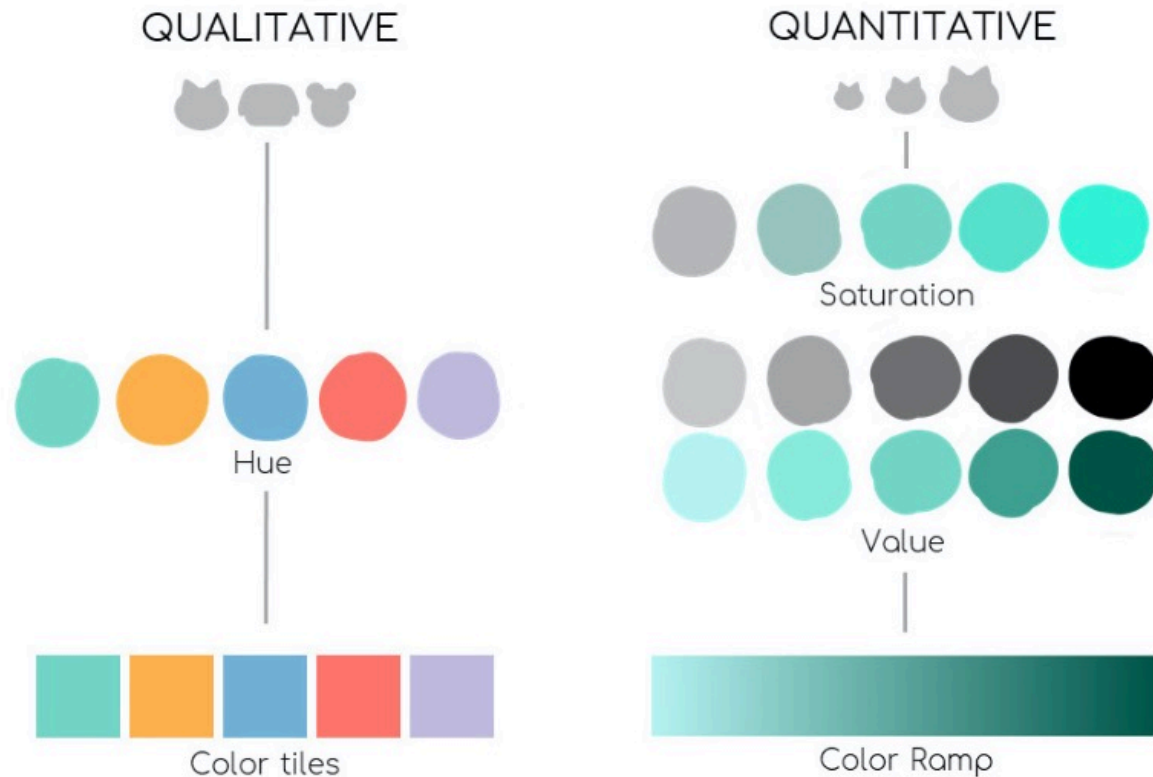
SATURATION



VALUE



DATA TYPES



Color can be qualitative or quantitative

Qualitative means that the different categories
Quantitative data can be arranged numerically

Quantitative

Darker = Higher Value

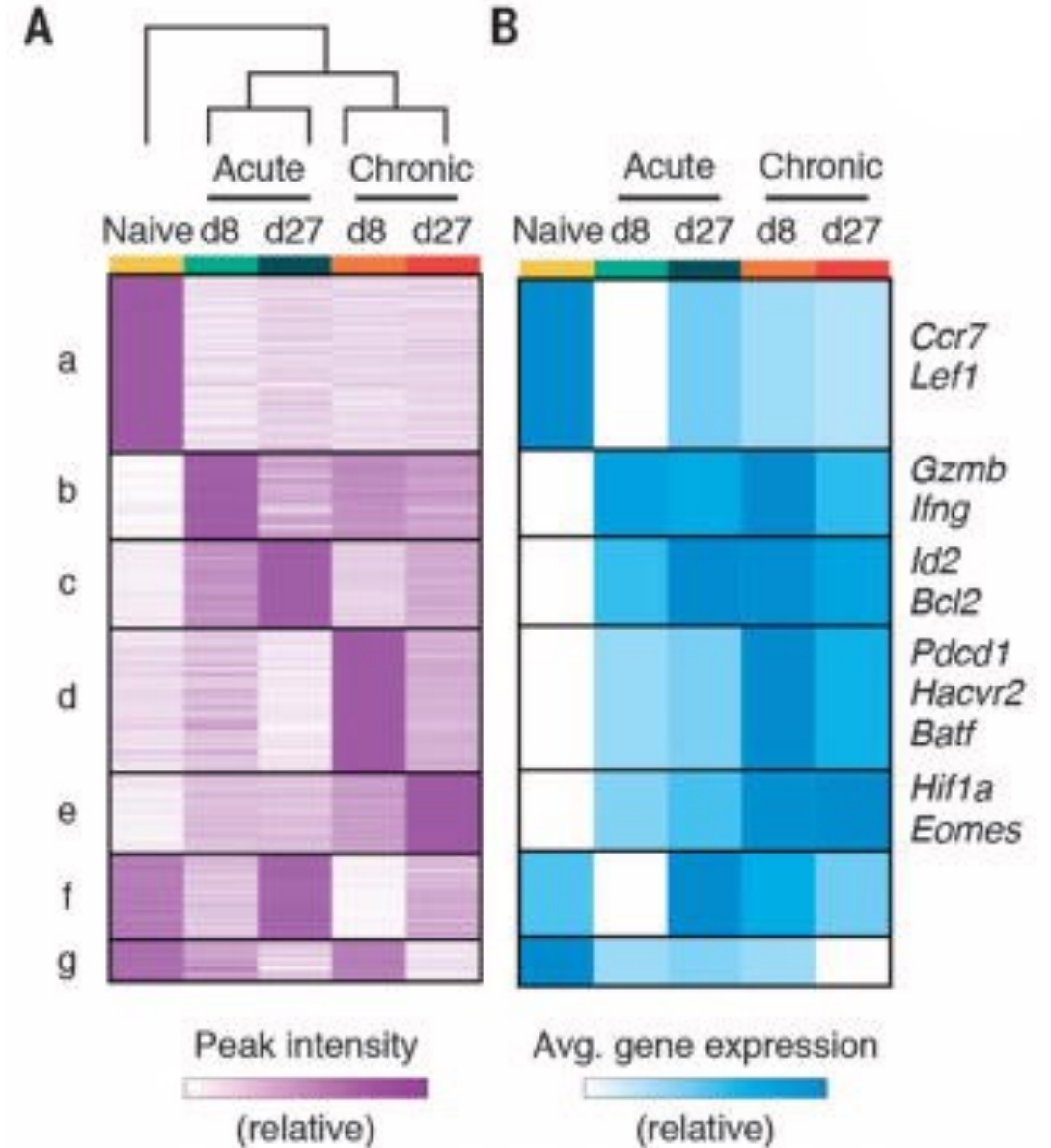
- Monochromatic image: darker (low value) attracts more attention than lighter (high value) hue
- The darker color in quantitative data will be “more important”



Quantitative

Darker = Higher Value

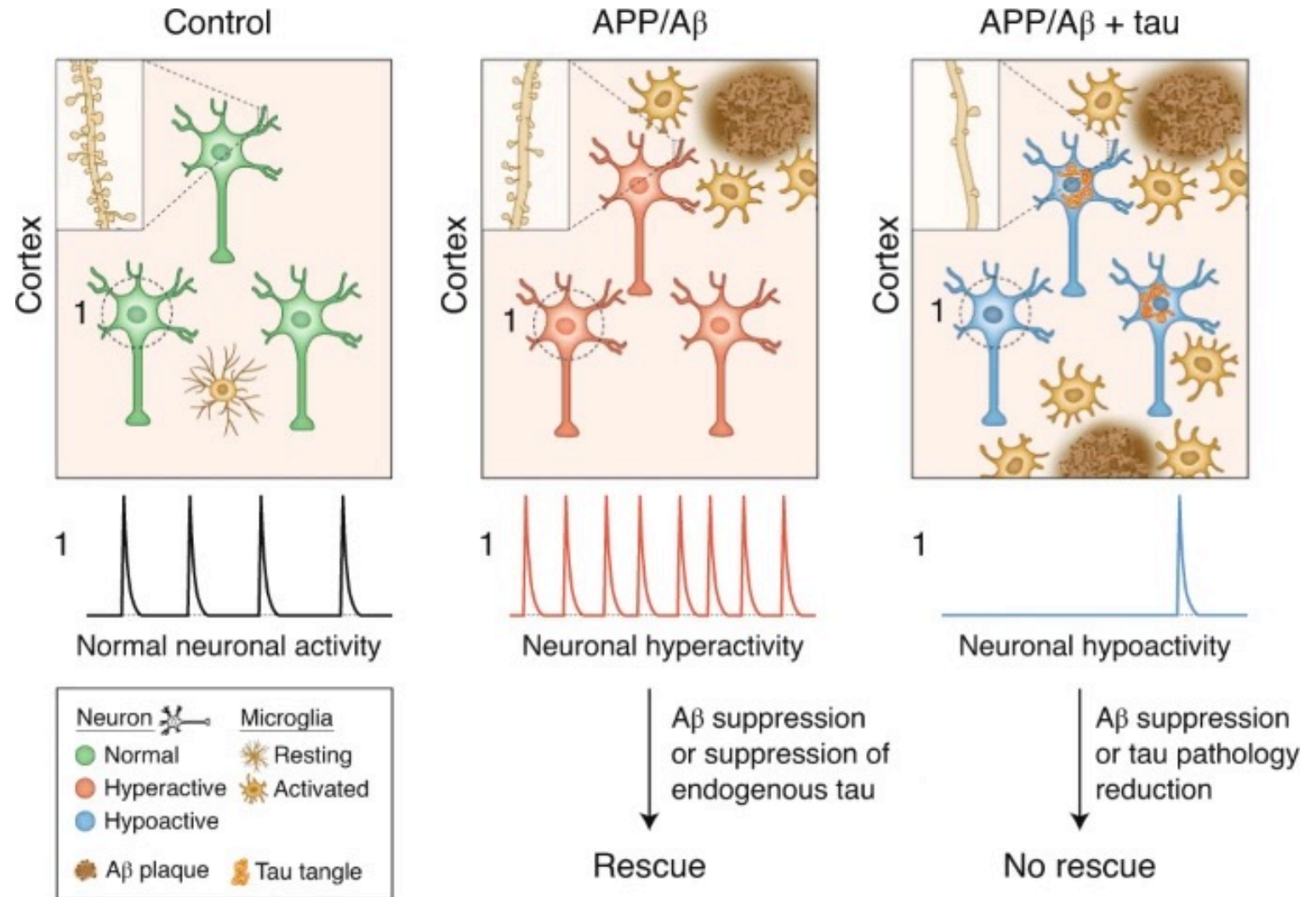
- Monochromatic image: darker (low value) attracts more attention than lighter (high value) hue
- The darker color in quantitative data will be “more important”



Qualitative

Select Hues in similar values

- Categories with similar importance should have same intensity and value

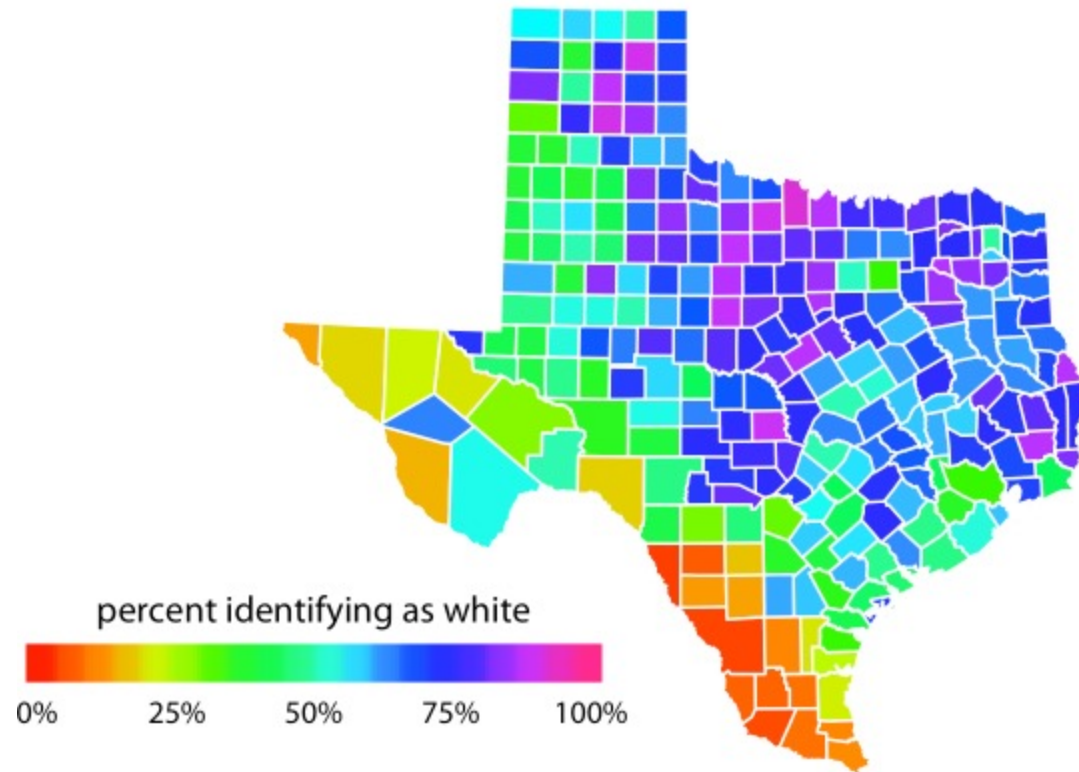


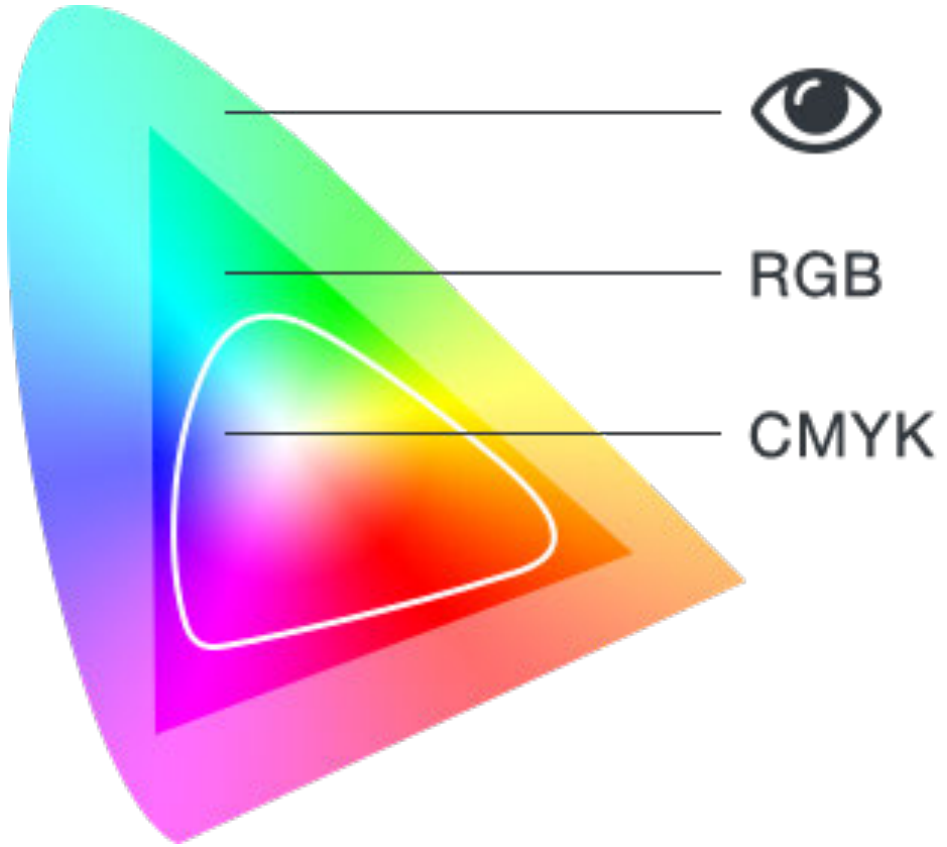
DON'T

Oversaturation

Highly saturated bright colors.

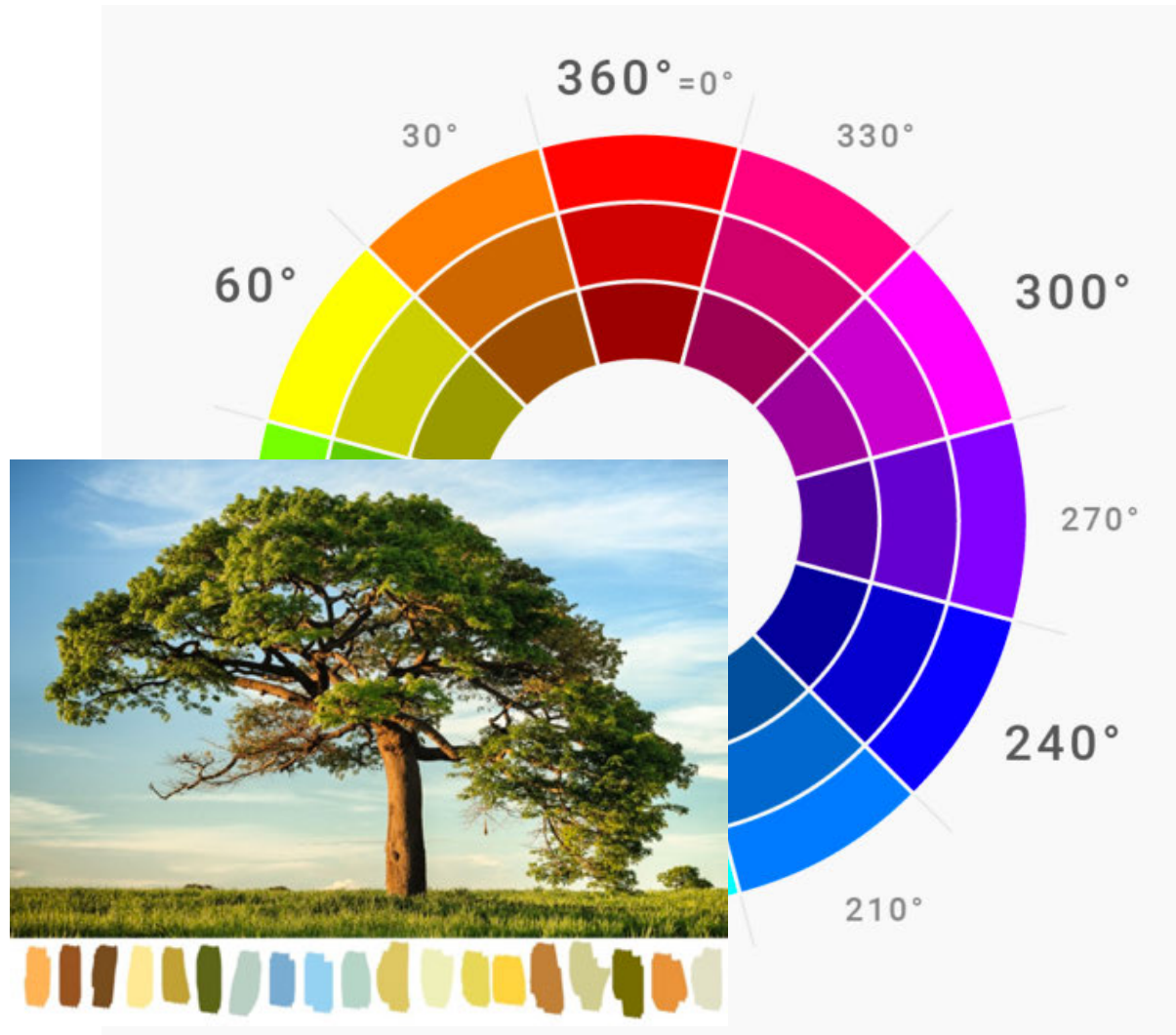
Your eyes do not know where to rest.





Oversaturation

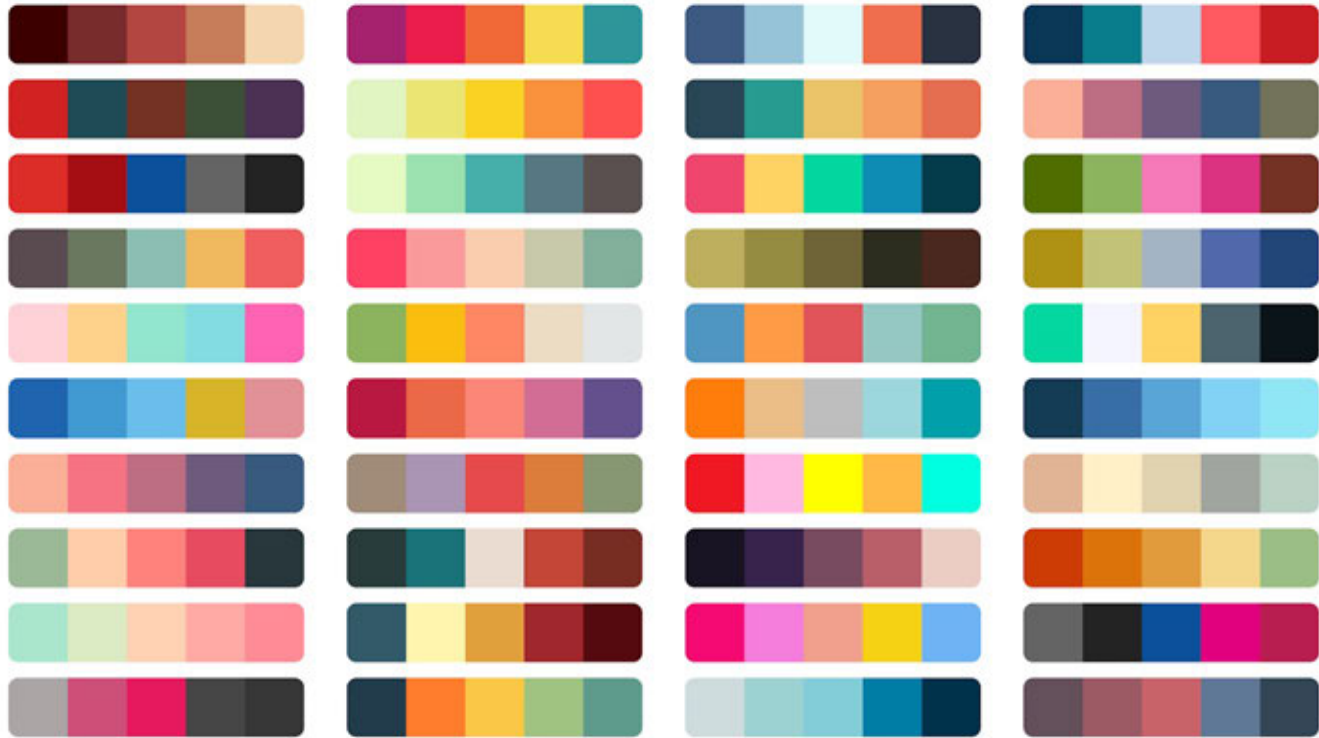
Monitors tend to show off their high saturation abilities.



<https://blog.datawrapper.de/beautifulcolors/>

Avoid Pure Colors

At perfect angles on color wheel, 0°, 90°, 180°, etc.
These are not “natural” colors that exist in nature.



Color Palette

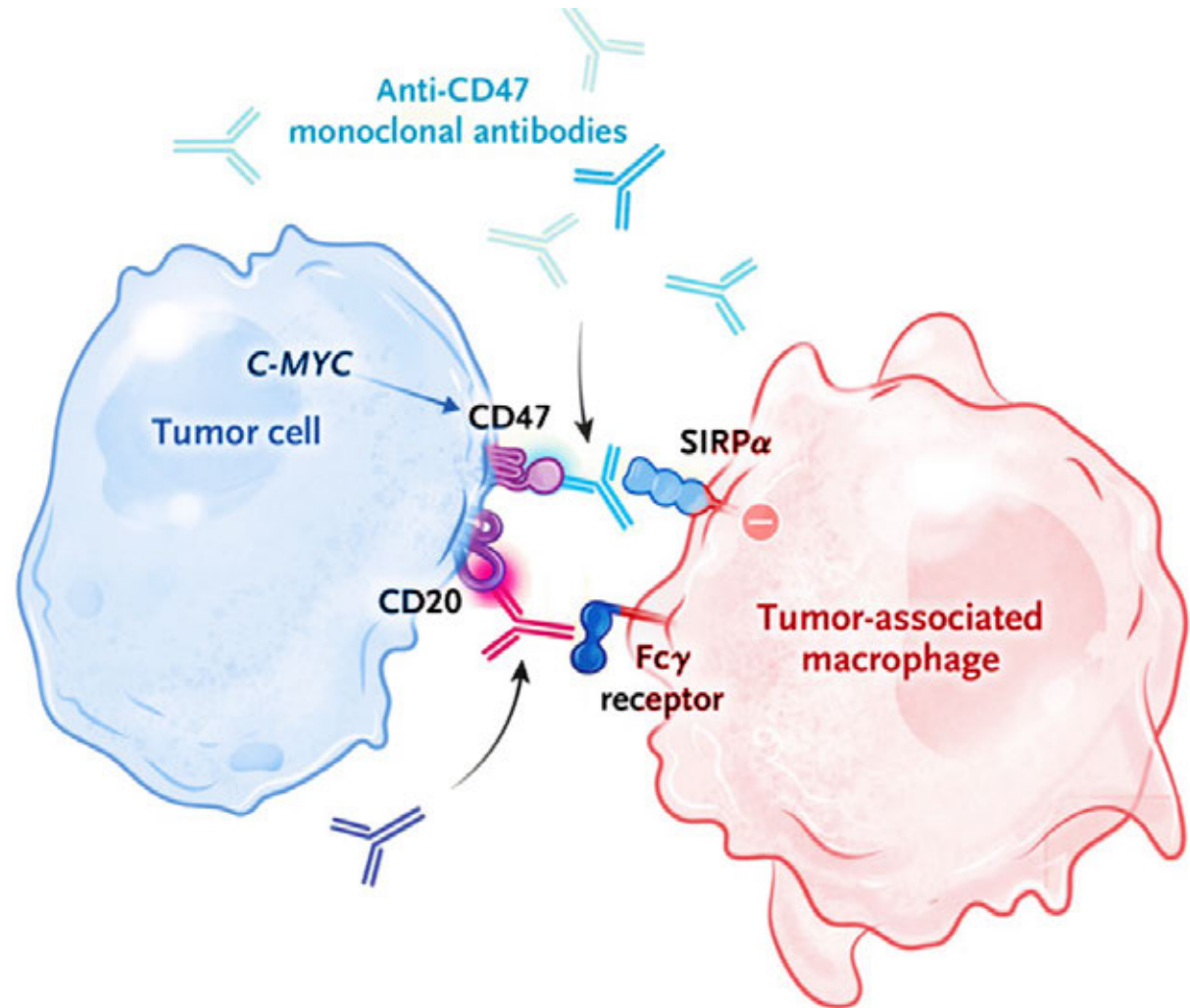
Search “data visualization color palette”



Color Symbolism

Inherent symbolism

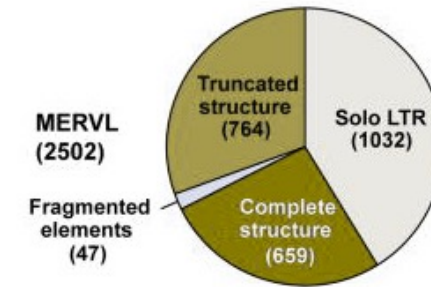
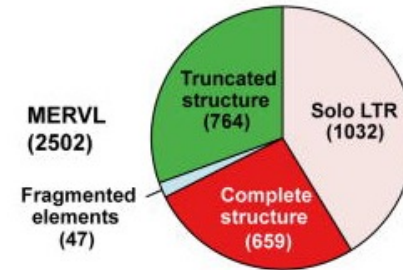
- Choose hues that make sense to the story.



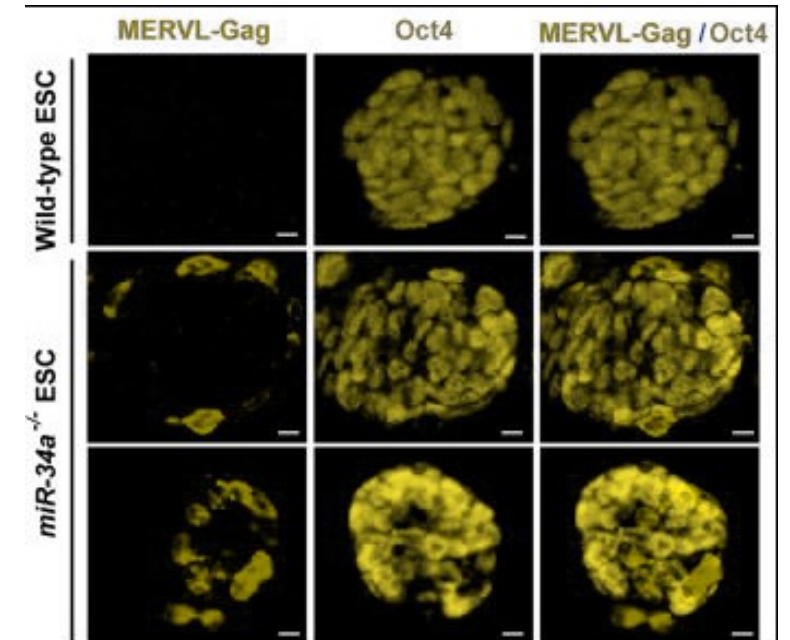
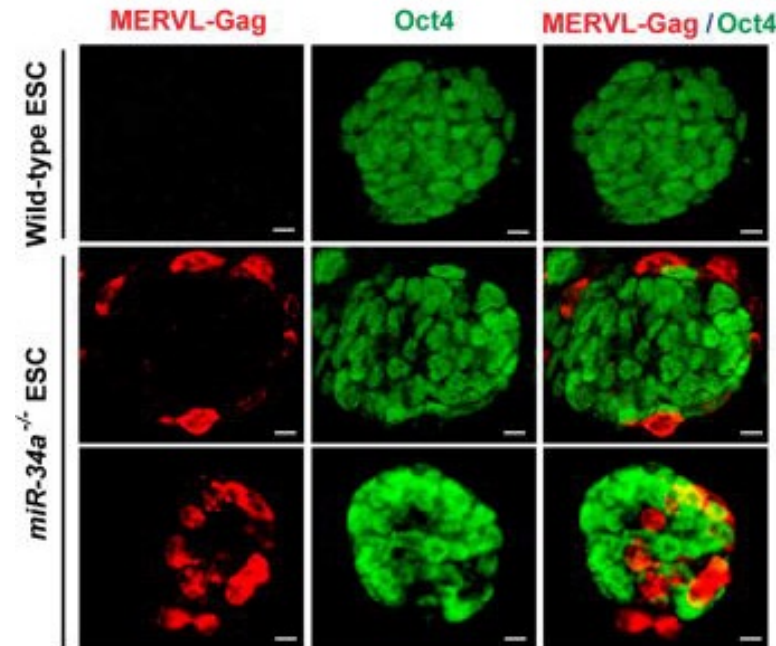
Accessibility

Color-blindness

- Men 8%, Women 0.5%
- Red/Green most common color deficiency (deuteranopia)



DON'T



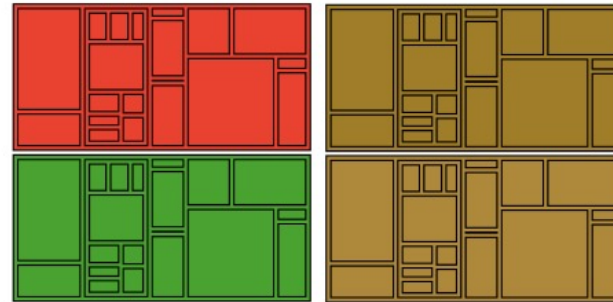
Accessibility

Color-blindness

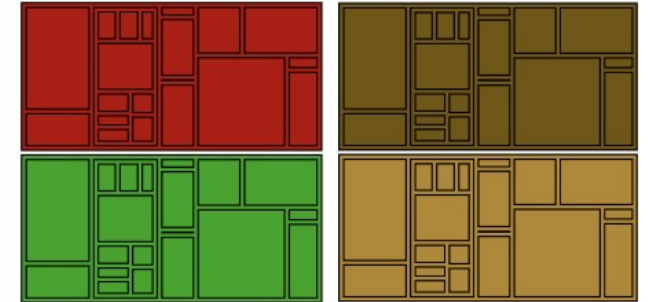
- Men 8%, Women 0.5%
- Red/Green most common color deficiency (deuteranopia)

Red/Green Color Deficiency Test

Red/Green Conflict



Red/Green No Conflict



Accessibility

Color-blindness

- Men 8%, Women 0.5%
- Red/Green most common color deficiency (deuteranopia)

Drag and drop or paste your file in the area below or: Prefrontal m...lescence.jpg

Trichromatic view: *Anomalous Trichromacy:* *Dichromatic view:* *Monochromatic view:*

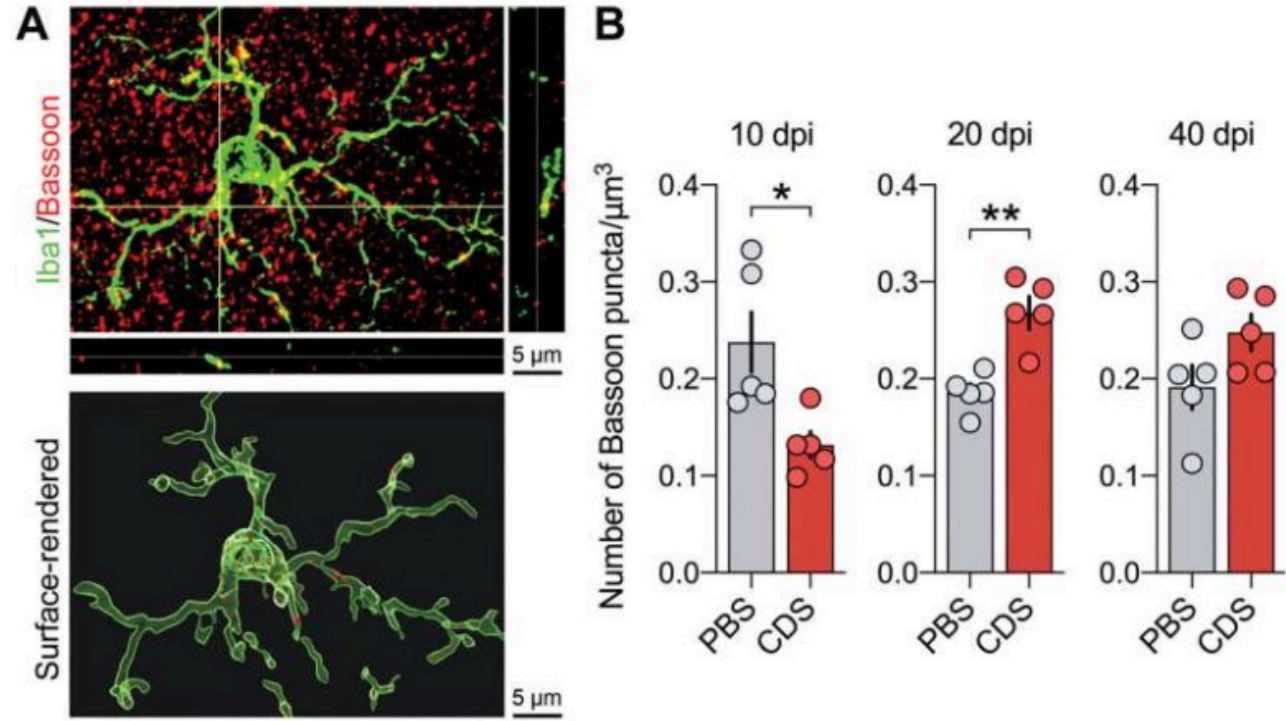
Normal Red-Weak/Protanomaly Red-Blind/Protanopia Monochromacy/Achromatopsia

Green-Weak/Deuteranomaly Green-Blind/Deuteranopia Blue Cone Monochromacy

Blue-Weak/Tritanomaly Blue-Blind/Tritanopia

Use lens to compare with normal view: No Lens Normal Lens Inverse Lens

[Reset View](#)



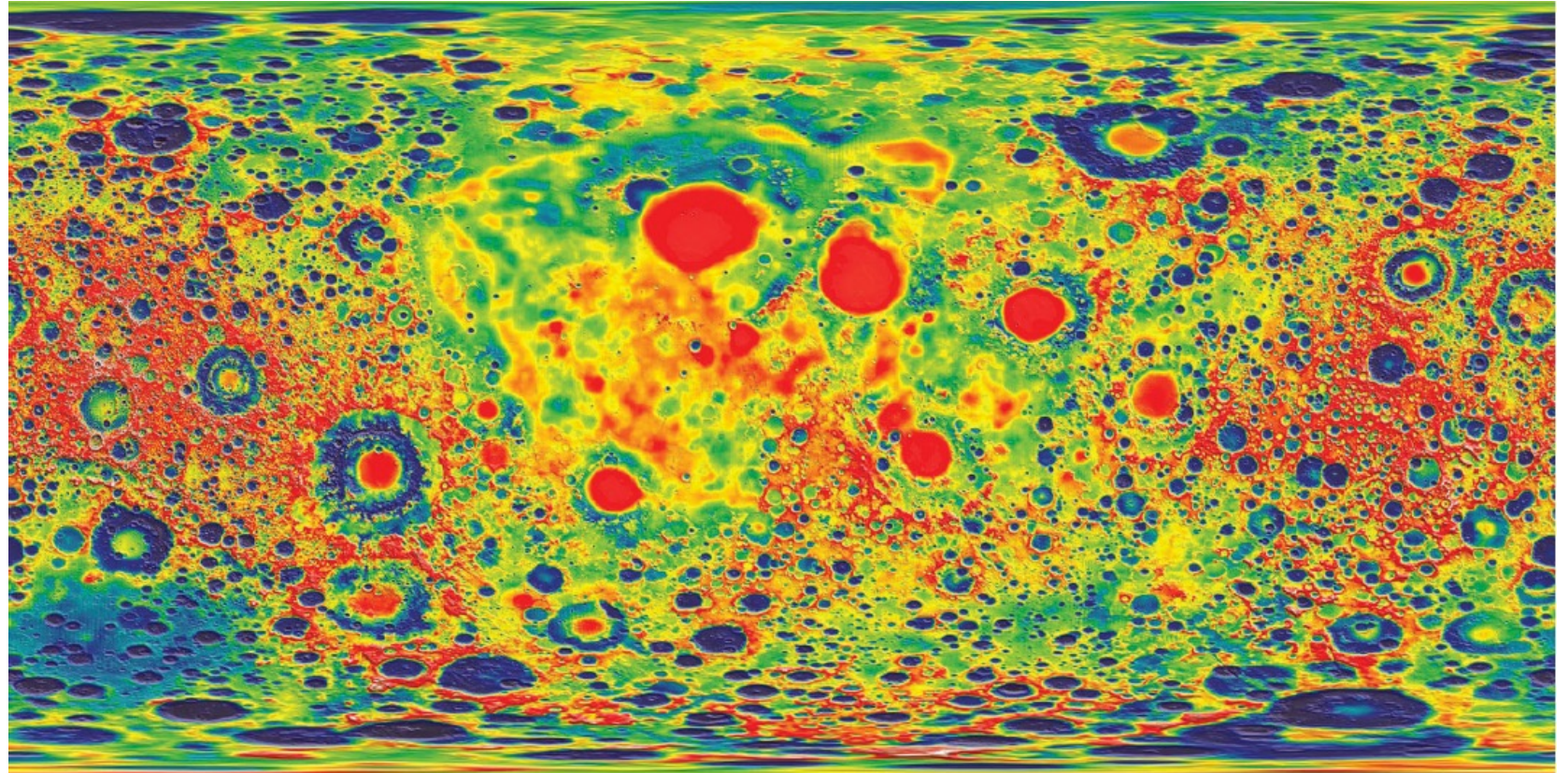
<https://www.color-blindness.com/coblis-color-blindness-simulator/>

Rainbows

DON'T

Avoid Rainbows

- Non-intuitive
- Hard to decipher

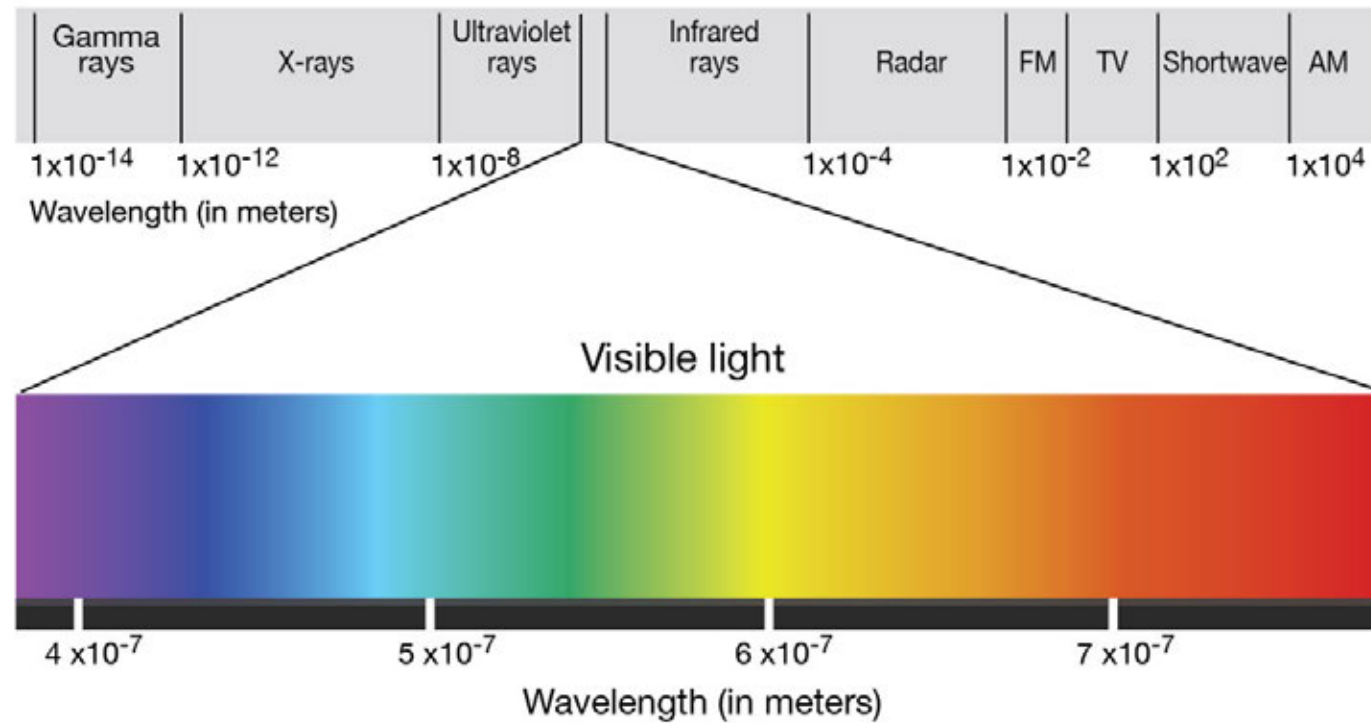


Rainbows

DON'T

Avoid Rainbows

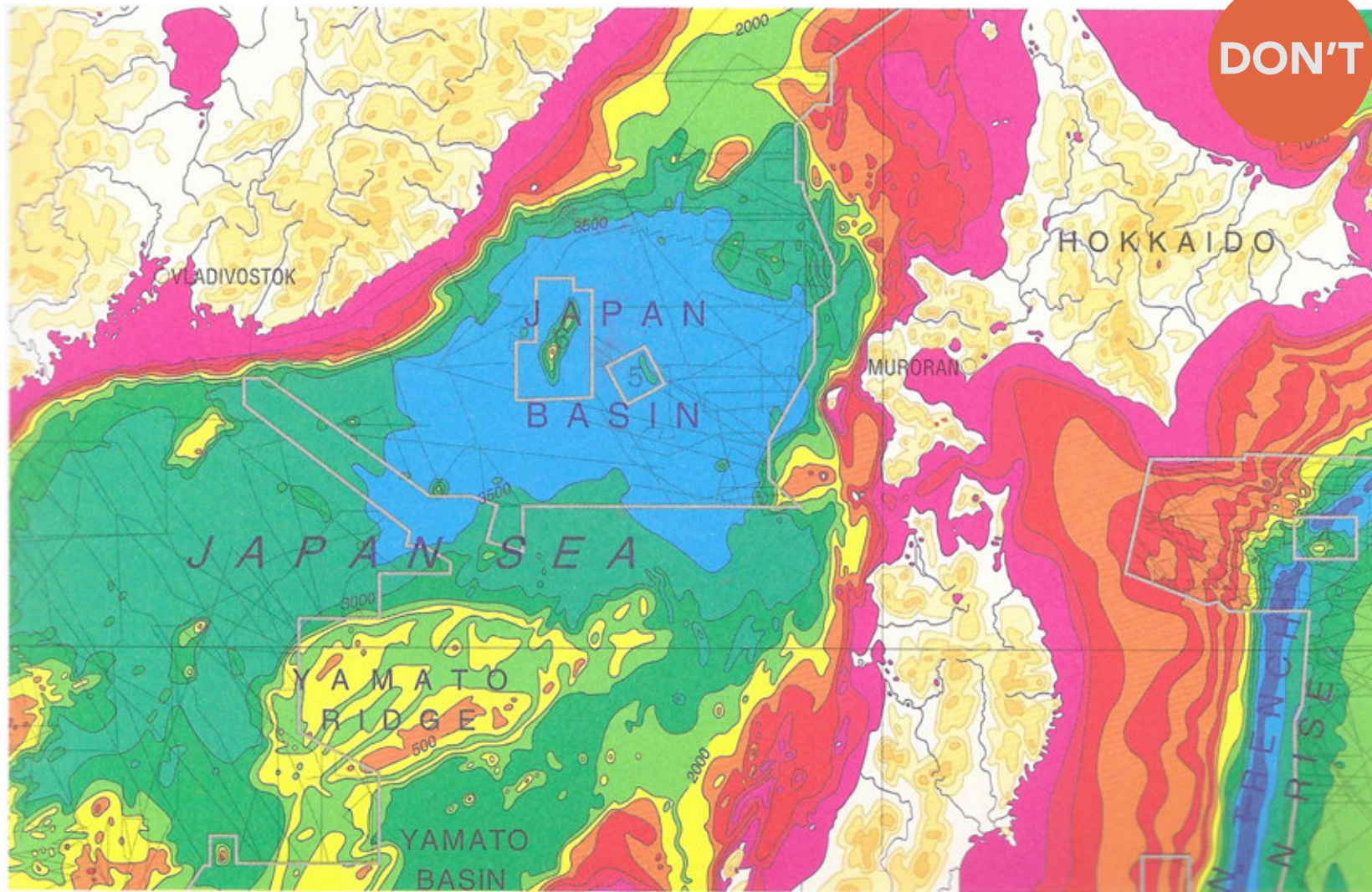
- Non-intuitive
- Hard to decipher



Rainbows

Avoid Rainbows

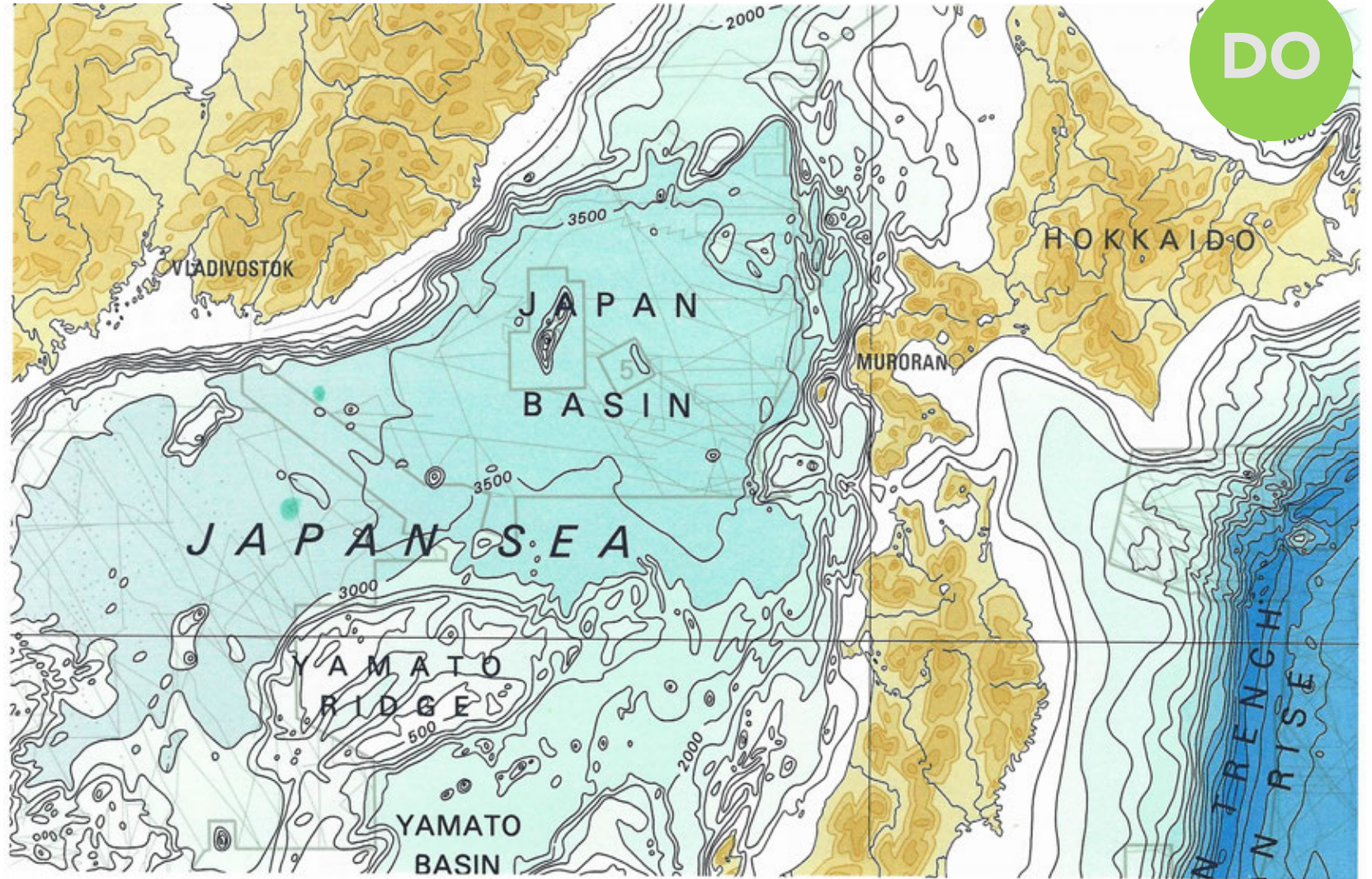
- Non-intuitive
- Hard to decipher



Rainbows

Avoid Rainbows

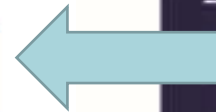
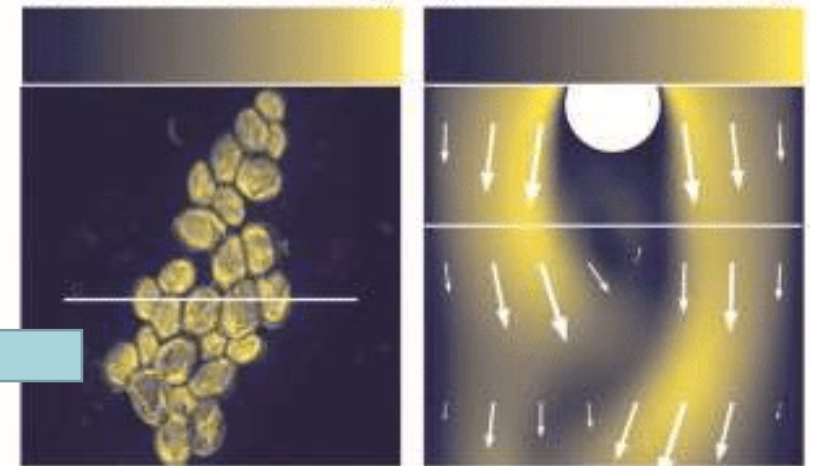
- Non-intuitive
- Hard to decipher



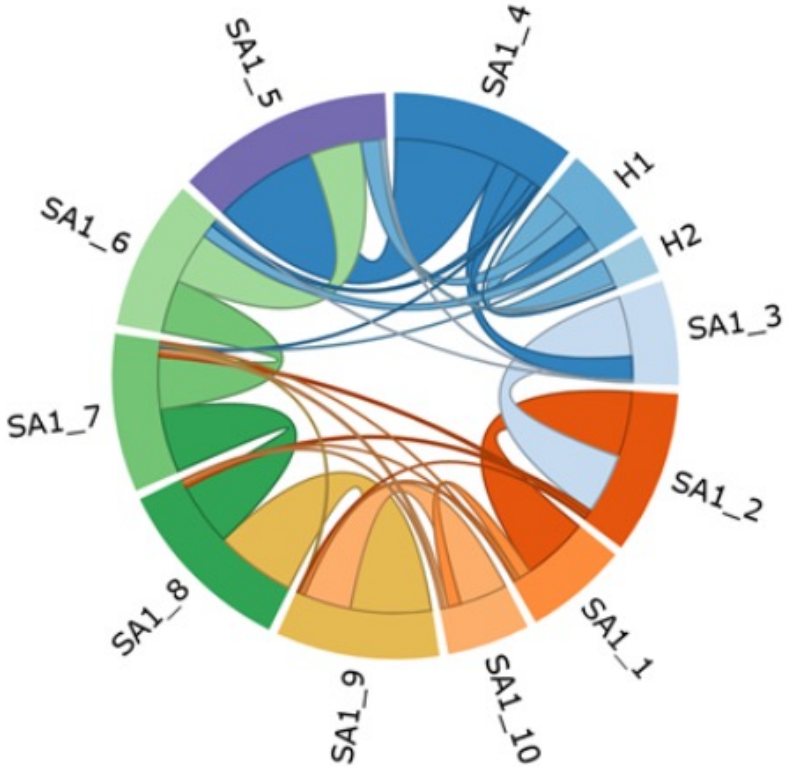
Rainbow alternatives



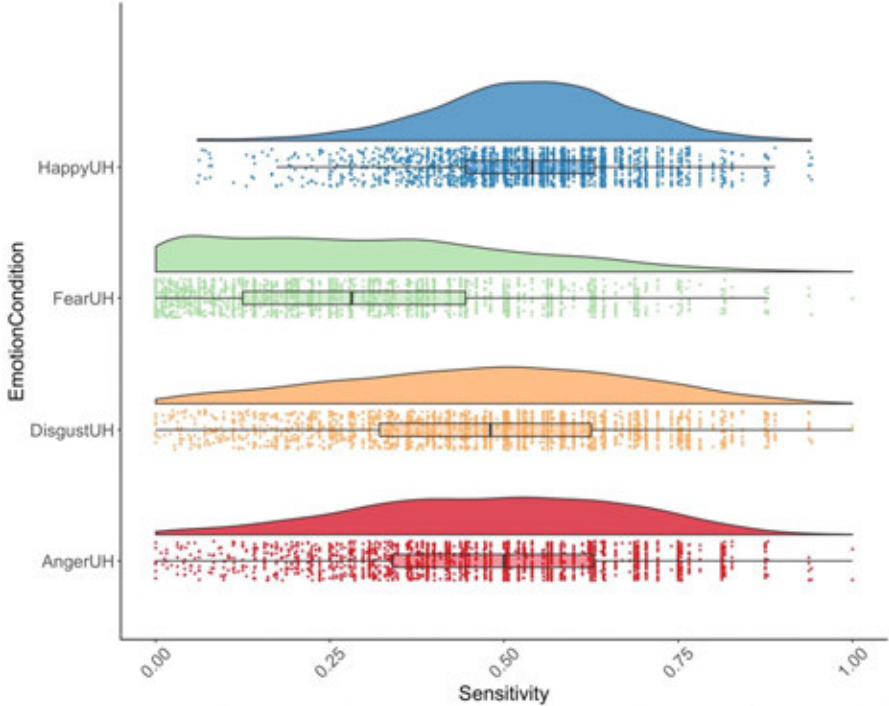
a) NanoSIMS Overlay b) Fluid Flow Overlay



Rainbow

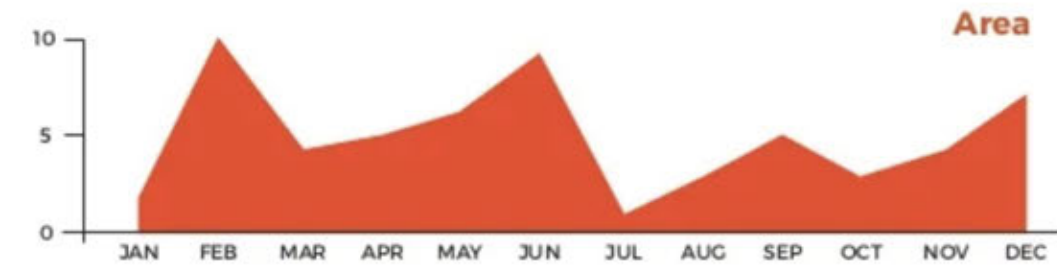
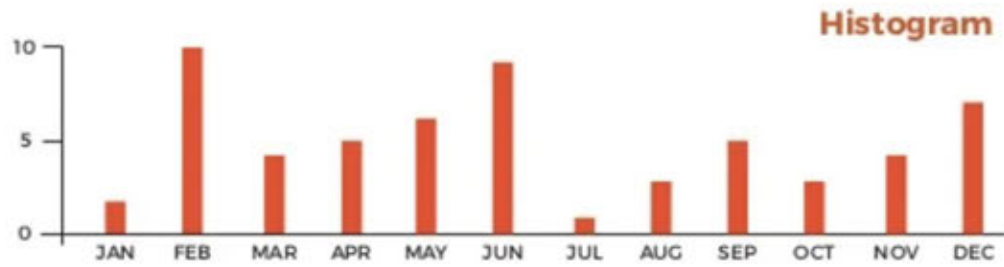
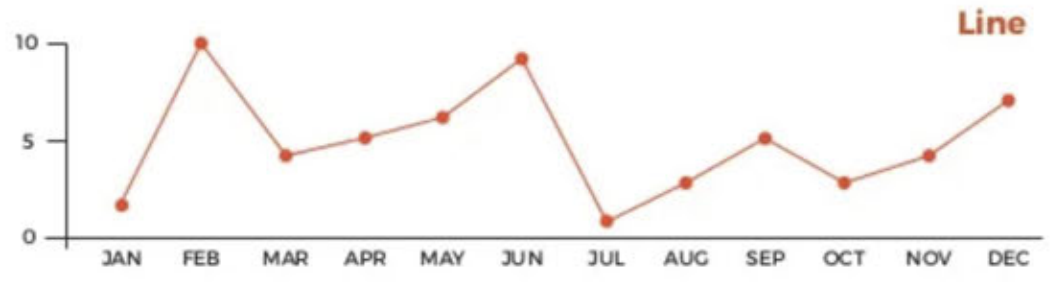
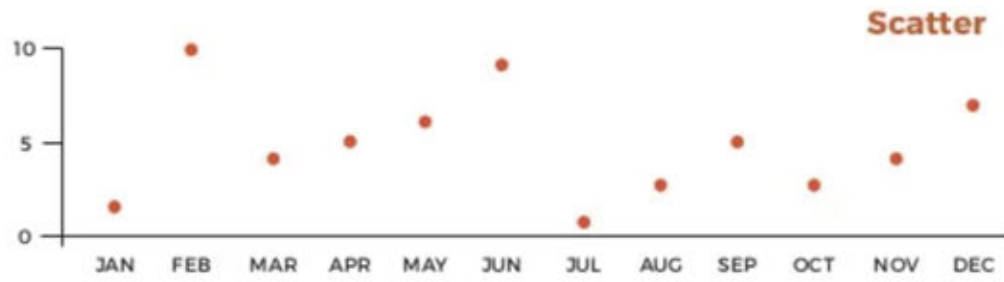


PDB Residue Interactions



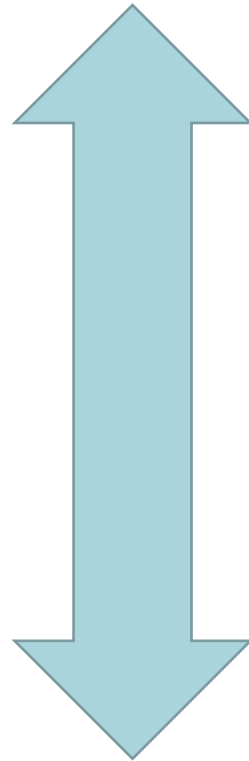
The background image shows a document with two charts. On the left is a stacked bar chart with three categories (yellow, red, cyan) and a y-axis labeled from 0 to 50. On the right is a line chart with two lines (green and red) and a y-axis labeled from 0 to 50. The text 'Chart Rules' is overlaid on the right side of the image.

Chart Rules

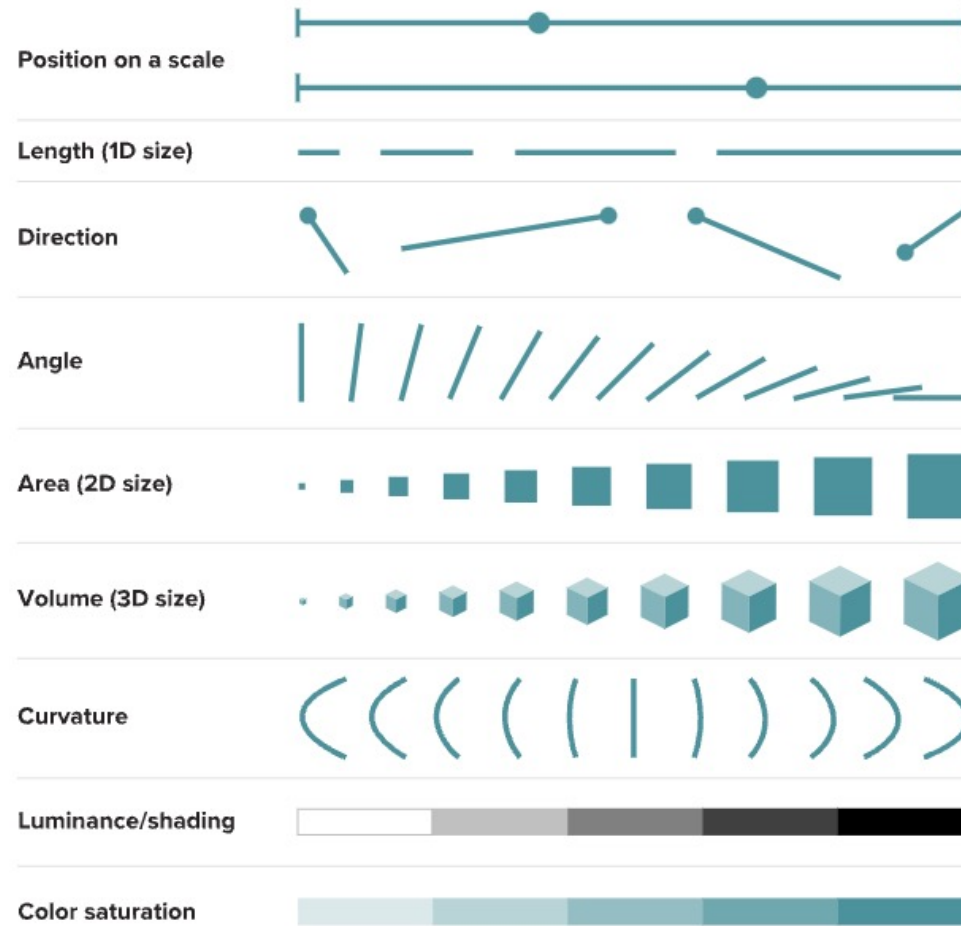


Visual Storytelling

Most effective

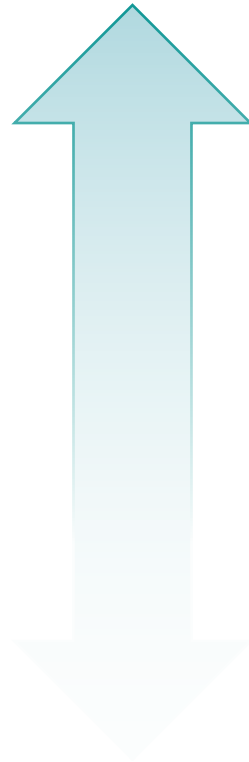


Least effective

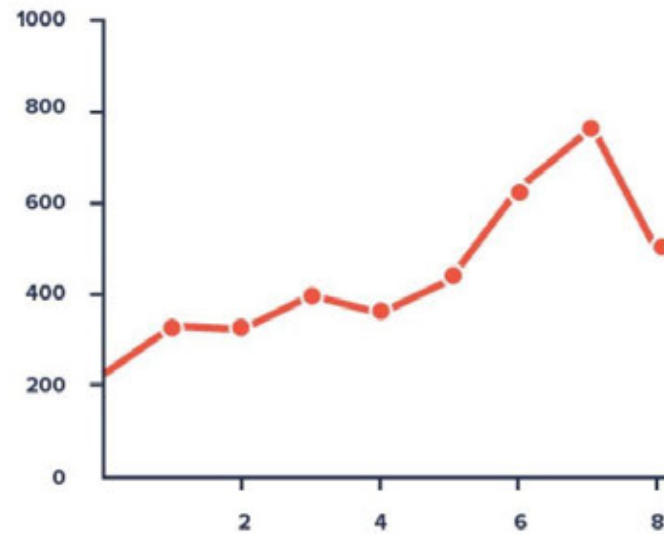


Visual Storytelling

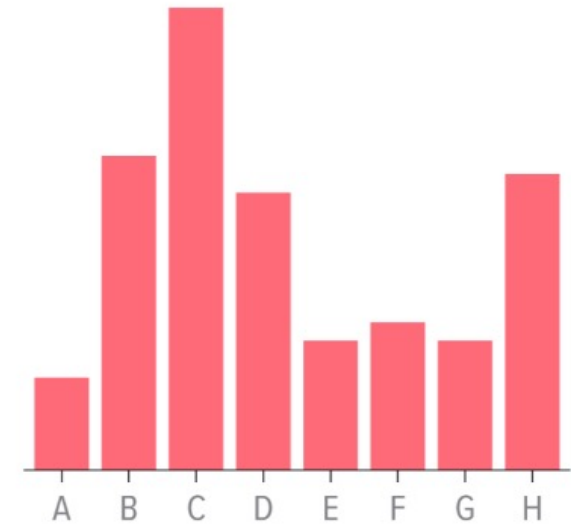
Most effective



Line Graph



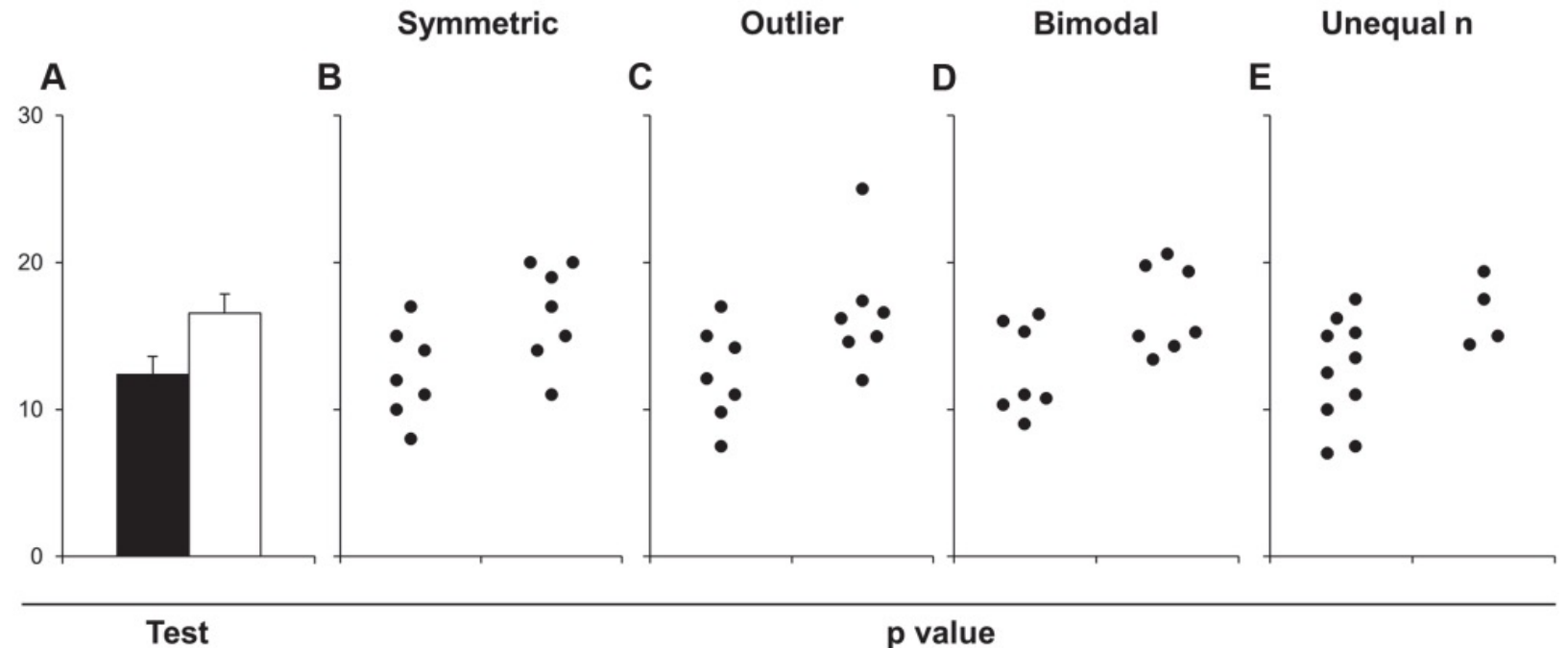
Bar Graph



Bar graphs

When to avoid bar or line graphs for datasets

- Distorted data
- Reader must infer instead of examine

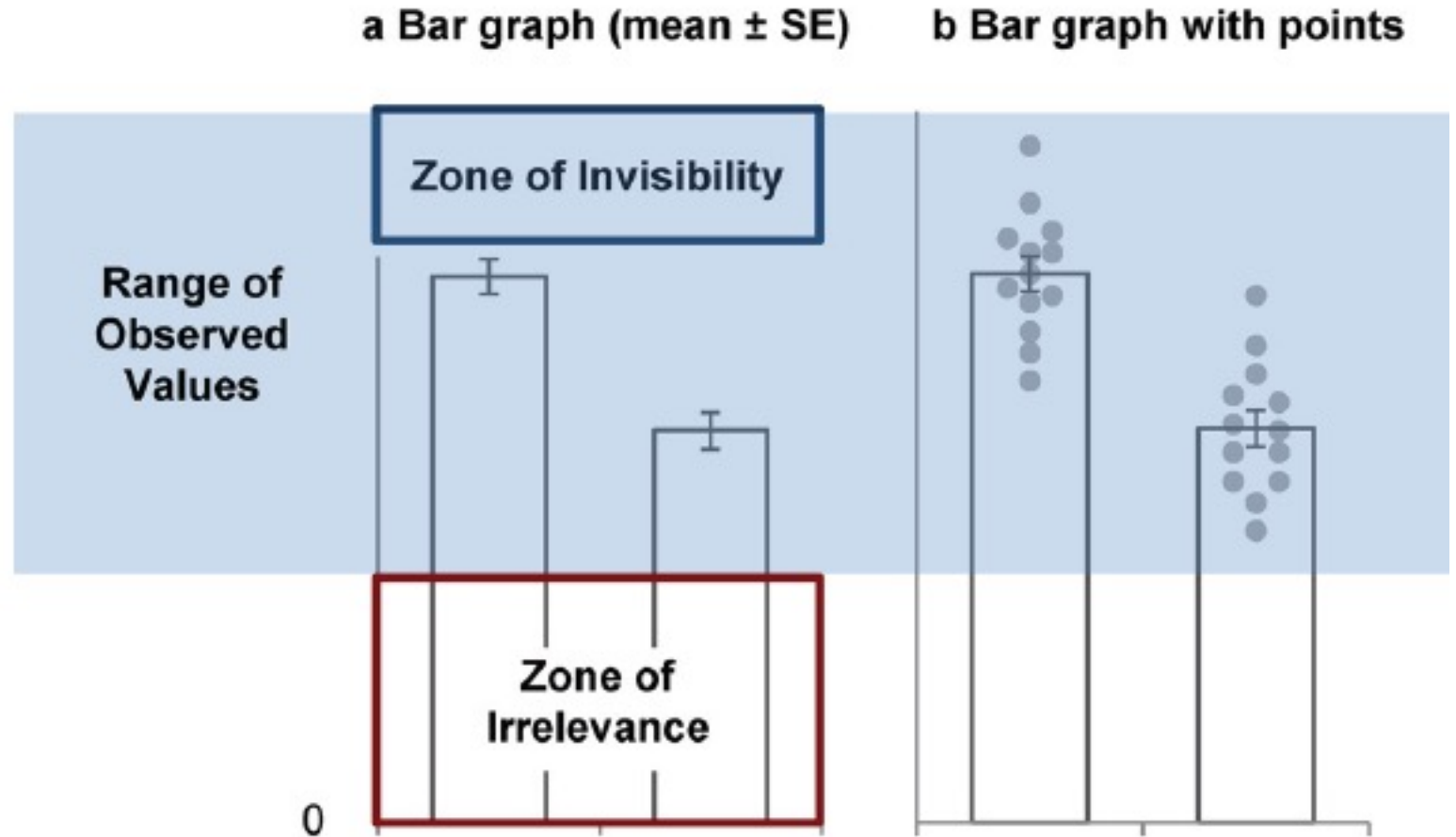


Weissgerber TL, Milic NM, Winham SJ, Garovic VD (2015) Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm. PLoS Biol 13(4): e1002128. <https://doi.org/10.1371/journal.pbio.1002128>

Bar graphs

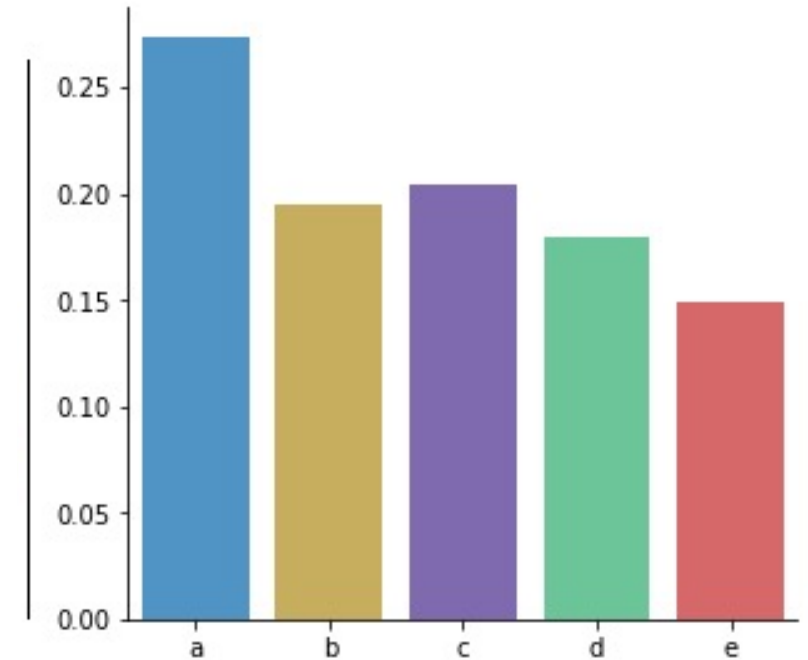
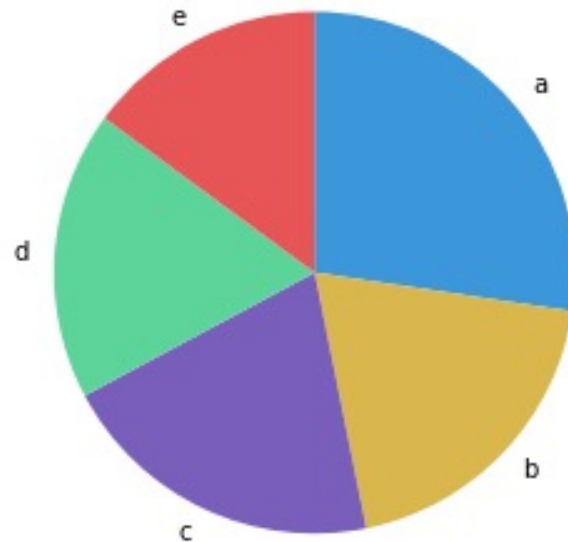
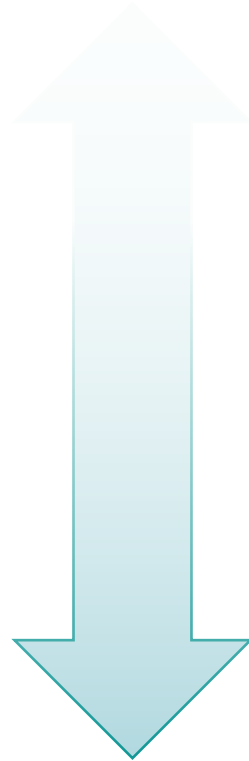
When to avoid bar or line graphs for datasets

- Distorted data
- Reader must infer instead of examine



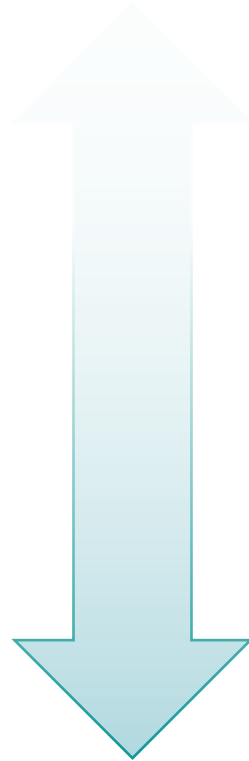
Visual Storytelling

Pie or donut chart



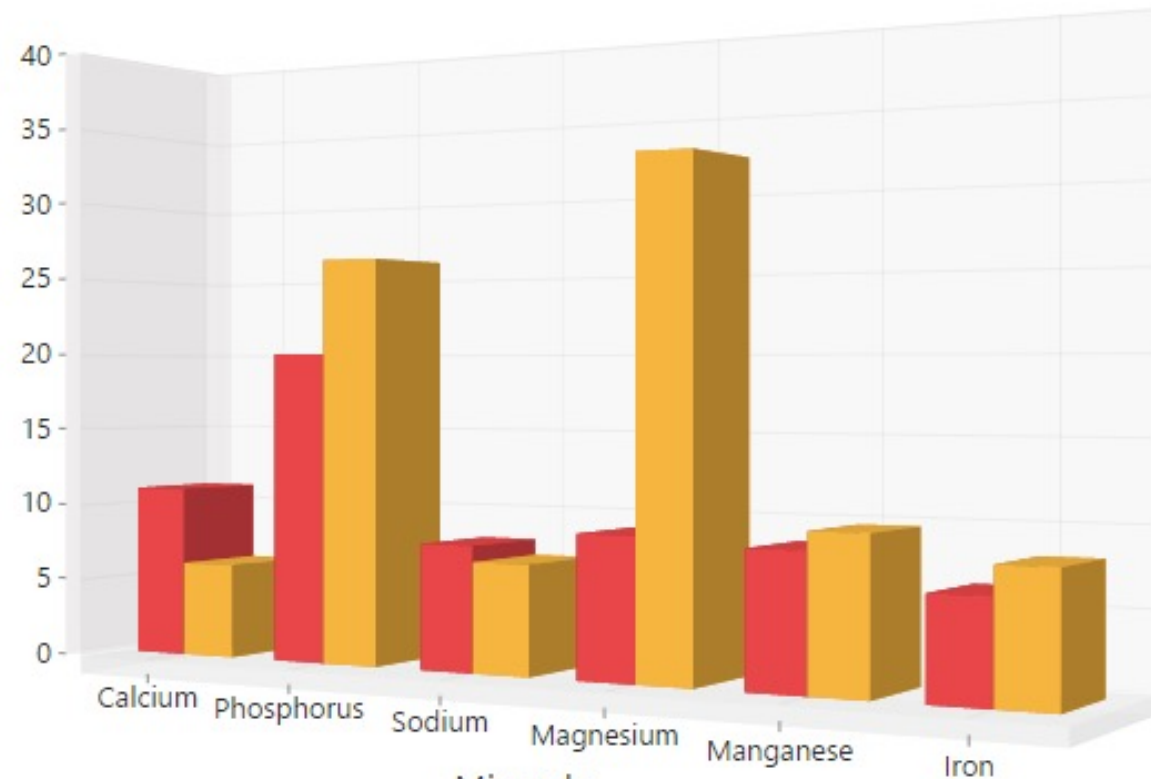
Less effective

Visual Storytelling



Less effective

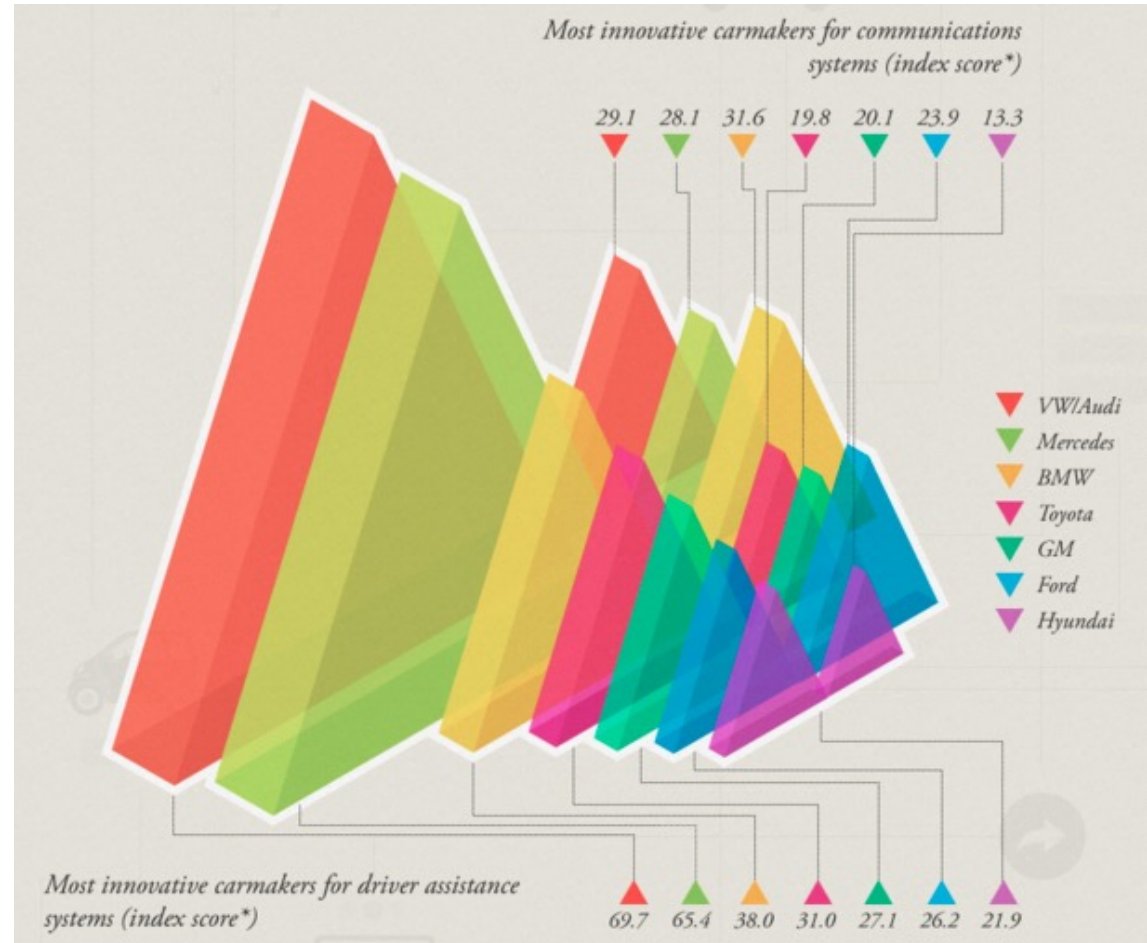
3D charts



Let data speak for itself

Avoid Unnecessary Information or Stylization

- Distracting
- Can cause misinterpretation



Clean up a dirty graph

DO LESS

MAKE IT READABLE

REMOVE UNNECESSARY ELEMENTS

THOUGHTFUL ALIGNMENT

SIMPLIFY/REDUCE DISTRACTIONS

MINIMIZE AXIS LABEL CONTRAST

FOCUS THE EYE ON WHAT MATTERS

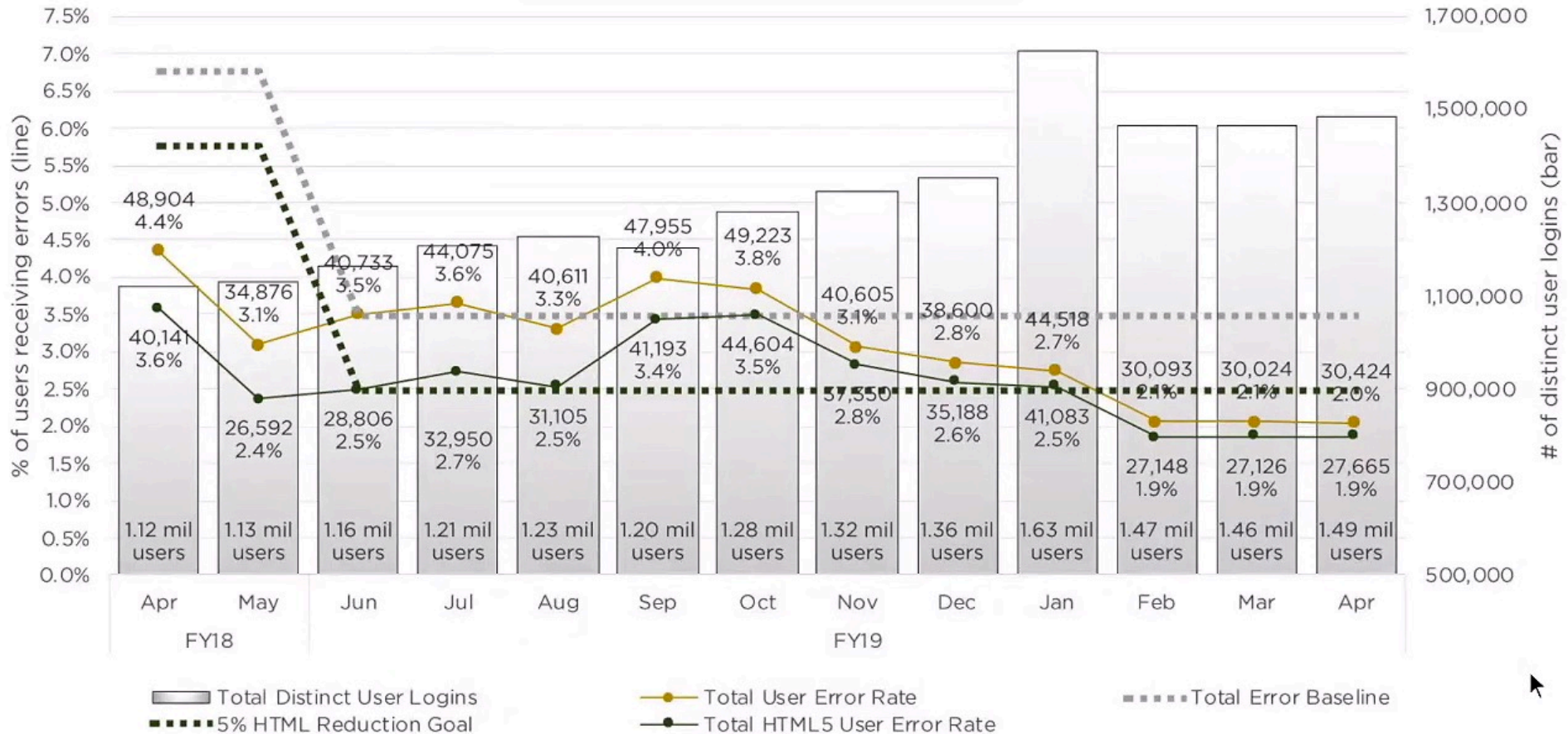
INTENTIONAL AND SPARE USE OF COLOR

STRATEGIC LABELING/ANNOTATIONS

INLINE LABELING

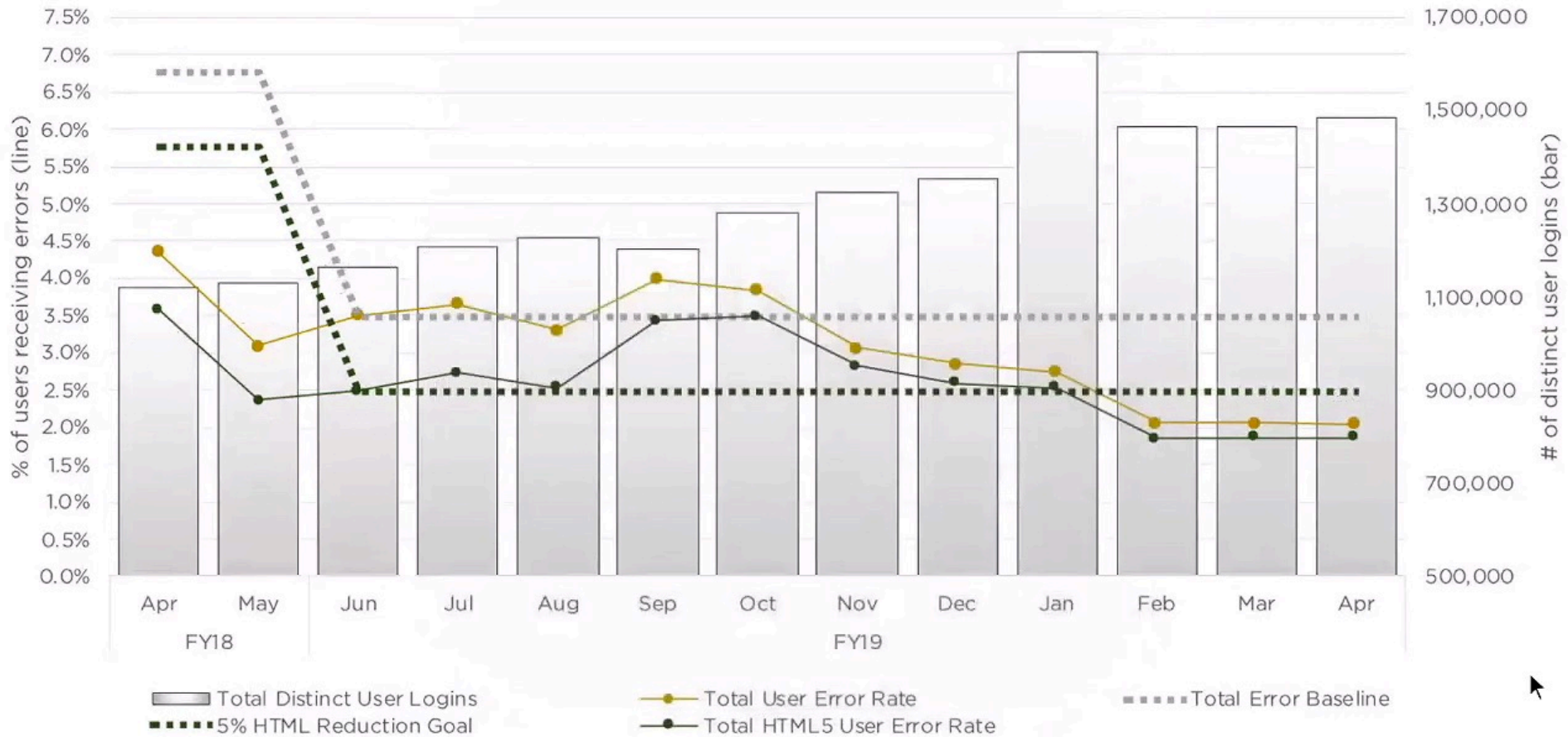
1. Remove unnecessary data

Clean up a dirty graph



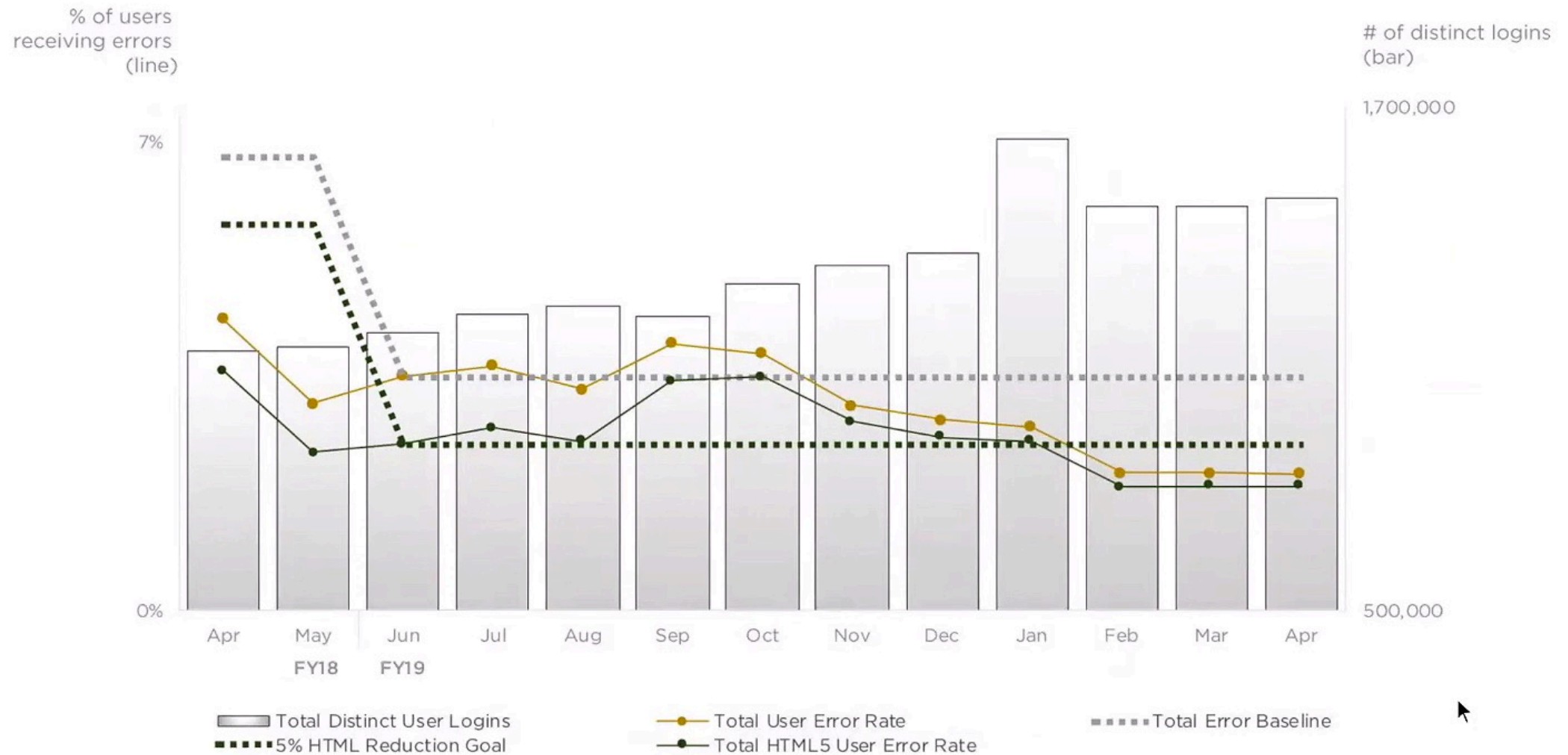
2. Remove unnecessary elements

Clean up a dirty graph



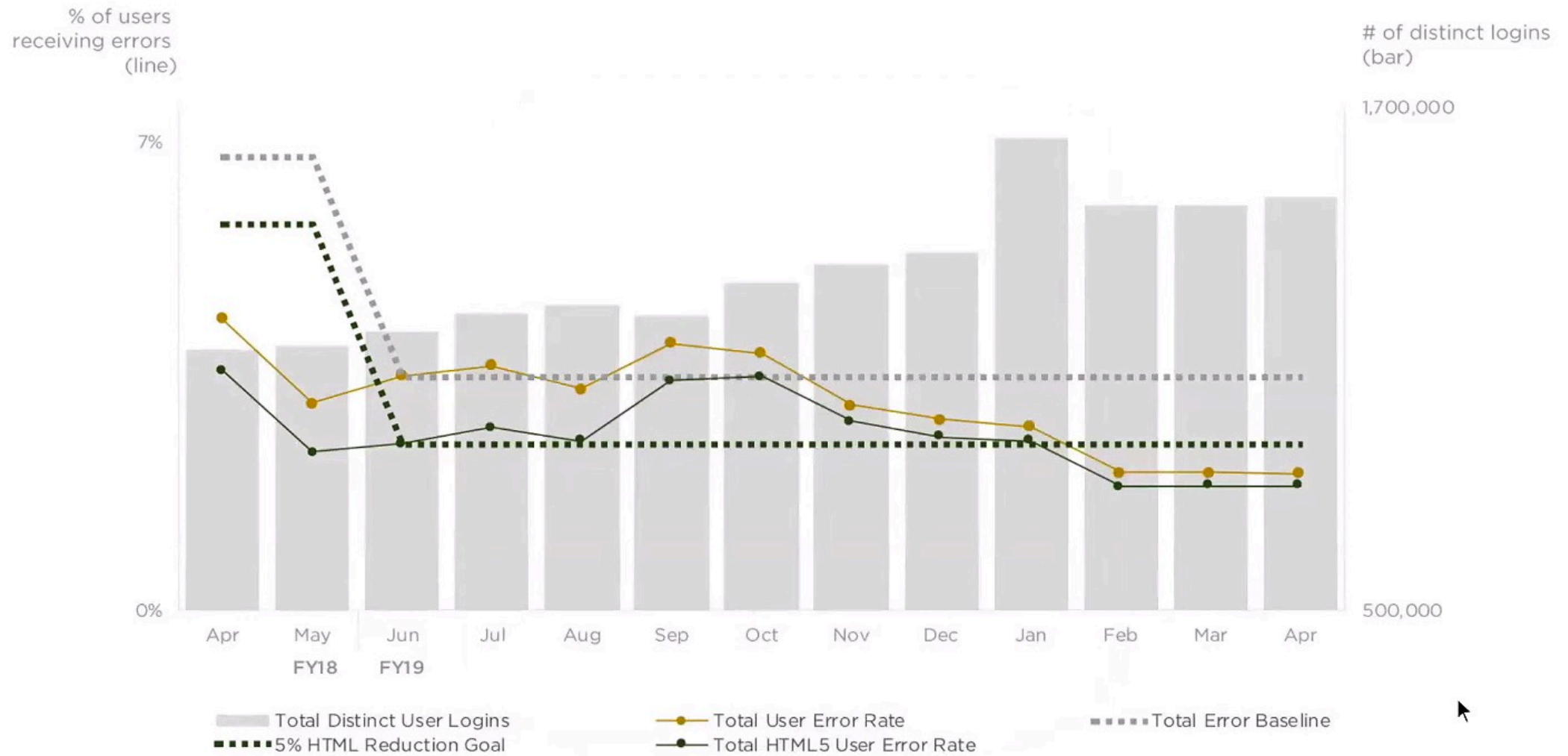
3. Simplify current data

Clean up a dirty graph



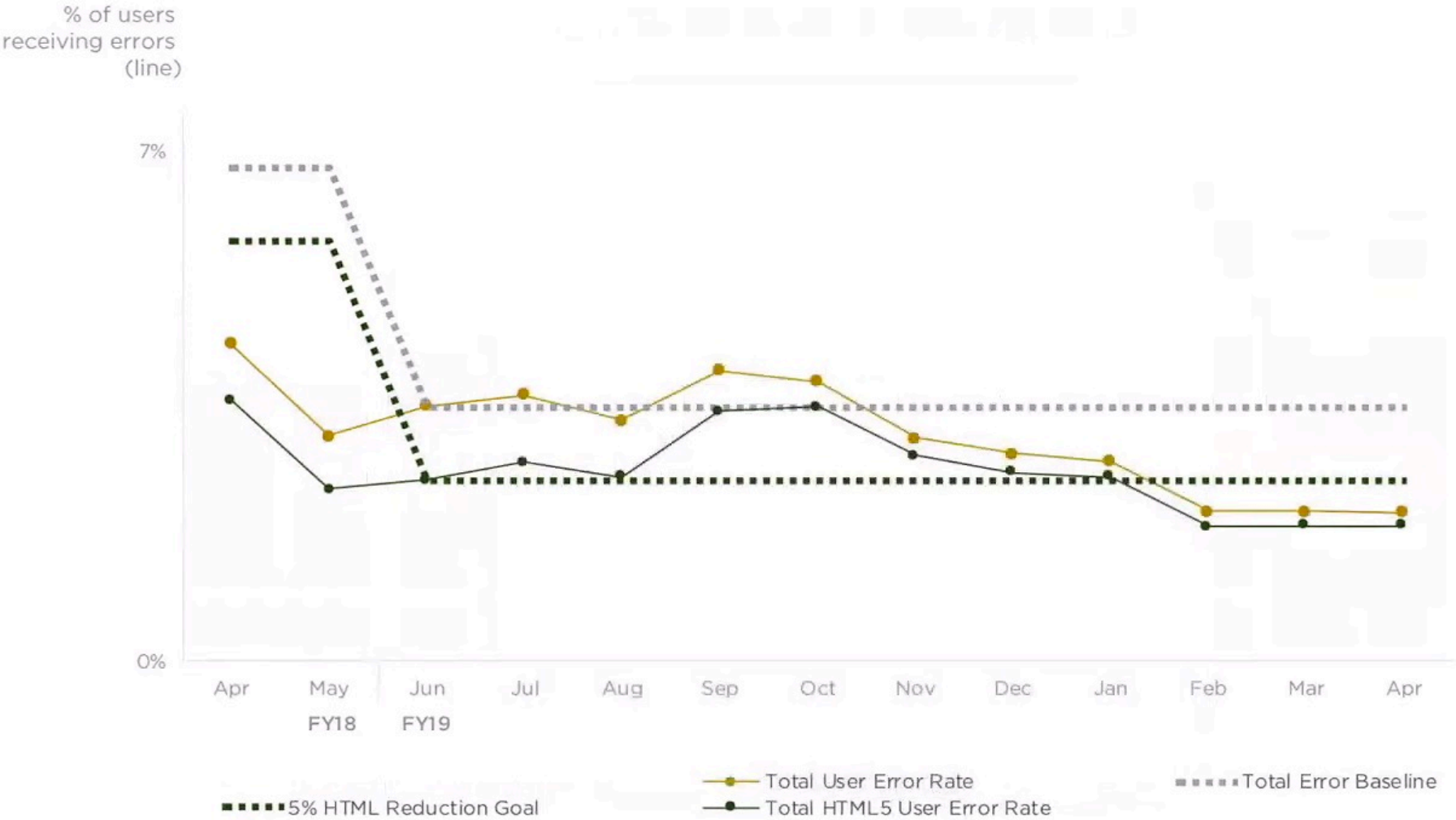
3. Simplify current data

Clean up a dirty graph



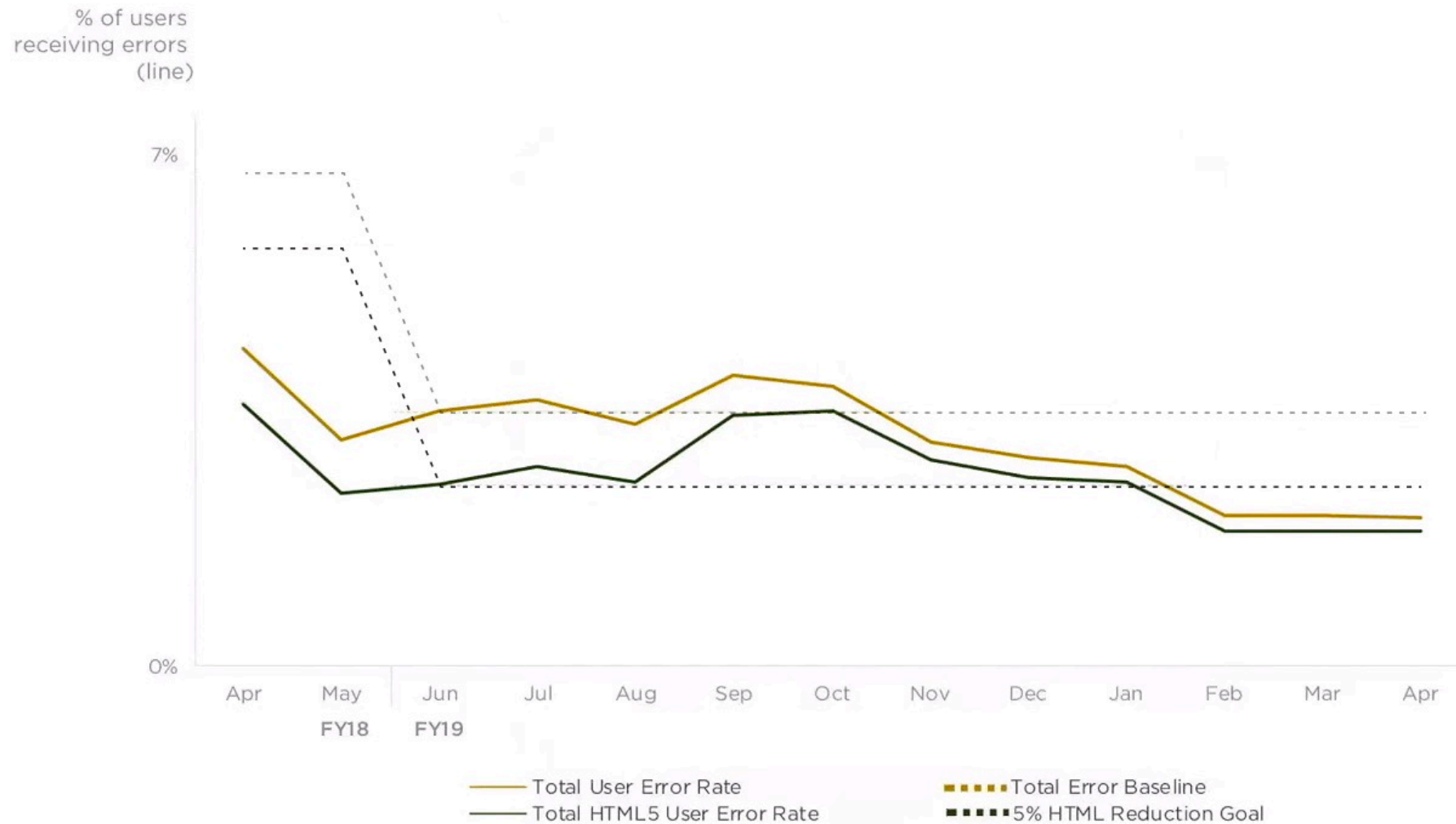
4. Reduce distractions

Clean up a dirty graph



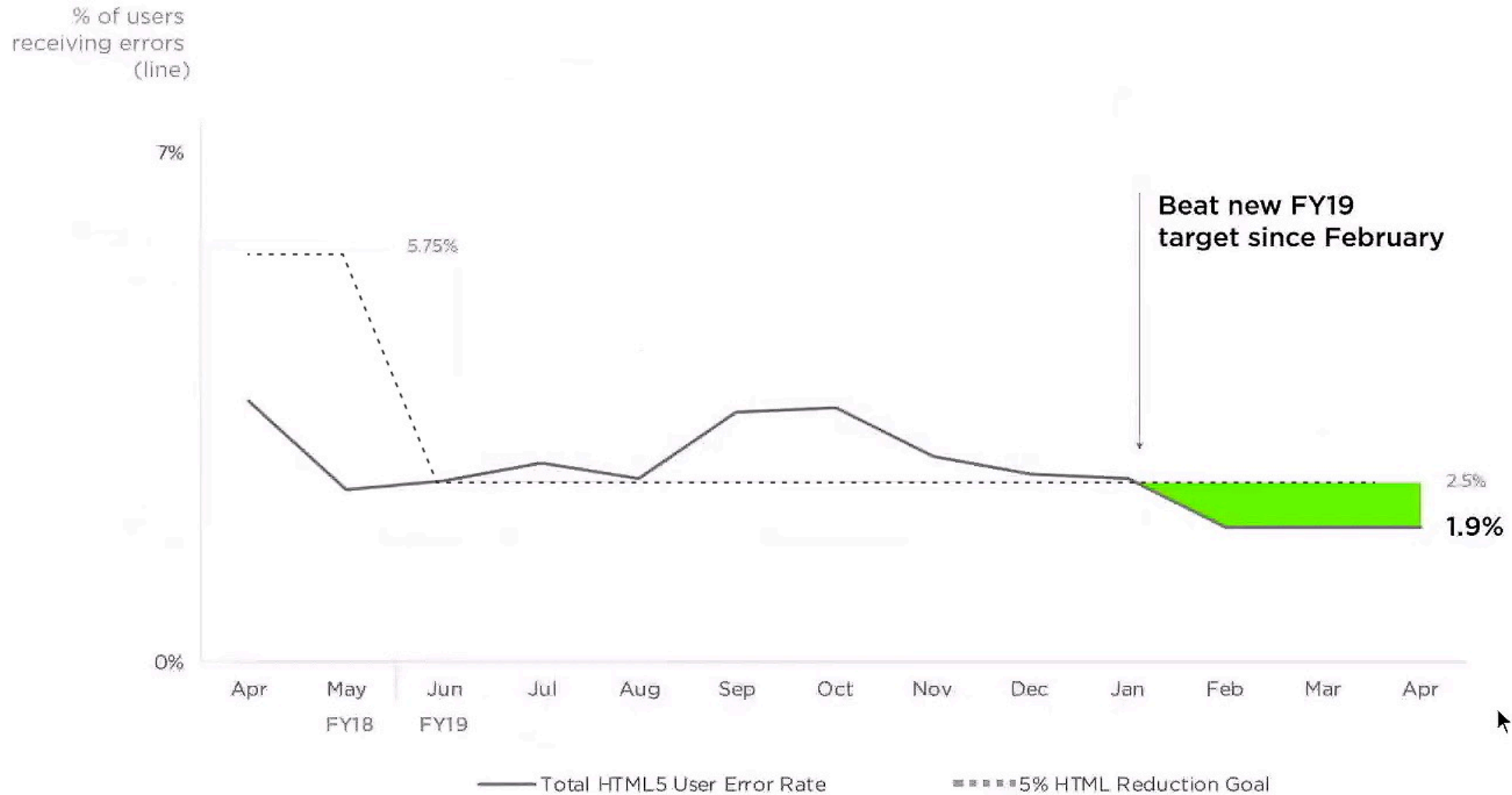
4. Reduce distractions

Clean up a dirty graph



5. Strategize attention

Clean up a dirty graph



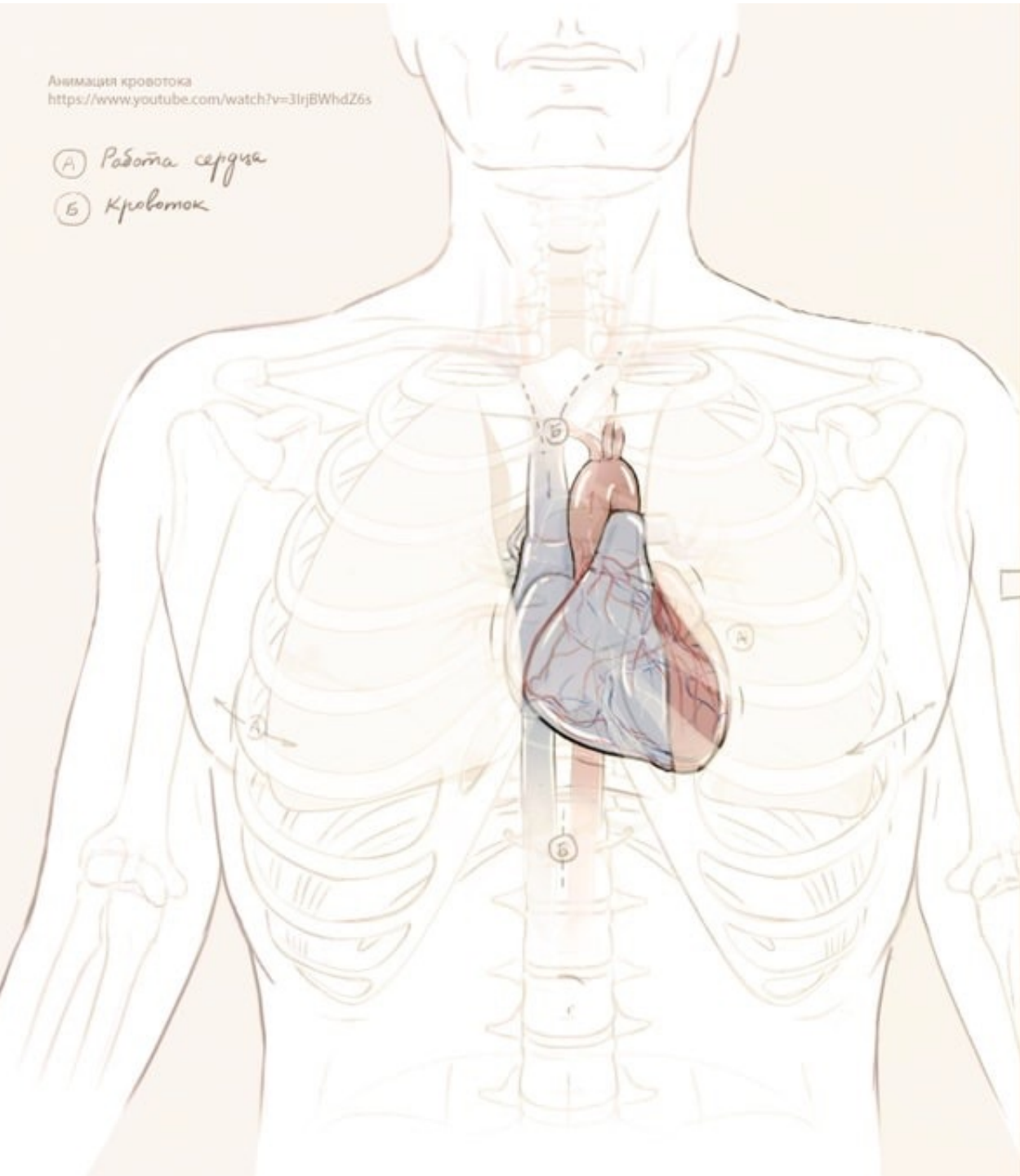
Clean up a dirty graph

1. Remove unnecessary data
2. Remove unnecessary elements
3. Simplify current data
4. Reduce distractions
5. Strategize attention

DO LESS

MAKE IT READABLE
REMOVE UNNECESSARY ELEMENTS
THOUGHTFUL ALIGNMENT
SIMPLIFY/REDUCE DISTRACTIONS
MINIMIZE AXIS LABEL CONTRAST
FOCUS THE EYE ON WHAT MATTERS
INTENTIONAL AND SPARE USE OF COLOR
STRATEGIC LABELING/ANNOTATIONS
INLINE LABELING

- Ⓐ Работа сердца
- Ⓑ Кровоток



Фигура ч. пловает/стоит
в "камере обследования"
мед.отсека

1. Не показывать
слушание
рефлекса/уши

⊕ участок мозга
(внесито!?)

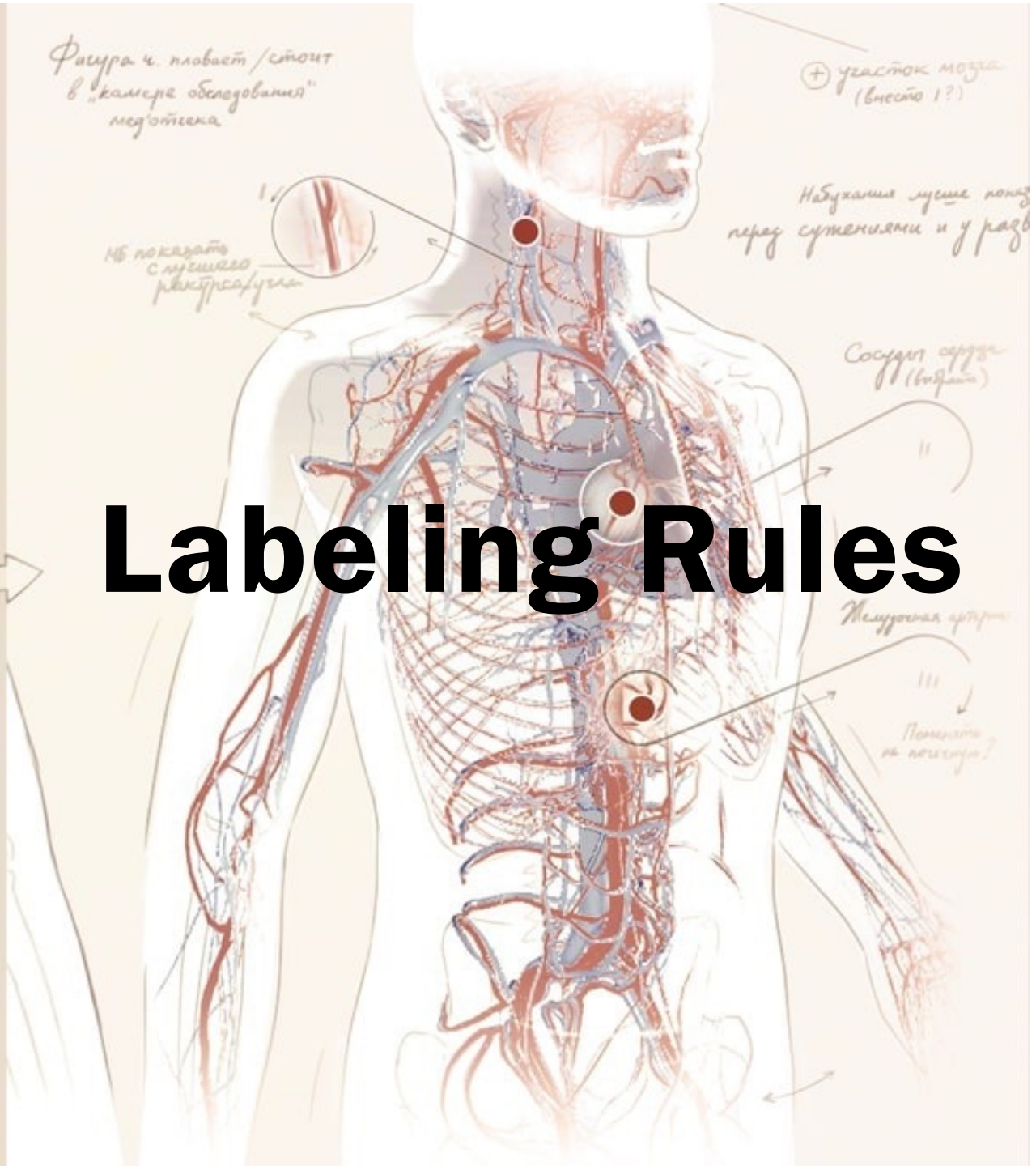
Набухание мышцы
перед суставами и у разго

Сосуды сердца
(визуализация)

Labeling Rules

Мускульная группа

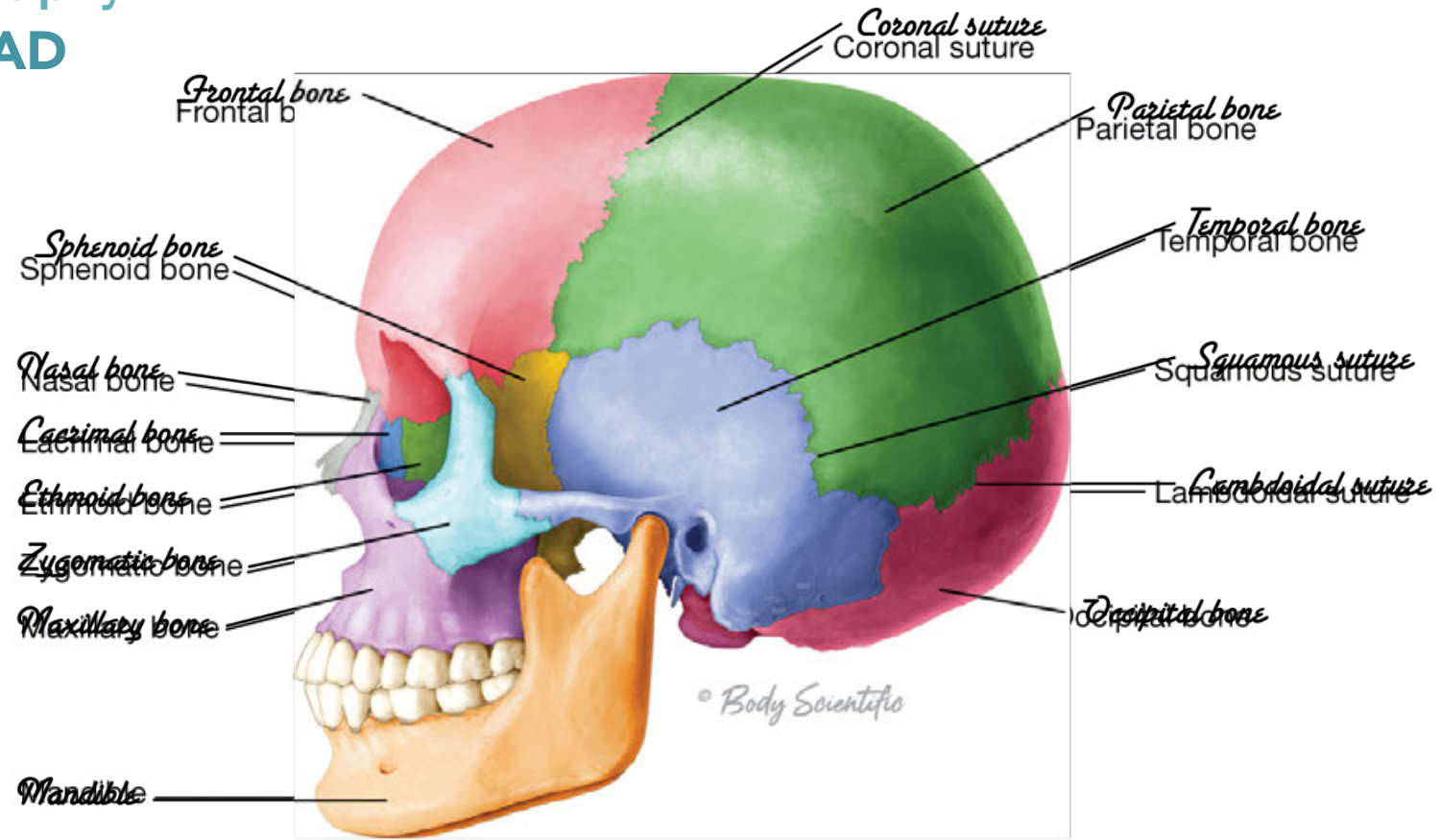
III
Поминать
на посылку?



Typography

Importance of Typography

- **EASY TO READ**



Side view

Choosing Typeface

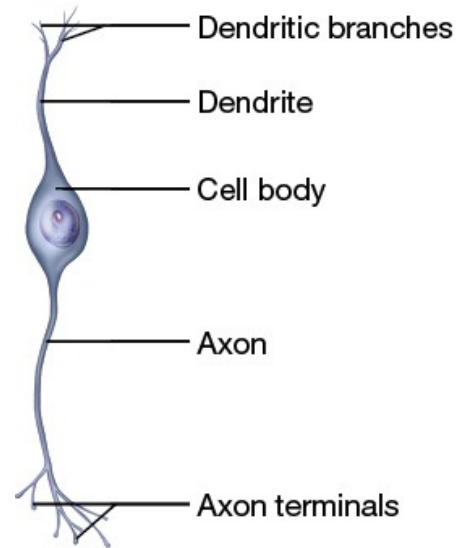
- Two main types of typeface
- Serif and Sans serif



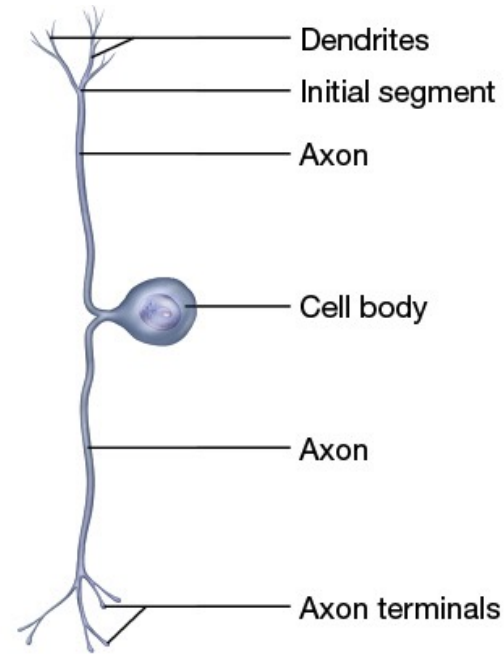
Good Labeling



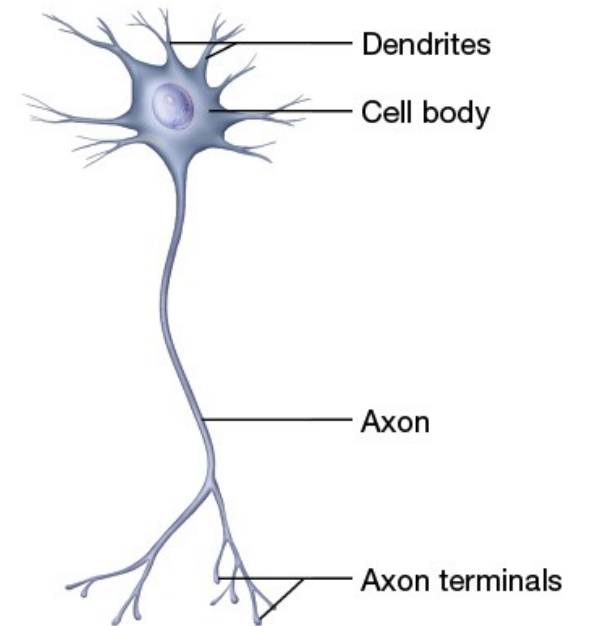
- **DO** choose straight lines when possible



A. Bipolar neuron



B. Unipolar neuron



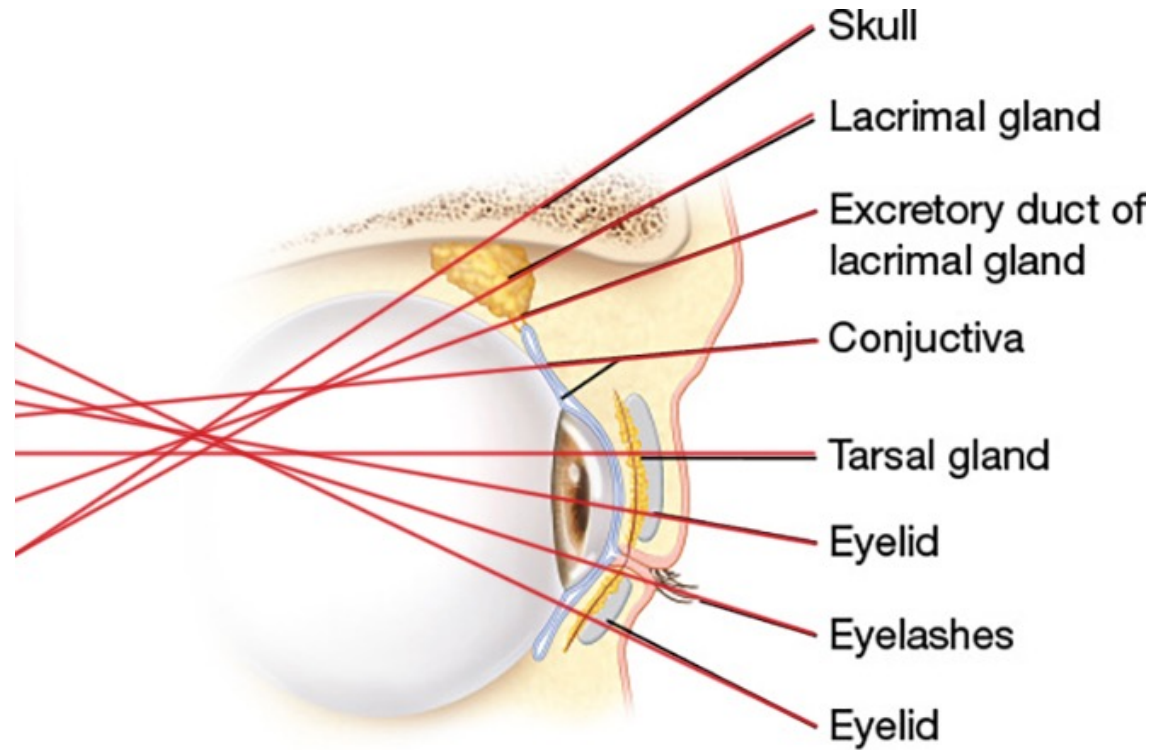
C. Multipolar neuron



Good Labeling

- **DO** make lines look as if converge at a hidden vanishing point

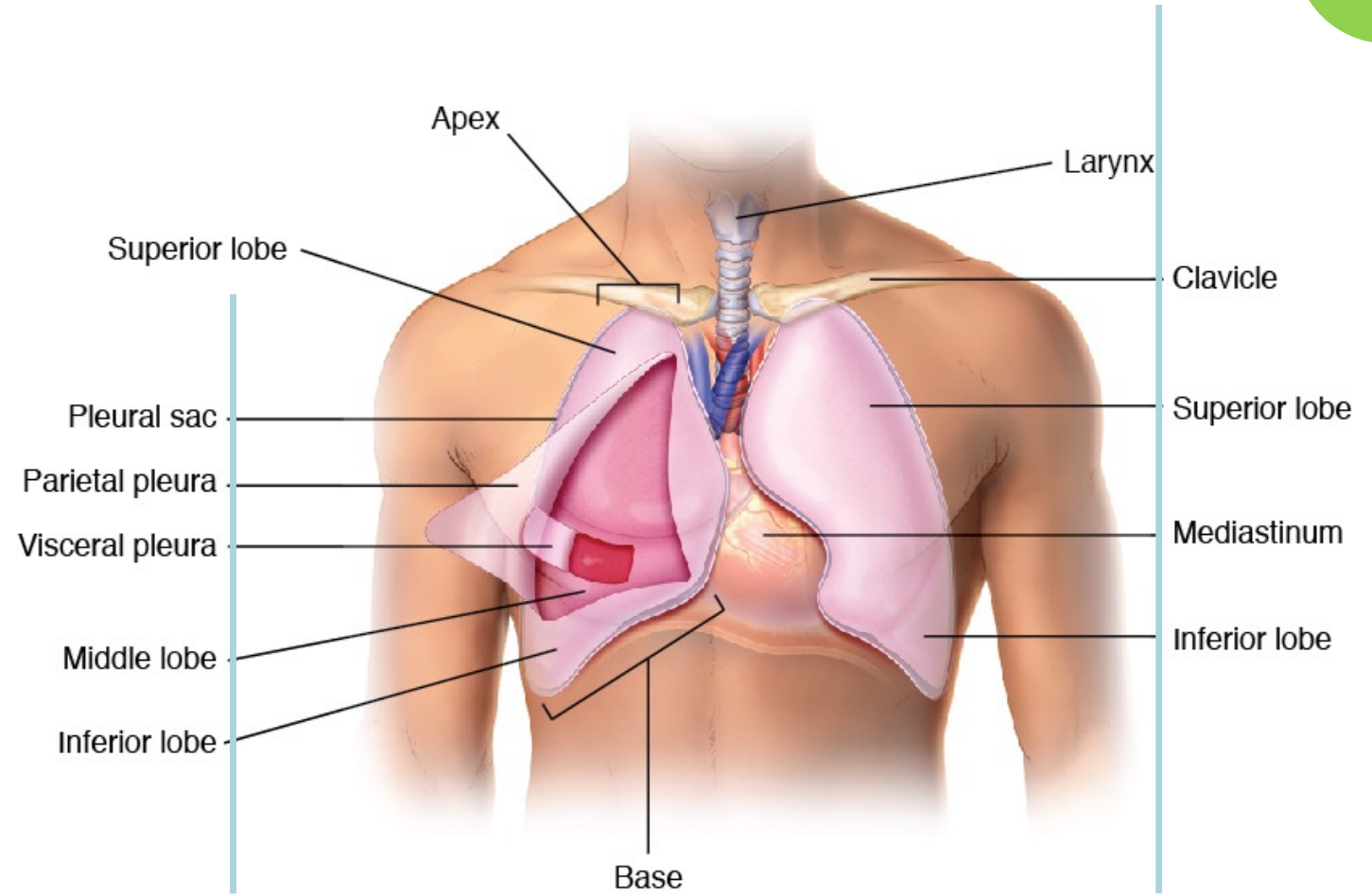
Look like "rays" or spokes of a wheel



B. Lateral view

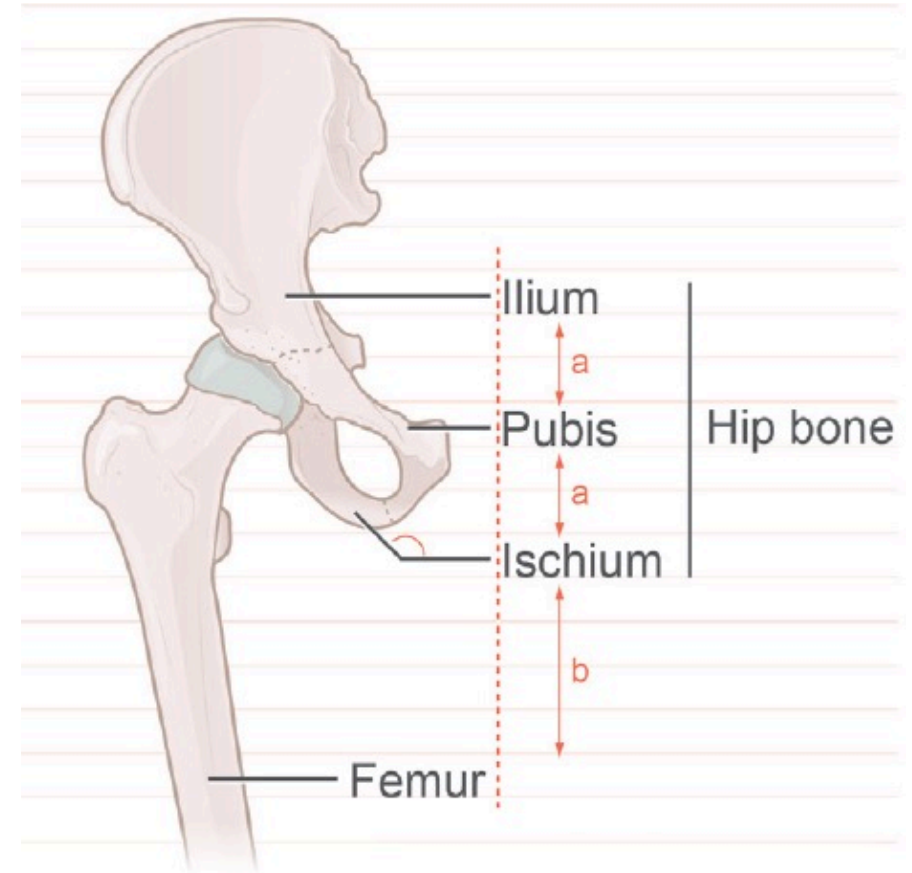
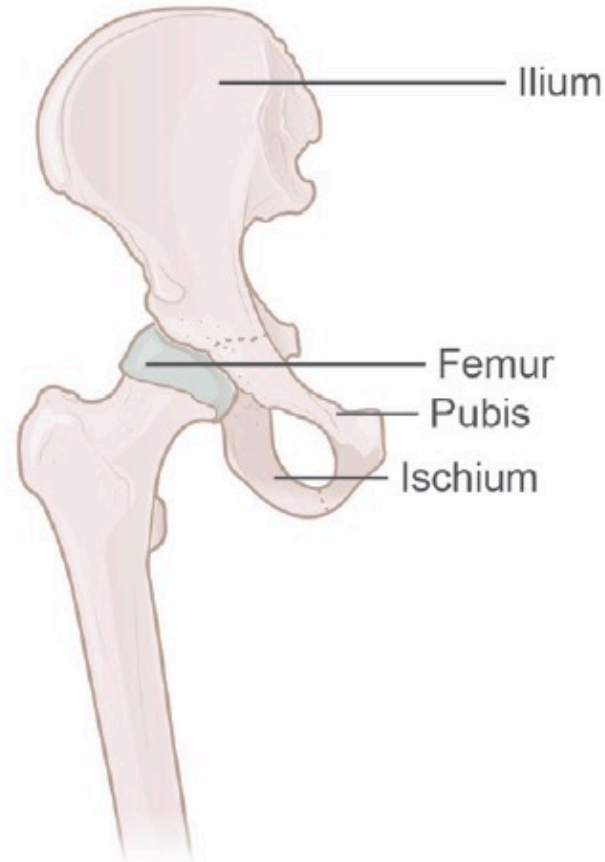
Good Labeling

- **DO** align for a neat look
- Both ways acceptable



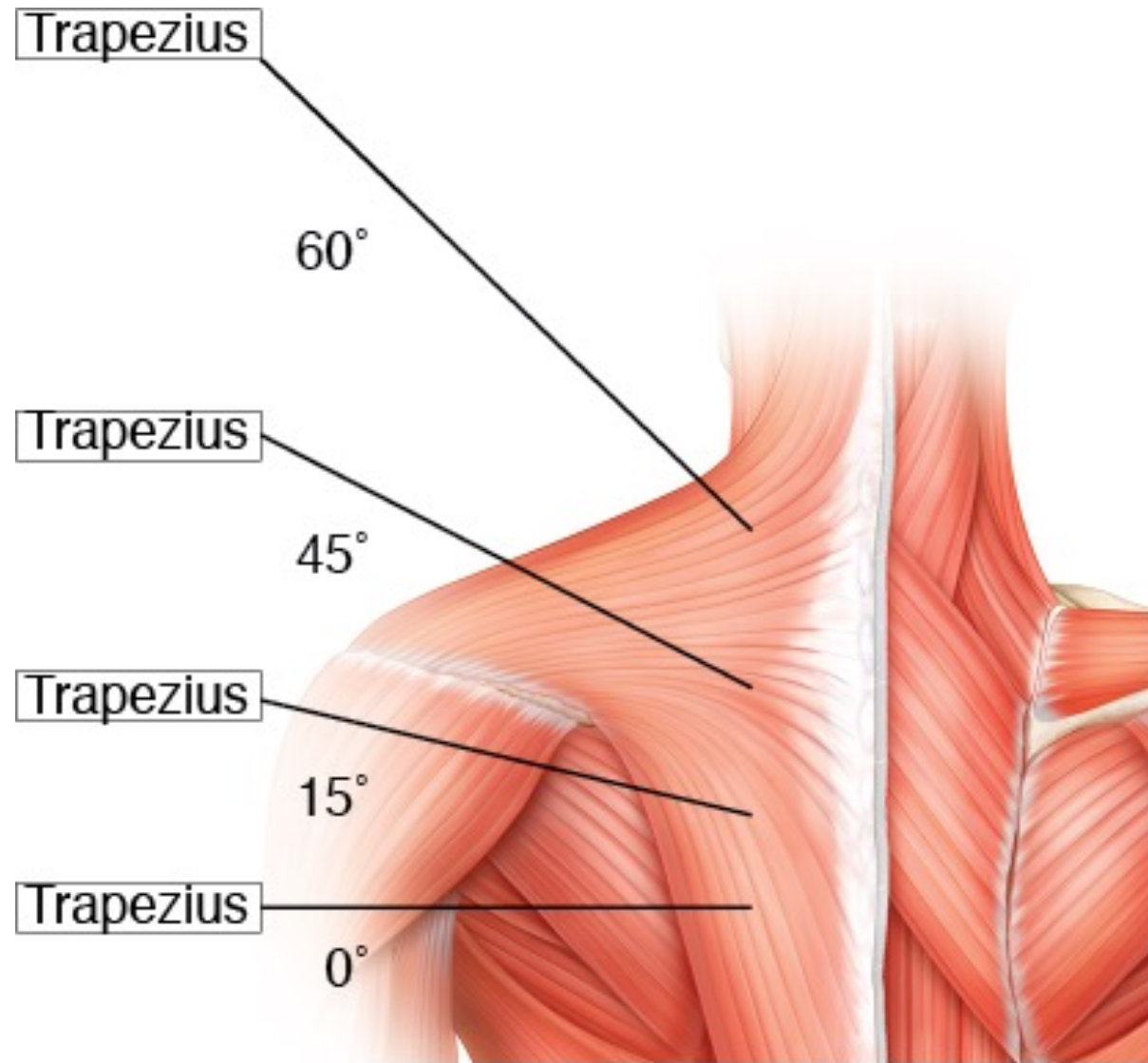
Good Labeling

- **DO** Group like labels



Good Labeling

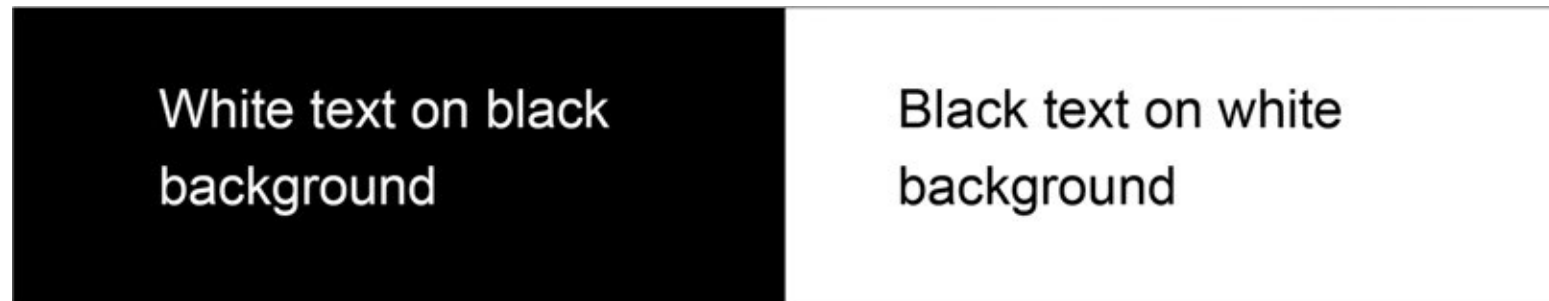
- **DO** point the leader line to the MIDDLE of the word, until you reach 45 degrees and then point to the corner



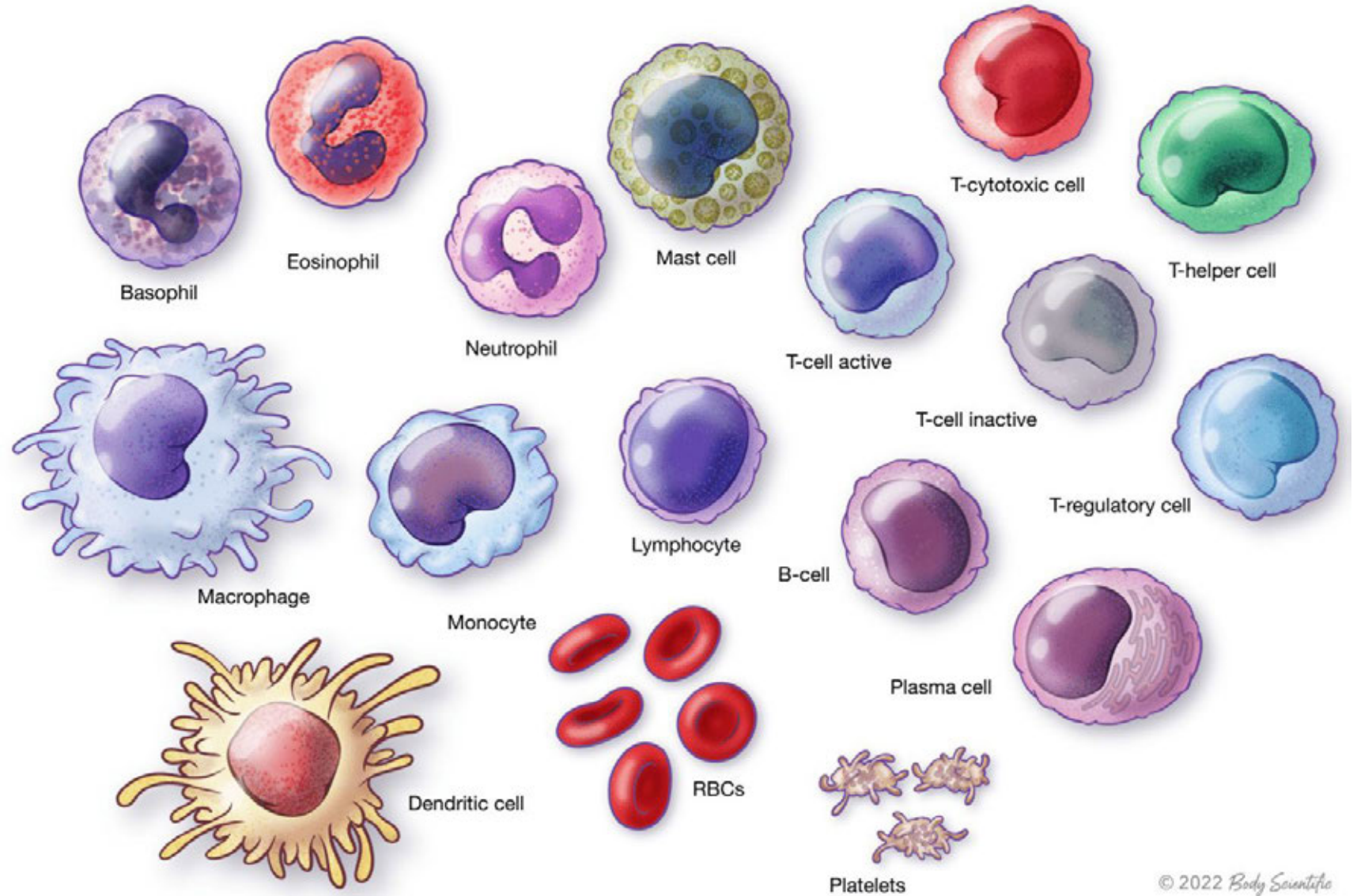


Good Labeling

- **DO** choose high contrast labels
- Web contrast ratio **21:1**



Example



Example

Mast Cell Mediators - Anaphylaxis

Inducible

Lipid Mediators

Platelet activating factor
leukotriene
prostaglandin

Cytokines

IL-4, -5, -6,
-8 and -13
TNF-alpha

Other enzymes

Beta-glucuronidase

Preformed

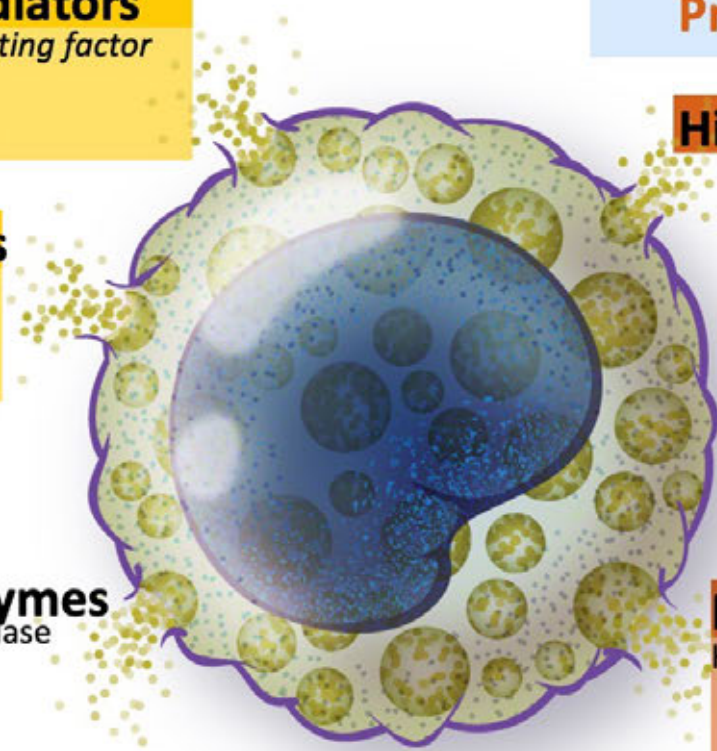
Histamine

Proteases

Tryptase
MMP-9

Proteoglycans

Heparin



Example

Mast Cell Mediators - Anaphylaxis



Inducible

Lipid Mediators

Platelet ac
leukotrien
prostaglan

Cytokini

IL-4, -5, -6,
-8 and -1
TNF-alpha

Other e
Beta-glucur

Foreground Color

#F8CF00



Lightness



Contrast Ratio

4.04:1

[permalink](#)

Normal Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

Preformed

Background Color

#2461B4



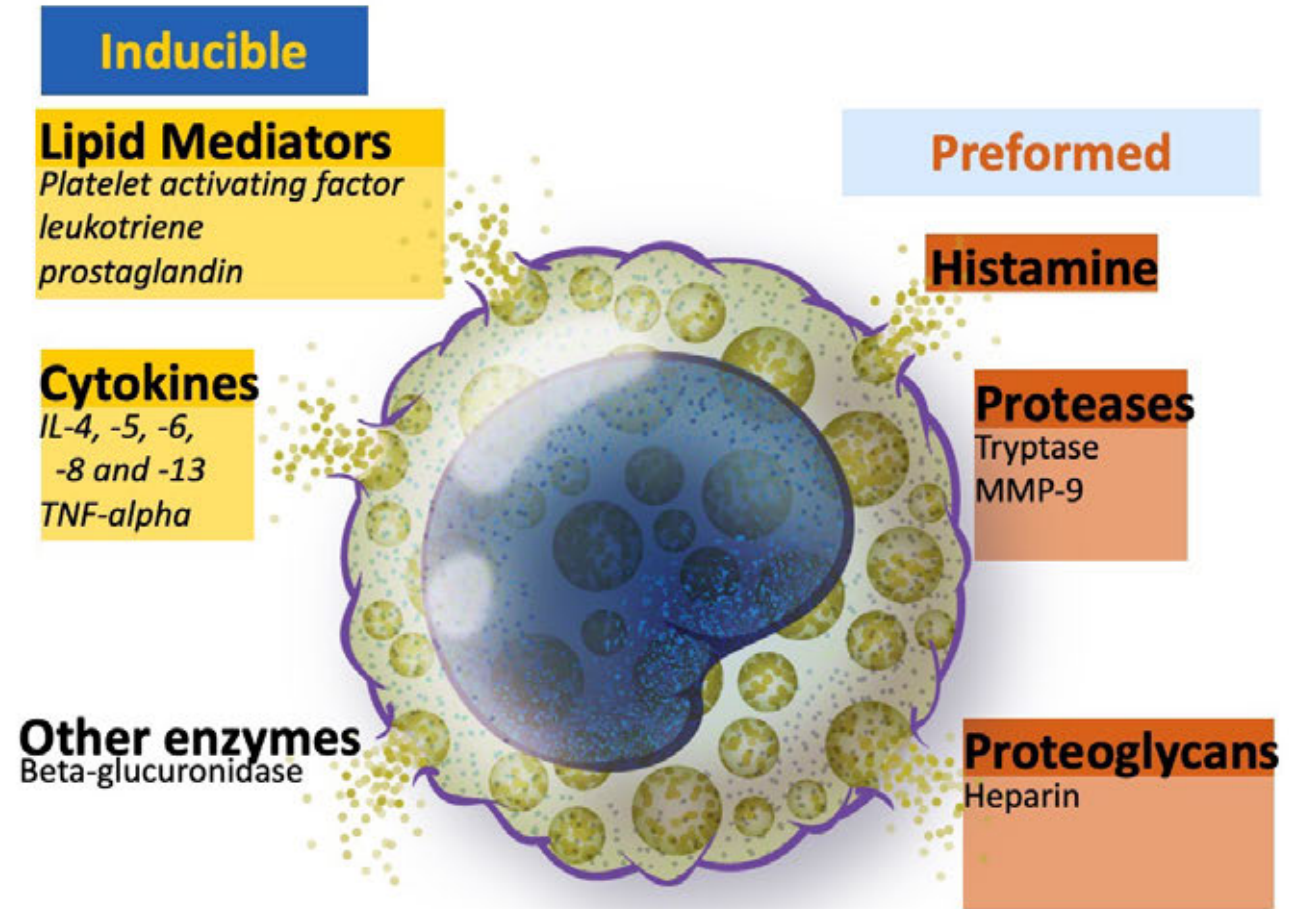
Lightness



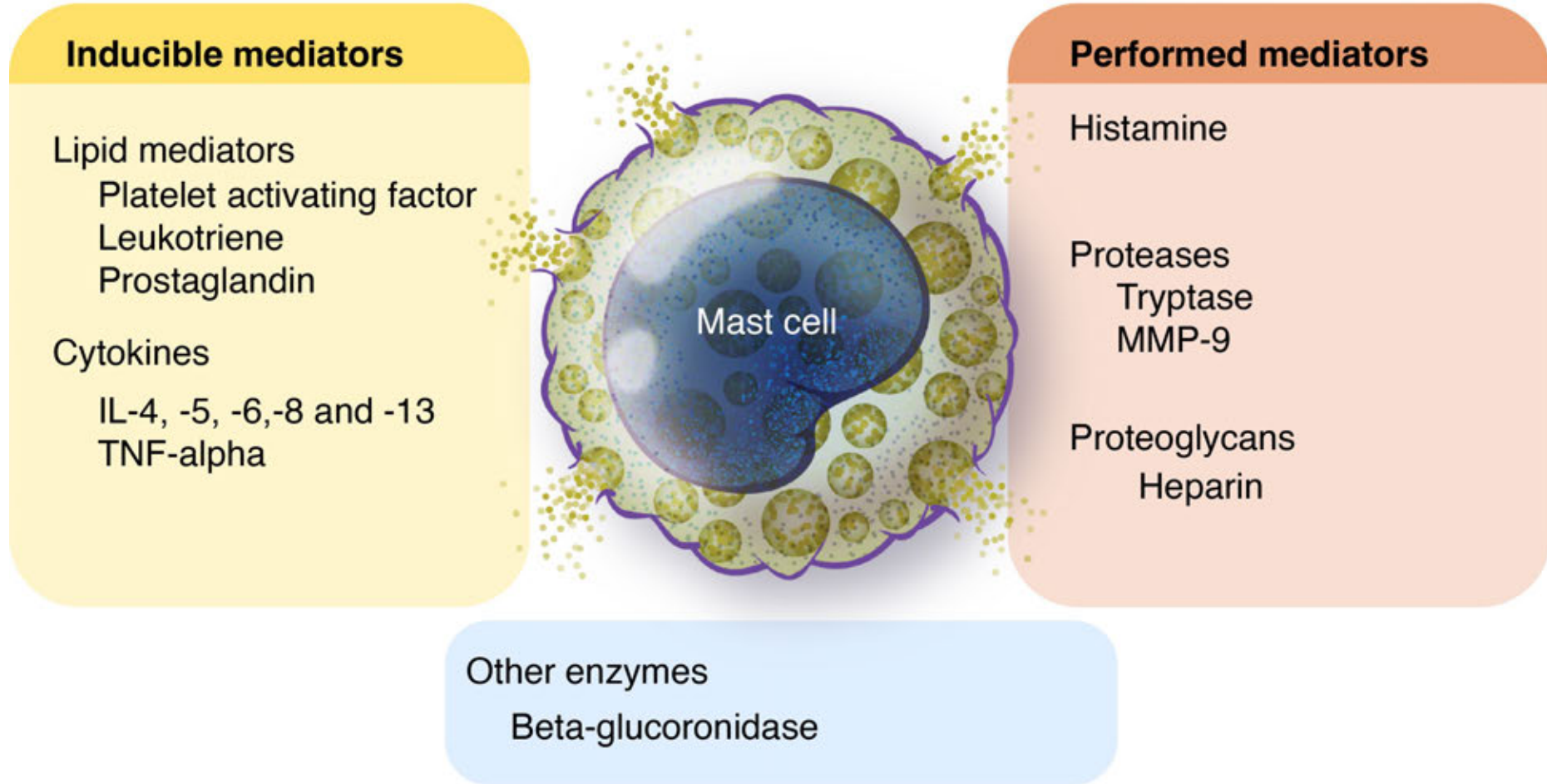
The five boxing wizards jump quickly.

Example

Mast Cell Mediators - Anaphylaxis



Anaphalaxis



Avoid unnecessary labels

DON'T

Know your audience and purpose?

- What is needed? What is superfluous?

MÉNIÈRE'S DISEASE

Ménière's disease (MD, or endolymphatic hydrops) is an inner ear condition that arises idiopathically and is normally followed by repeated cases of symptoms such as vertigo, tinnitus, and hearing loss, and aural fullness. While risk factors and pathophysiology of this disease are still being discovered, MD is understood to result from a build up of pressure and inflammation in the cochlea, semicircular canals, utricle, and saccule.

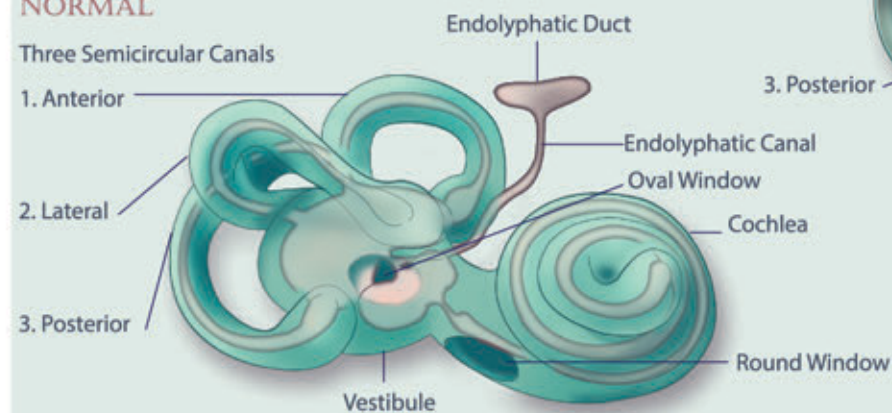
NORMAL

Three Semicircular Canals

1. Anterior

2. Lateral

3. Posterior



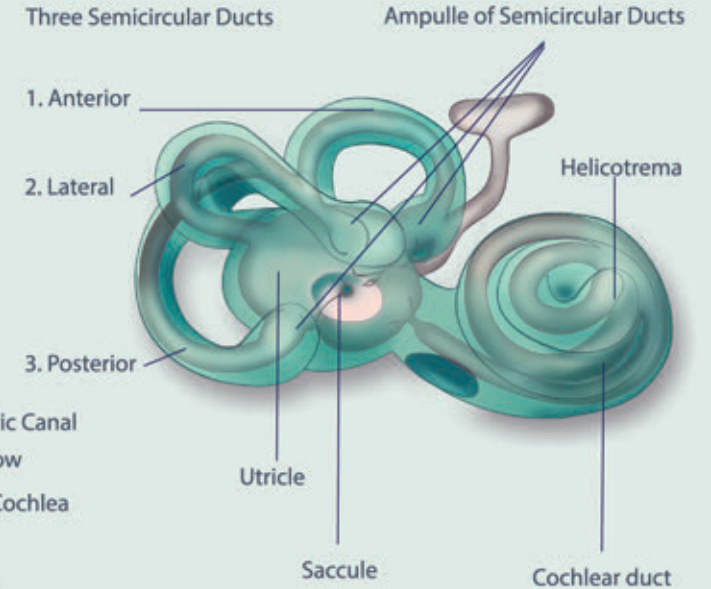
DISEASED

Three Semicircular Ducts

1. Anterior

2. Lateral

3. Posterior



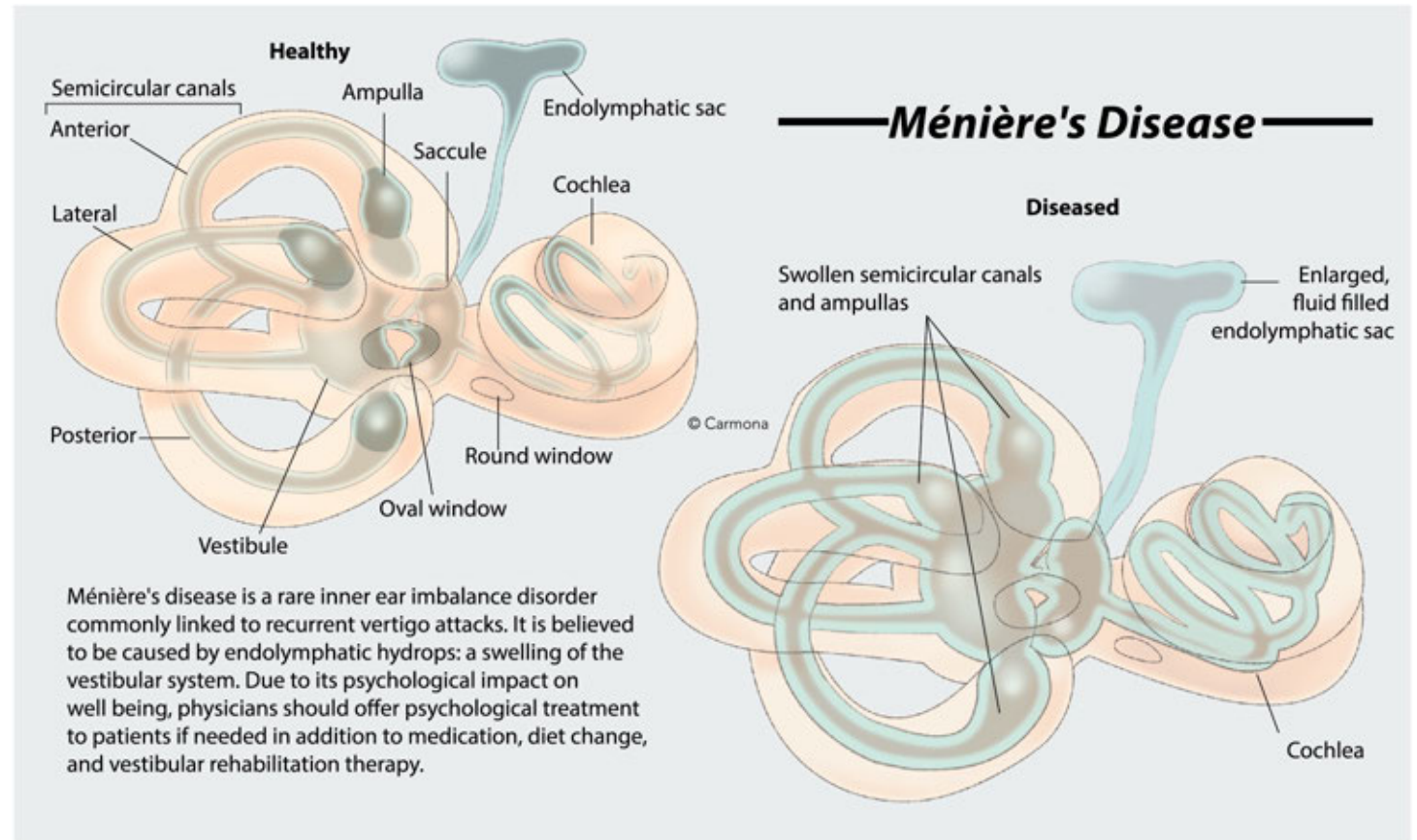
©Suleman

Avoid unnecessary labels

DON'T

Know your audience and purpose?

- What is needed? What is superfluous?

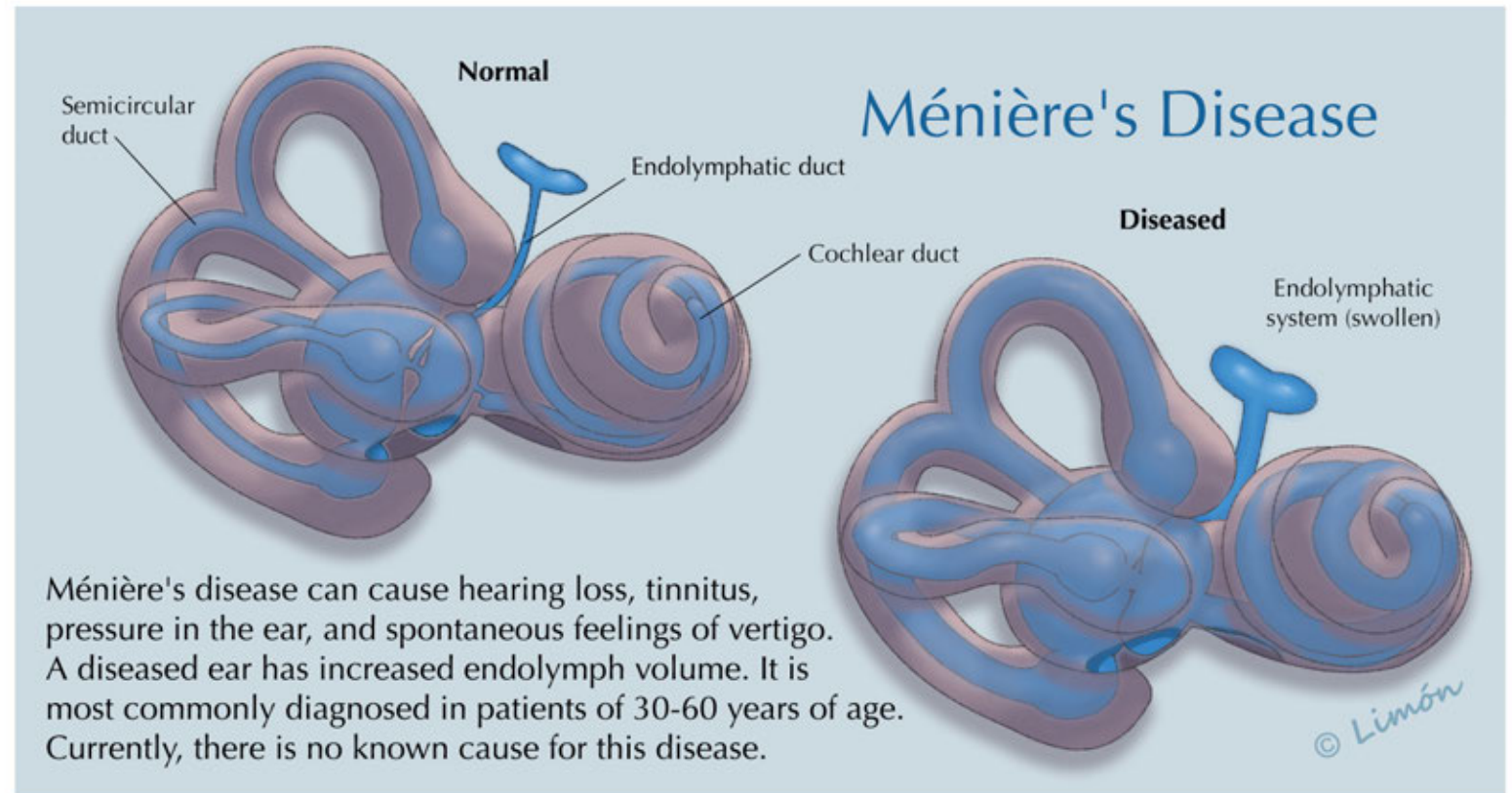


Avoid unnecessary labels

DO

Know your audience and purpose?

- What is needed? What is superfluous?



Arrows

What is the most popular arrow head?

Arrow 1



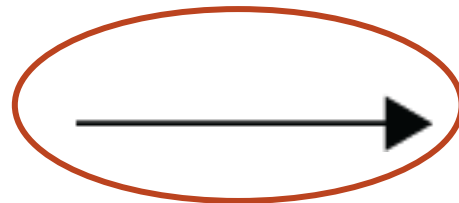
Arrow 2



Arrow 3



Arrow 4



“Next”



Arrow 5



Arrow 6

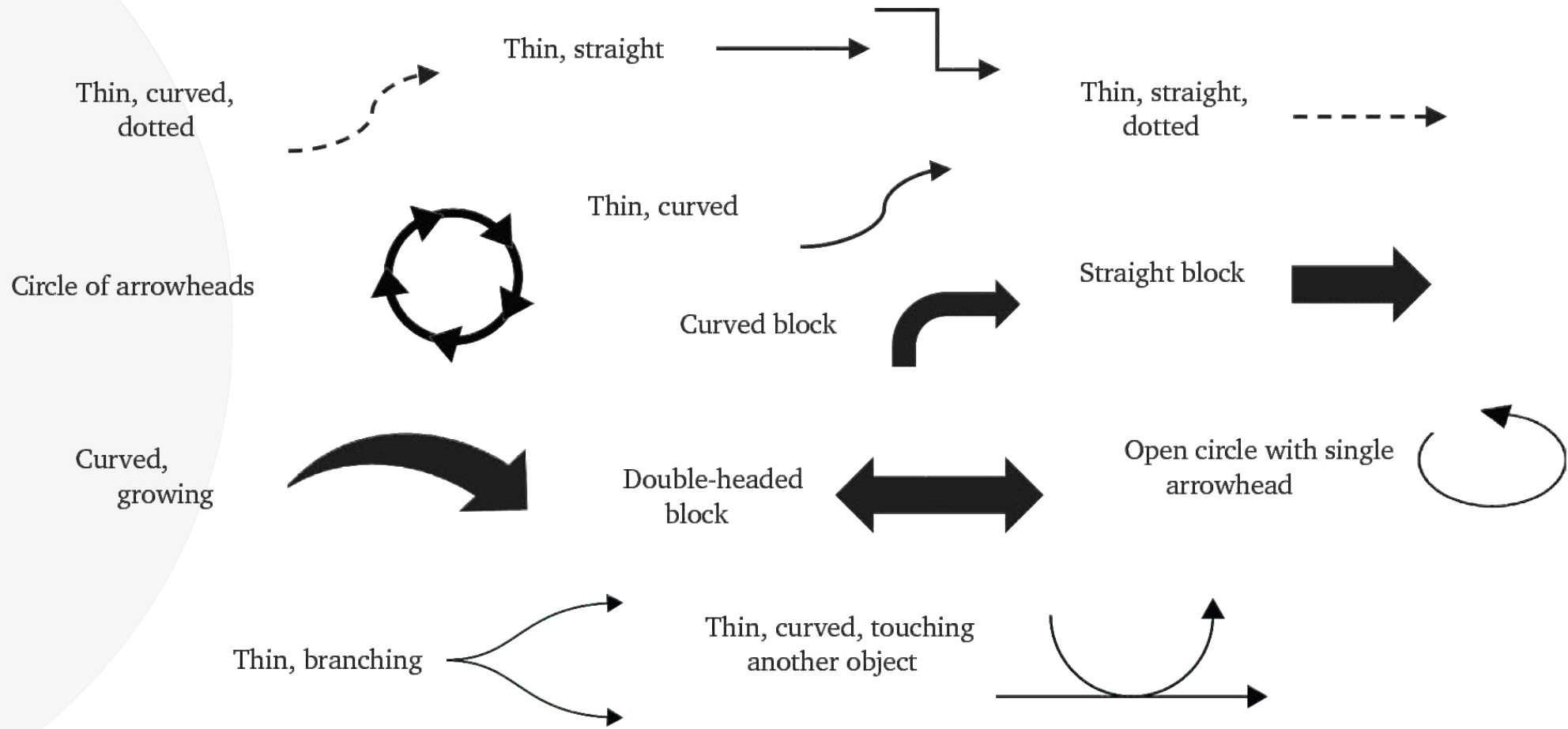


Arrow 7



Arrow 8

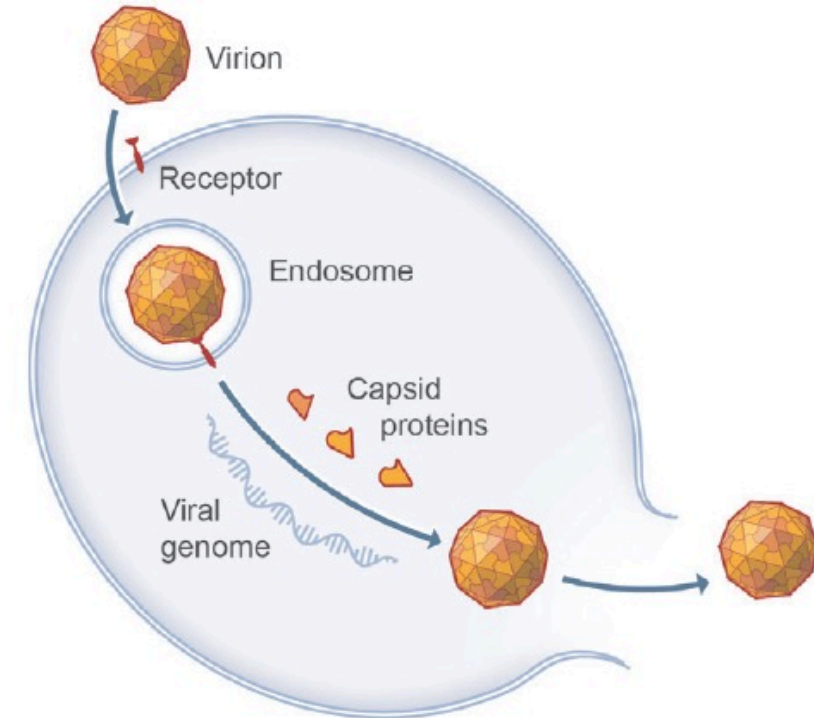
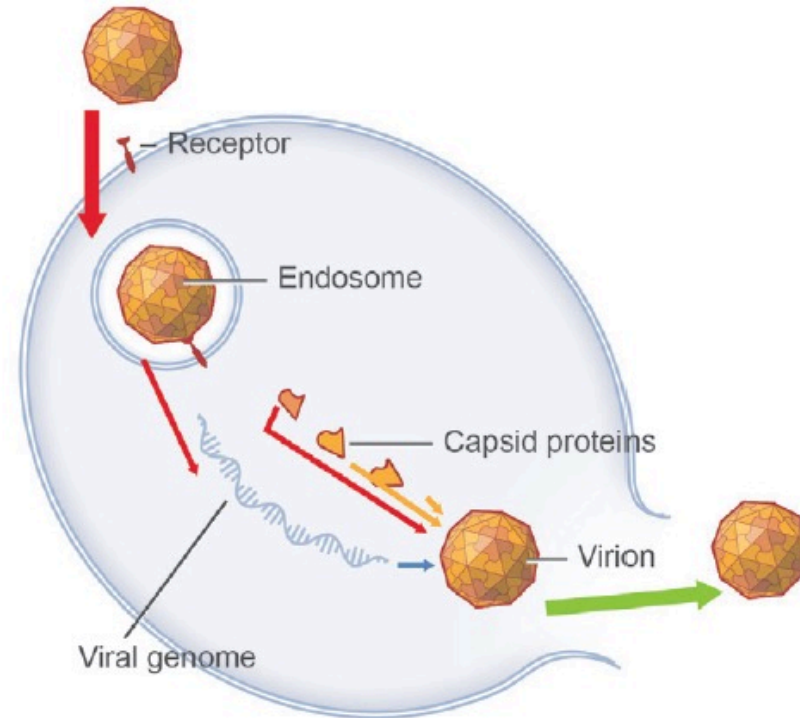
Arrows



Directionality of Arrows

Guide the readers through steps

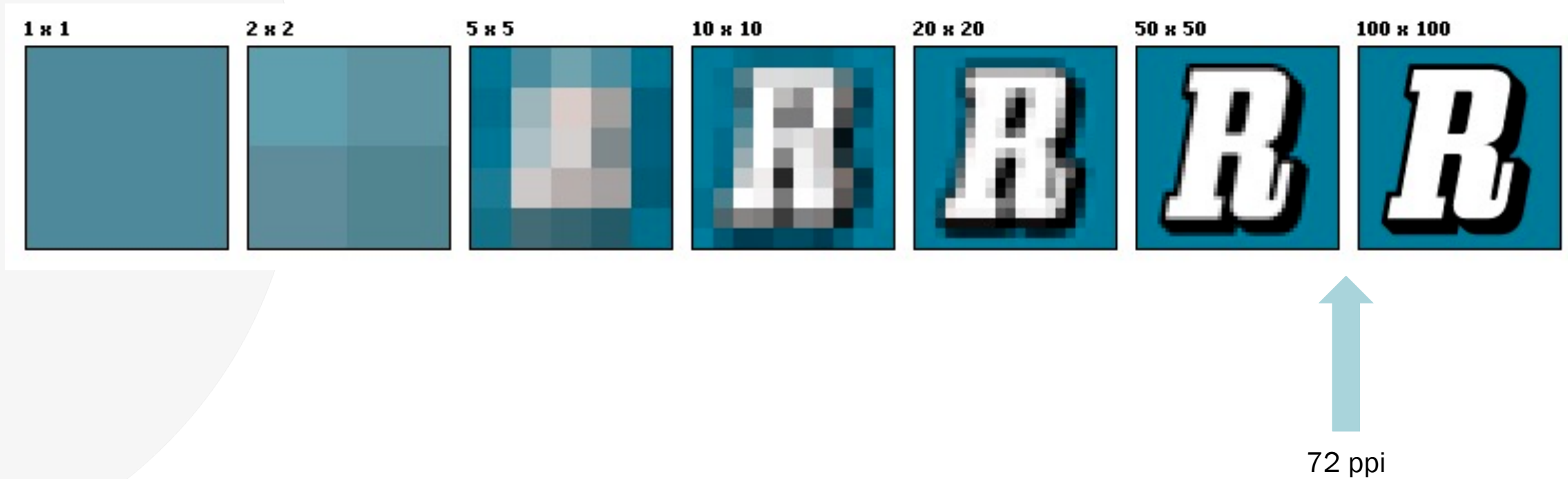
- End of an arrow aligned with the start of a new one
- Can you merge any arrows – are all arrows needed?
- Choose neutral arrows, brightly colored arrows compete with the salience of the illustration





Resolution

Screen 72 ppi



https://en.wikipedia.org/wiki/Image_resolution

Resolution

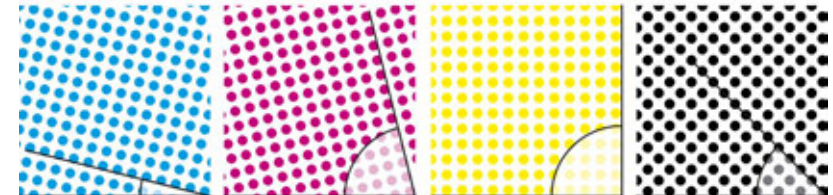
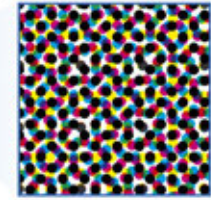
Print 300 ppi



35% C, 35% M, 35% Y, 35% K



Round halftone dots, standard angles



Cyan 15°

Magenta 75°

Yellow 90°

Black 45°

← 300 dpi

<https://www.bigacrylic.com/what-is-dpi-printing-on-metal-and-acrylic/>

Resolution

Where to start?

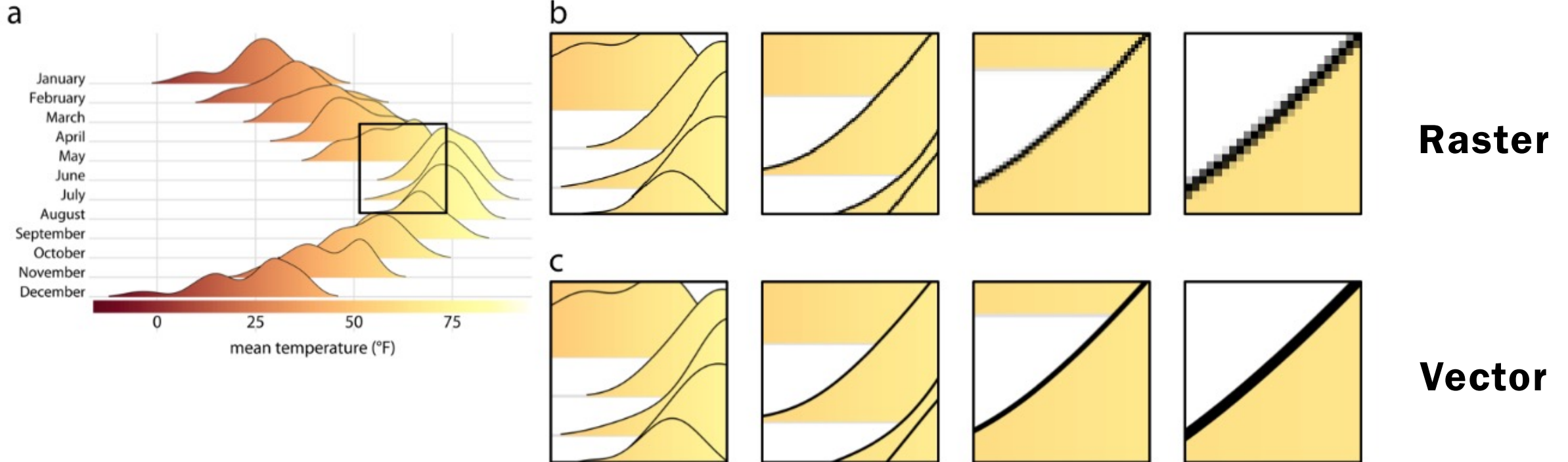
300 ppi

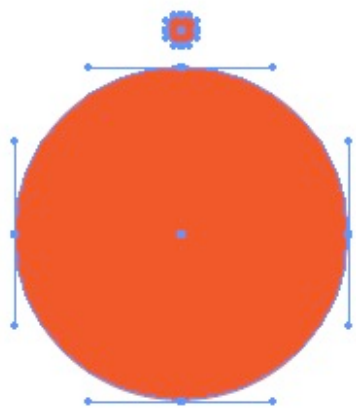
Dimension: Half or Full page

Resolution: 300 ppi

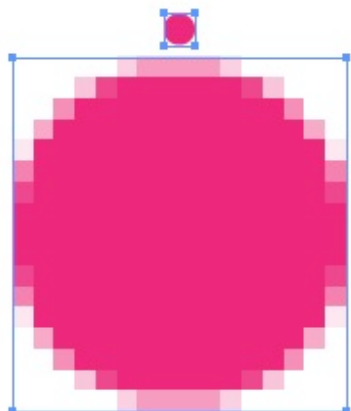


Type of Graphic

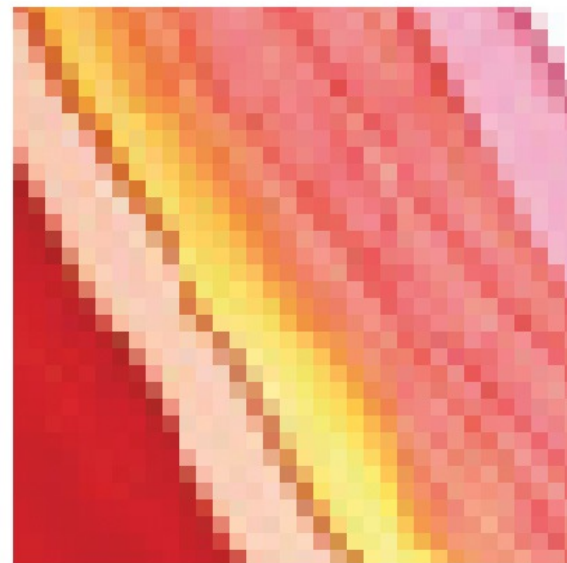
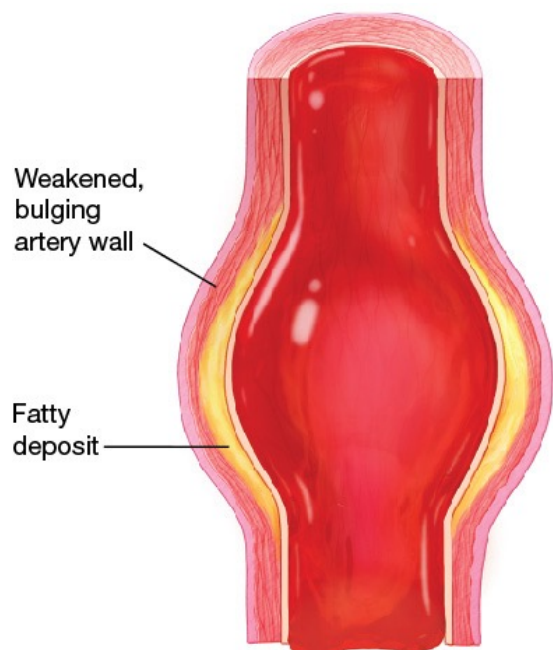




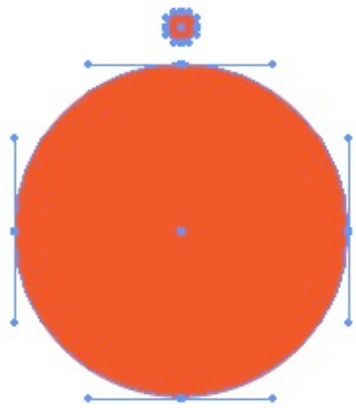
VECTOR



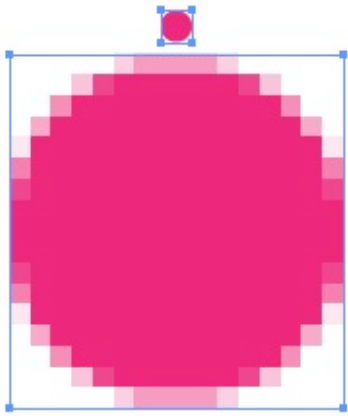
RASTER



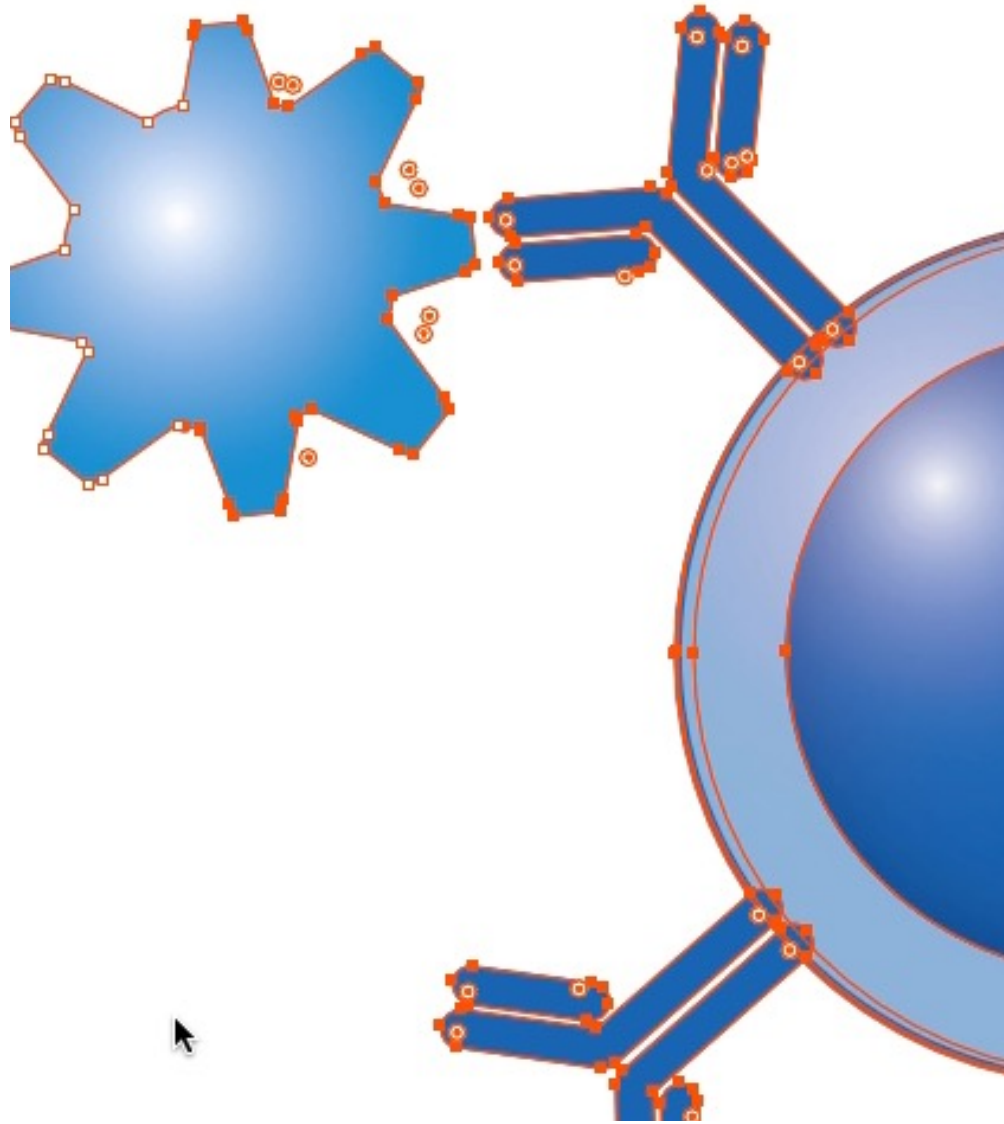
Raster



VECTOR



RASTER

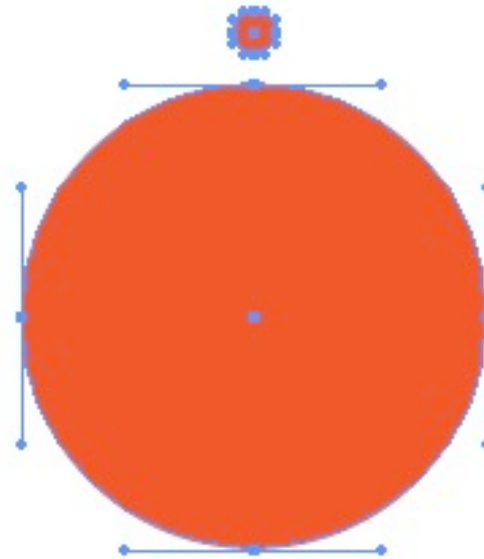


Vector

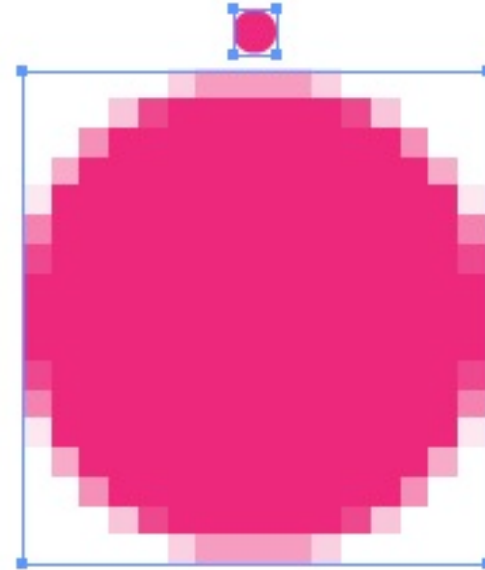
File Format?

SVG

EPS



VECTOR



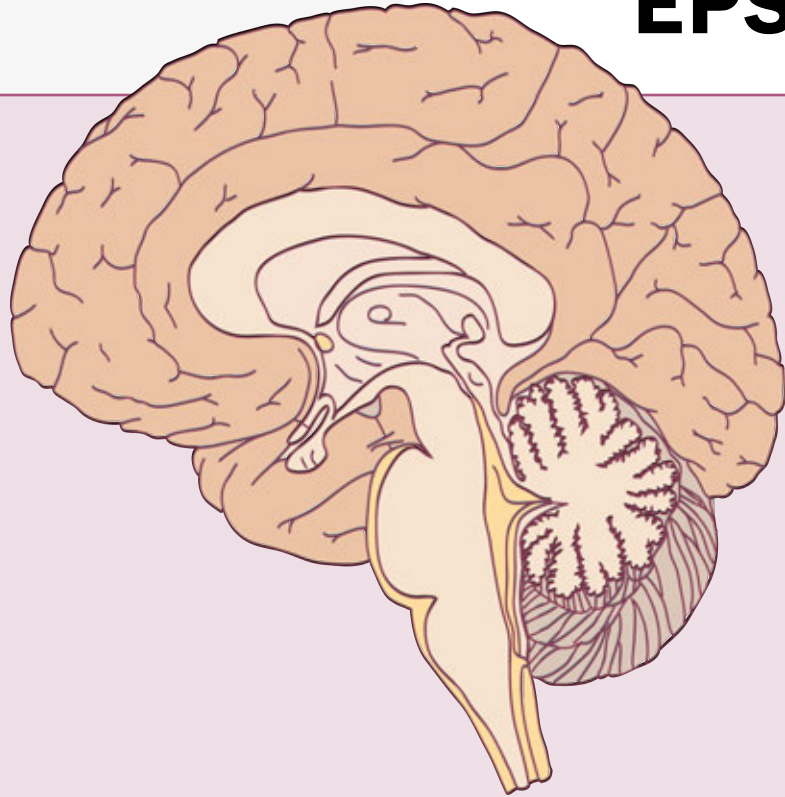
RASTER

JPG

PNG

File Format?

SVG
EPS



PNG



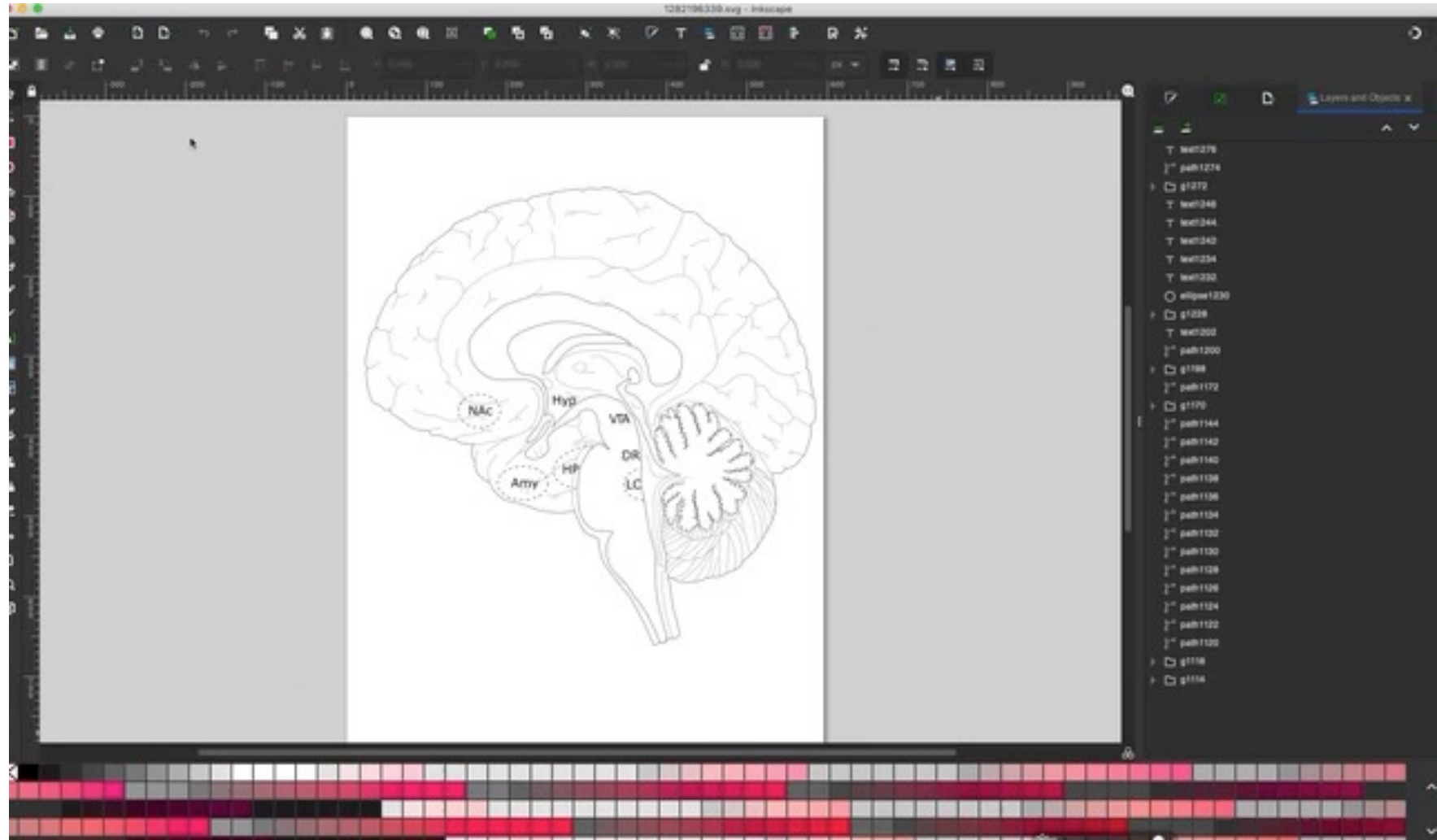
JPG



Vector

Vector art is editable!

- Add fill color
- Change stroke weight
- Delete labels

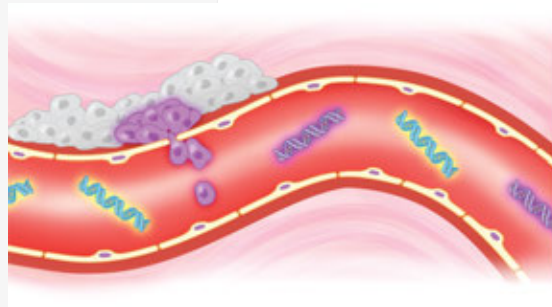




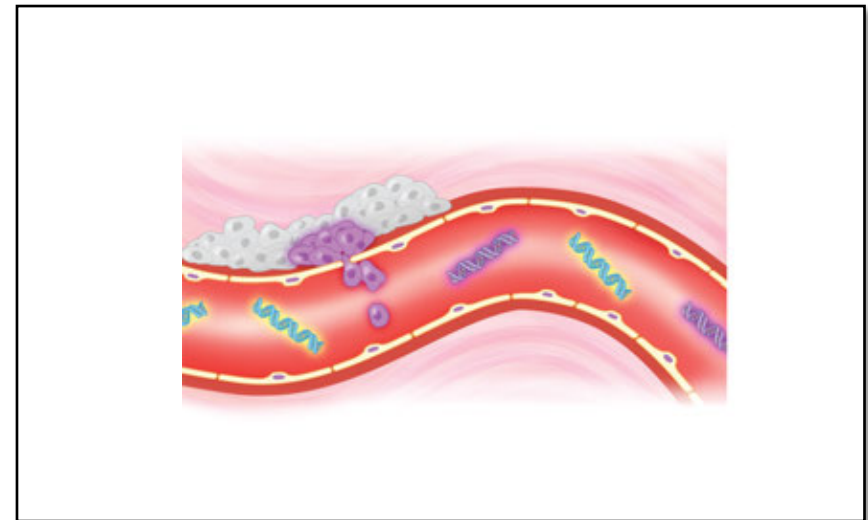
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Google



Copy + Paste



Copyright Infringement

Example

- Up to \$150,000 per willful infringement
- Illustrator 33 illustrations, registers in 2 “groups”
- Offender \$300,000
- Defendant \$3.6 Million



© Amy Sullivan

Amy Sullivan vs Flora

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Free scientific images



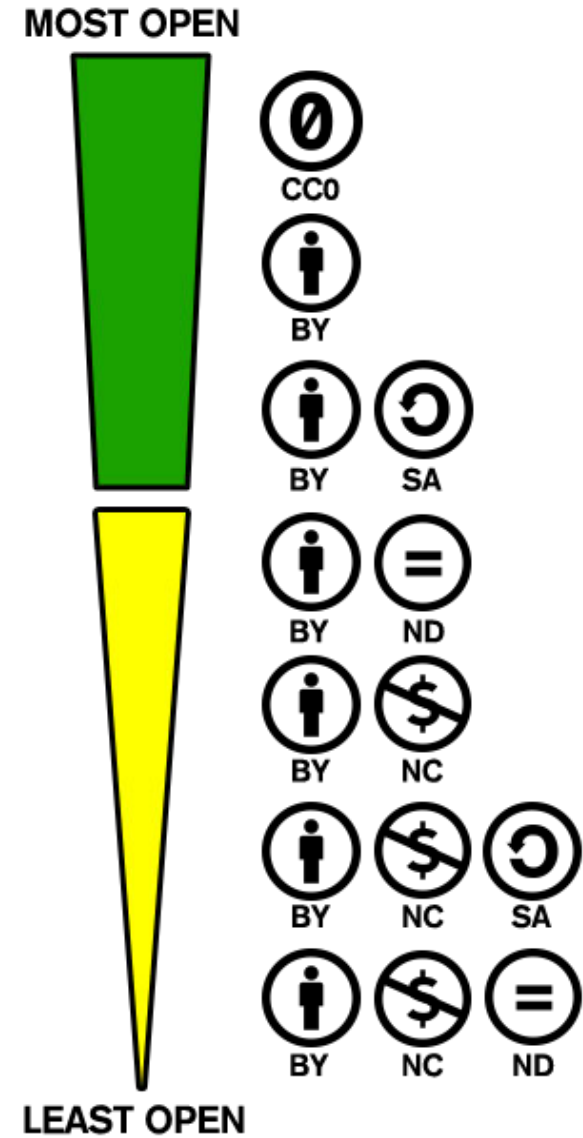
Google Search

I'm Feeling Lucky

Creative Commons

Most Artists Want Attribution

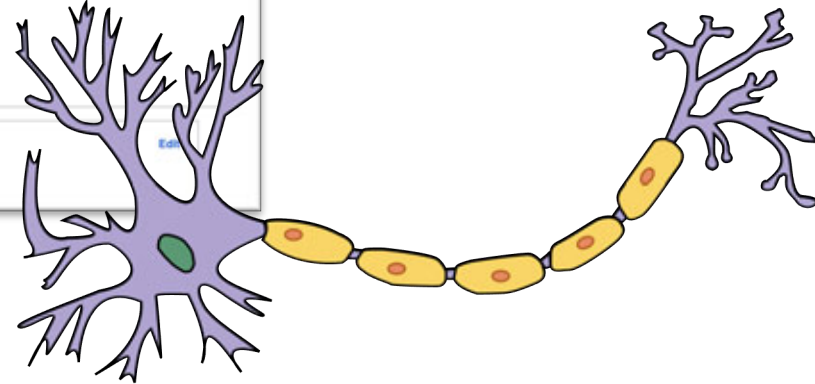
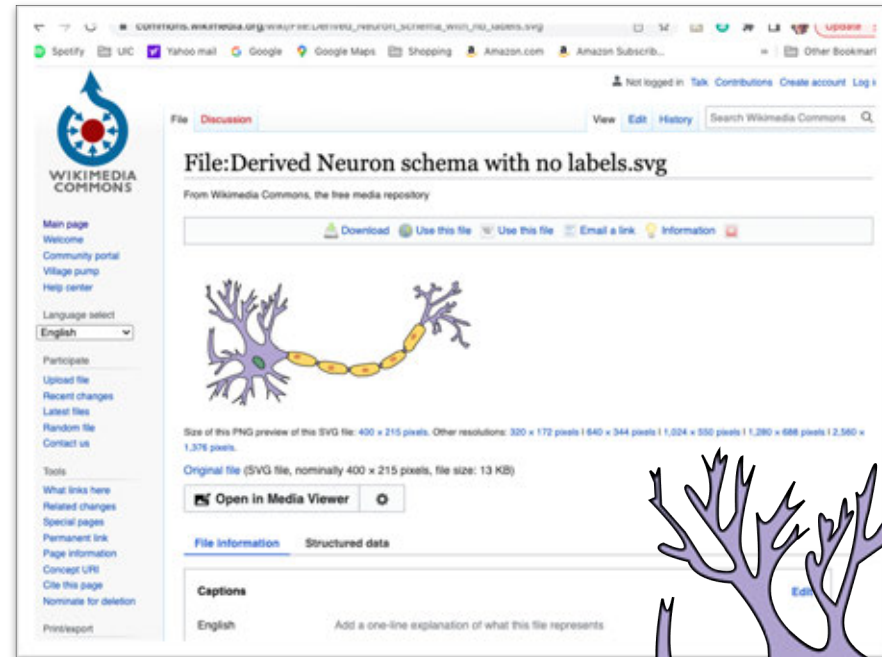
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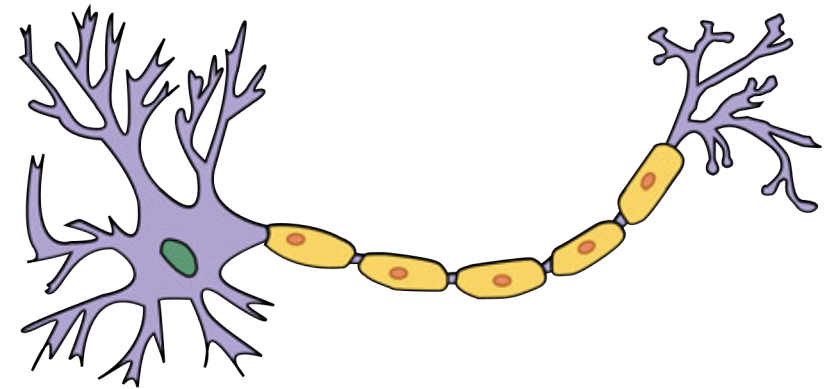
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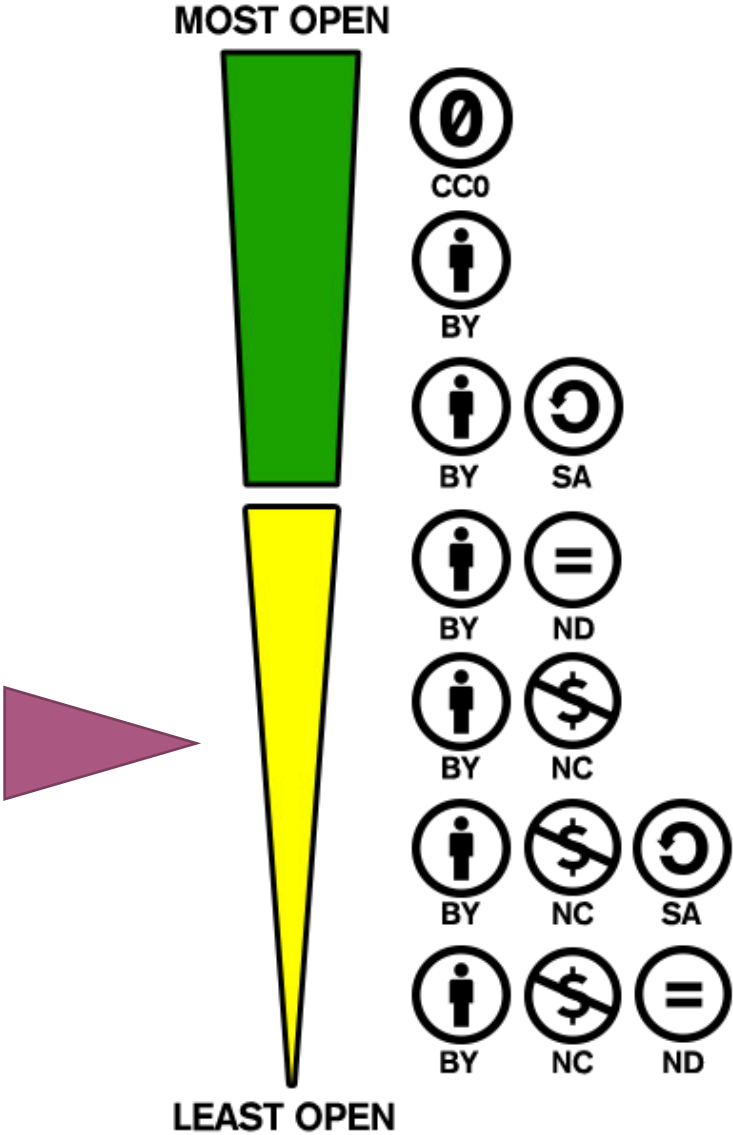


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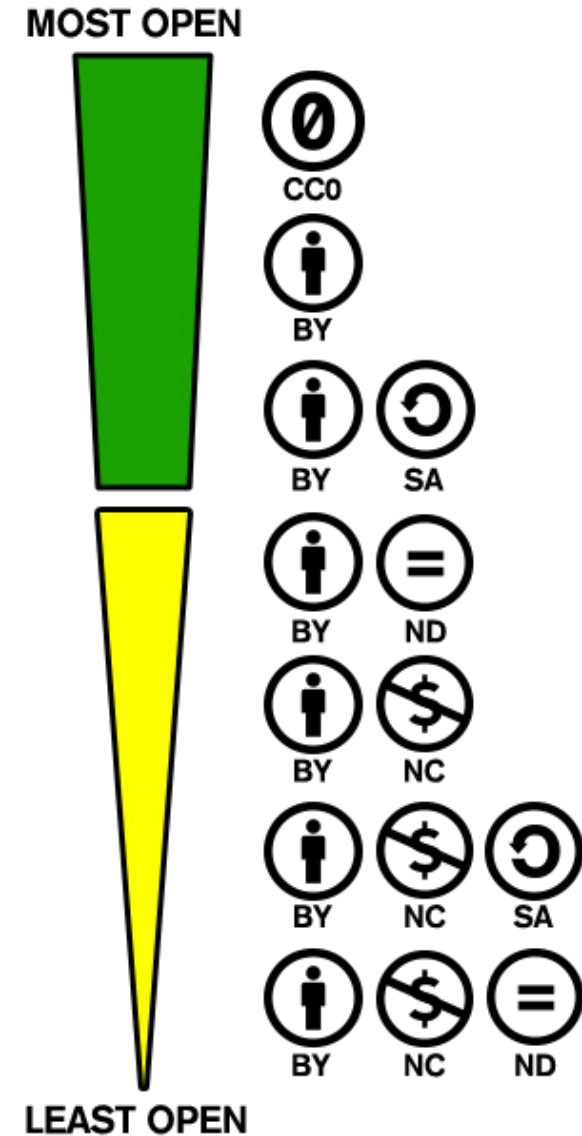
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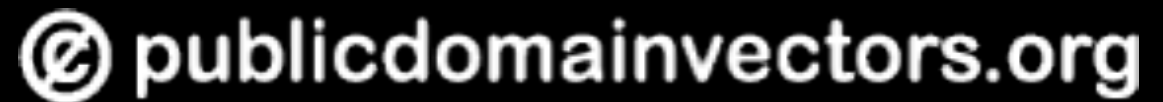


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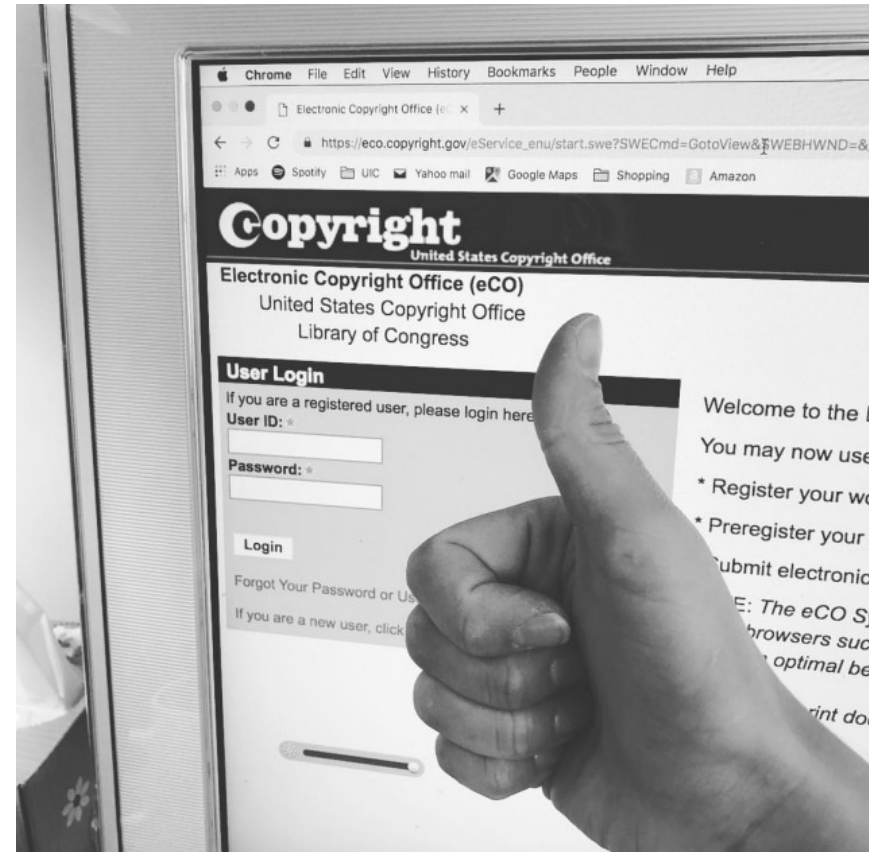


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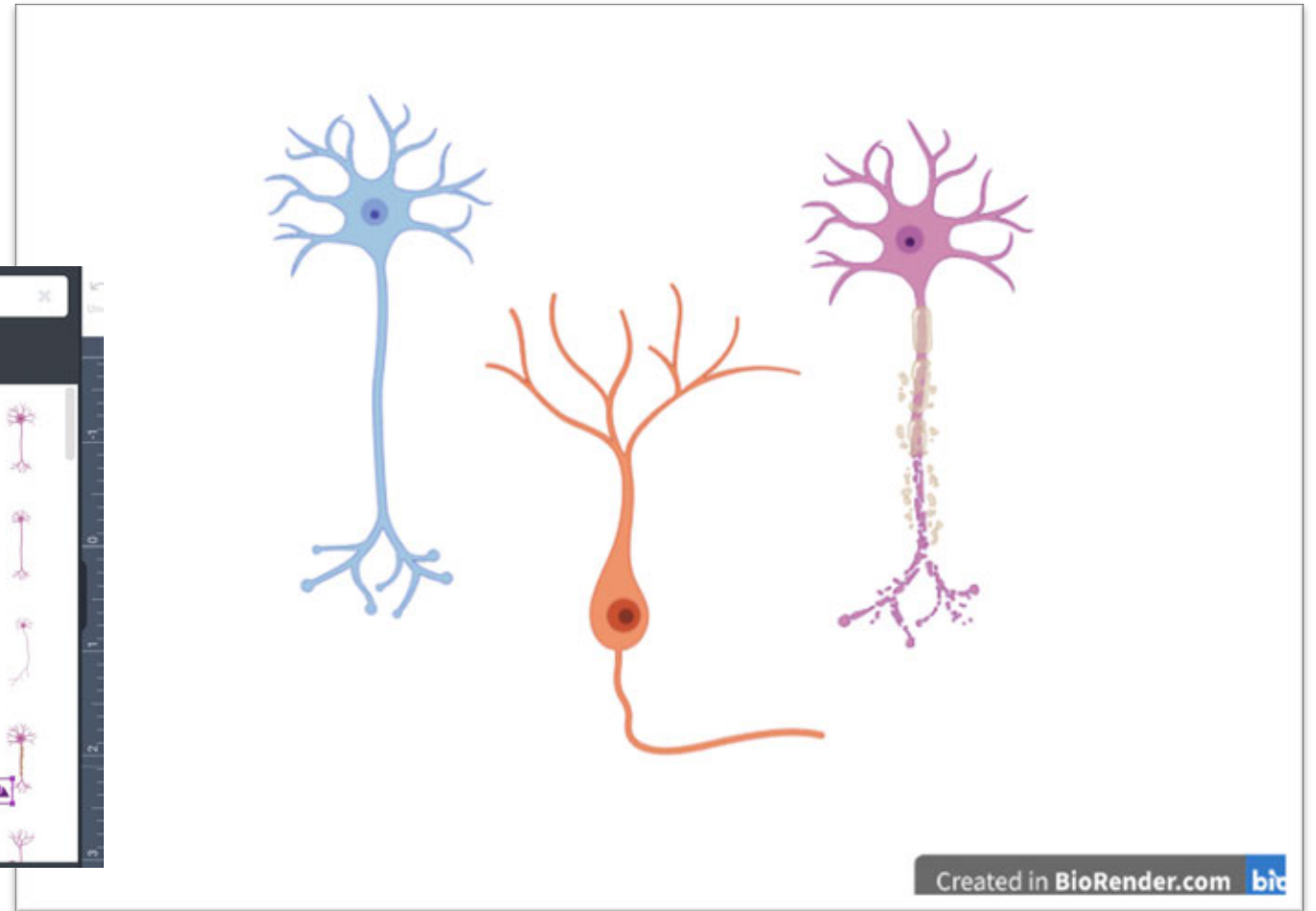
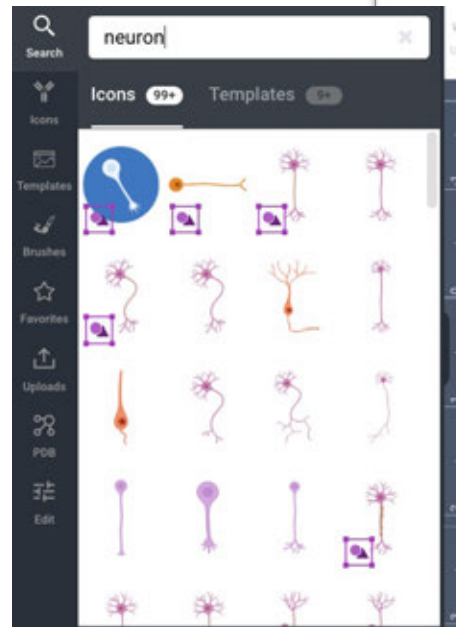


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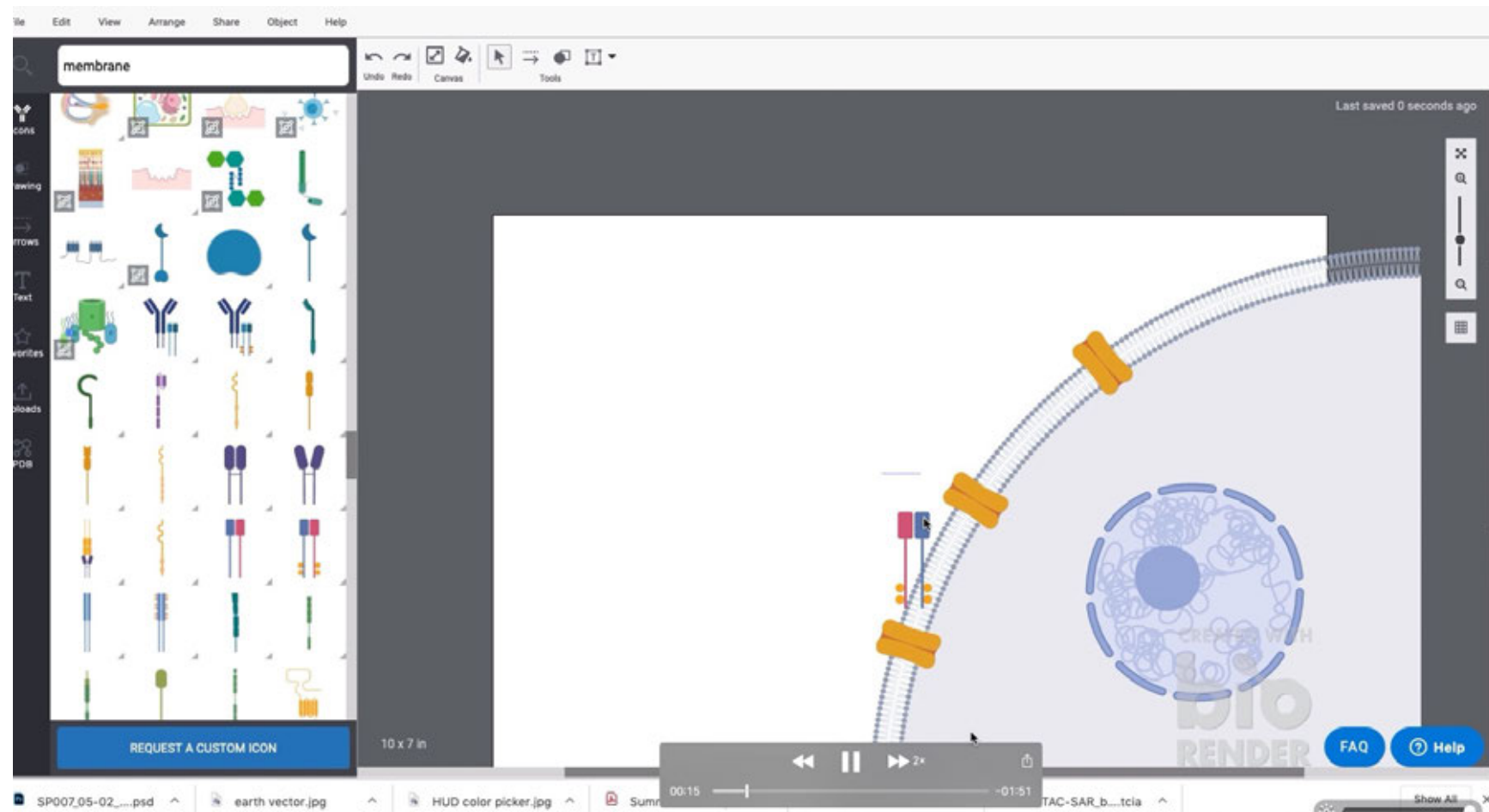
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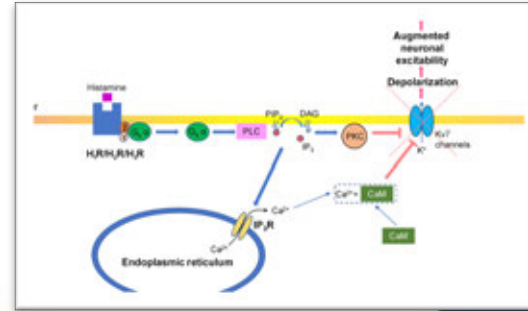


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Thank you!

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