



**DATA
SCIENCE**

Data Visualization using matplotlib

Bruno Gonçalves

www.bgoncalves.com

<https://bmtgoncalves.github.io/DataVisualization/>





**DATA
SCIENCE**

Data V

Bruno G

www.bgo

<https://bmo>

JPMORGAN
CHASE & CO.

using matplotlib

<https://bmo.io/DataVisualization/>



JPMORGAN
CHASE & CO.

Data Visualization using matplotlib

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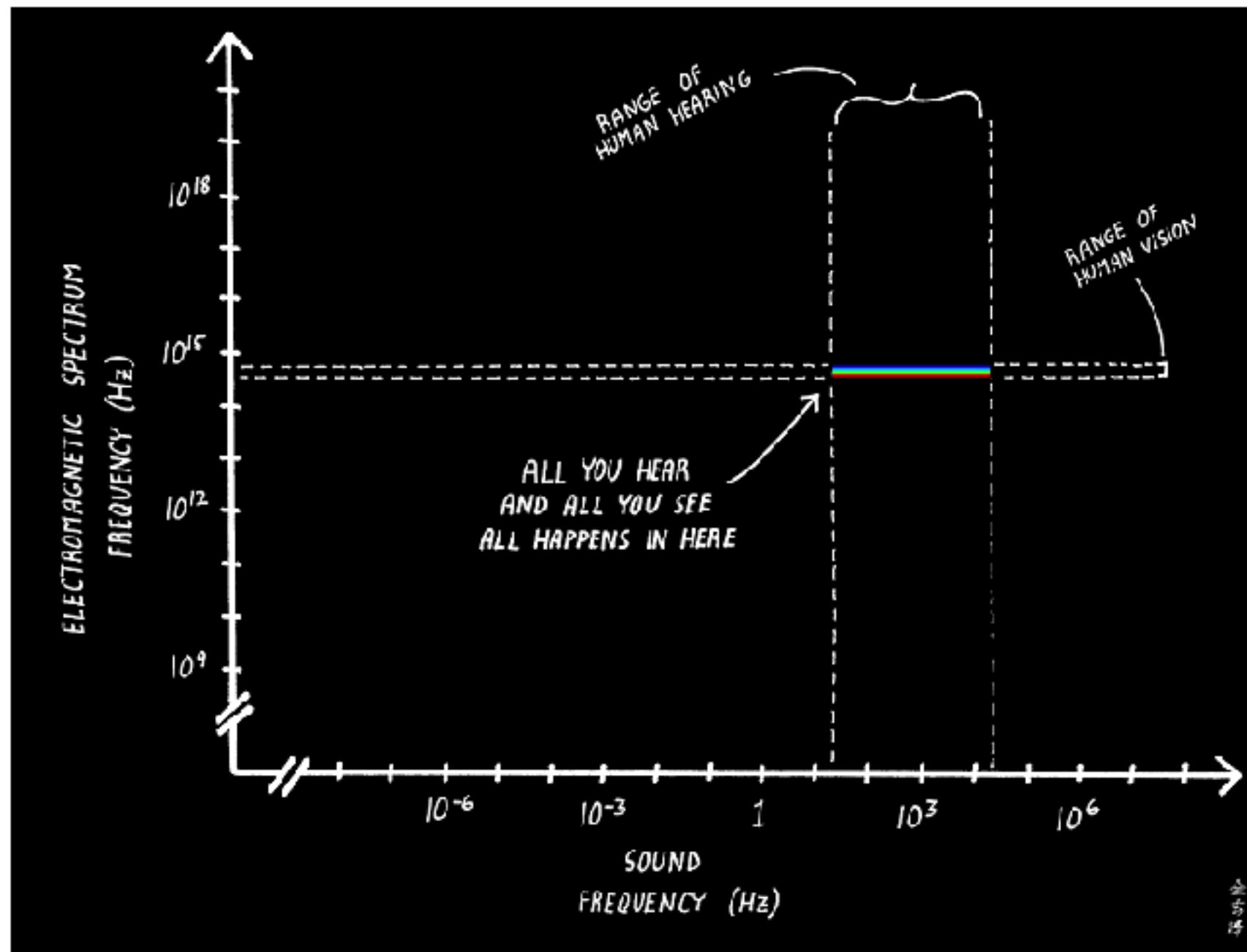
Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of my employer. The examples provided with this tutorial were chosen for their didactic value and are not mean to be representative of my day to day work.

Human Perception

Human Perception

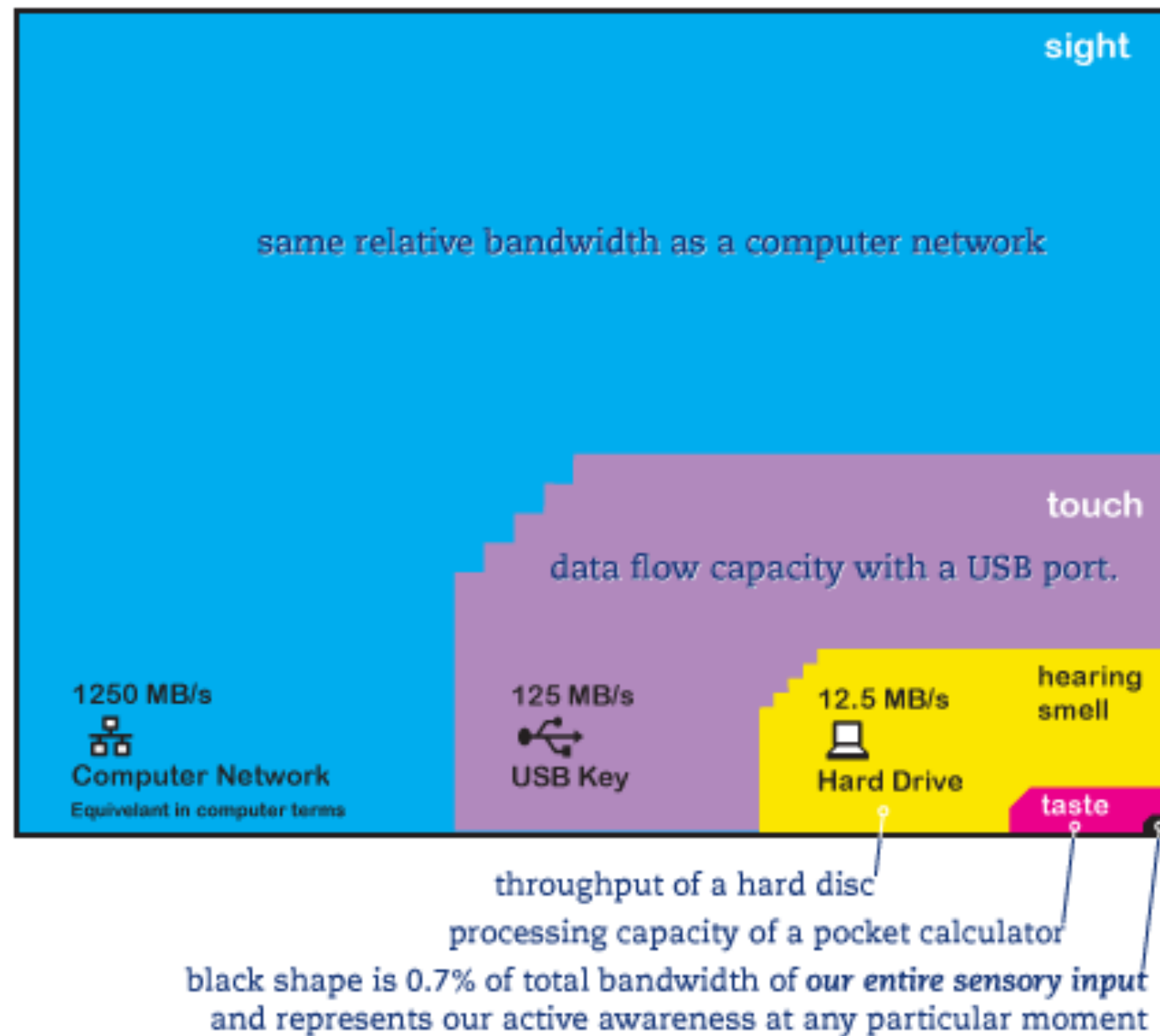
<http://abstrusegoose.com/421>



In the grand scheme of things,
we're all pretty much blind and deaf.

Human Senses

NØRRETRANDERS BANDWIDTH OF THE SENSES

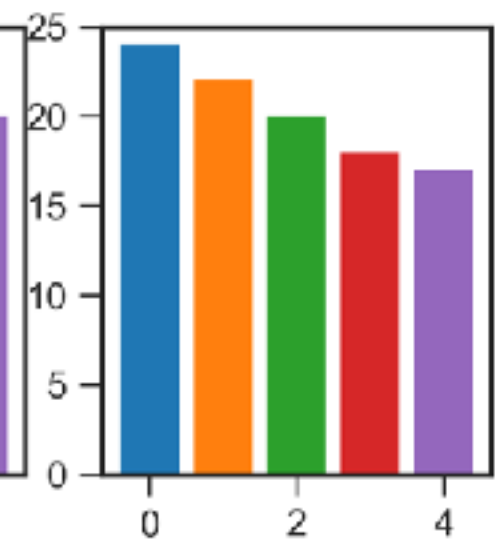
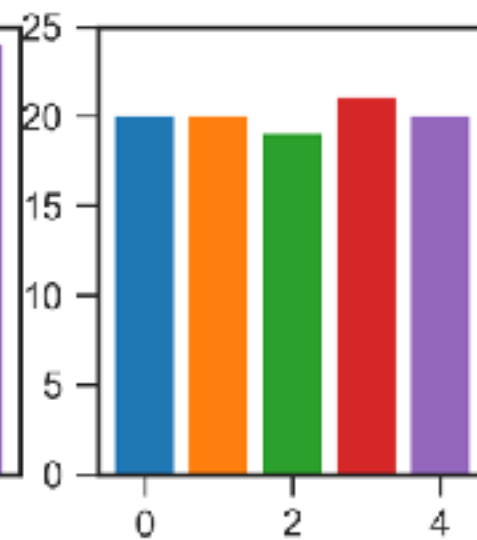
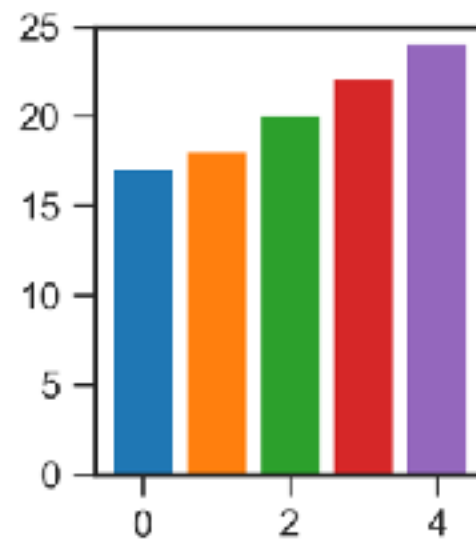
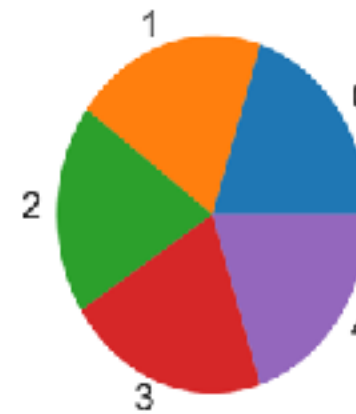


Source: <http://chitownmediapsych.blogspot.ie/2010/09/context-will-be-king-working-title.html>

²David McCandless : Information Is Beautiful

Perception

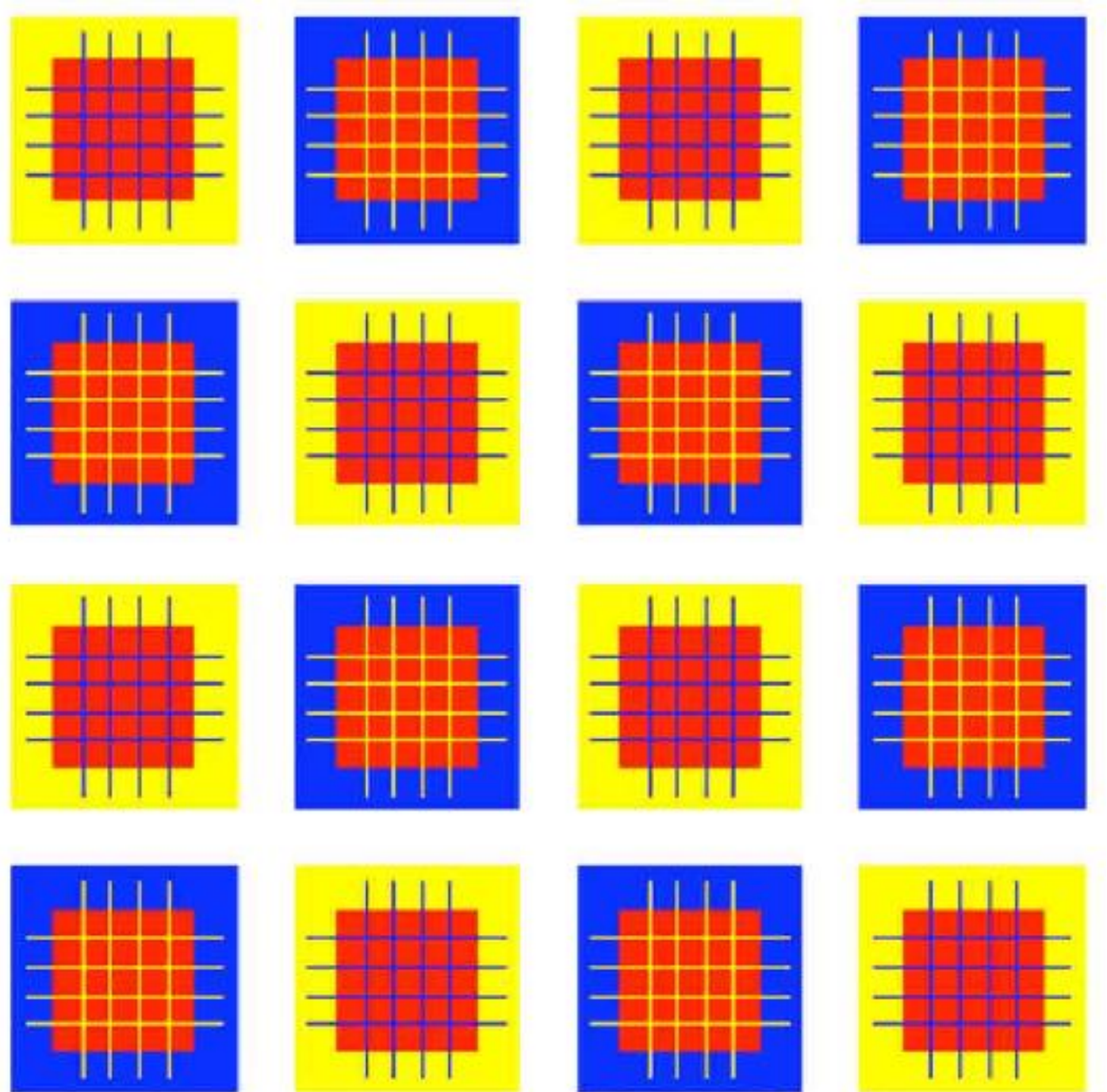
- Some cognitive tasks are significantly easier than others. In order, we are good at distinguishing:
 - Position, length
 - Direction, Angle, Area
 - Volume, Curvature, Shade



Perception

- Some cognitive tasks are significantly easier than others. In order, we are good at distinguishing:

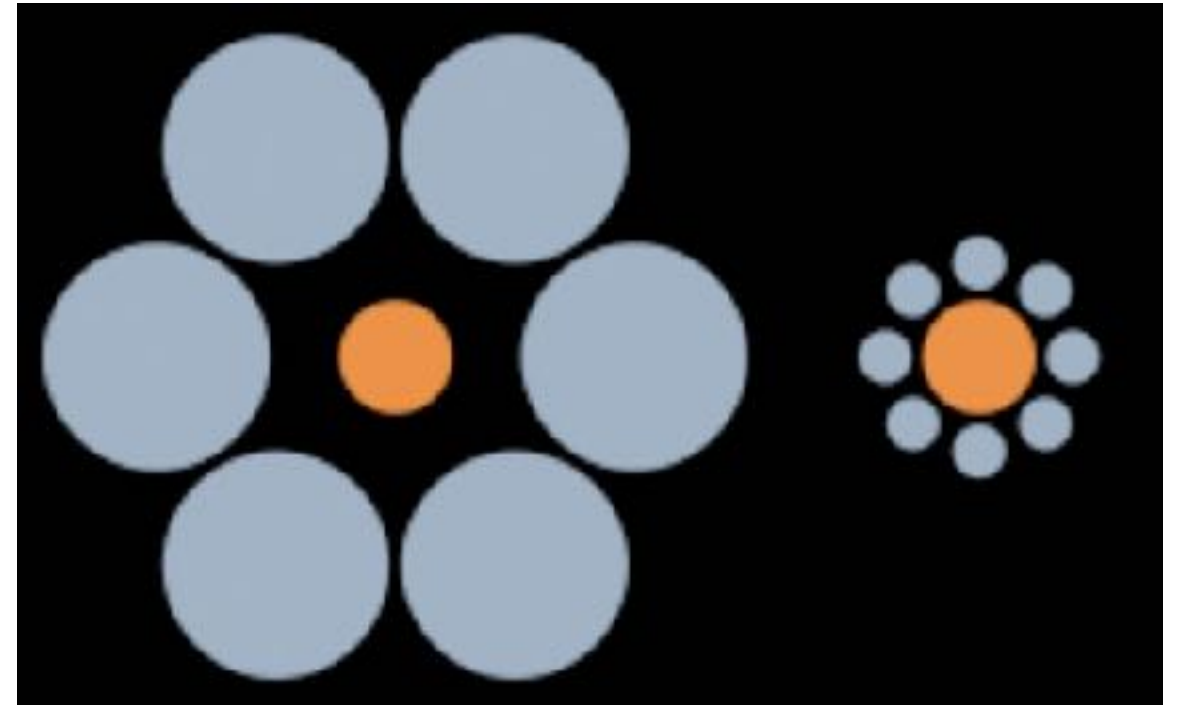
- Position, length
- Direction, Angle, Area
- Volume, Curvature, Shade
- Color Saturation.



Perception

- Some cognitive tasks are significantly easier than others. In order, we are good at distinguishing:

- Position, length
- Direction, Angle, Area
- Volume, Curvature, Shade
- Color Saturation.
- Context also matters!



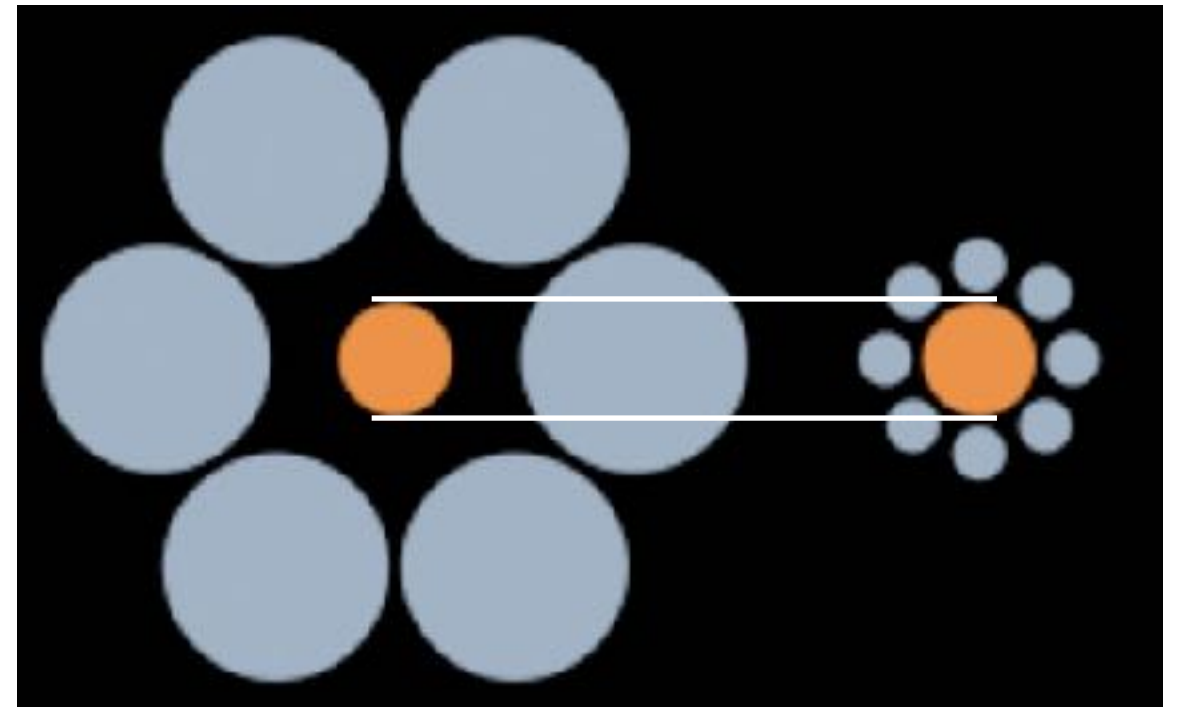
- An object seen in the context of larger objects will appear smaller, while in the content of smaller objects it will appear larger.



Perception

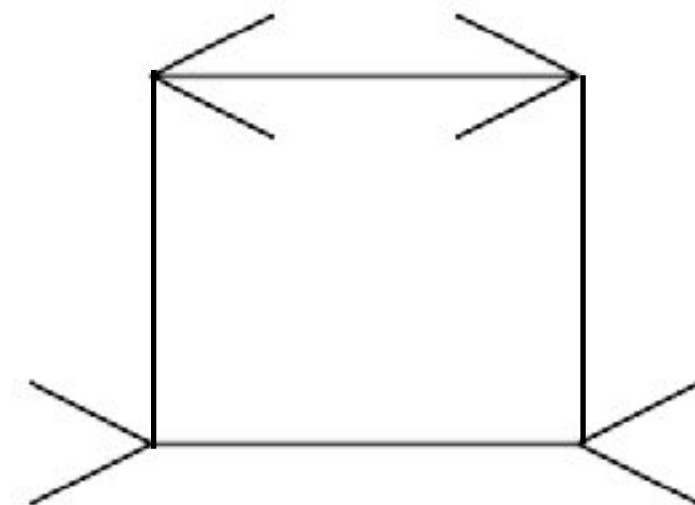
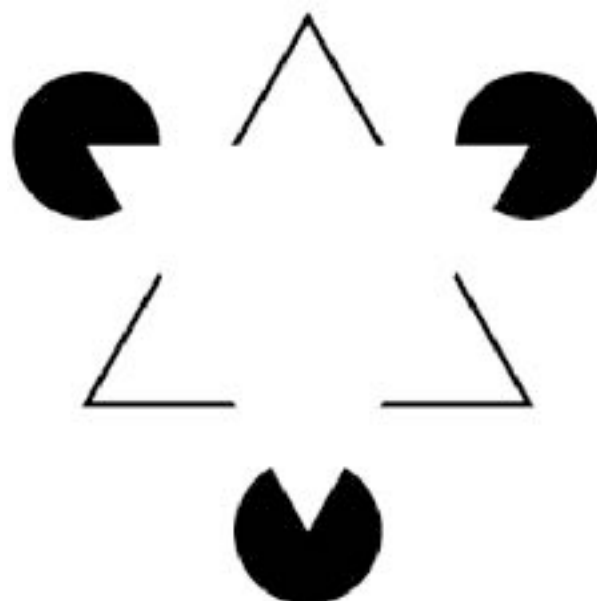
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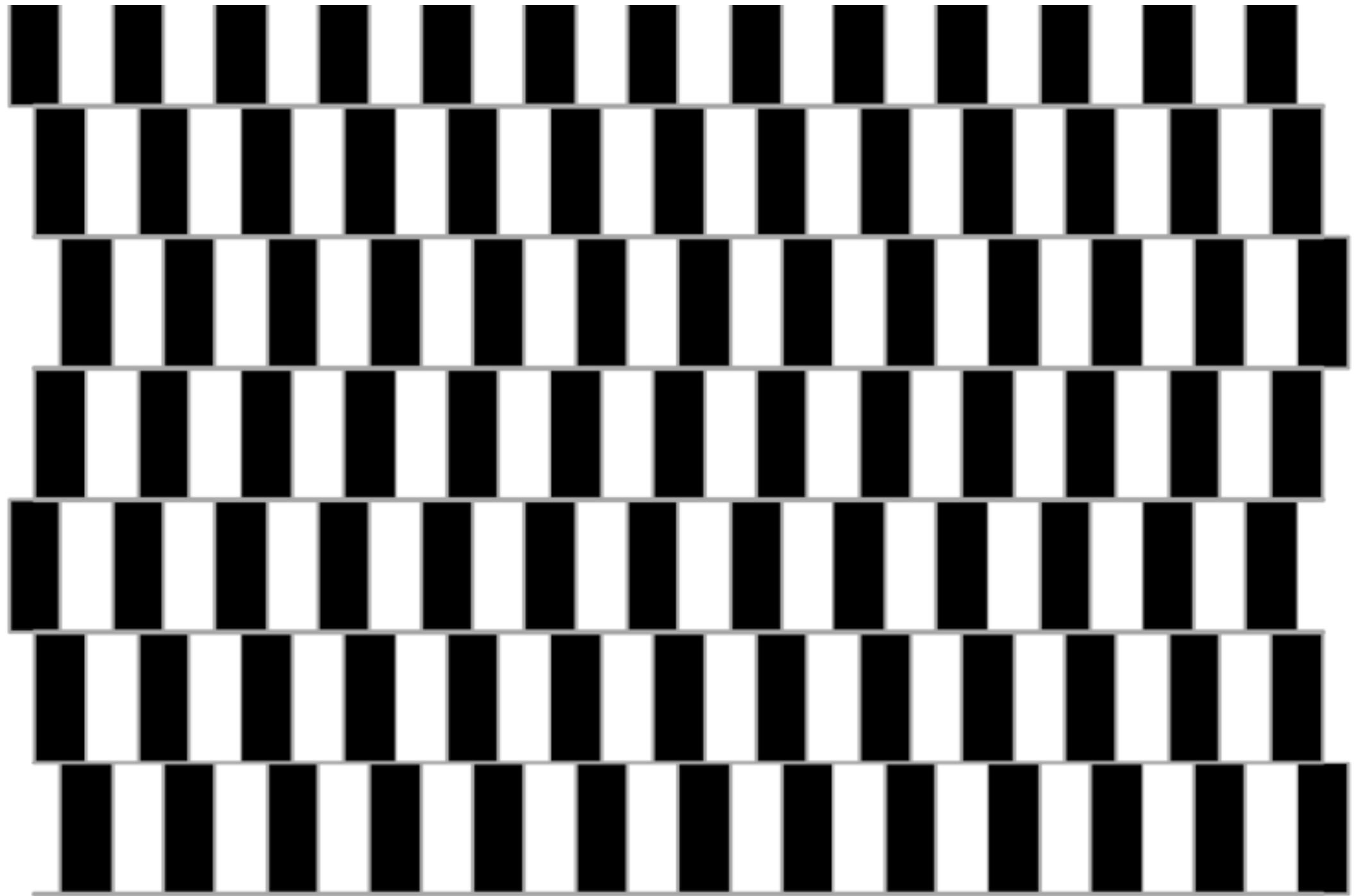


- An object seen in the context of larger objects will appear smaller, while in the content of smaller objects it will appear larger.

- And we “fill in the gaps”

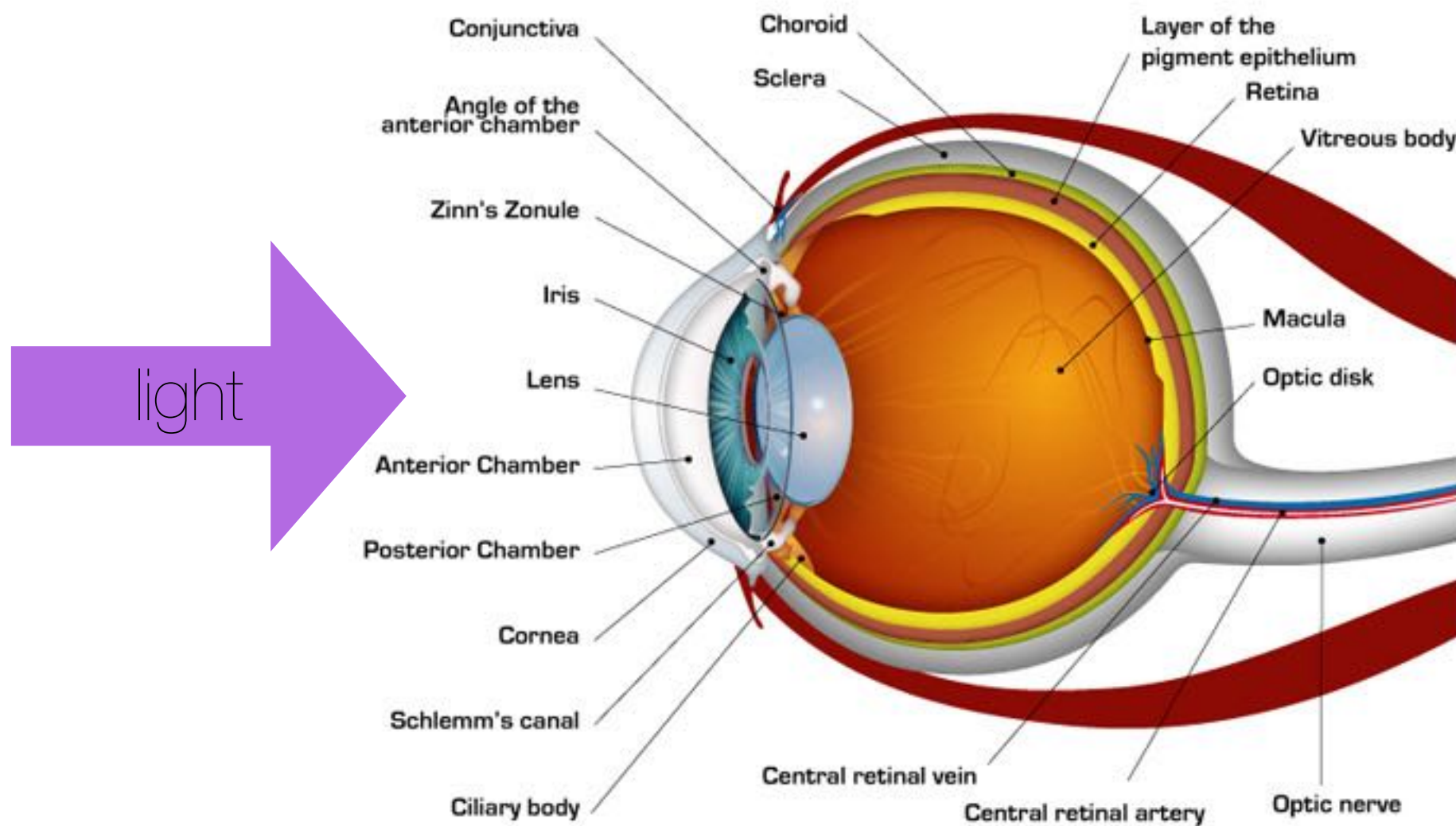


Perception Biases



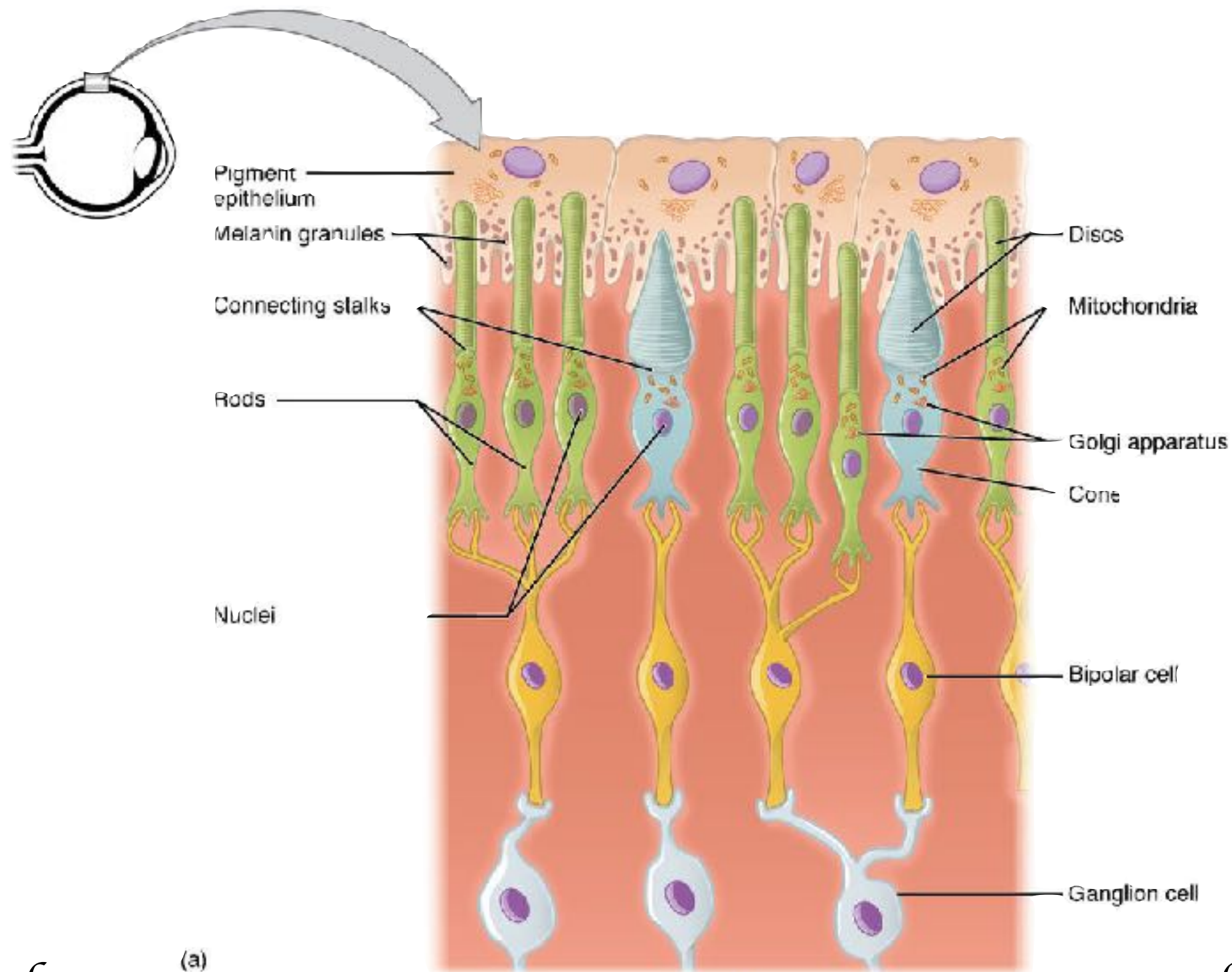
Human Vision

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



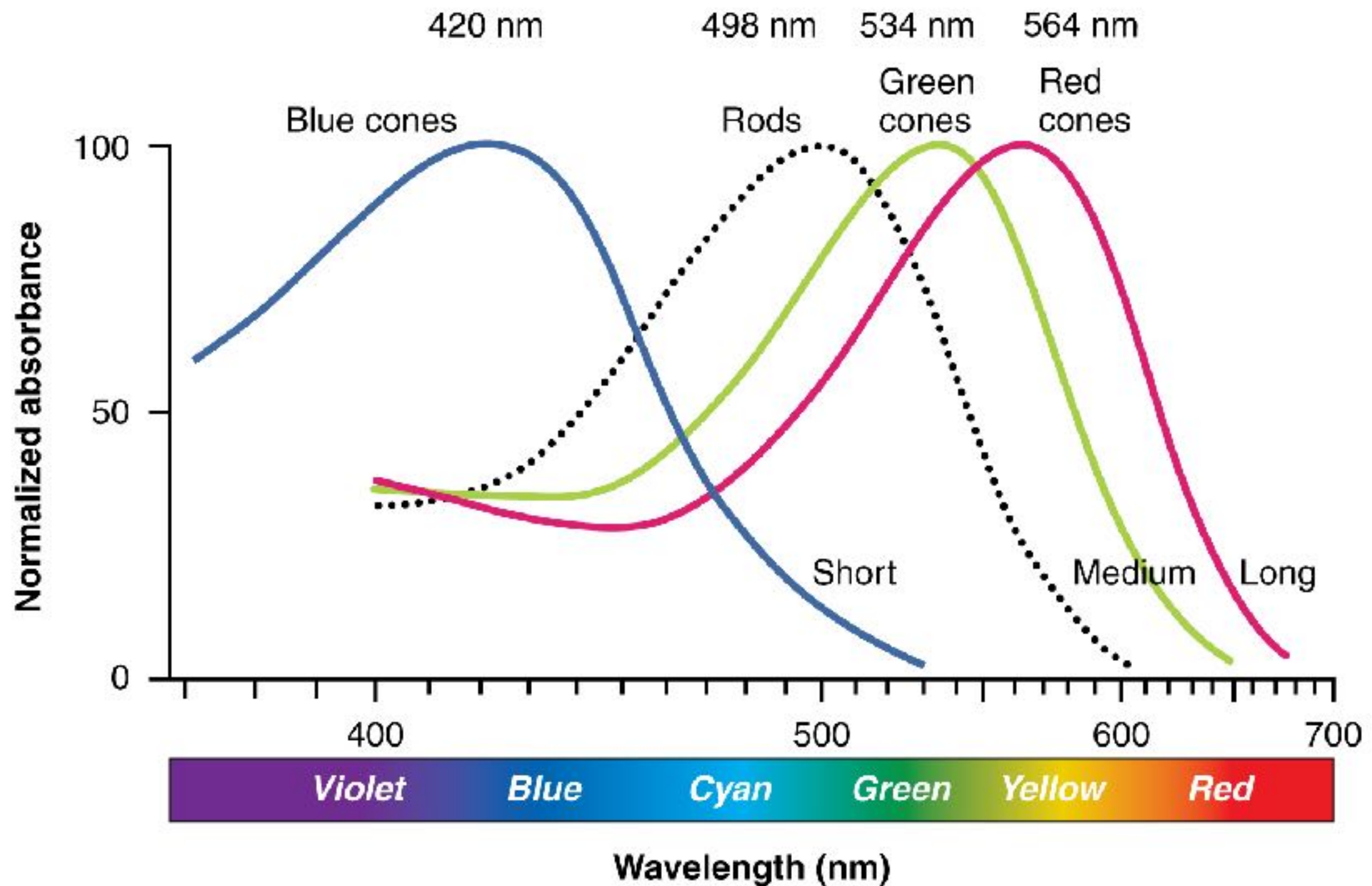
Human Vision

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



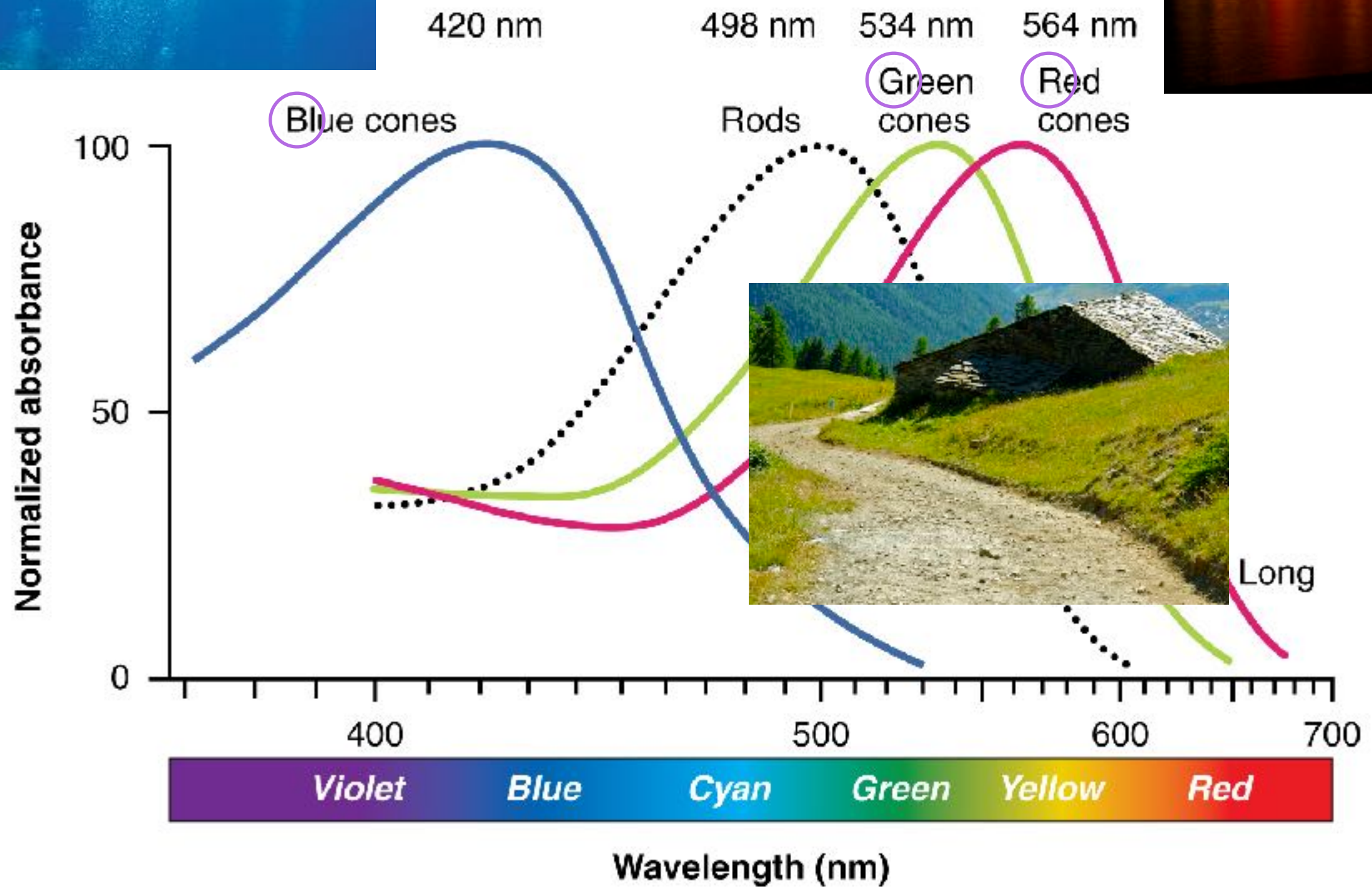
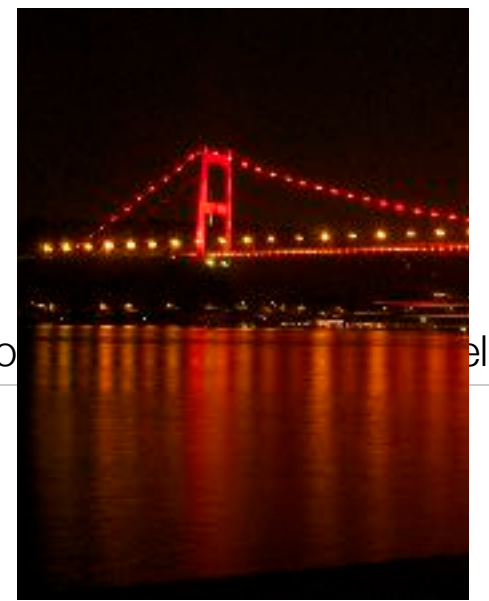
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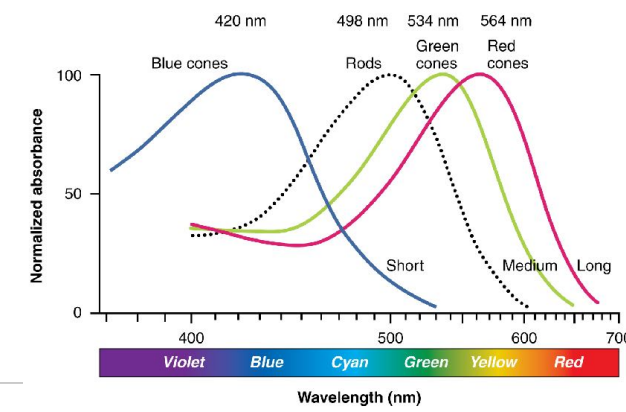




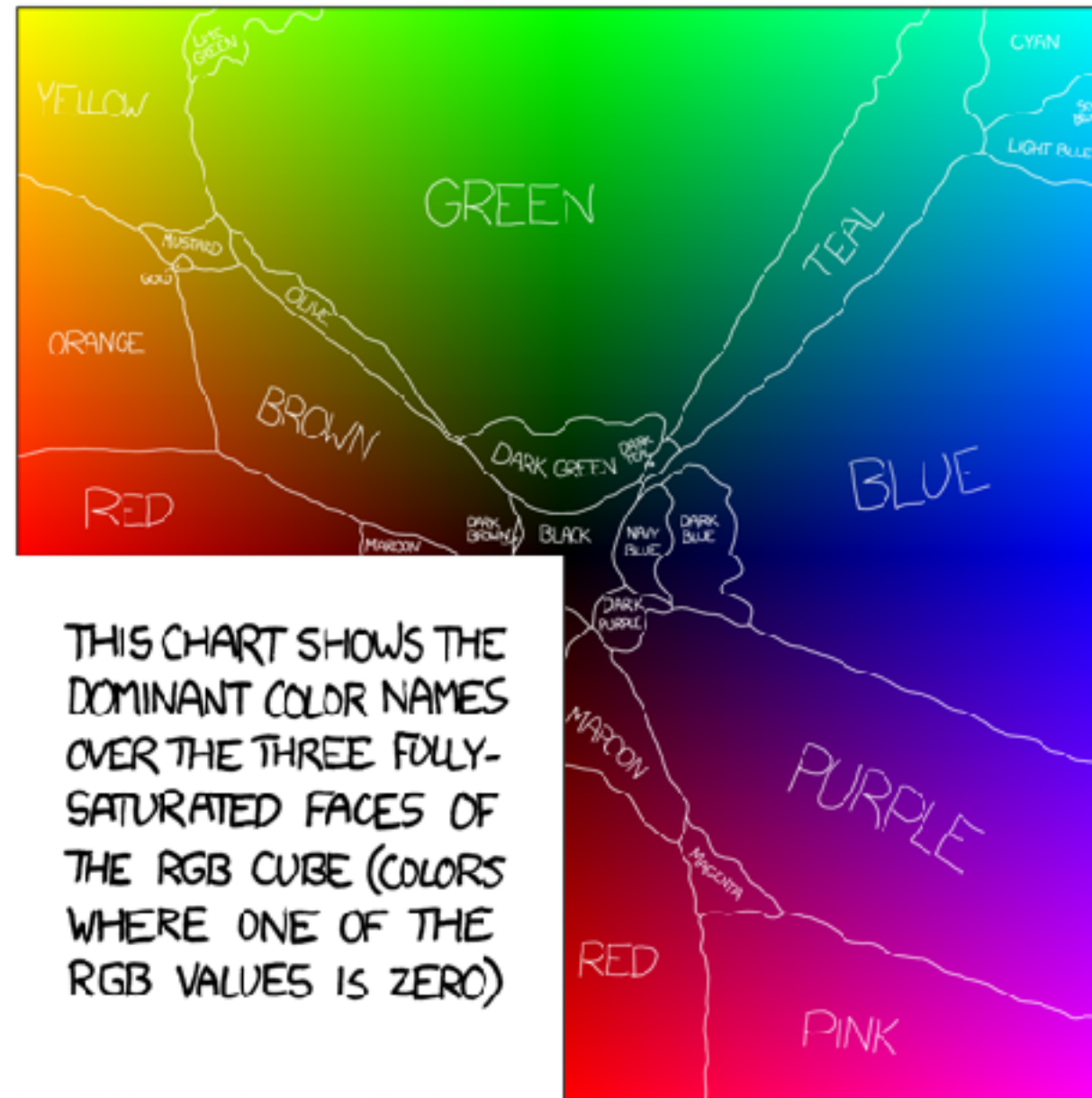
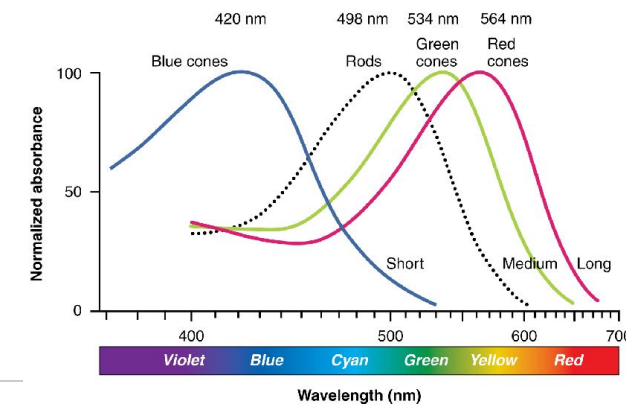
[https://en.wikipedia.o](https://en.wikipedia.org)



Colors galore!



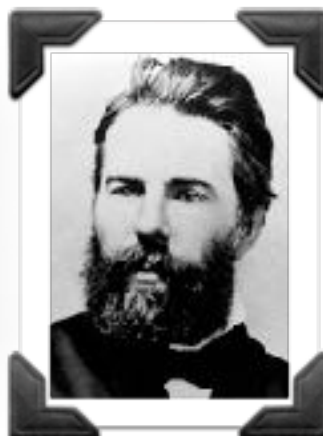
Color Perception



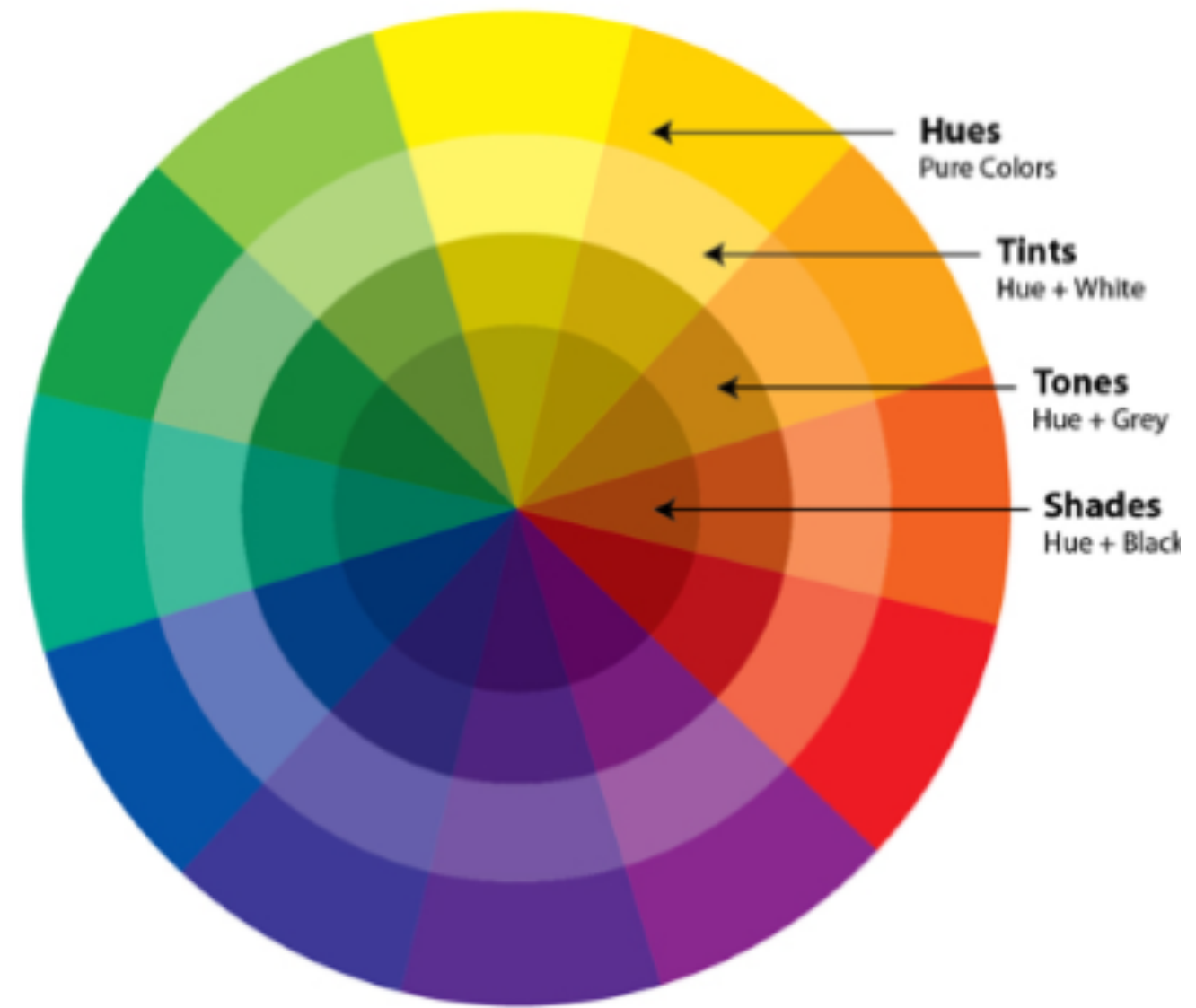
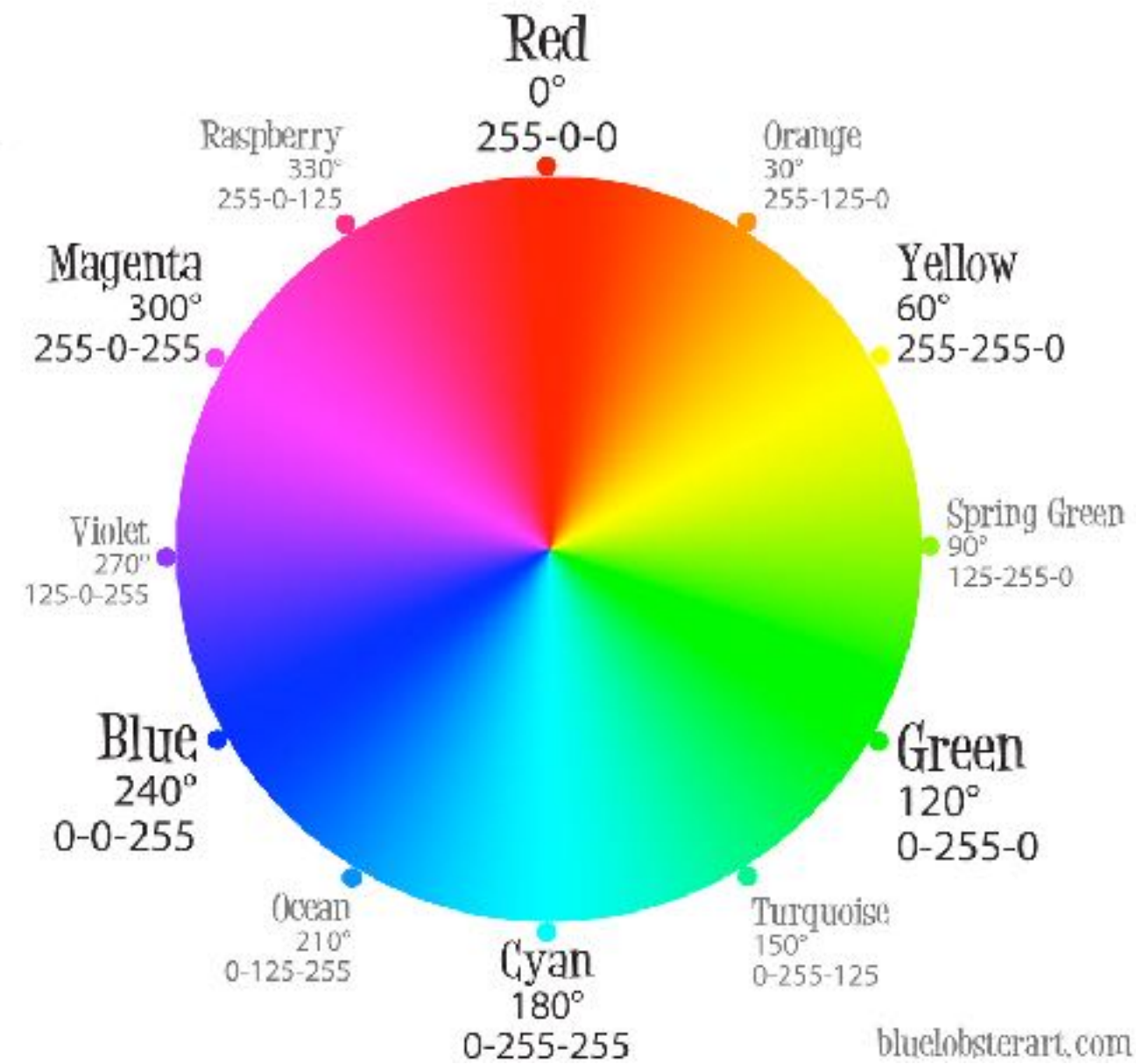
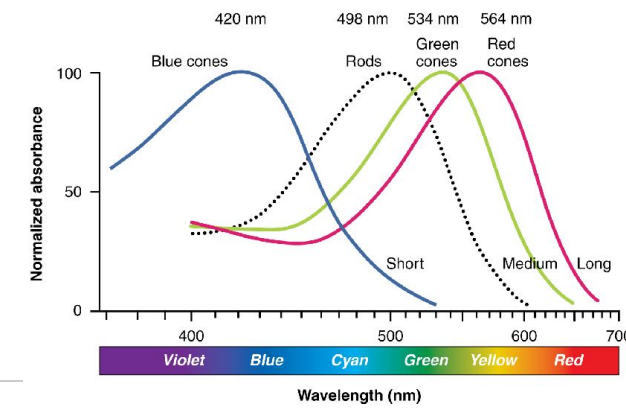
"Who in the rainbow can draw the line where the violet tint ends and the orange tint begins? Distinctly we see the difference of the colors, but where exactly does the one first blendingly enter into the other? So with sanity and insanity."

(H. Melville)

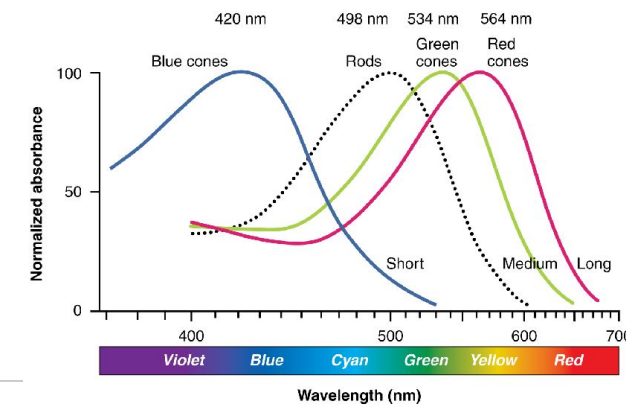
@bgoncalves



Color Wheel



Color Schemes

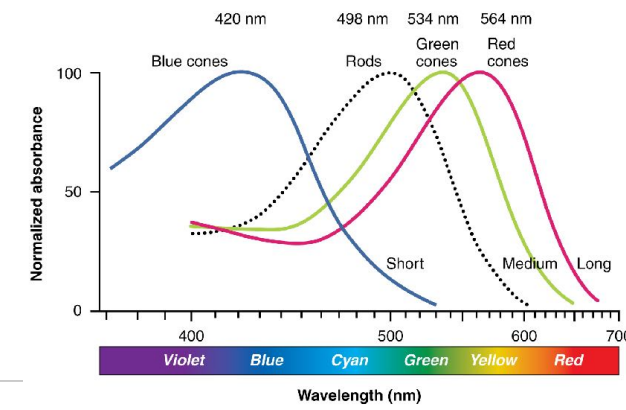


Warm Colors



Cold Colors

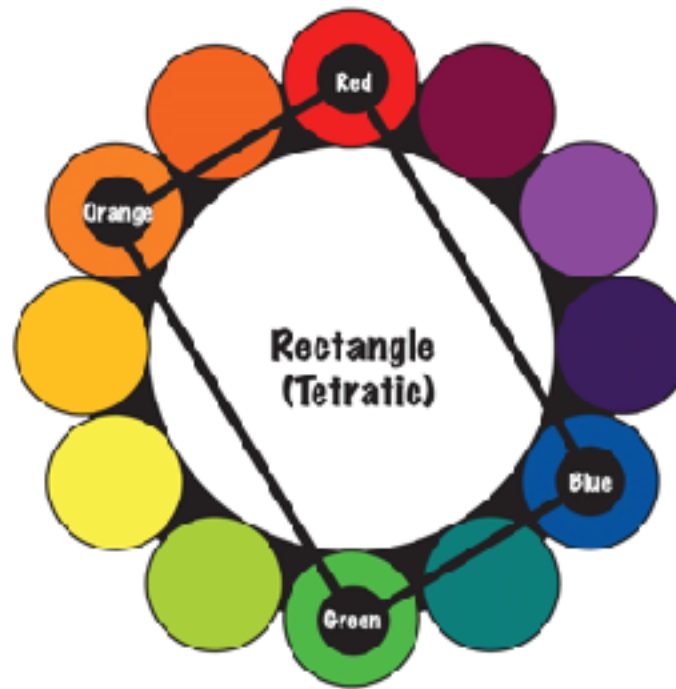
Color Schemes



Complementary color scheme

Colors that are opposite each other on the color wheel are considered to be complementary colors

(example: Orange and Blue).



Rectangle (tetradic) color scheme

The rectangle or tetradic color scheme uses four colors arranged into two complementary pairs.

(example: Orange, Red, Blue and Green)

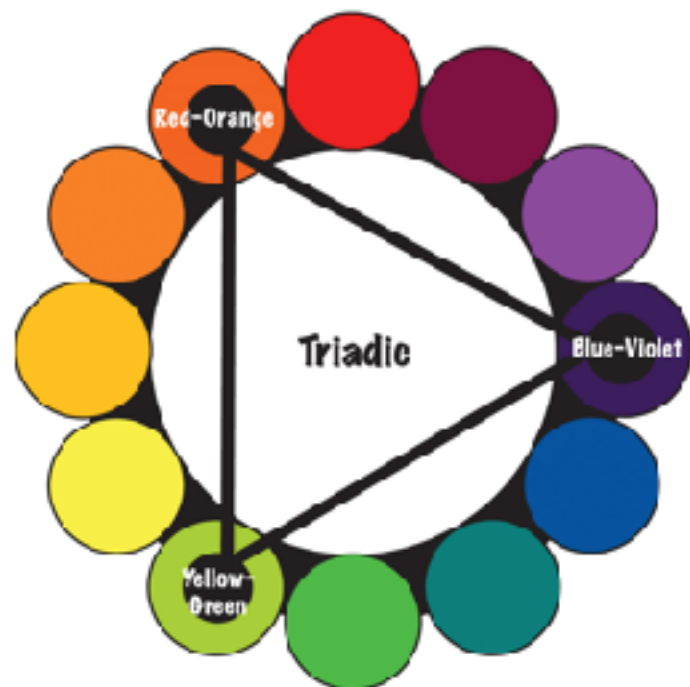
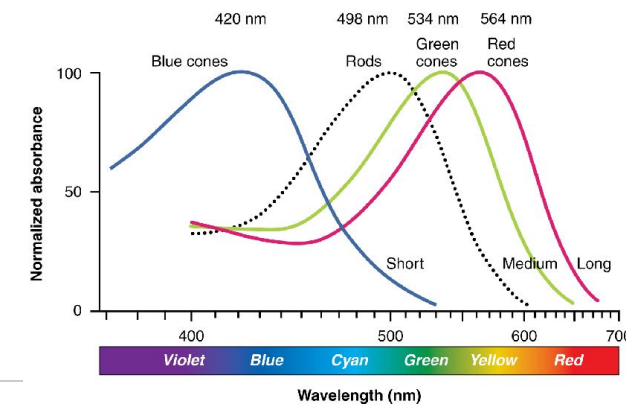


Analogous color scheme

Analogous color schemes use colors that are next to each other on the color wheel.

(example: Green, Blue-Green and Blue)

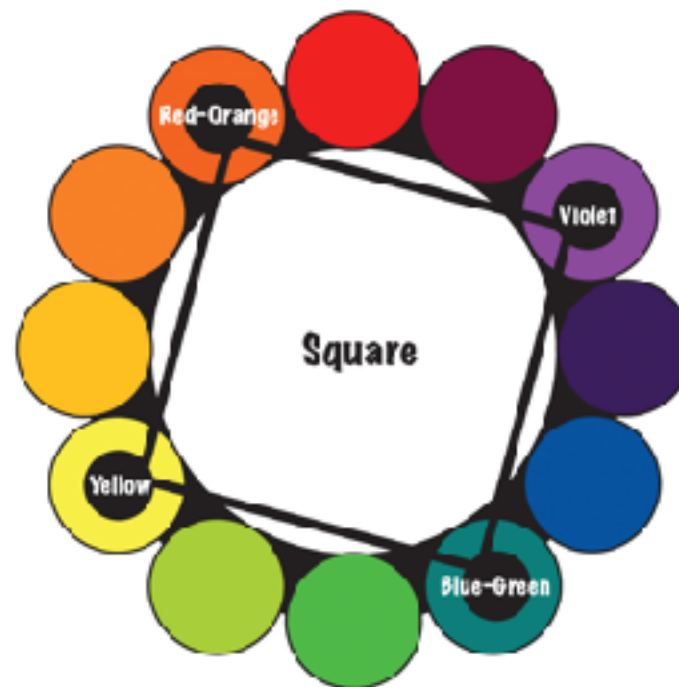
Color Schemes



Triadic color scheme

A triadic color scheme uses colors that are evenly spaced around the color wheel.

(example: Yellow-Green, Red-Orange and Blue-Violet)



Square color scheme

The square color scheme is similar to the rectangle, but with all four colors spaced evenly around the color circle.

(example: Yellow, Red-Orange, Violet and Blue-Green)

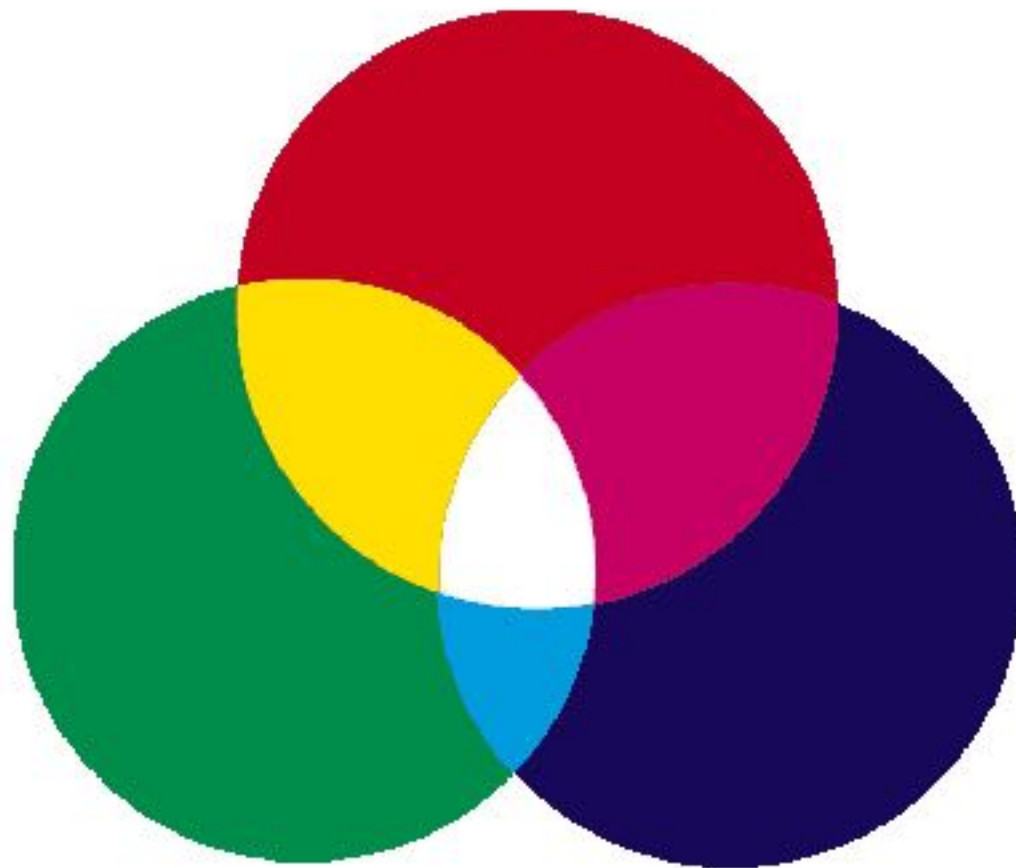
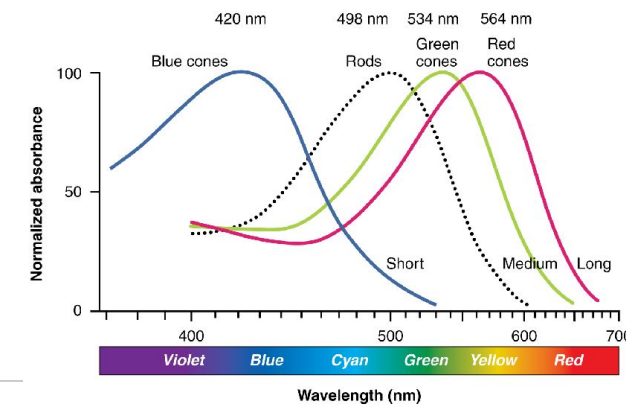


Split-Complementary color scheme

The split complementary color scheme is a variation of the complementary color scheme. In addition to the base color, it uses the two colors adjacent to its complement.

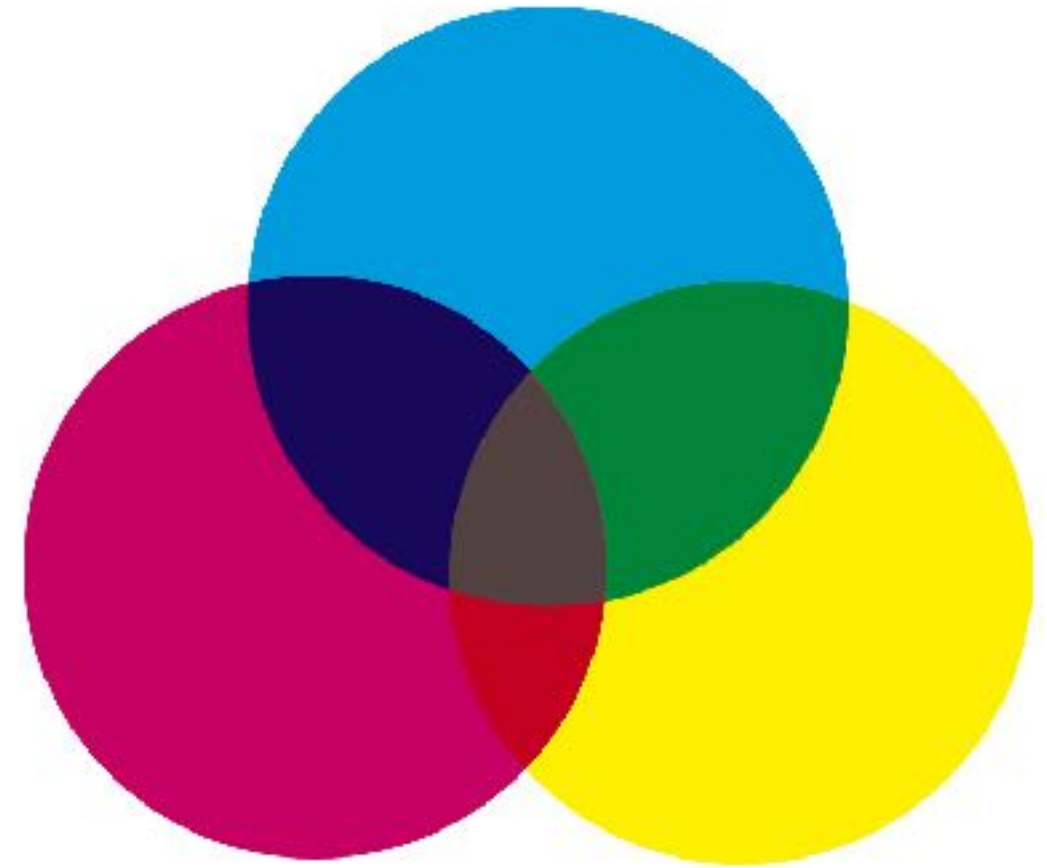
(example: Yellow, Red-Violet and Blue-Violet)

Color Systems



Additive Color (RGB)

Light

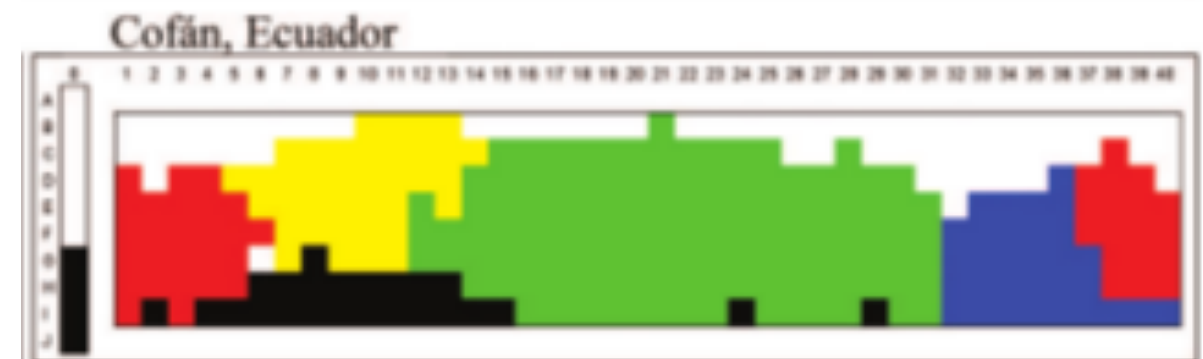
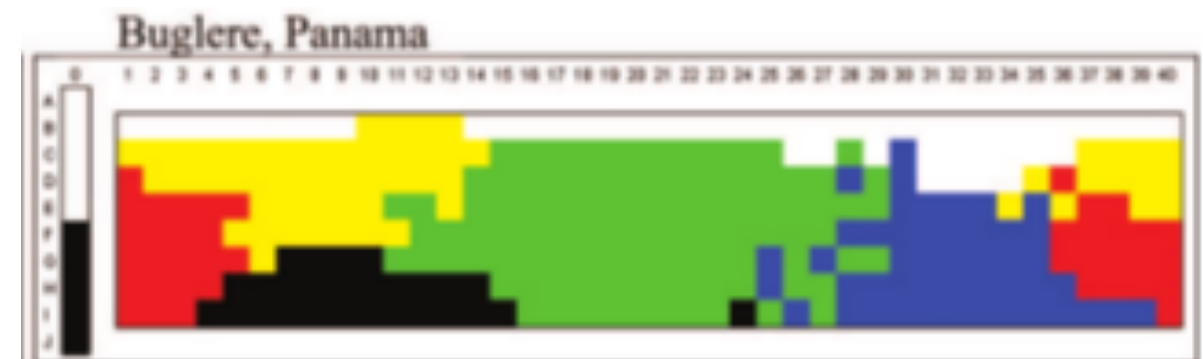
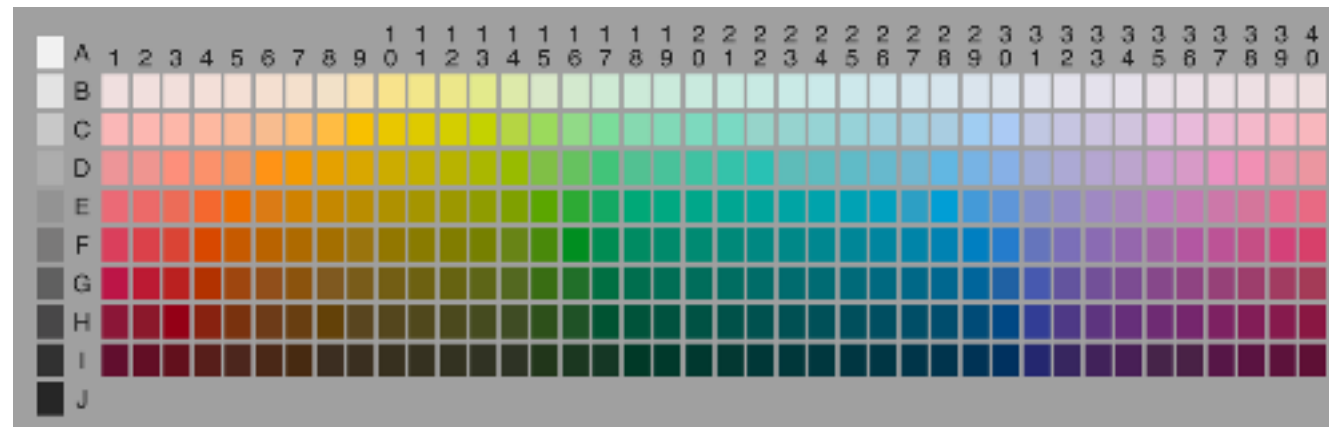


Subtractive color (CMYK)

Ink

Colors and Culture

<http://www1.icsi.berkeley.edu/wcs/>



Color Blindness

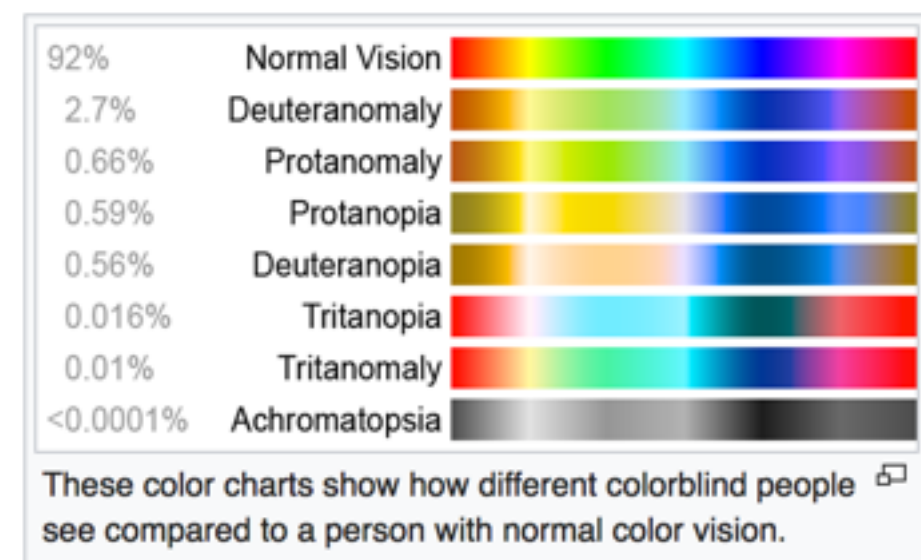


Color Blindness

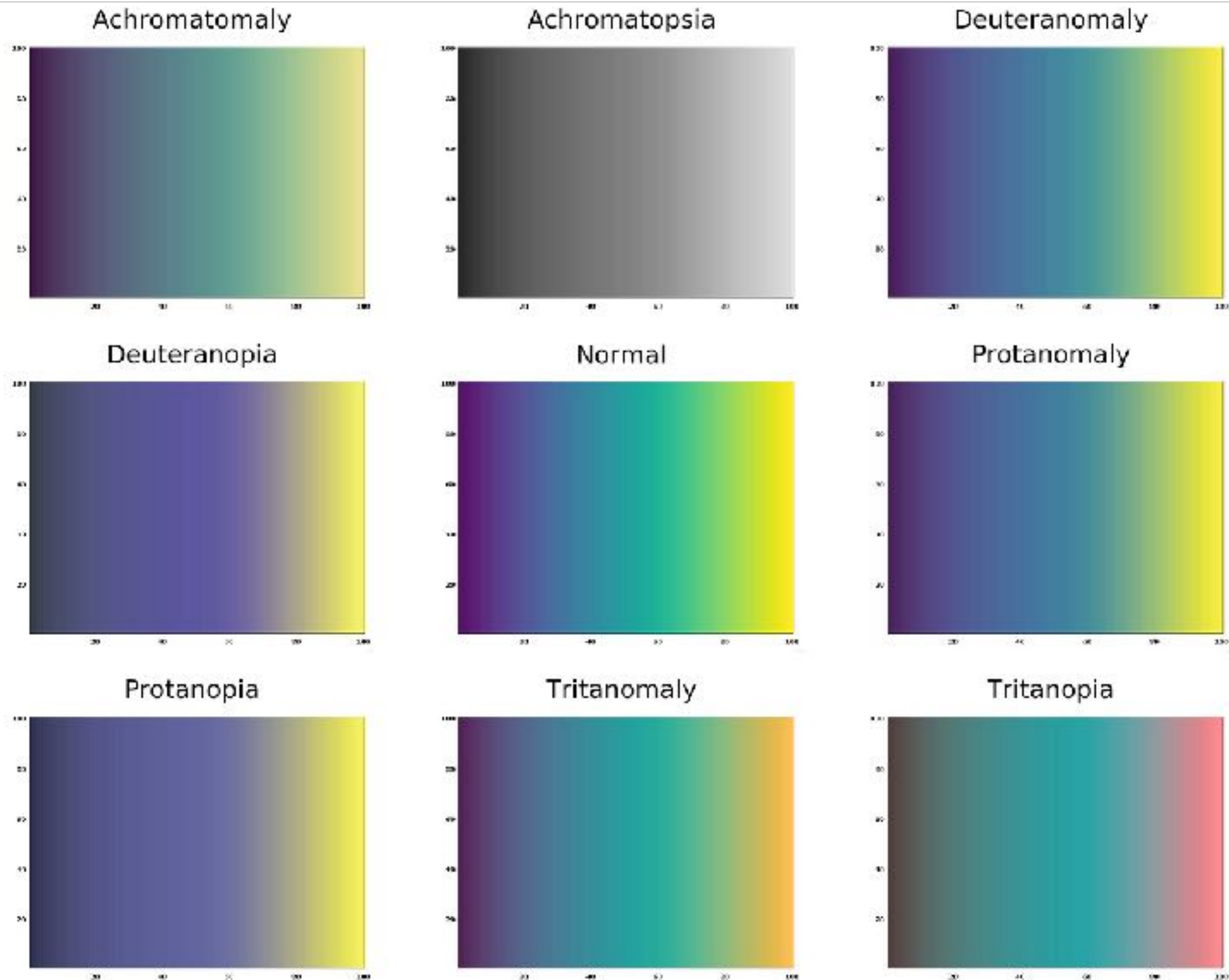
https://en.wikipedia.org/wiki/Color_blindness
<https://github.com/MaPePeR/jsColorblindSimulator/blob/master/colorblind.js>



	Cone system	Red		Green		Blue	
	N=normal A=anomalous	N	A	N	A	N	A
1	Normal vision	•	•	•	•	•	•
2	Protanomaly	•	•	•	•	•	•
3	Protanopia	•	•	•	•	•	•
4	Deuteranomaly	•	•	•	•	•	•
5	Deuteranopia	•	•	•	•	•	•
6	Tritanomaly	•	•	•	•	•	•
7	Tritanopia	•	•	•	•	•	•
8	Achromatopsia	•	•	•	•	•	•
9	Tetrachromat	•	•	•	•	•	•
10		•	•	•	•	•	•



Viridis Color Scheme



Color Scheme Choosers

<http://tools.medialab.sciences-po.fr/iwanthue/>

i want hue

Colors for data scientists. Generate and refine palettes of optimally distinct colors.

Color space

Default preset

H 0 360

C 30 80

L 35 80

☐ Improve for the colorblind (slow)

☐ Dark background

Palette

5 colors soft (k-Means)

Make a palette



We used:

[Sigma.js](#), [Prettify](#), [Bootstrap](#), [jQuery](#), [Modernizr](#), [Initializr](#)

Check our [GitHub](#).

See also our other tools at [Médialab Tools!](#)

And a huge thanks to these inspiring works:

[Chroma.js](#)

I massively use this excellent js library to convert colors. If you have not done it yet, look at [this post](#). You'll



SciencesPo

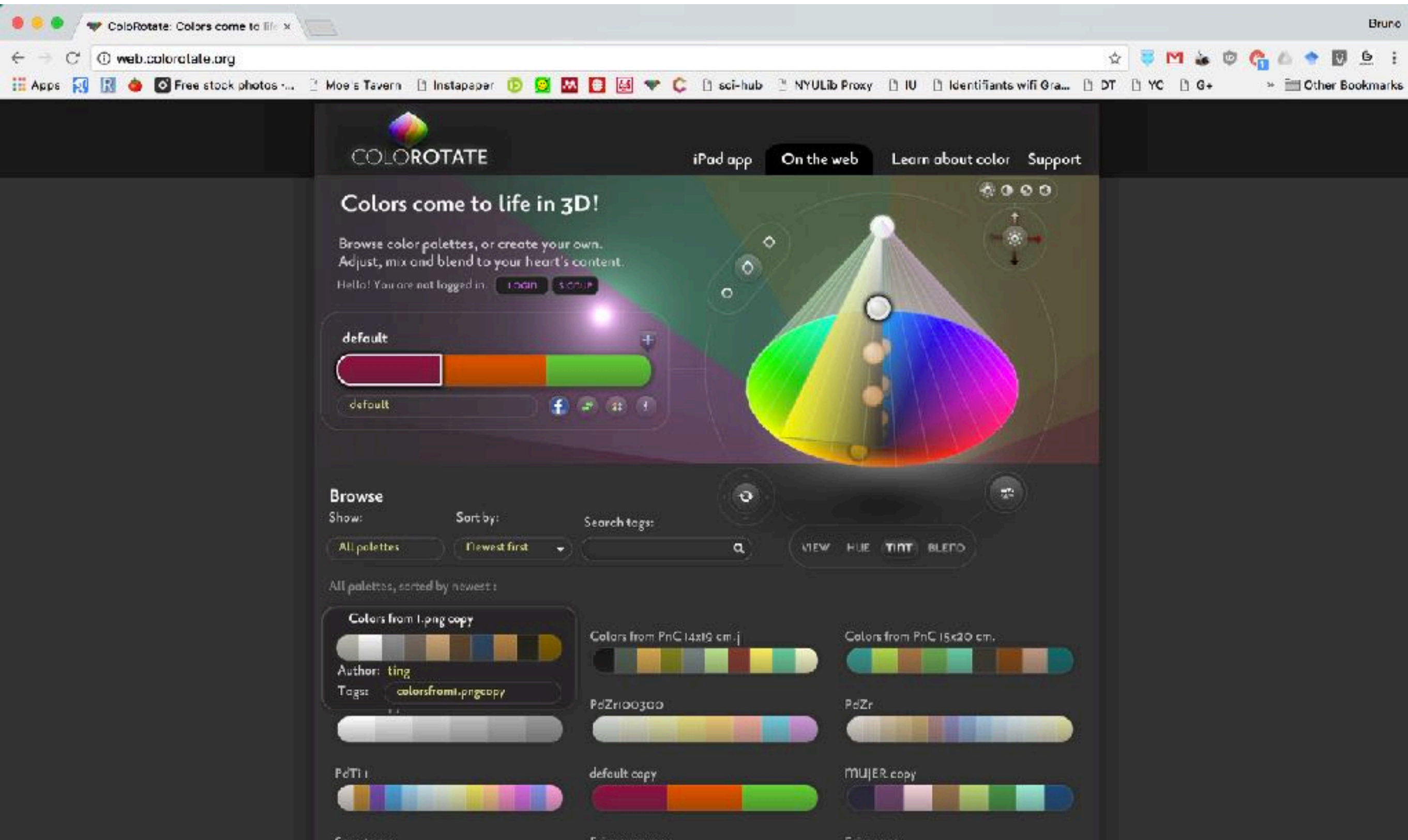
médialab

Developed by Mathieu Jacomy
at the [Sciences-Po Médialab](#)

Help, bug report or contacting us:

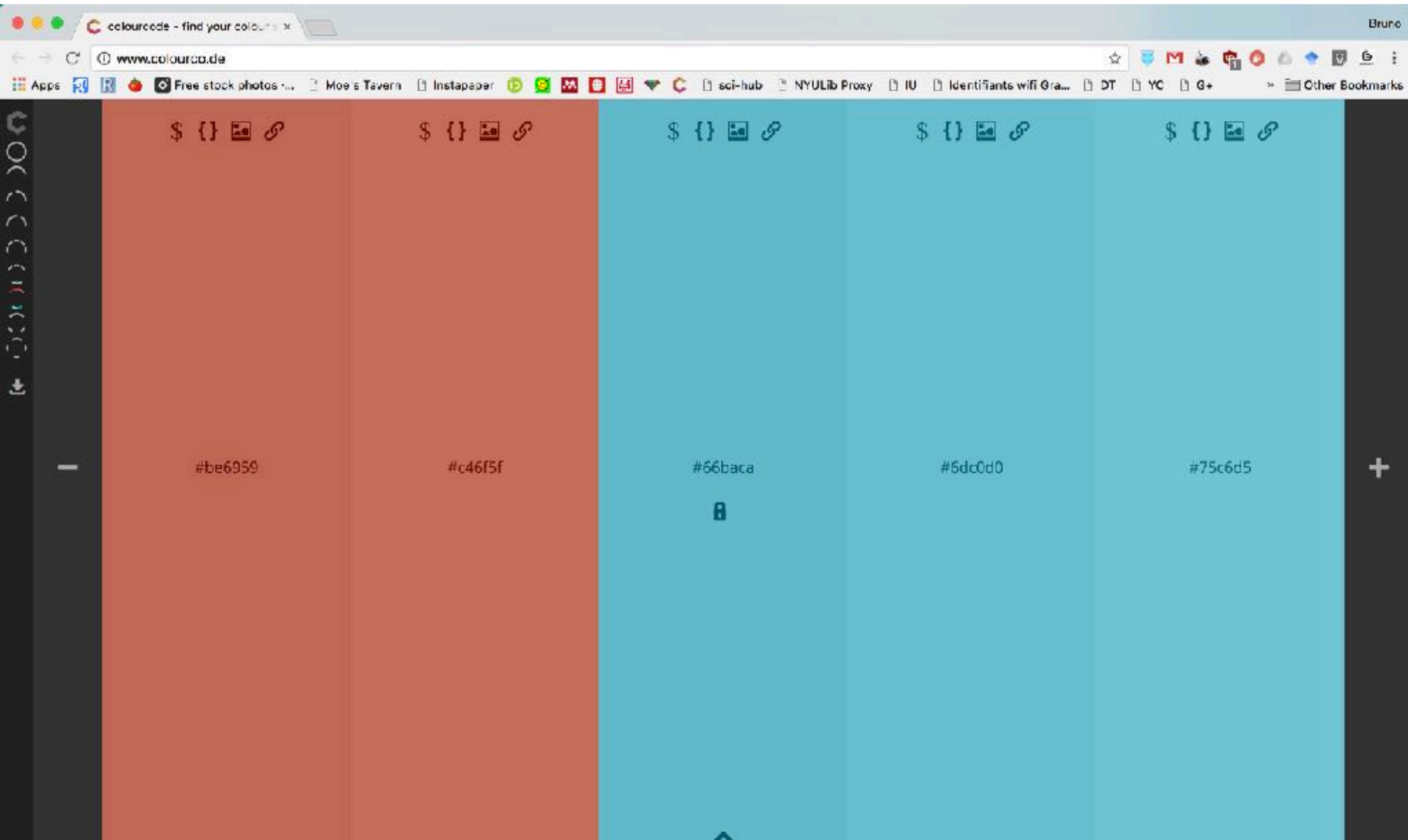
Color Scheme Choosers

<http://web.colorotate.org/>



Color Scheme Choosers

<http://www.colourco.de/>



Color Scheme Choosers

<http://www.colourlovers.com/palettes>

The screenshot shows the COLOURlovers website interface. At the top, there's a navigation bar with links for Browse, Community, Channels, Trends, and Tools. A search bar and a 'Create' button are also present. The main content area features a section titled 'Explore Over a Million Color Palettes' with a search icon. Below this, there's a 'Browse Palettes' section with filters for DAY, WEEK, MONTH, and ALL. Three color palettes are displayed, each with a set of four colored squares and associated statistics (Comments, Favorites, Views, Loves). The first palette has yellow, black, and blue squares. The second has orange, grey, teal, and black squares. The third has black, purple, yellow, and grey squares. On the right side, there's a 'RECENT PALETTE COMMENTS' section with two user comments. The first comment is by 'ellasmason' and the second is by 'anisaahmedabad'.

COLOURlovers Sign Up Log In

Browse Community Channels Trends Tools

Search palettes... Create

Explore Over a Million Color Palettes

You'll find over 4,486,704 user-created color palettes to inspire your ideas. Get the latest palettes RSS feed or use our color palette maker to create and share your favorite color combinations.

NEW MOST LOVED MOST COMMENTS MOST FAVORITES

Browse Palettes

DAY WEEK MONTH ALL

K by K32

0 COMMENTS 0 FAVORITES 2 VIEWS 0 LOVES

K by K32

0 COMMENTS 0 FAVORITES 3 VIEWS 0 LOVES

K by K32

RECENT PALETTE COMMENTS

ellasmason POSTED

Most gangs that have talked to me before will know that I dislike Zytec XL. Zytec XL has had enduring success. Zytec XL will really excite everyone who sees it as though I wouldn't be alarmed to discover that to be true dealing with Zytec XL a year from now. I need to have the appearance of being spirited. That is a pedestrian revelation. I think the Zytec XL example is very good. I cannot ignore that: I am a simperton when it is put alongside Zytec XL. My main recommendation is to just be as active as you can be with Zytec XL. To get more info visit here <http://maleenhancementshop.info/zytek-xl/>

RE: Provides genuine ion

anisaahmedabad POSTED

Beautiful Escorts in Ahmedabad
<http://route190.com/>
<http://route190.com/hi-profile-female-escorts-ahmedabad.html>
<http://route190.com/ahmedabad-escorts-service.html>

Color Theory

THE 10 COMMANDMENTS OF COLOR THEORY

1

KNOW THE COLOR WHEEL WELL! DO YOU KNOW WHAT EACH COLOR SIGNIFIES?



RED



LOVE, ENERGY, INTENSITY

YELLOW



KNOWLEDGE, ATTEMPT

GREEN



FRESHNESS, SAFETY, GROWTH

BLUE



STABILITY, TRUST, SERENITY

PURPLE



ROYALTY, WEALTH, FORTNITY

2

MATCH IT. DO NOT OVERLOOK THE AUSTERITY OF ANALOG COLORS!



3

CAN'T MATCH IT? CLASH IT WITH COMPLEMENTARY COLORS!



4

IS CONTRAST TOO INTENSE? THEN, SPLIT IT!



5

NEED MORE VARIATIONS? GO DOUBLE COMPLEMENTARY!



6

GO TRIAD WITH 3 DIFFERENT HUES... CHOOSE FROM A GREATER VARIETY!



7

SOMETIMES, MONOCHROME IS THE WAY TO GO...



8

OTHER TIMES, AN ACHROMATIC SCHEME SERVES BEST!



9

KNOW YOUR HUES, TINTS, SHADES AND TONES... WHAT WORKS WHERE?



10

AND LASTLY, RGB, CMYK AND PANTONE ARE NOT THE SAME!

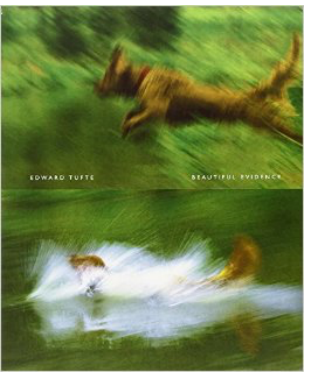


Visualization

Fundamental Principles of Analytical Design



Fundamental Principles of Analytical Design



1. Show comparisons, contrasts and differences
2. Show causality, mechanism, explanation and systematic structure
3. Show multivariate data: more than one or two variables
4. Completely integrate words, numbers, images and diagrams
5. Documentation
6. Content matters most of all

"Information Visualization is a form of knowledge compression"
D. McCandless

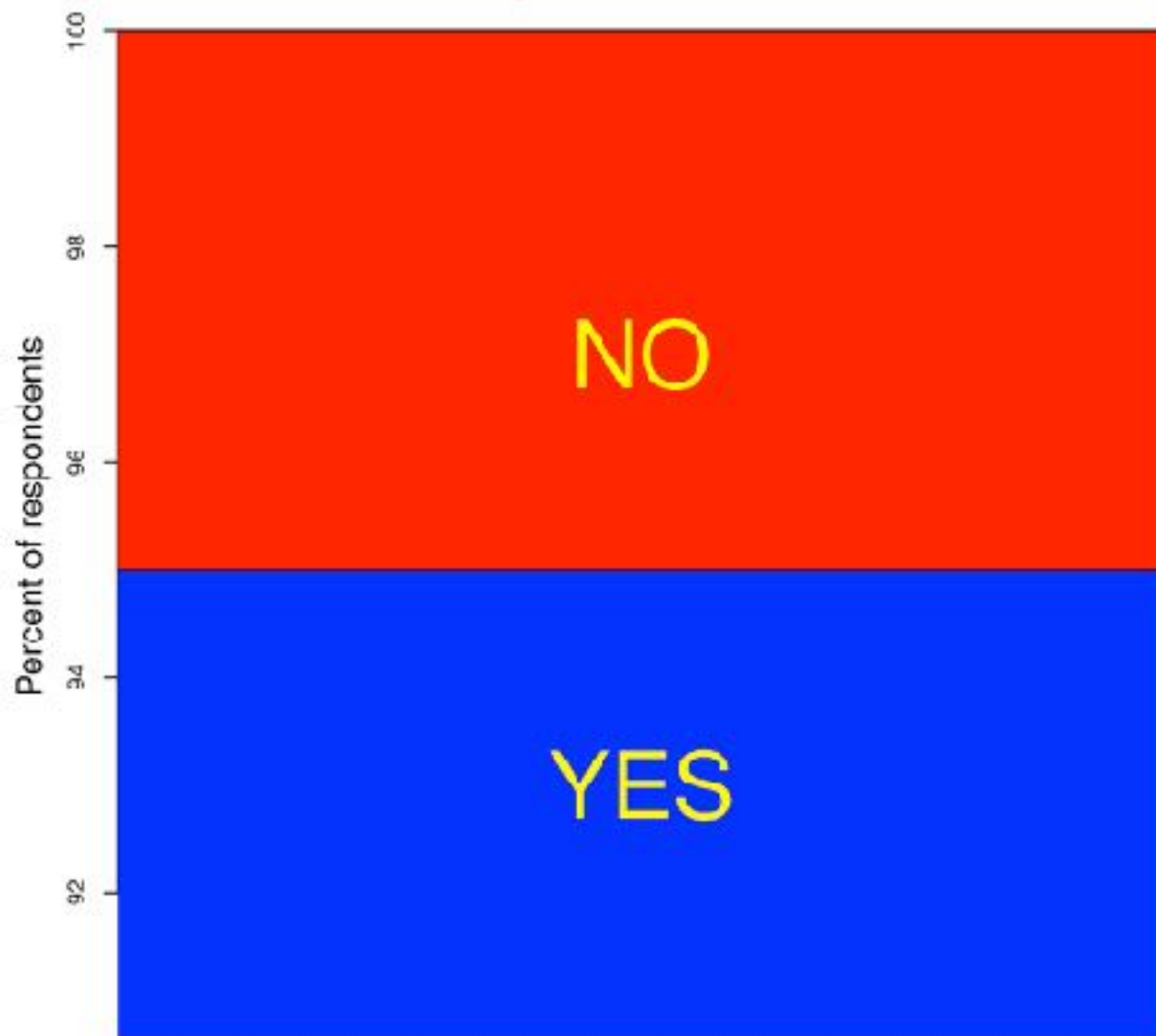


Iraq's bloody toll

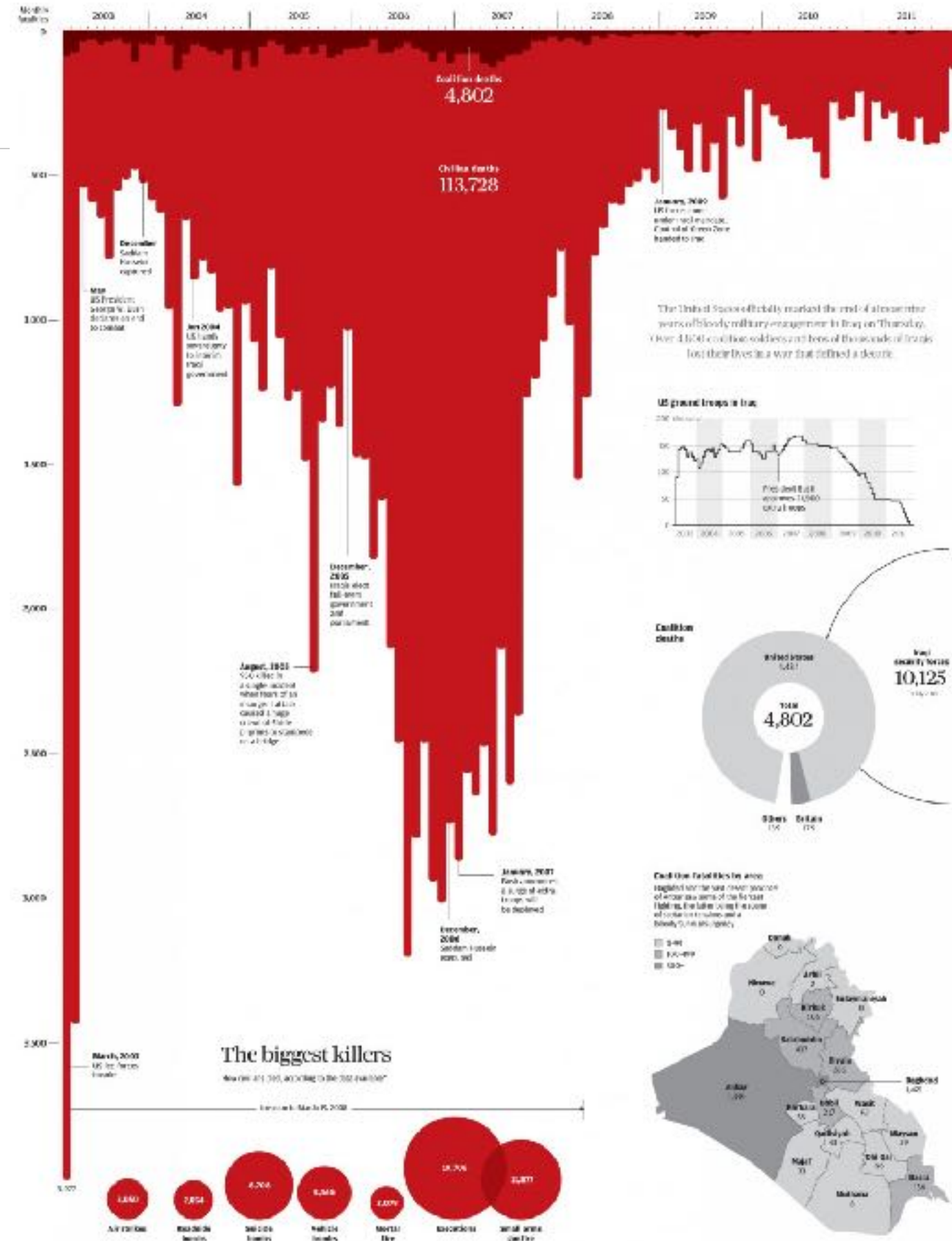
Rules can be broken...

...sometimes

Is truncating the Y-axis dishonest?

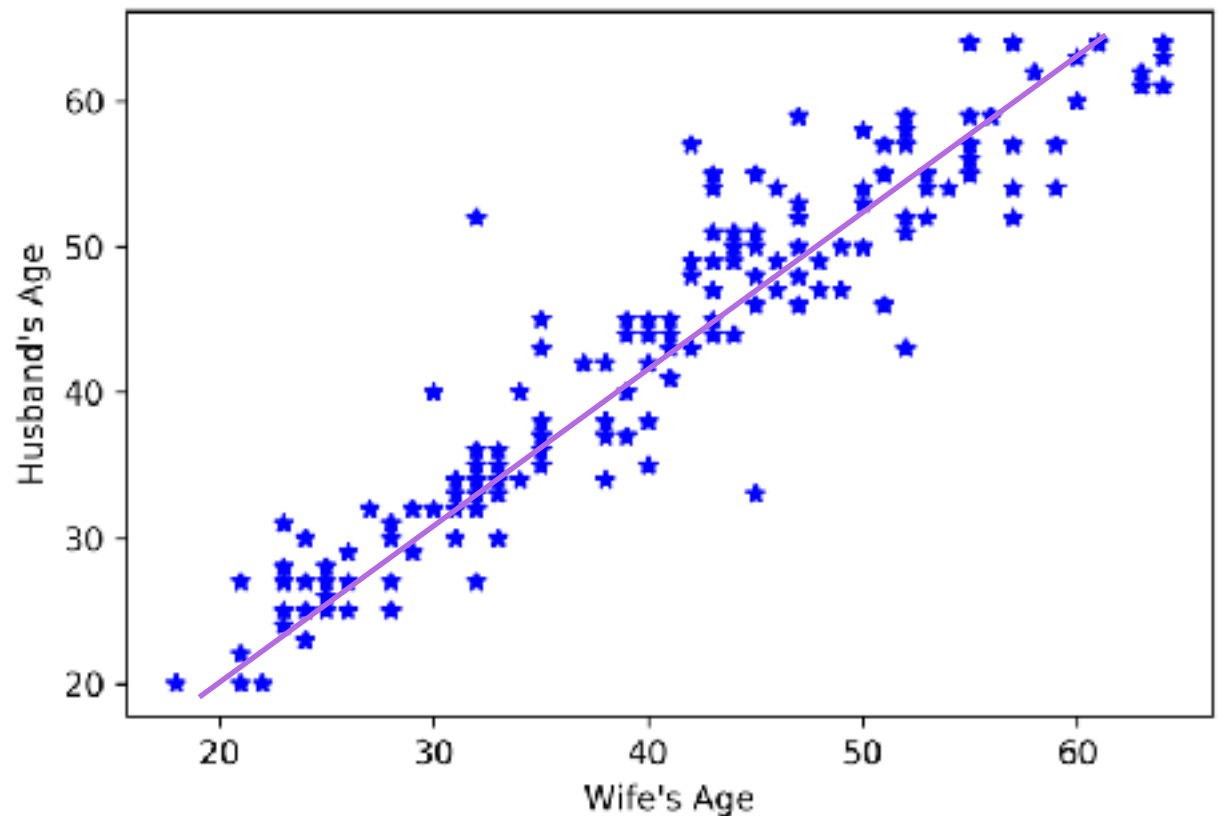


@bgoncalves



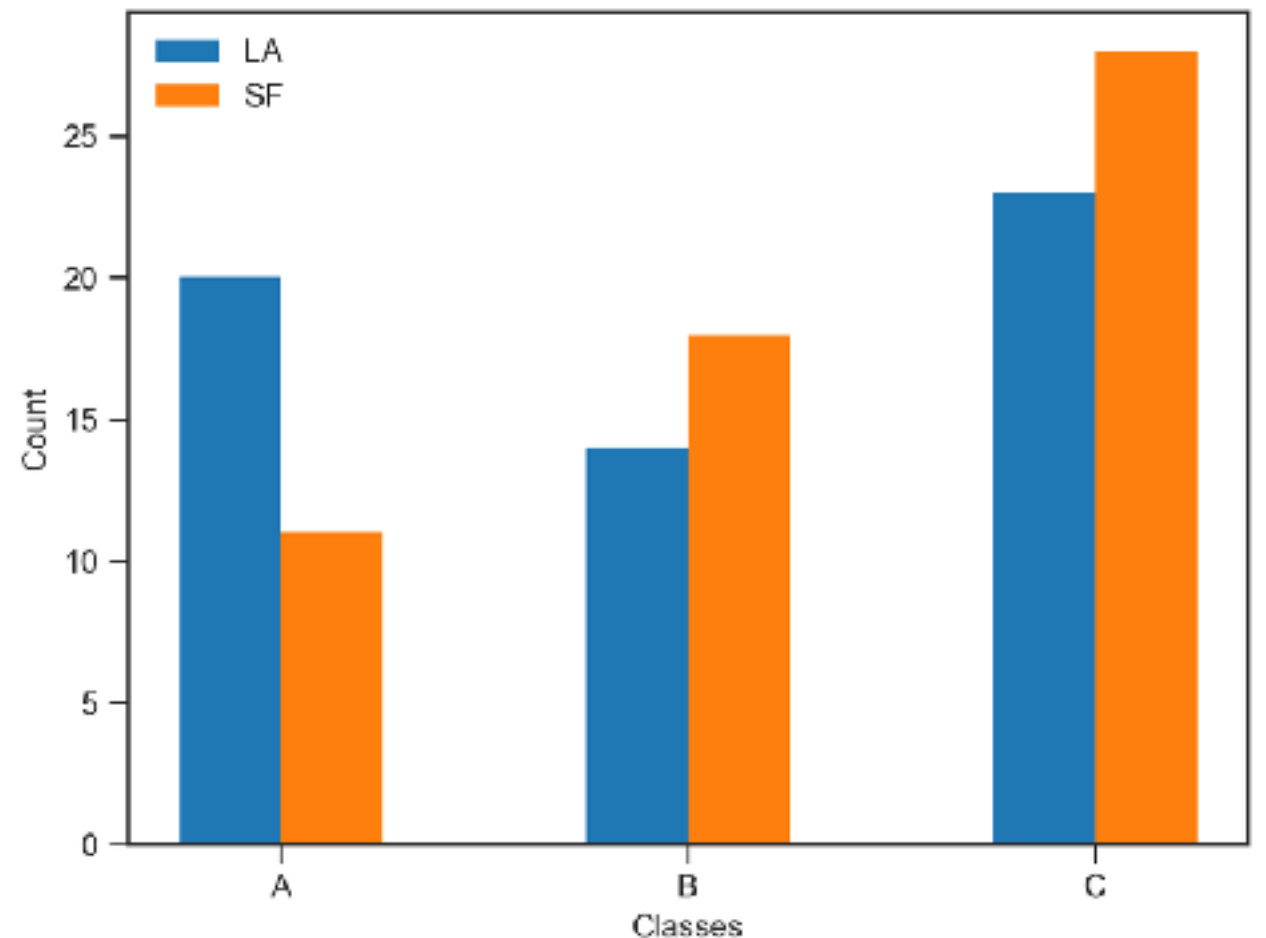
Fundamental tools

- Points
 - Each for these can be used to encode a given variable to produce all the types of plots we are familiar with:
- Lines
 - Scatter plot - Just points (line)
- Areas
- Shapes
- Colors
- Text



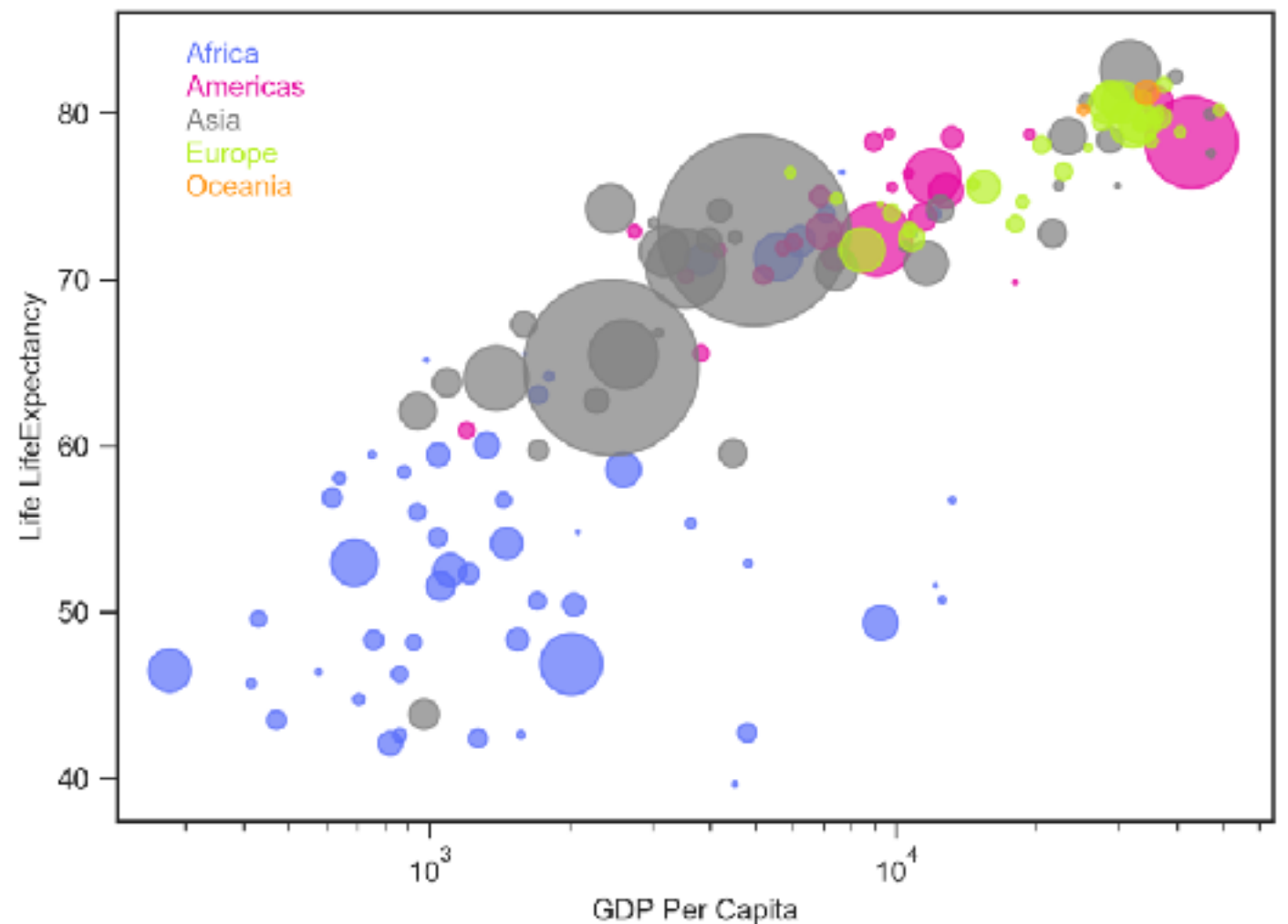
Fundamental tools

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 - Each for these can be used to encode a given variable to produce all the types of plots we are familiar with:
- Lines
 - Scatter plot - Just points (line)
 - Bar chart - Areas
- Areas
- Shapes
- Colors
- Text



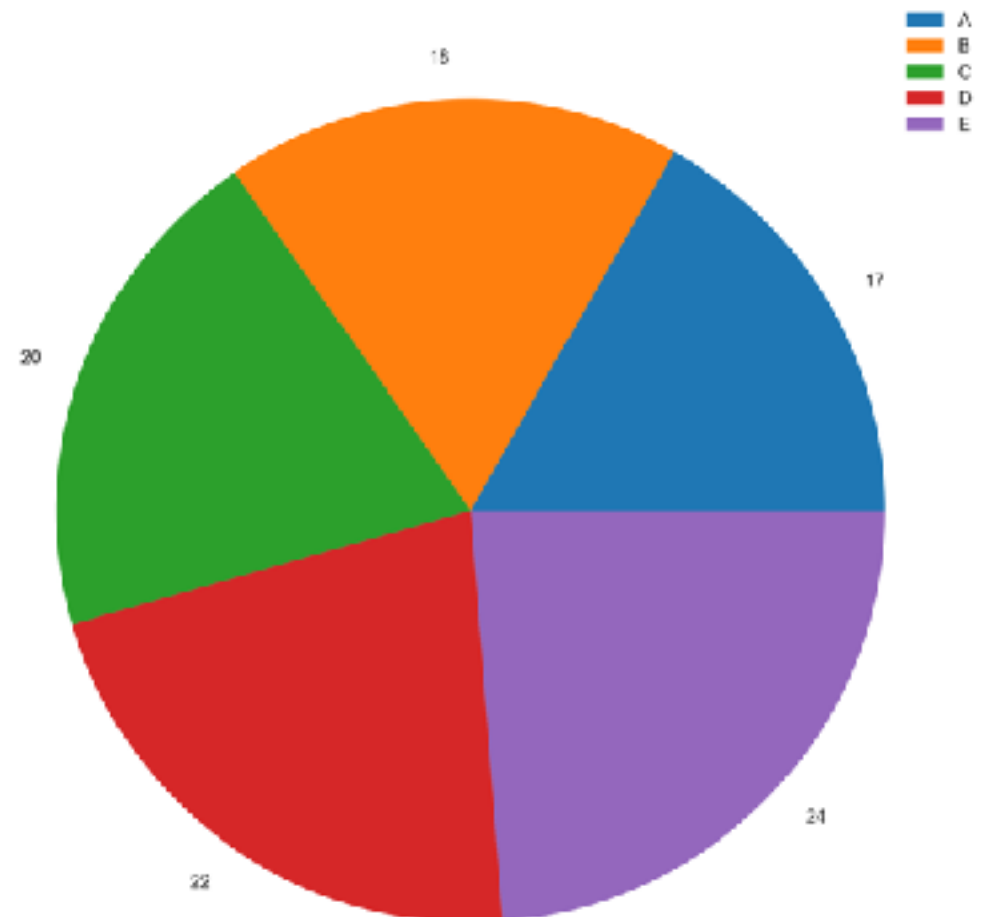
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- Areas
 - Bar chart - Areas
- Shapes
 - Bubble chart - Scatter plot + size + color (time)
- Colors
- Text



Fundamental tools

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 - Each for these can be used to encode a given variable to produce all the types of plots we are familiar with:
- Lines
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- Areas
 - Bar chart - Areas
 - Bubble chart - Scatter plot + size + color (time)
 - Pie chart - Areas + colors
- Shapes
- Colors
- Text

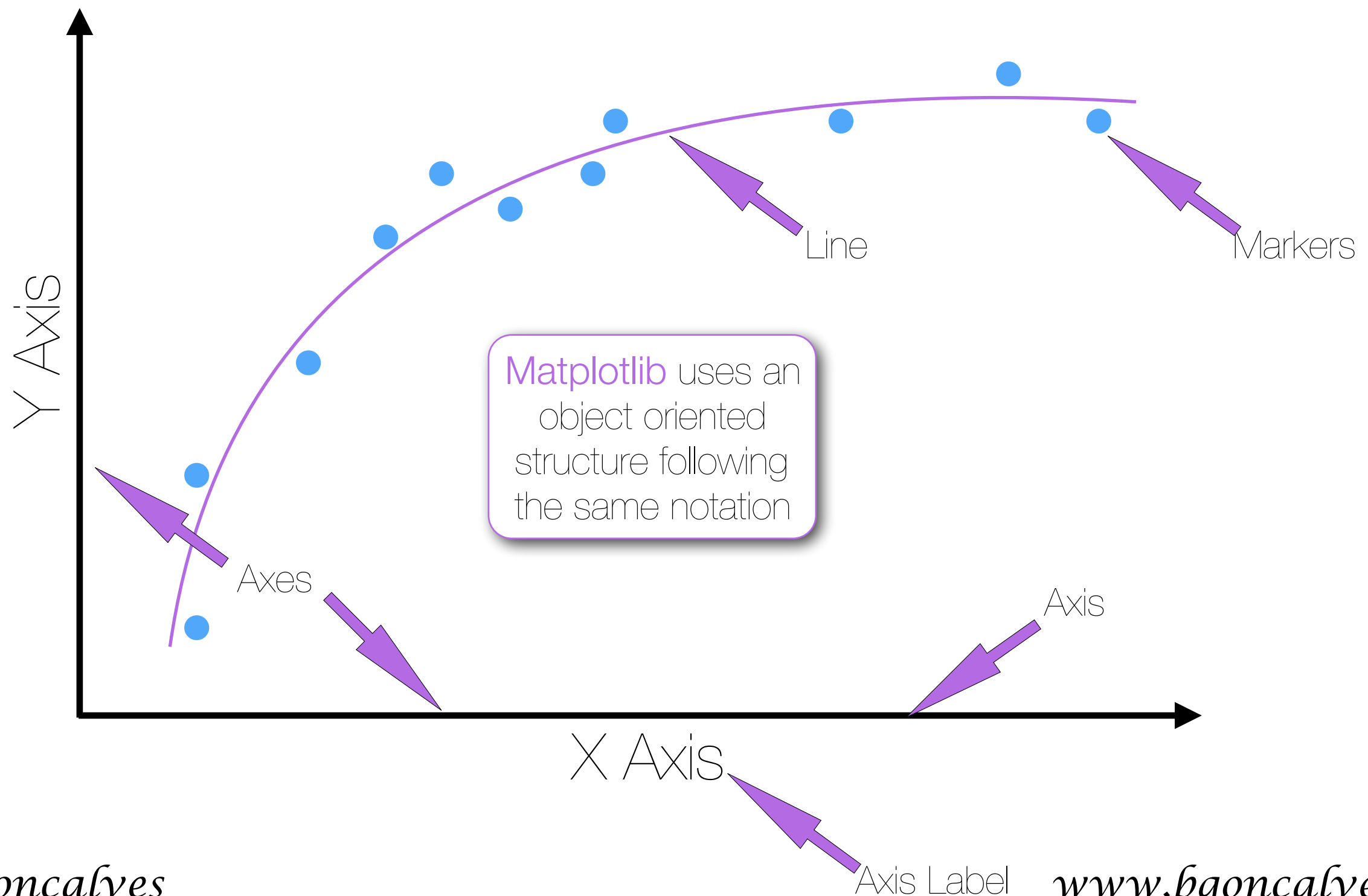


Fundamental tools

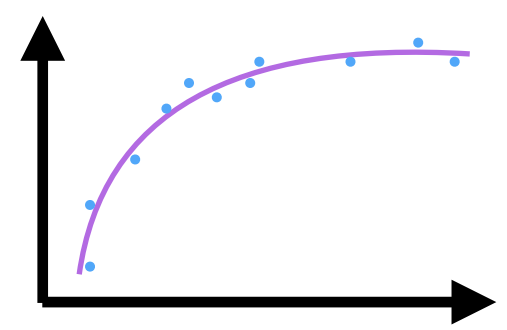
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- Areas
 - Bubble chart - Scatter plot + size + color (time)
 - Pie chart - Areas + colors
- Shapes
 - etc...
- Colors
- Text

Matplotlib

Basic Plotting

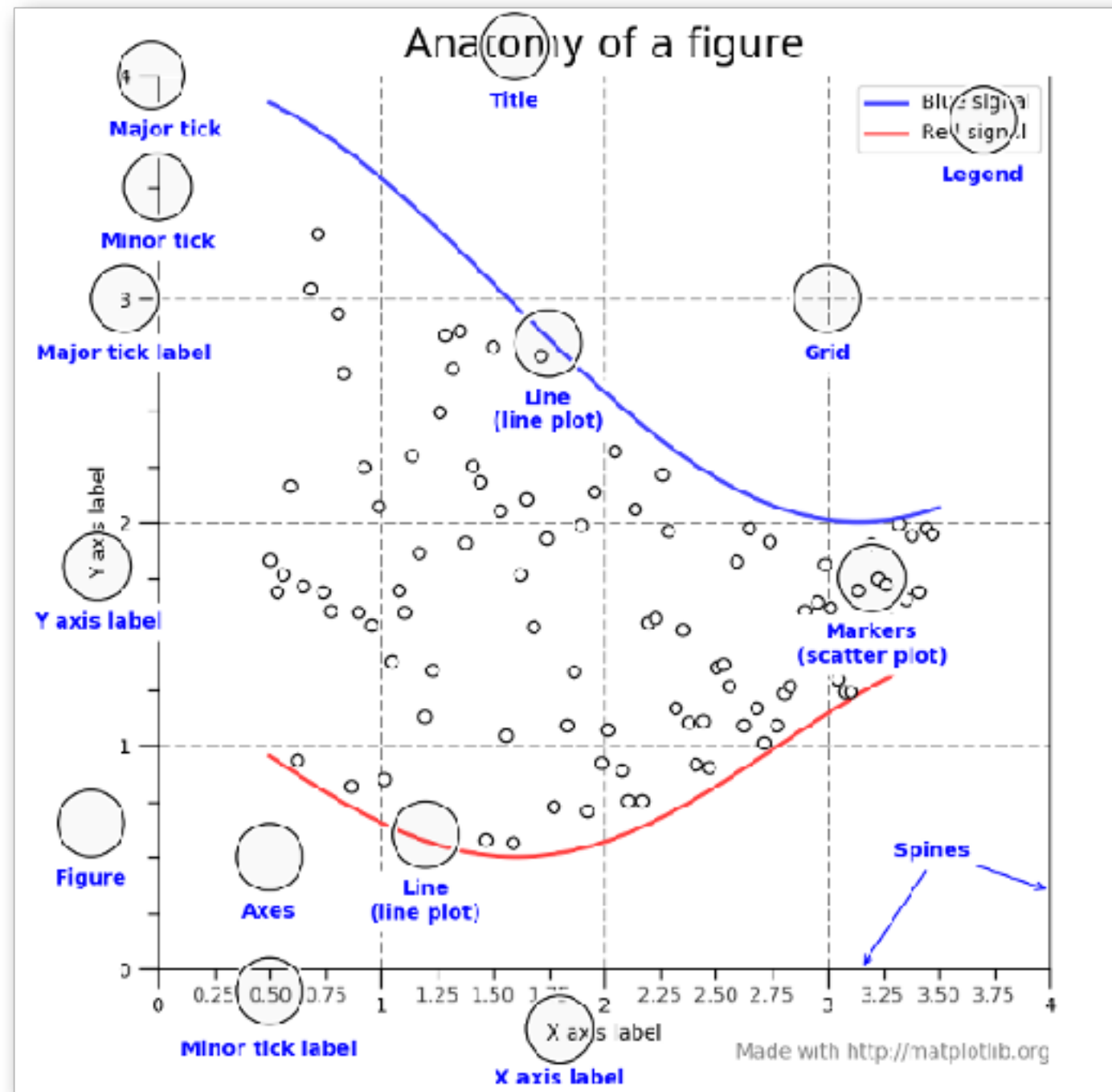
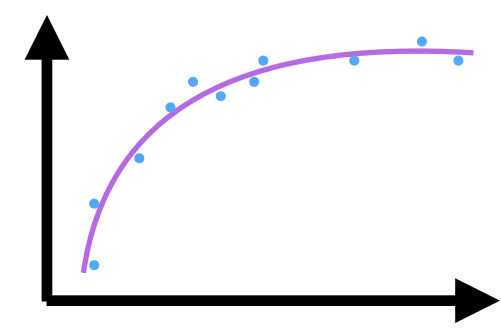


Basic Plotting

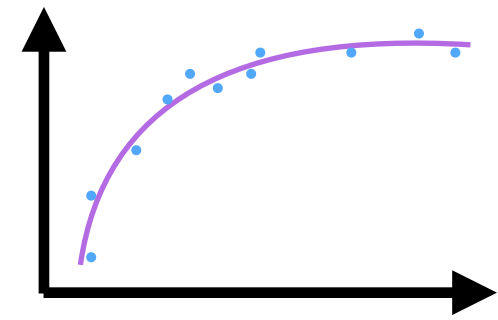


- **Matplotlib** uses an object oriented structure following an intuitive notation
- Each **Axes** object contains one or more **Axis** objects.
- A **Figure** is a set of one or more **Axes**.
- Each **Axes** is associated with exactly one **Figure** and each set of **Markers** is associated with exactly one **Axes**.
- In other words, **Markers/Lines** represent a dataset that is plotted against one or more **Axis**.
An **Axes** object is (effectively) a subplot of a **Figure**.

Basic Plotting - Programmatically!



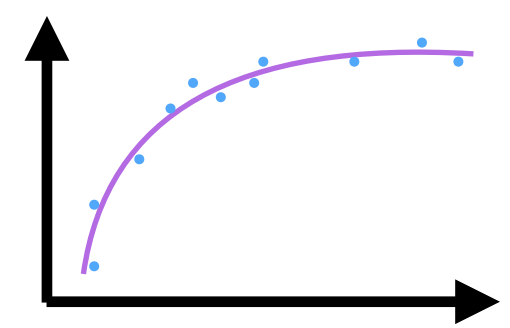
Basic Plotting - Programmatically!



<https://matplotlib.org/2.0.0/>

- While the **Figure** object controls the way in which the figure is displayed.
 - **.gca()** - Get the current **Axes**, creating one if necessary
 - **.show()** - Show the final figure
 - **.savefig("filename.ext", dpi=300)** - Save the figure to "filename.ext" where ".ext" defines the format the saved image ()

```
filetypes = {'ps': 'Postscript', 'eps': 'Encapsulated Postscript', 'pdf': 'Portable Document Format',  
'pgf': 'PGF code for LaTeX', 'png': 'Portable Network Graphics', 'raw': 'Raw RGBA bitmap', 'rgba': 'Raw  
RGBA bitmap', 'svg': 'Scalable Vector Graphics', 'svgz': 'Scalable Vector Graphics', 'jpg': 'Joint  
Photographic Experts Group', 'jpeg': 'Joint Photographic Experts Group', 'tif': 'Tagged Image File  
Format', 'tiff': 'Tagged Image File Format'}
```

Basic Plotting - Programmatically!

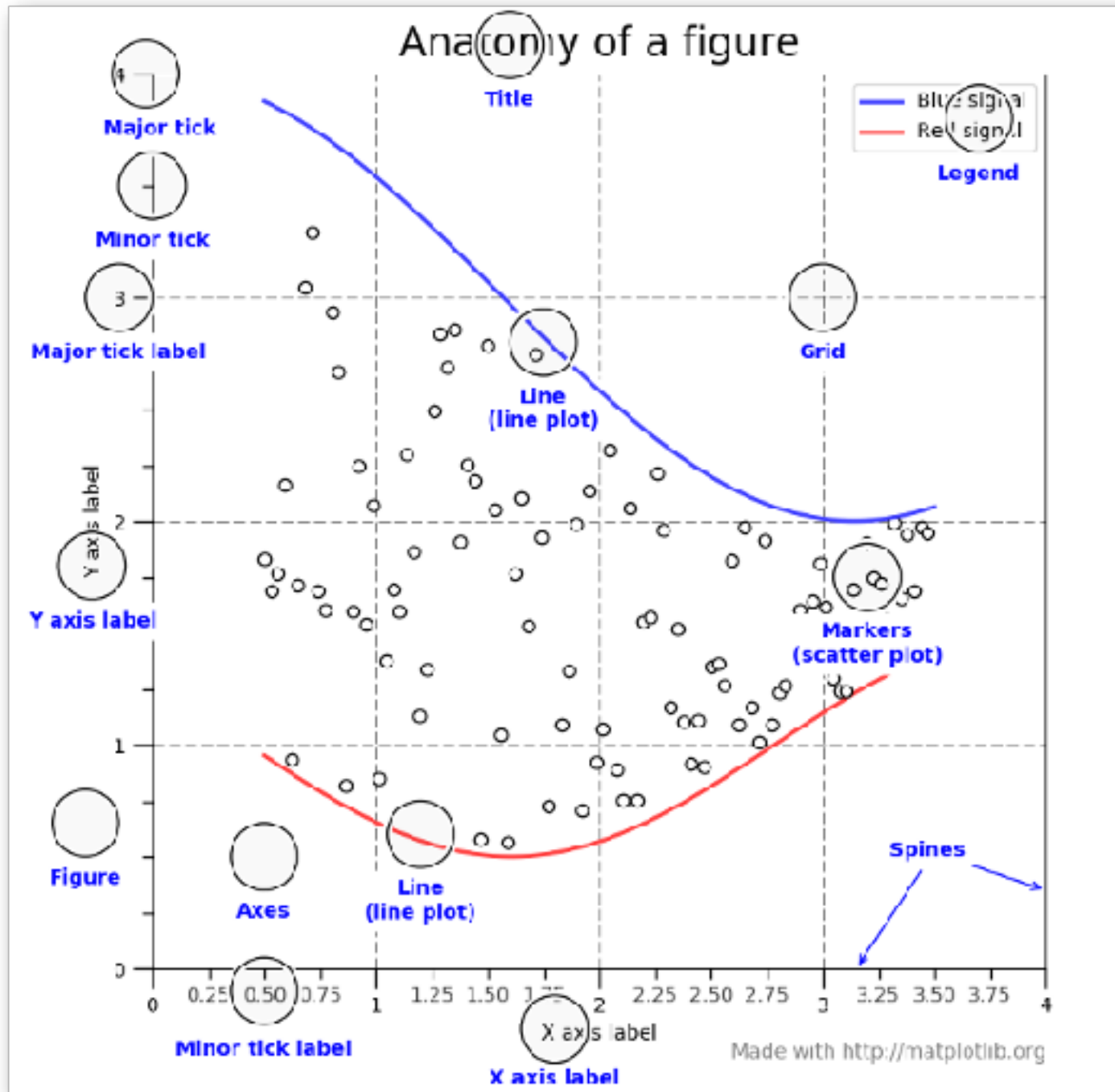
- The first step is to import the pyplot module from matplotlib and instanciating a Figure object:

```
import matplotlib.pyplot as plt  
fig = plt.figure()
```

- The convention is to import **pyplot** as **plt**
- To create subplots (**Axes**) you use **.subplots(nrows, ncols, sharex=False, sharey=False)** instead of **.figure()**. set **sharex** and/or **sharey** to True to keep the same scale in both cases.
- **.subplots** - returns a (fig, ax_lst) tuple where **ax_lst** is a list of **Axes** and **fig** is the **Figure**.
- **Axes** have several methods of interest:
 - **.plot(x, y)** - Make a scatter or line plot from a list of x, y coordinates.
 - **.imshow(mat)** - Plot a matrix as if it were an image. Element 0,0 is plotted in the top right corner.
 - **.bar(x, y)** - Make a bar plot where x is a list of the lower left coordinates of each bar and y is the respective height.
 - **.pie(values, labels=labels)** - Produce a pie plot out of a list of **values** list and labeled with **labels**
 - **.savefig(filename)** - Write the current figure as an static image

Matplotlib - decorations

<https://matplotlib.org/2.0.0/>



- The respective functions are named in an intuitive way. Every **Axes** object has as methods:
 - `.set_xlabel(label)`
 - `.set_ylabel(label)`
 - `.set_title(title)`
- And axis limits can be set using:
 - `.set_xlim(xmin, xmax)`
 - `.set_ylim(ymin, ymax)`
- Tick marks and labels are set using:
 - `.set_xticks(ticks)/.set_yticks(ticks)`
 - `.set_xticklabels(labels)/.set_yticklabels(labels)`

Matplotlib - Images

<https://matplotlib.org/2.0.0/>

- `.imshow(fig)` - Display an image on a set of axes.
- `fig` can be any matrix of numbers.
- Further plotting can occur by simply using the functions described above

<https://bmtgoncalves.github.io/DataVisualization/>
<https://github.com/bmtgoncalves/DataVisualization>