

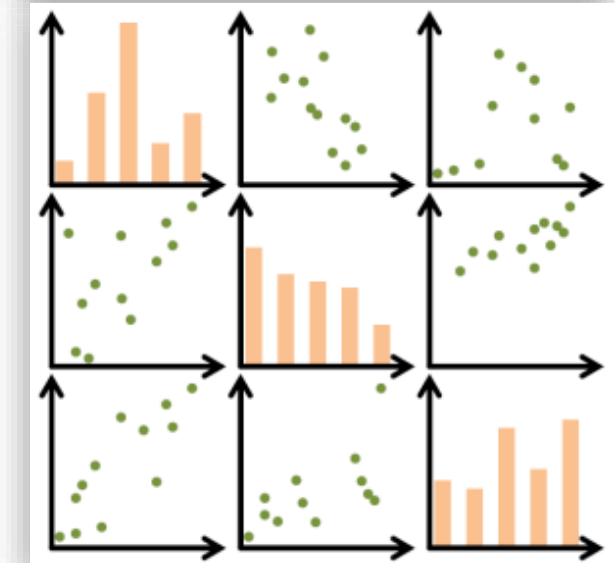
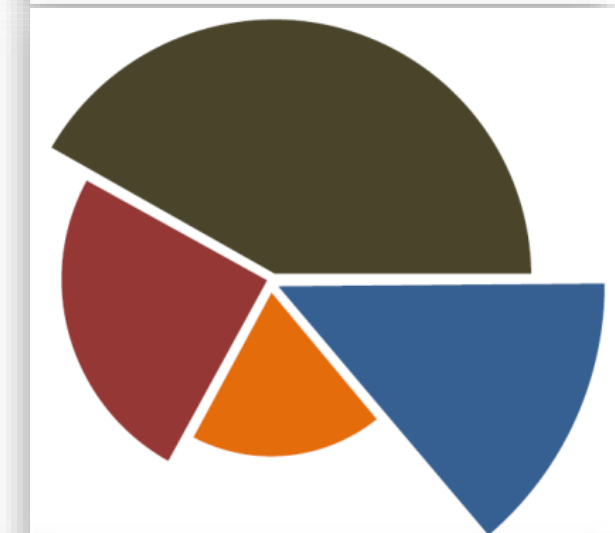
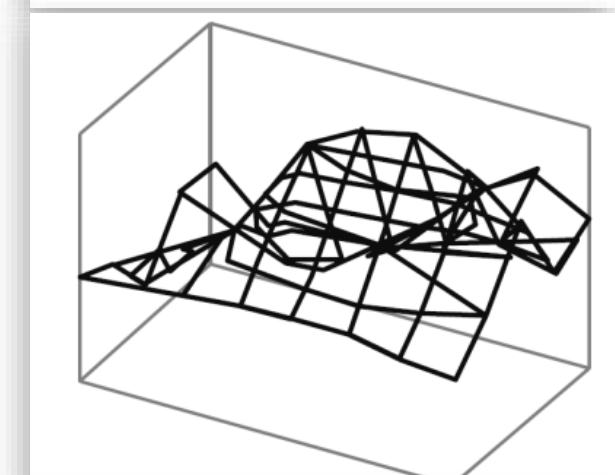
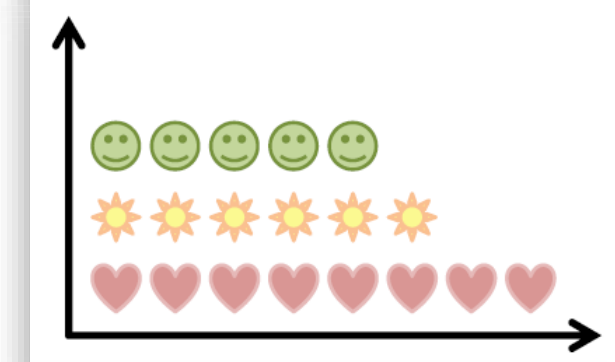
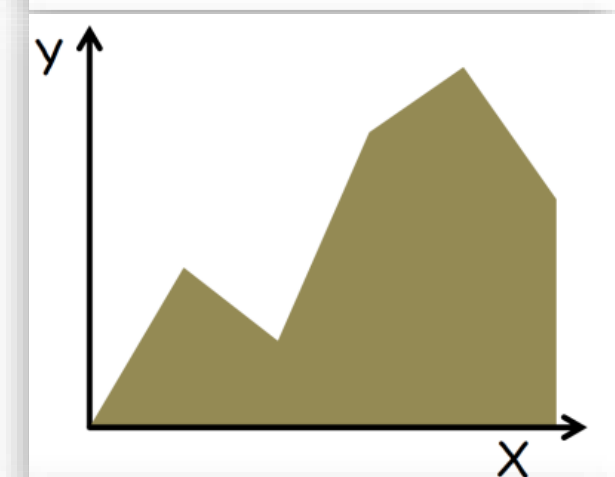
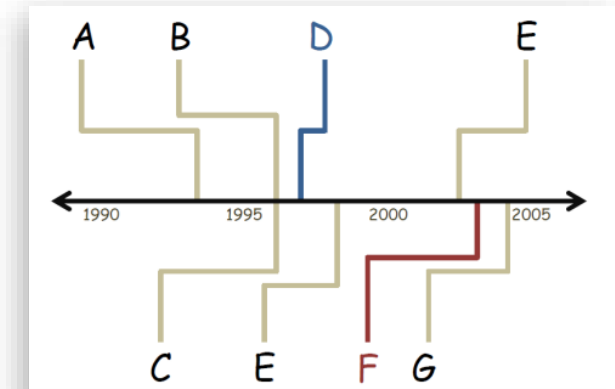
# Visual Encodings (Continued), Color

CS 7250

SPRING 2020

*Prof. Cody Dunne*

*NORTHEASTERN UNIVERSITY*



*Slides and inspiration from Michelle Borkin, Krzysztof Gajos, Hanspeter Pfister, Miriah Meyer, Jonathan Schwabish, and David Sprague*

# READING QUIZ

*5 min*

**BURNING QUESTIONS?**

PREVIOUSLY, ON CS 7250...

# Analysis



What?

What data is shown?

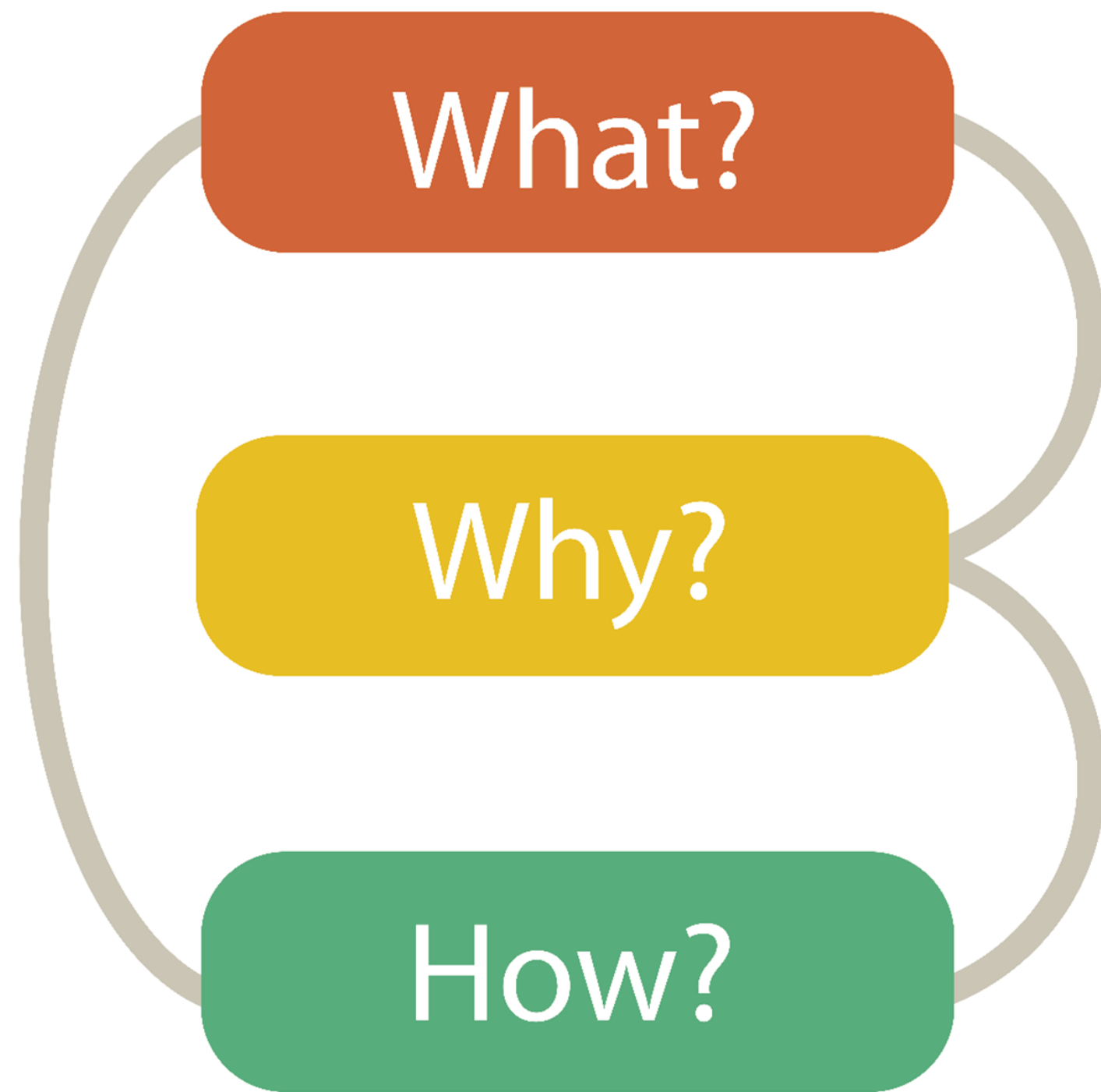
Why?

Why is the user analyzing / viewing it?

How?

How is the data presented?

# Analysis
















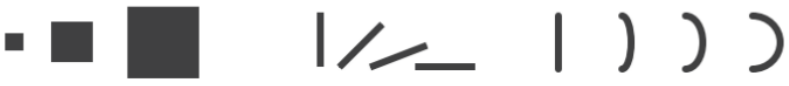




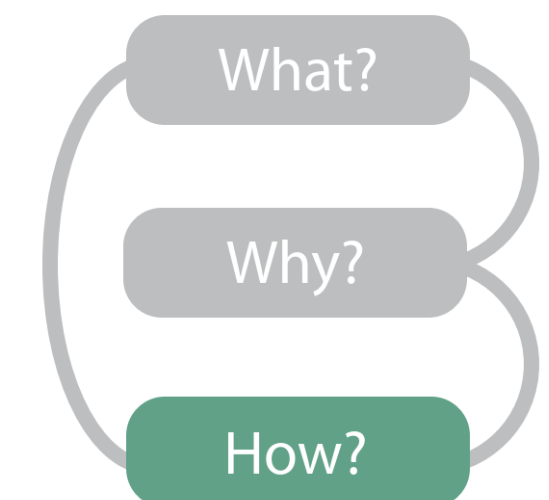
DATA ABSTRACTION

TASK ABSTRACTION

VISUAL ENCODING

# VISUAL ENCODING

		How?			
		Encode	Manipulate	Facet	Reduce
➔	Arrange	➔ Express 	➔ Separate 	➔ Juxtapose 	➔ Filter 
		➔ Order 	➔ Align 	➔ Partition 	➔ Aggregate 
		➔ Use 	➔ Select 	➔ Superimpose 	➔ Embed 
➔	Map	from <b>categorical</b> and <b>ordered</b> attributes	➔ Color ➔ Hue  ➔ Saturation  ➔ Luminance 		
		➔ Size, Angle, Curvature, ... 			
		➔ Shape 			
		➔ Motion <i>Direction, Rate, Frequency, ...</i> 			



# Arrange Tables

## → Separate, Order, Align Regions

→ Separate



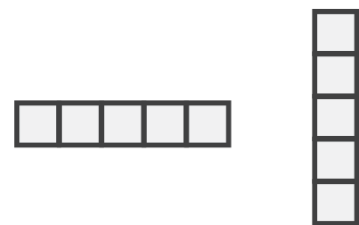
→ Order



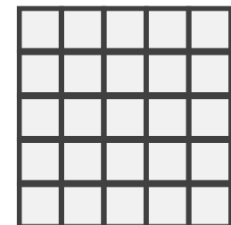
→ Align



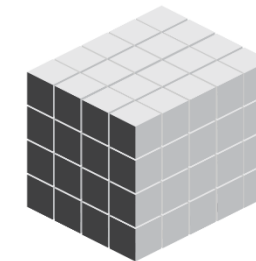
→ 1 Key  
*List*



→ 2 Keys  
*Matrix*



→ 3 Keys  
*Volume*



→ Many Keys  
*Recursive Subdivision*



Key: an independent attribute that can be used as a unique index (Tableau Dimension)

Value: a dependent attribute (i.e., cell in a table) (Tableau Measures)

*Categorical or Ordinal*

*Categorical Ordinal, or Quantitative*



Now, ON CS 7250...

# Analysis



What?

Why?

How?

DATA ABSTRACTION

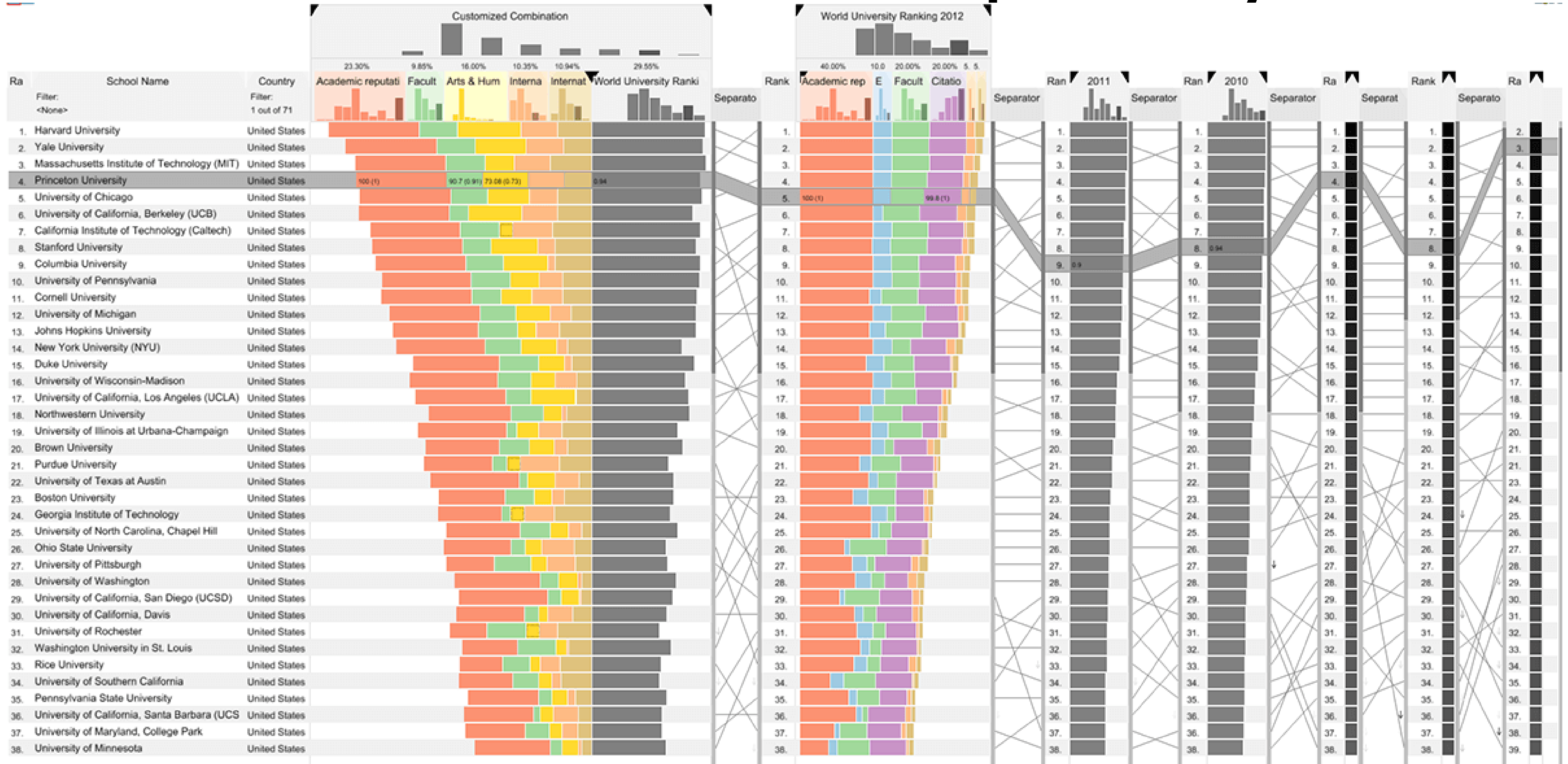
TASK ABSTRACTION

VISUAL ENCODING

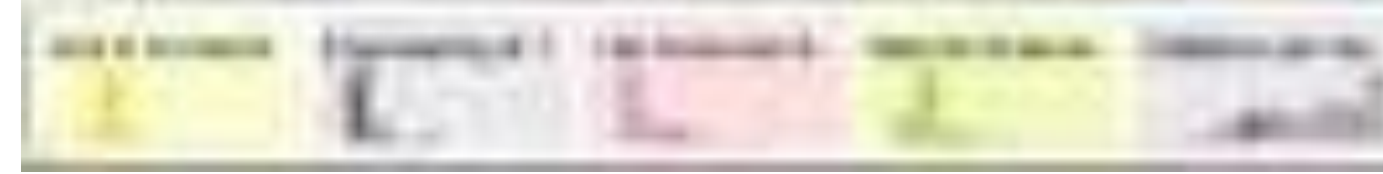
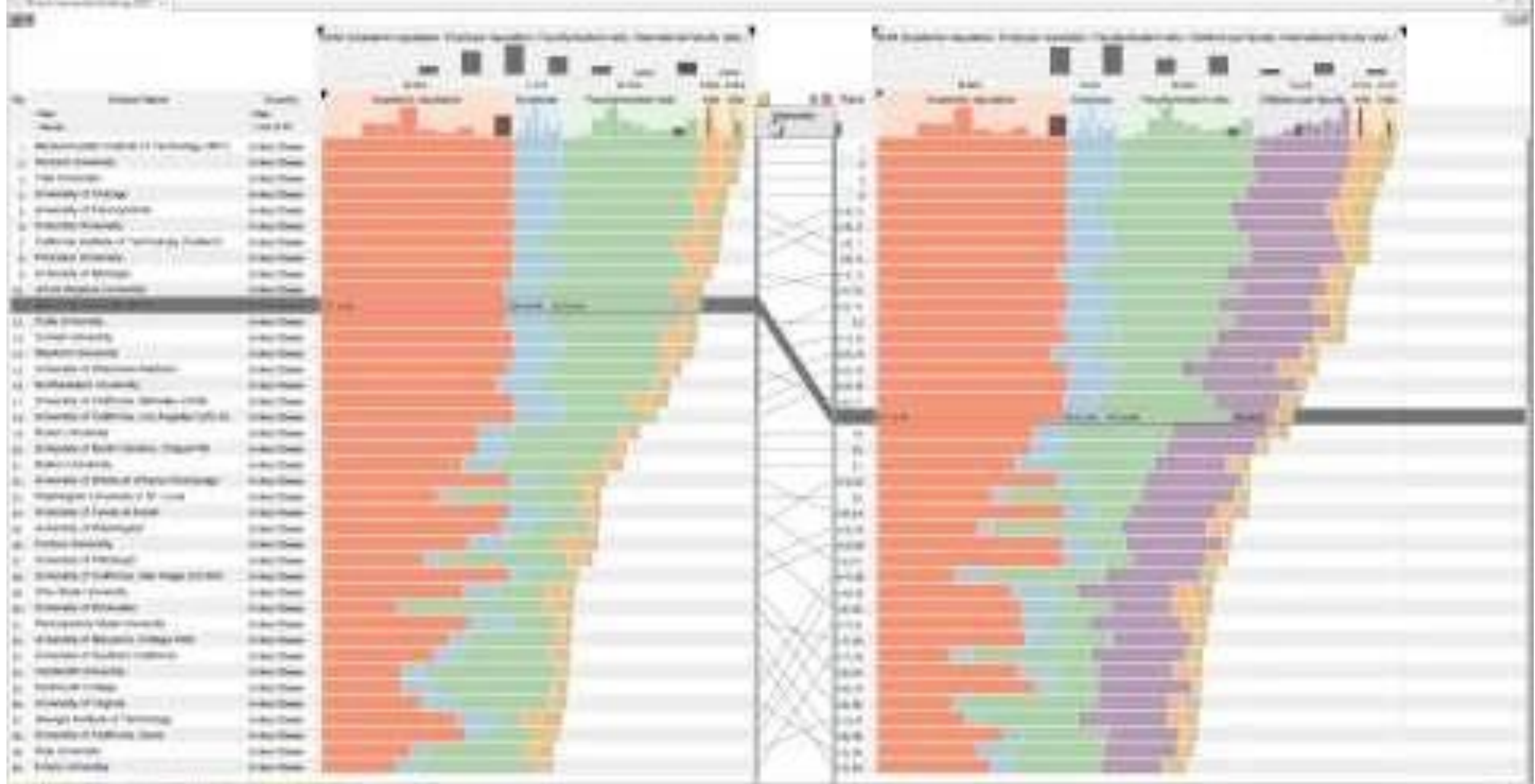
# GOALS FOR TODAY

- Learn (still more) about visual encodings, esp. arranging tables
- Learn how to pick appropriate visual representations based on attribute type and perceptual properties

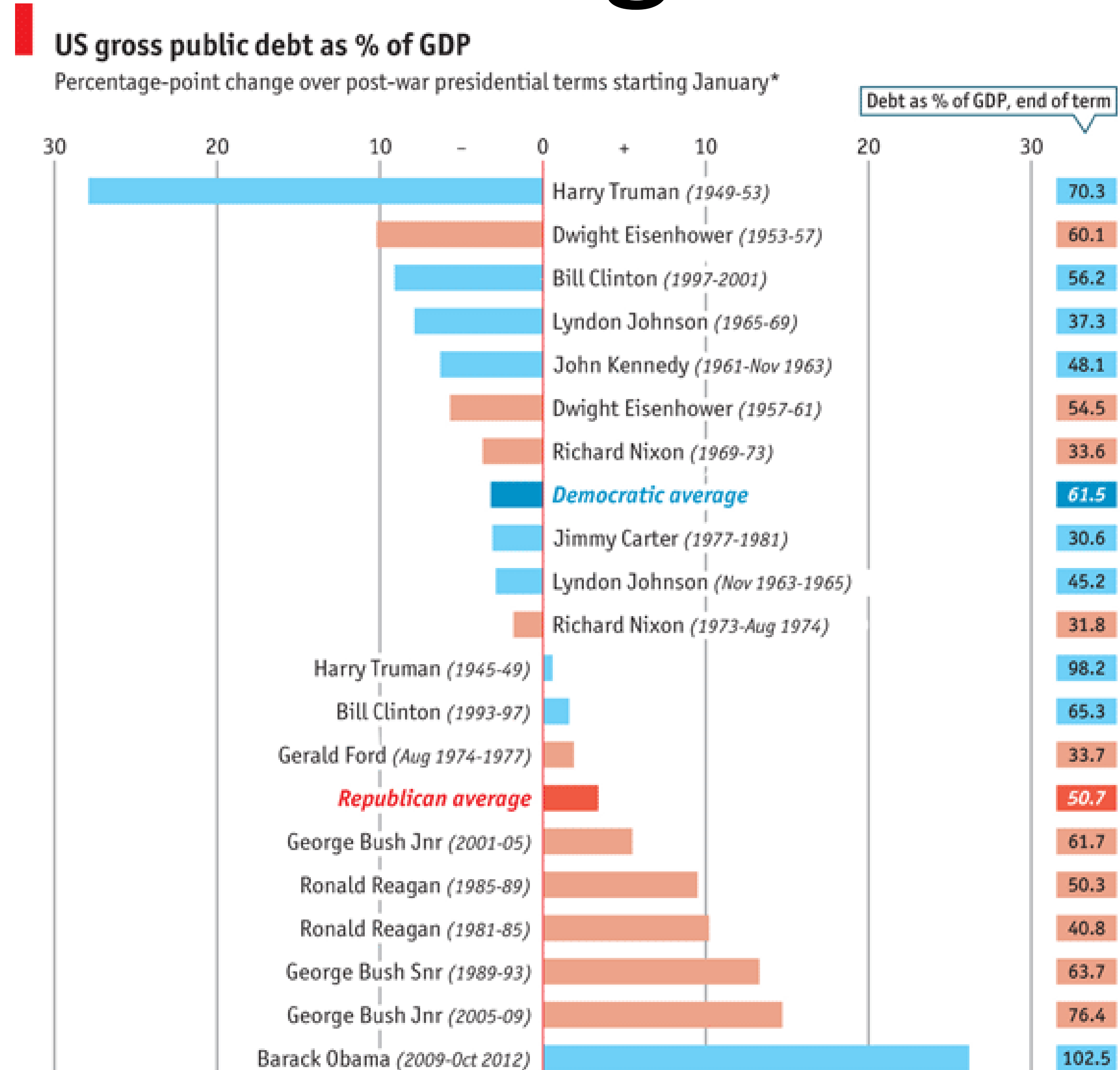
# How to handle multiple keys...?







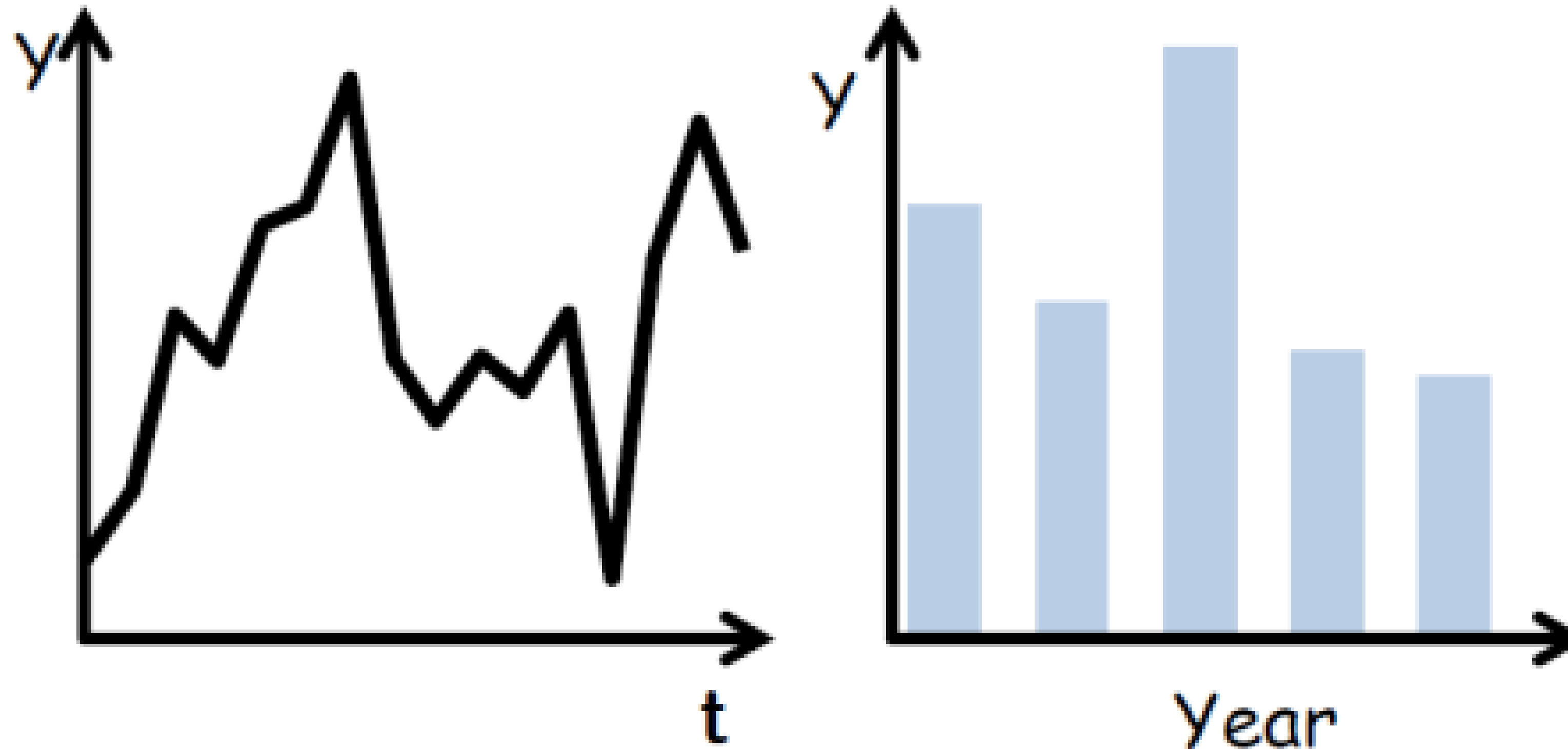
# Divergent



Sources: Bureau of Economic Analysis; Thomson Reuters; White House; *The Economist*

\*Unless otherwise stated

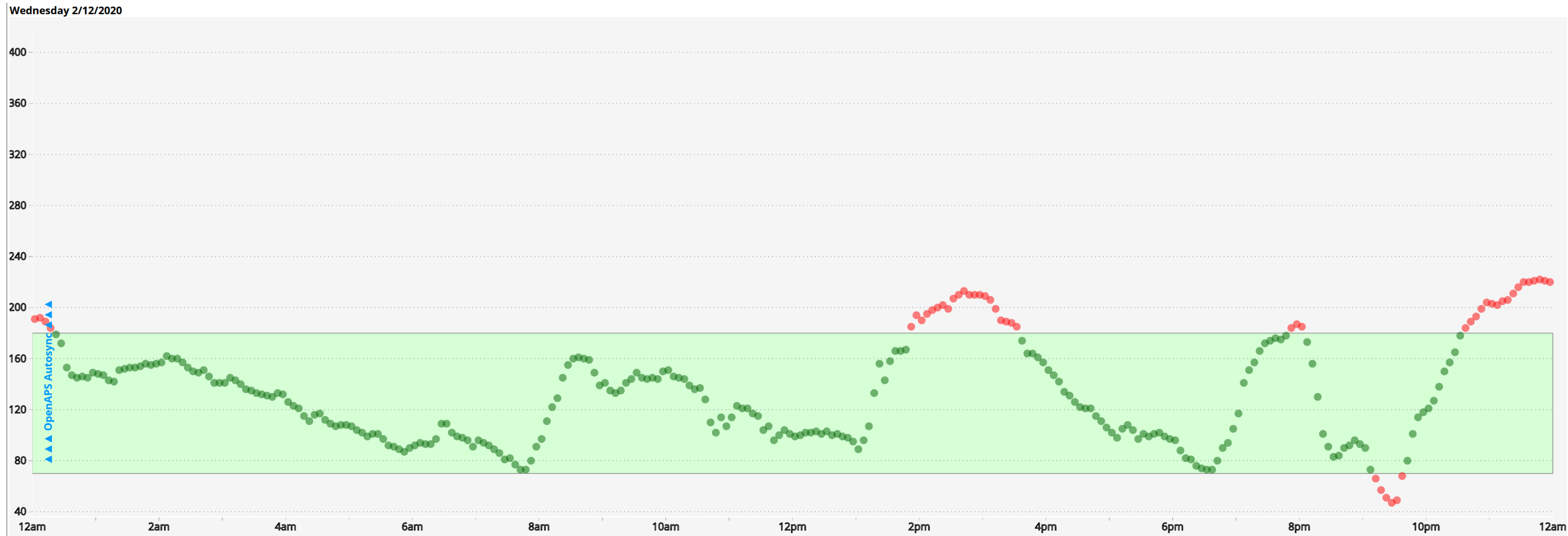
# Time Series



(Quantitative data over time)



# Time Series

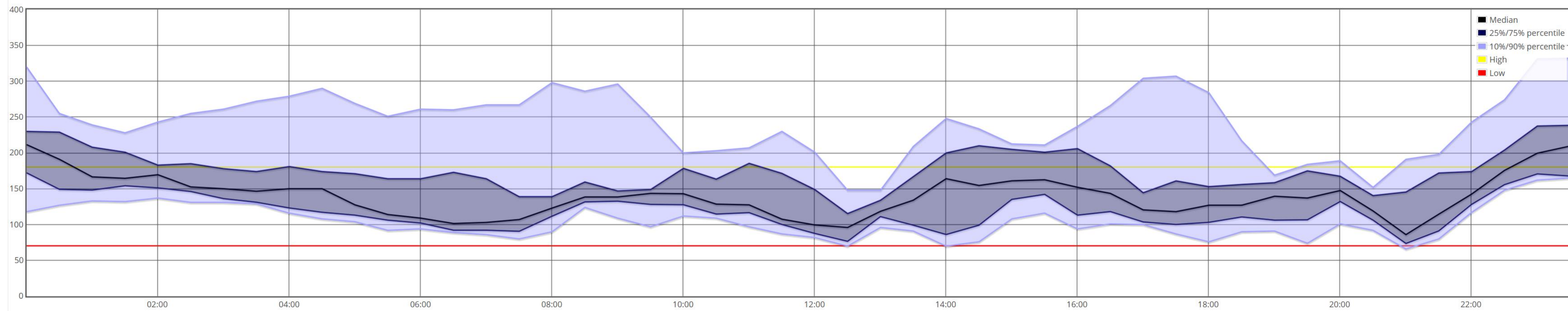


(Quantitative data over time)



# Time Series Distributions

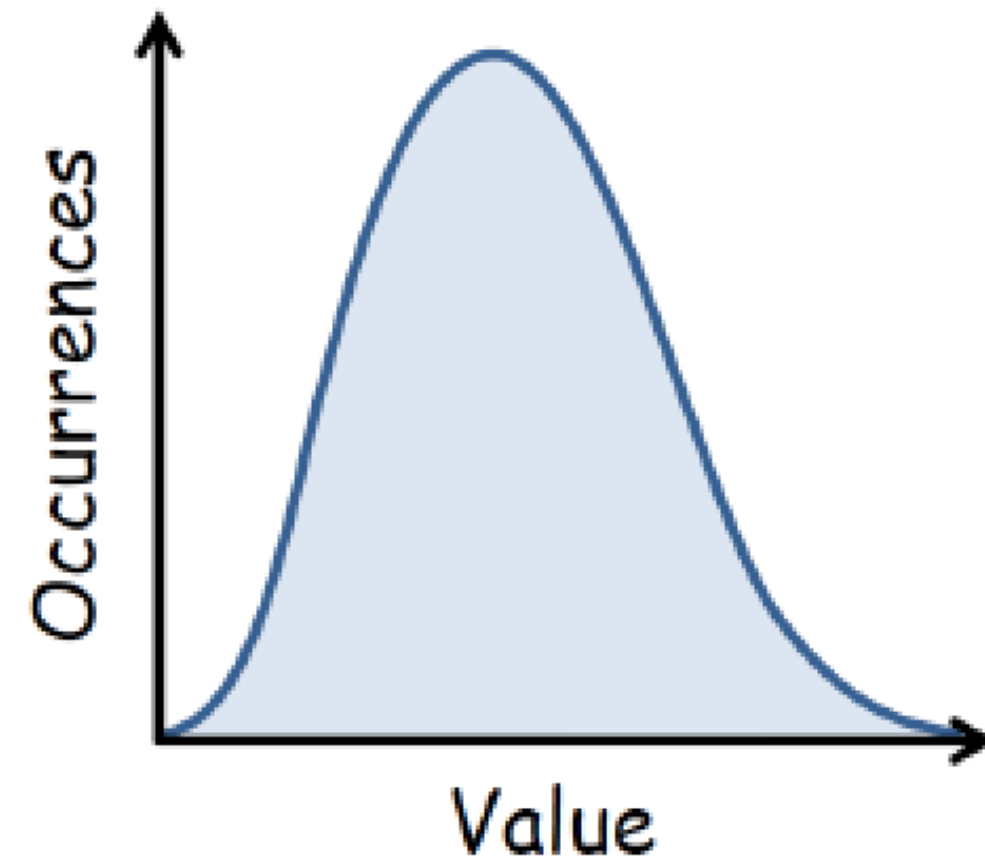
Glucose Percentile report



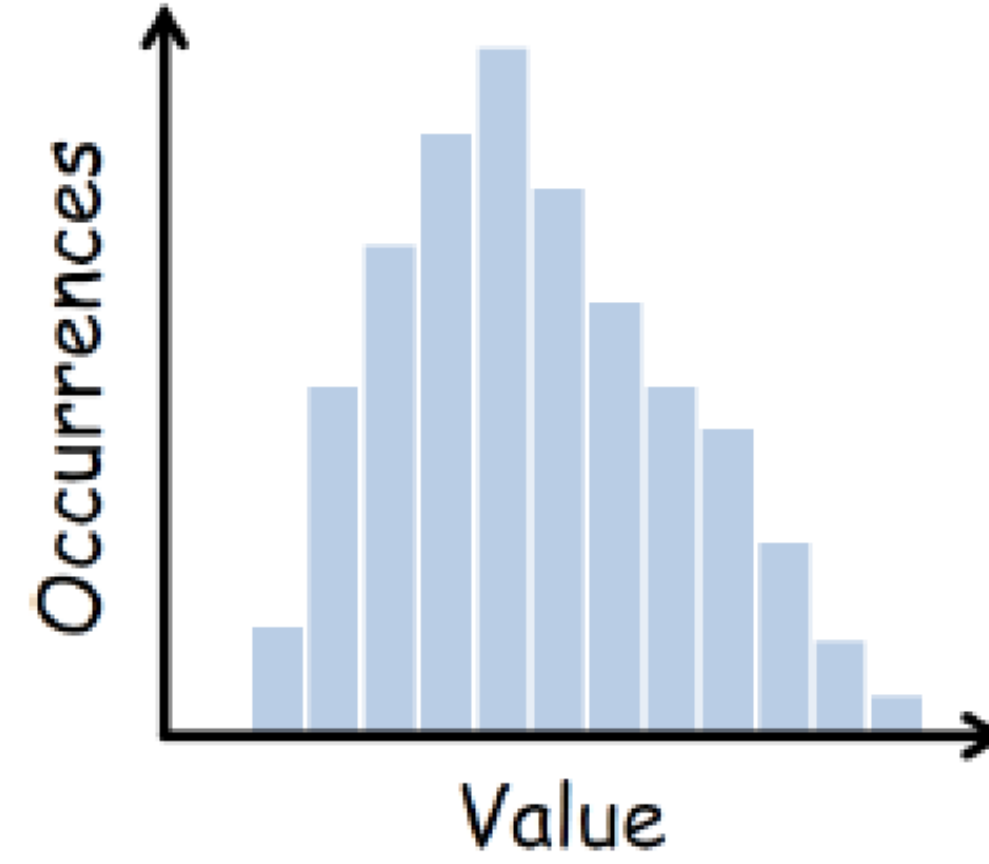
(Quantitative data over time)

# Distributions & Correlations

Distribution Curve



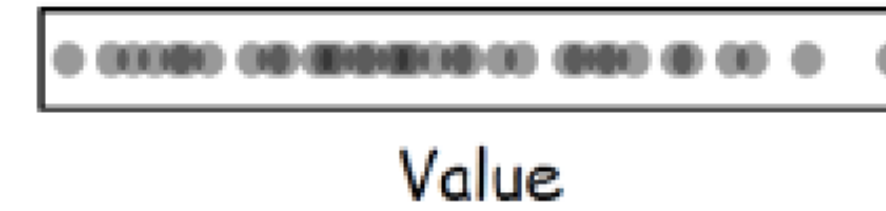
Histogram



Box-And-Whisker Plot



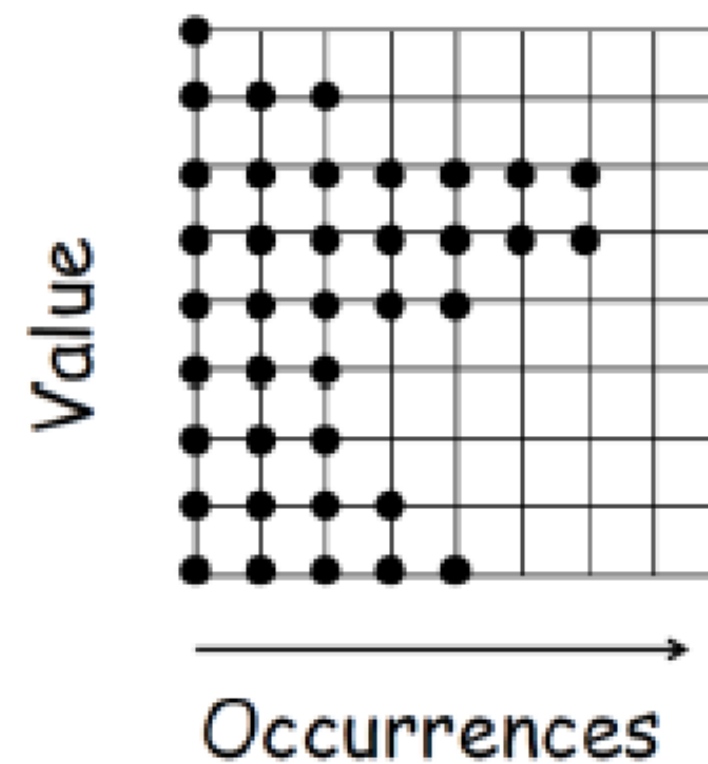
Point Graph



Stripe Graph



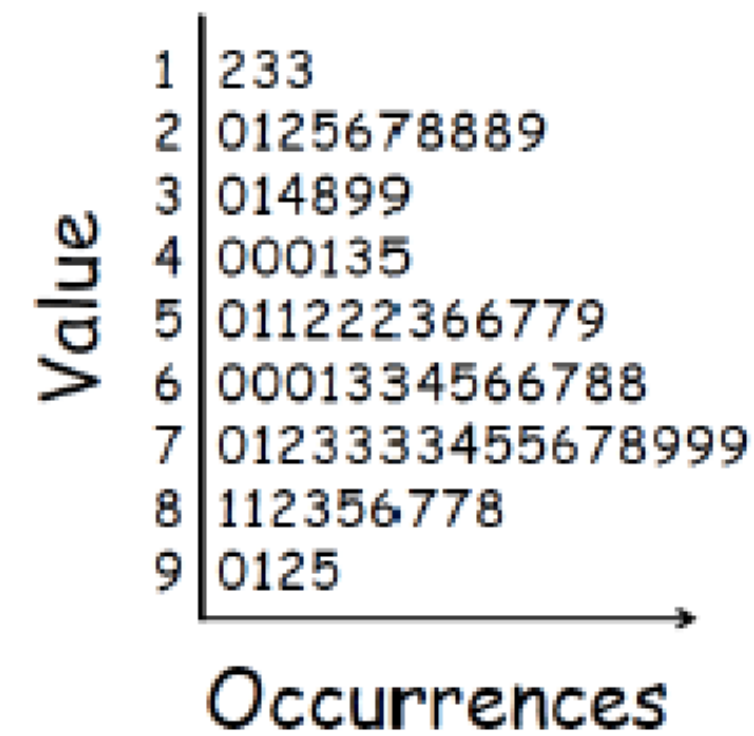
Dot Array



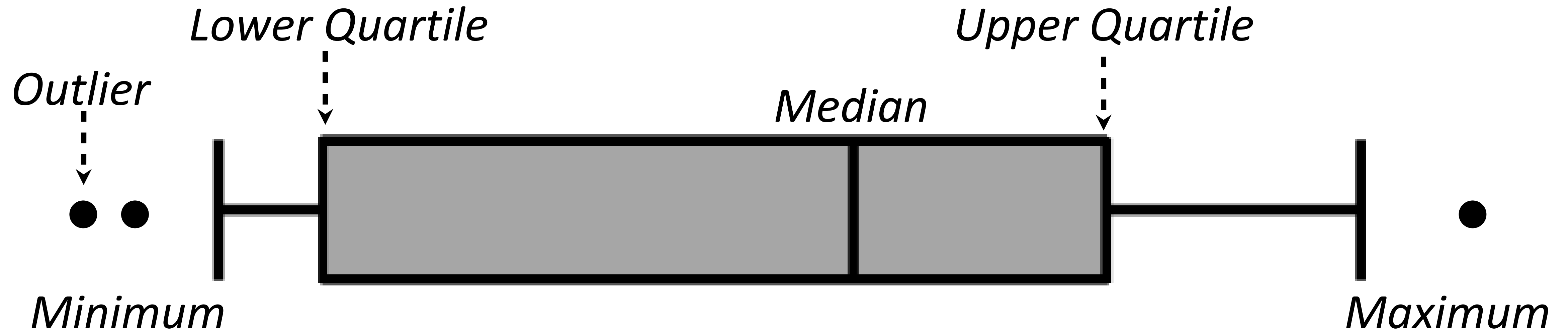
Tally Chart



Stem-And-Leaf Plot

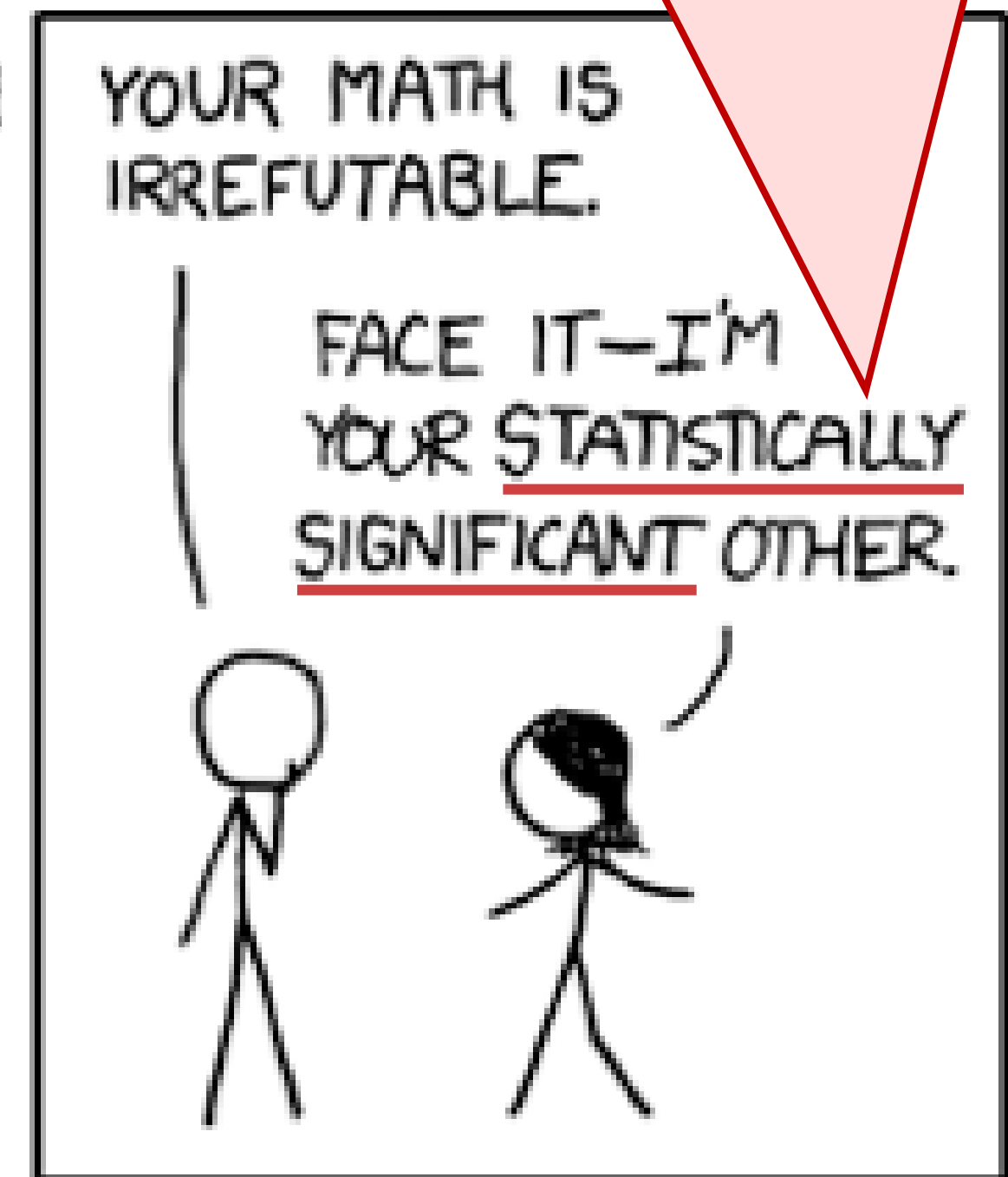
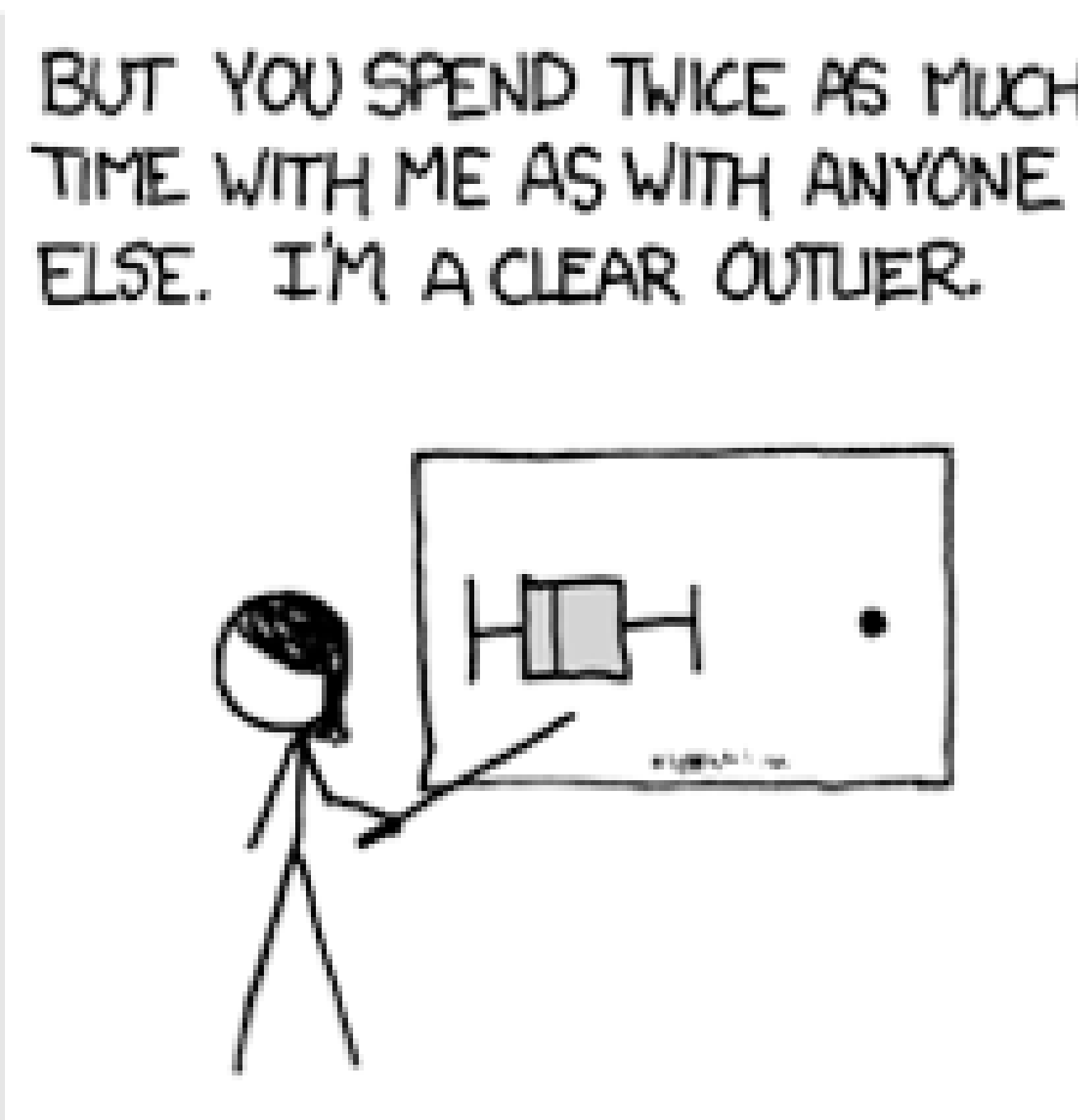
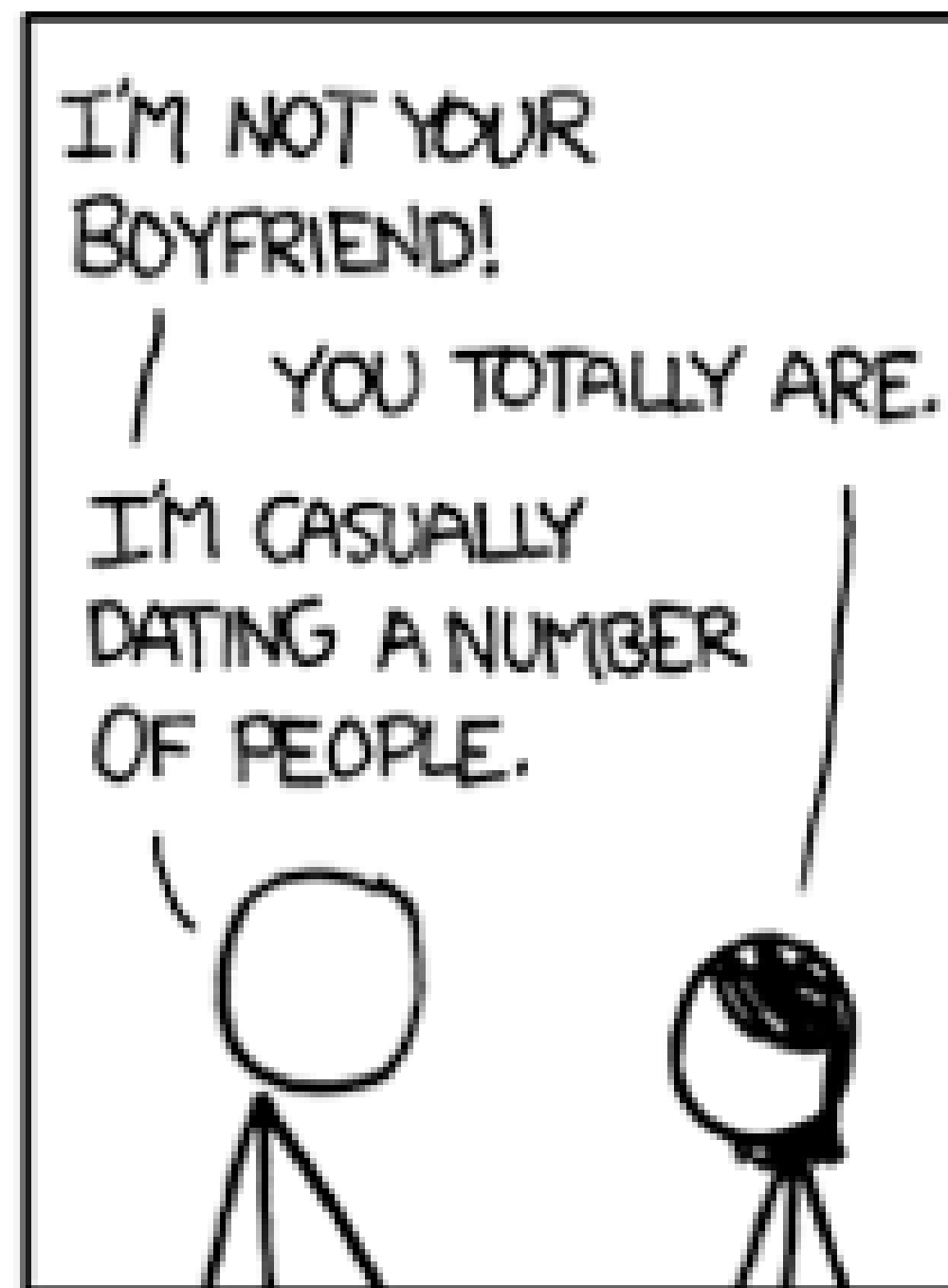
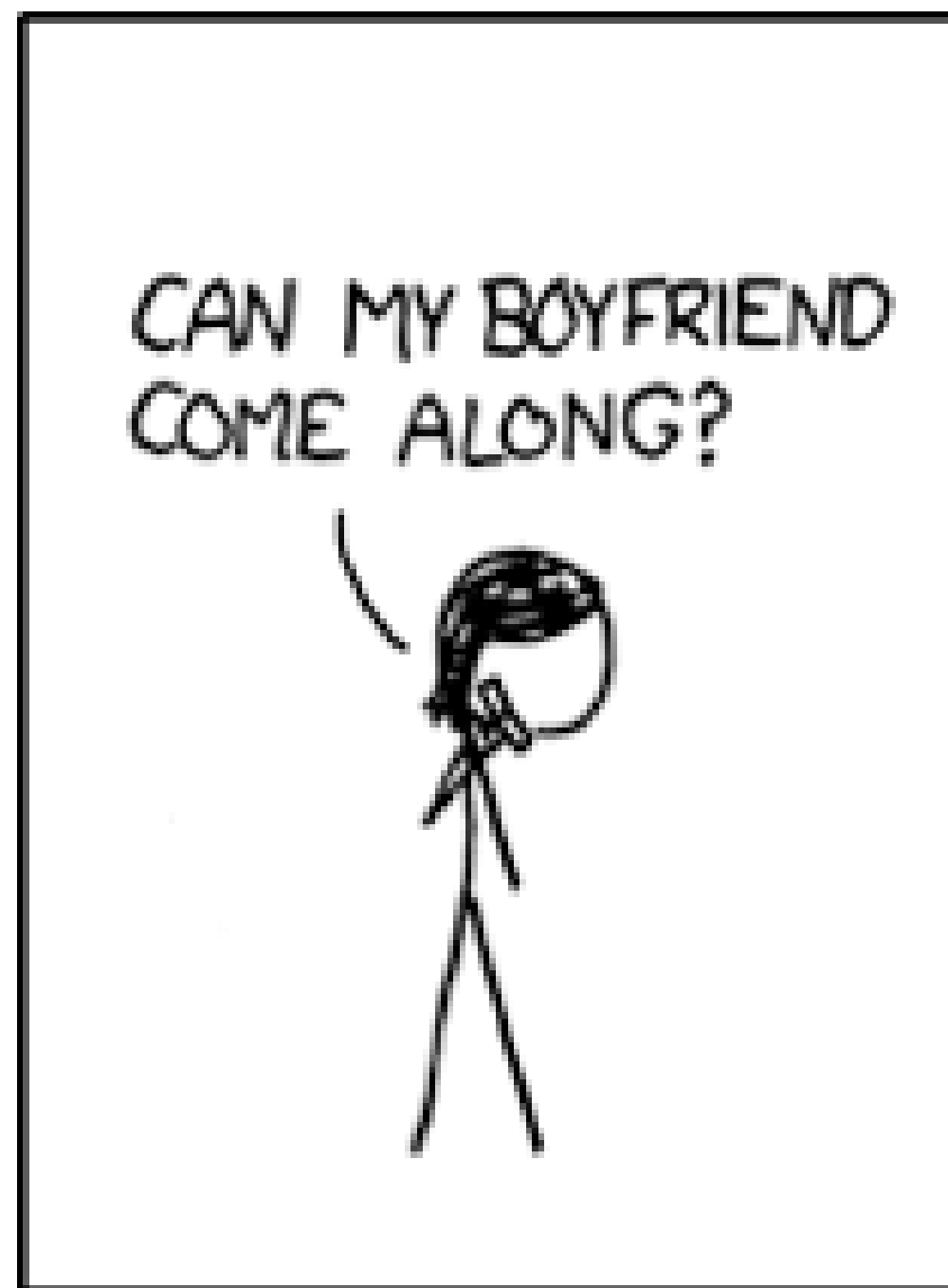


# Distributions & Correlations

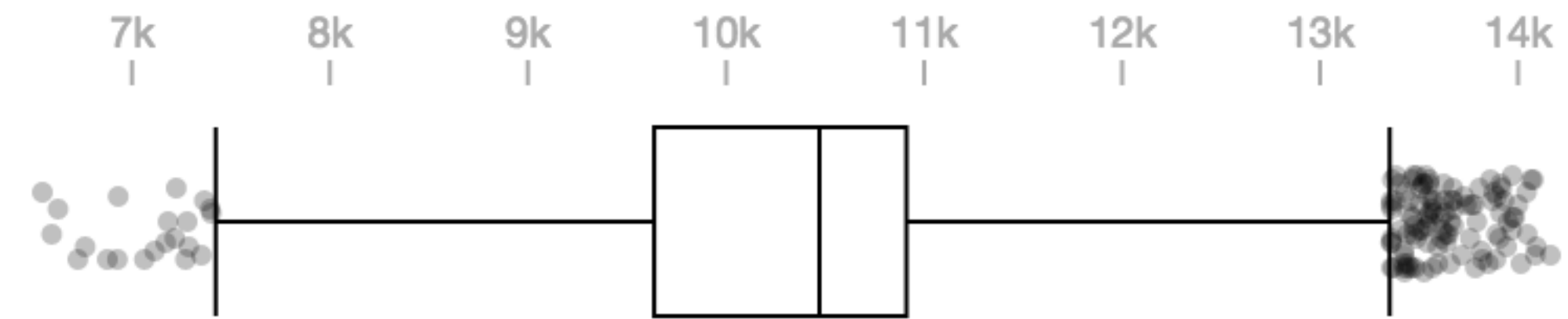
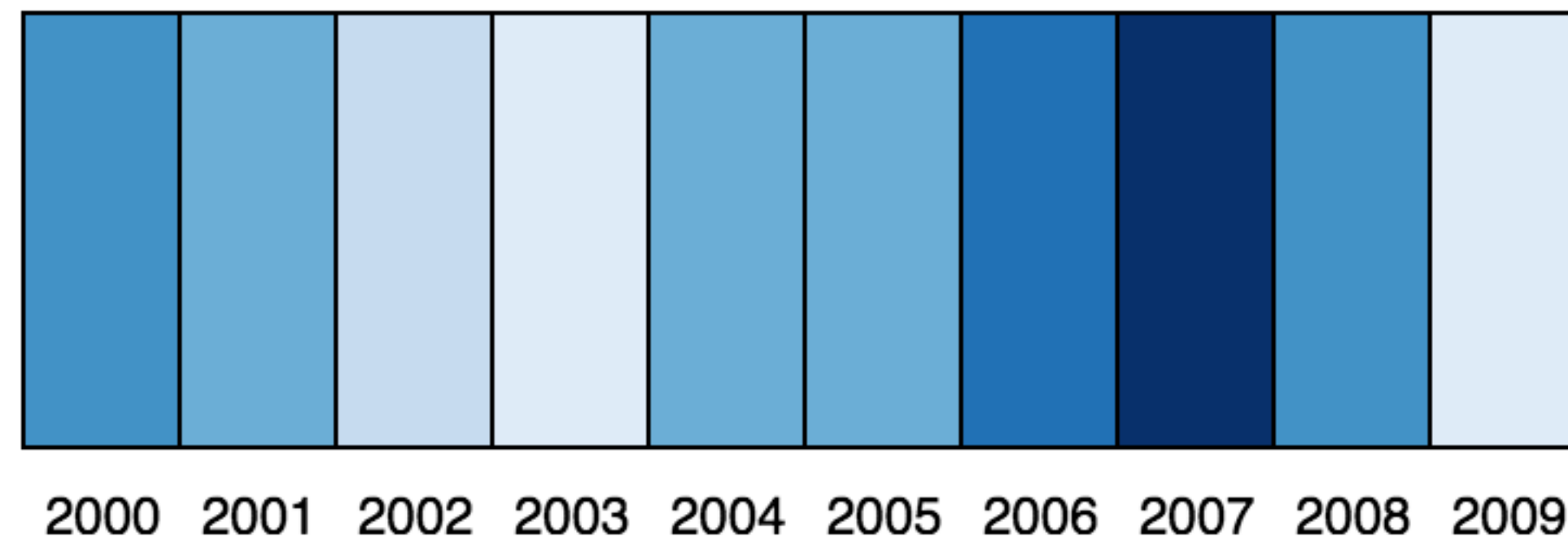


BOX AND WHISKER PLOT

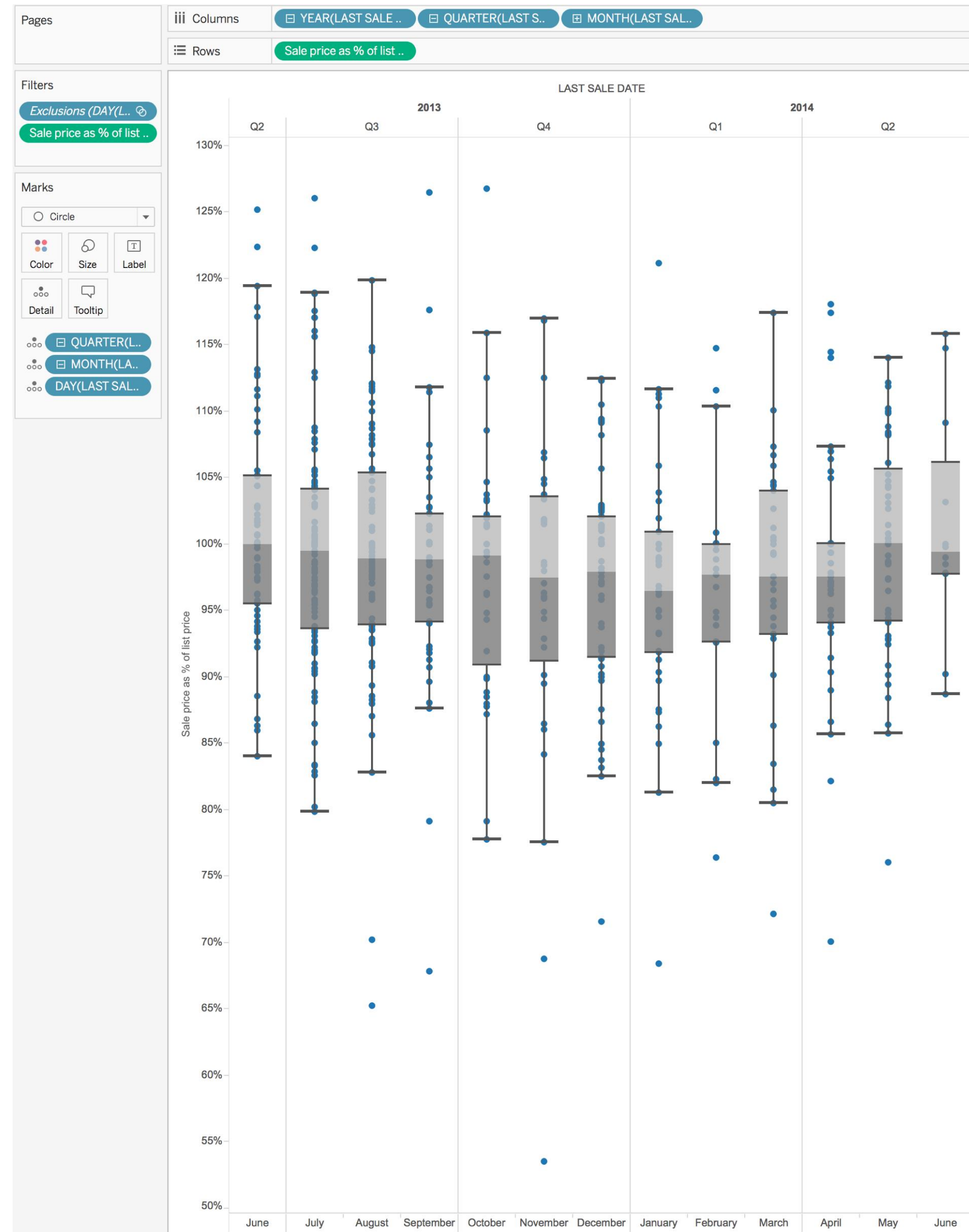
Dichotomous statistical thinking is problematic (e.g.,  $p < .05$  = significant)... and this means nothing w/o context about the tests used!!!



# Distributions & Correlations



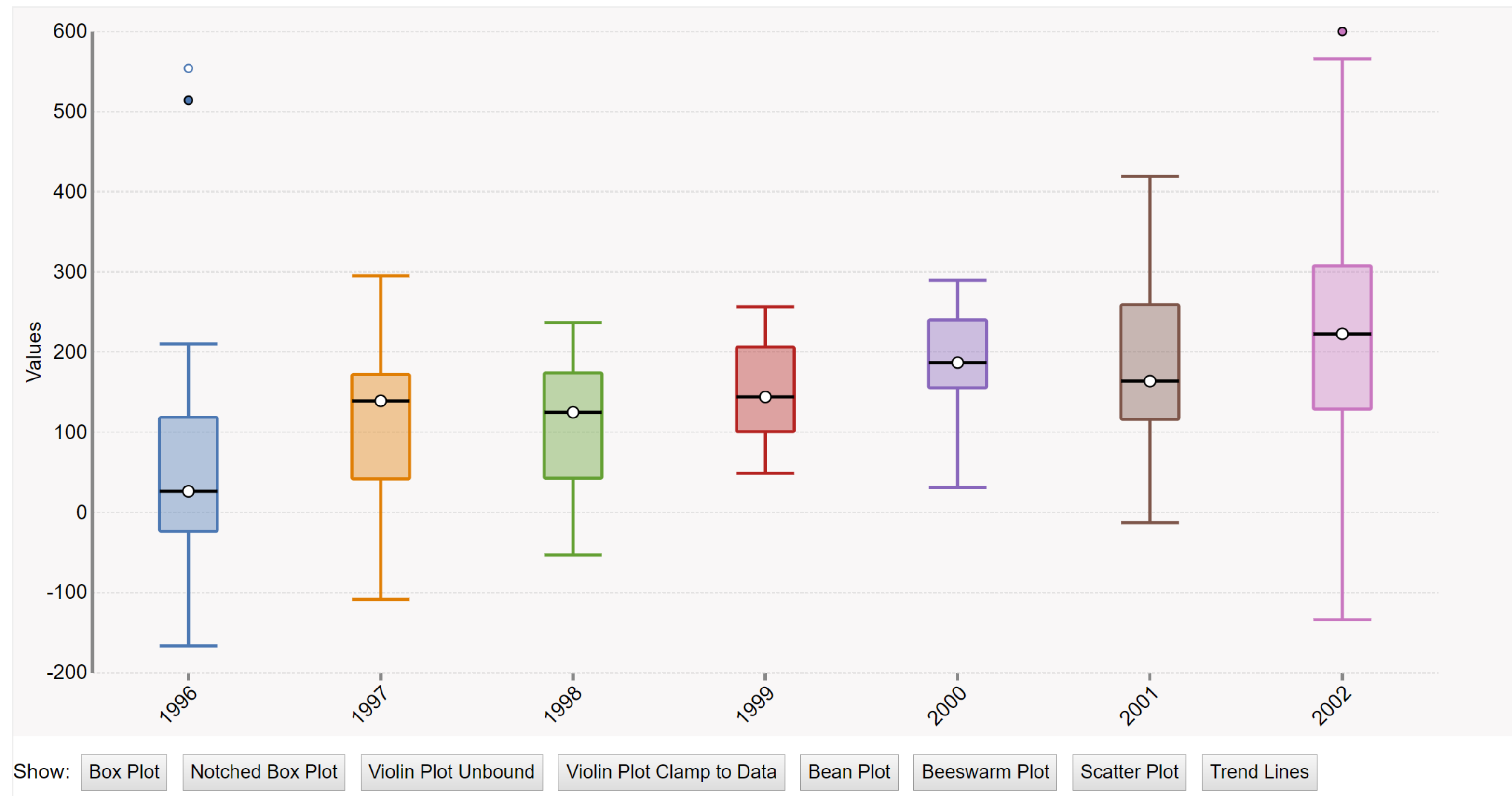
# Distributions & Correlations

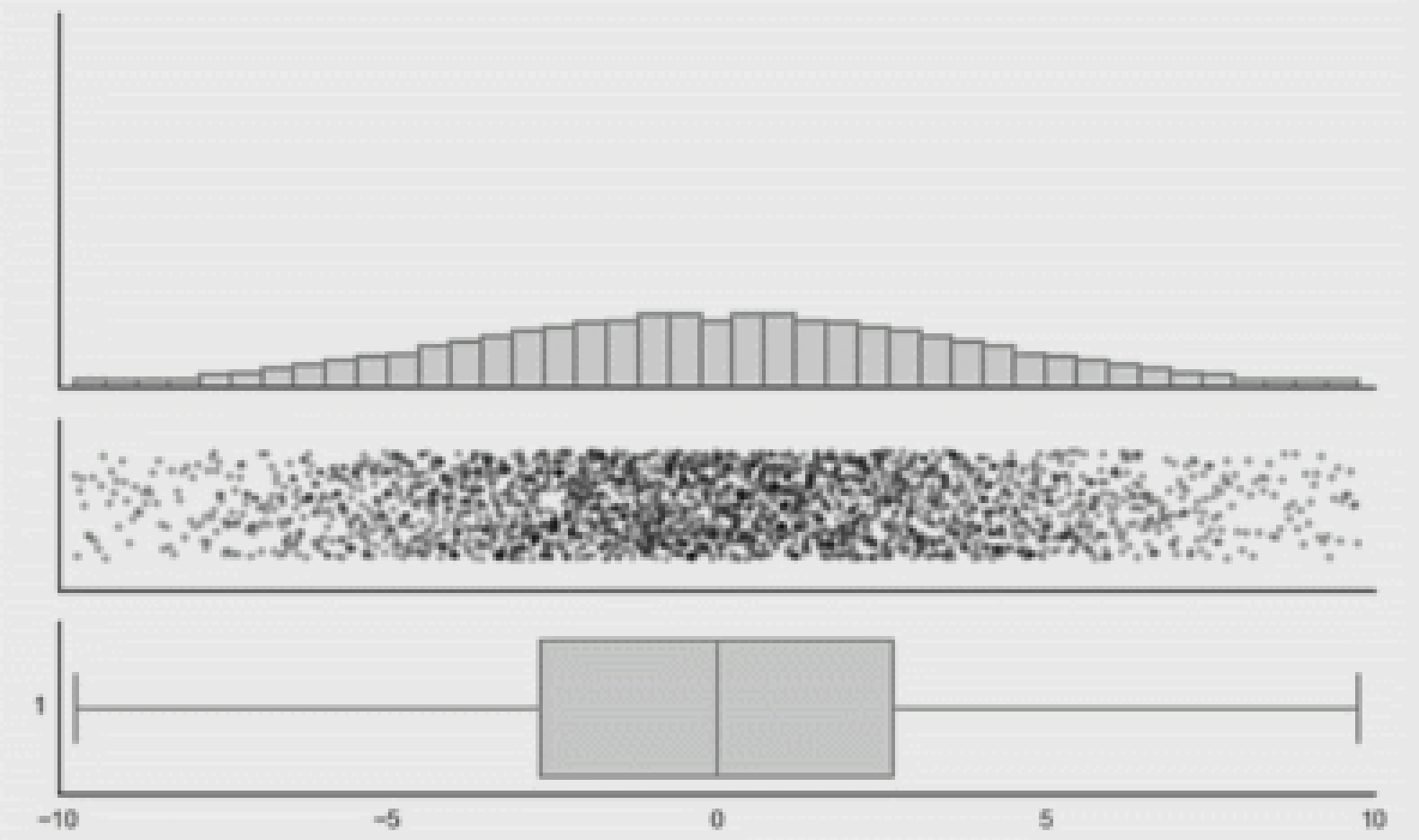
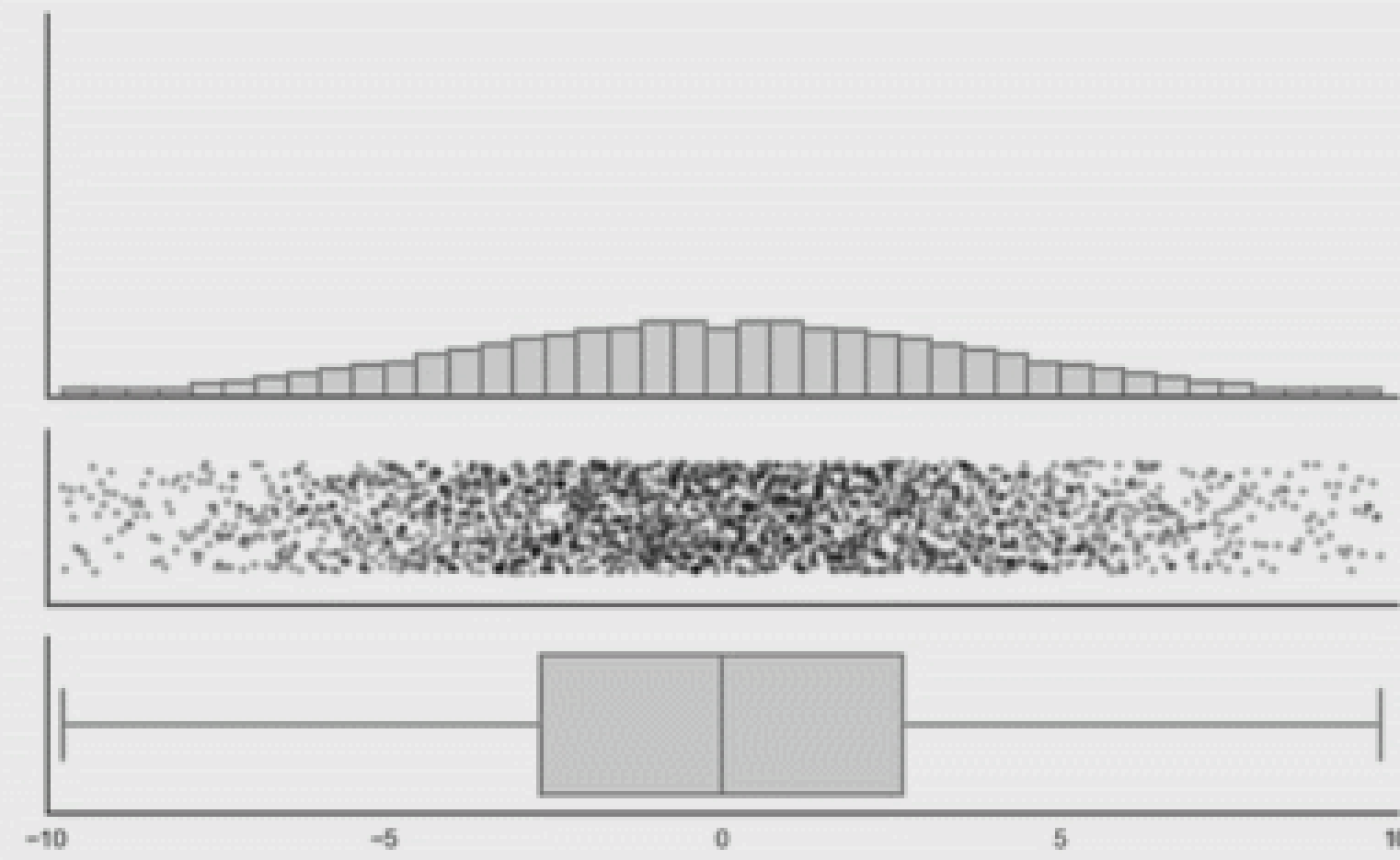
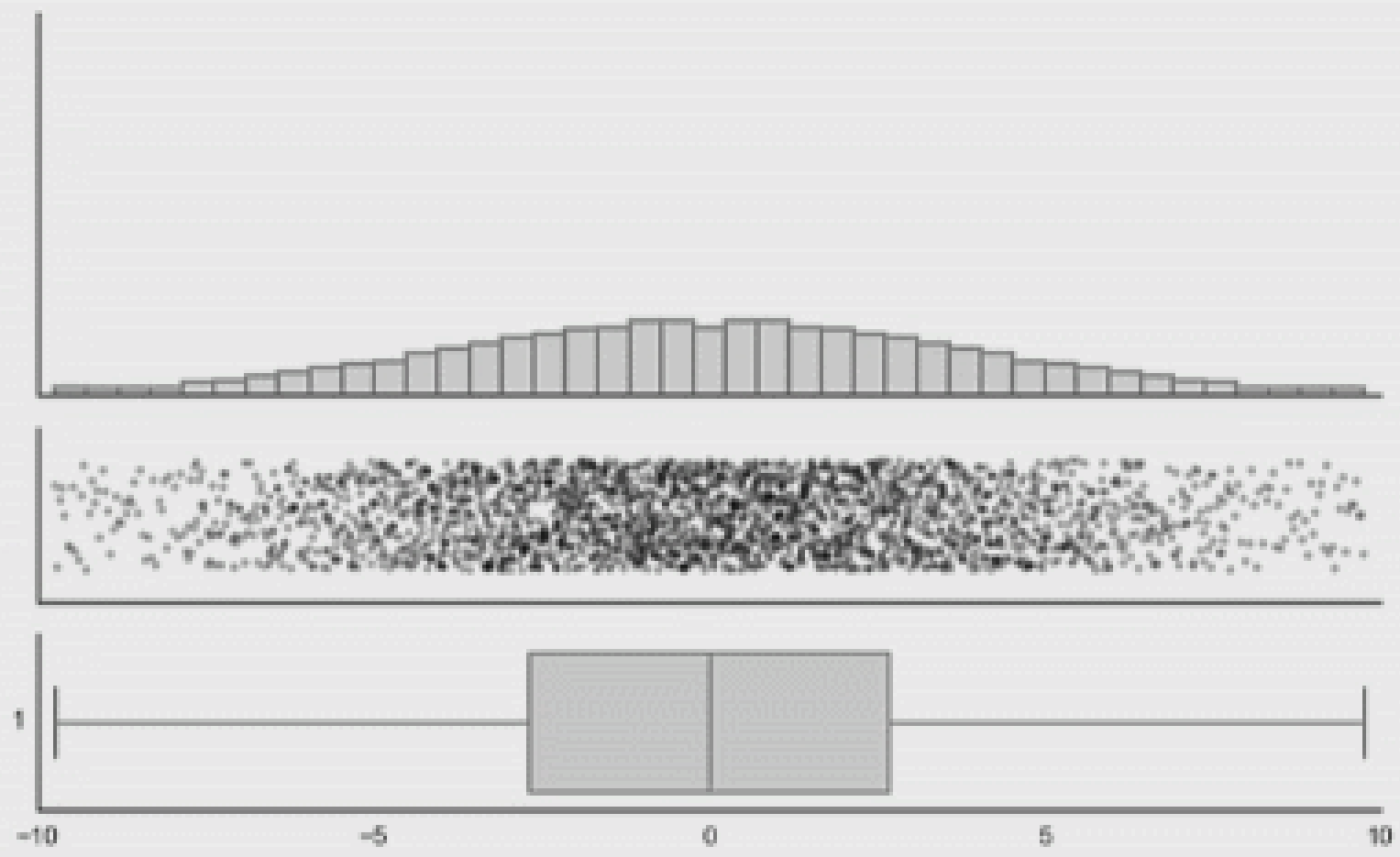




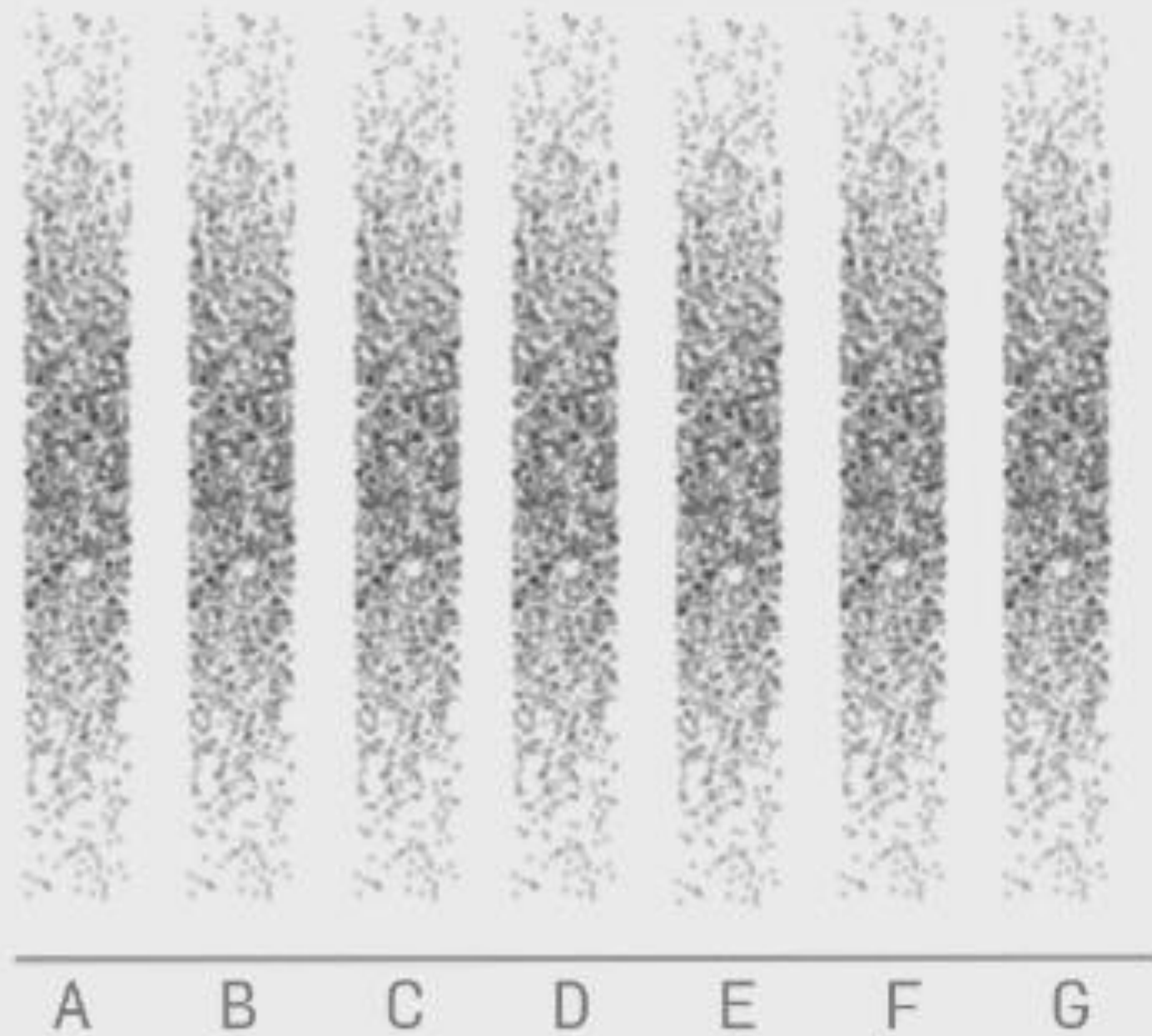
# Distributions & Correlations

## Violin Plot + Box Plot v3

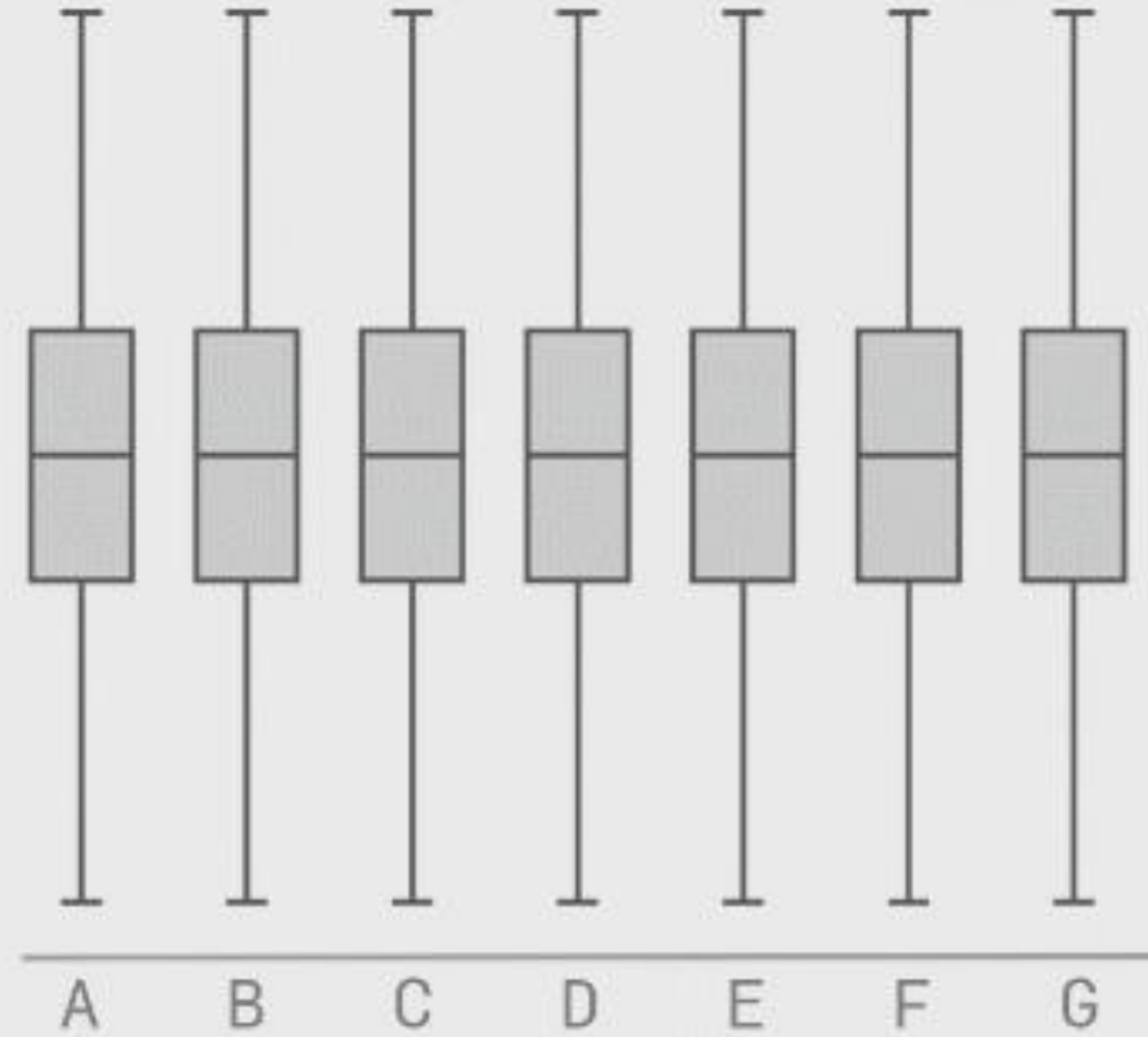




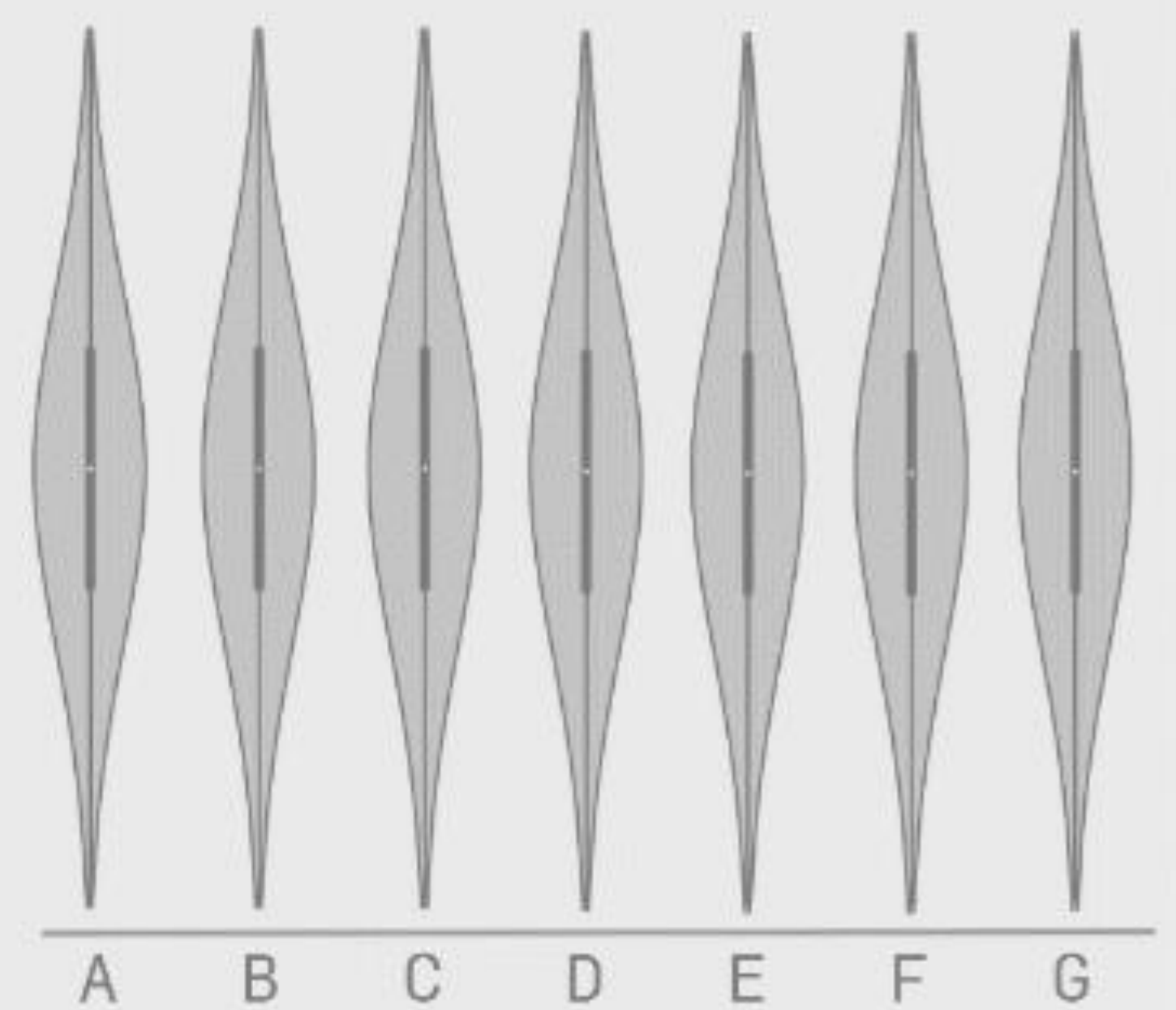
**Raw Data**



**Box-plot of the Data**

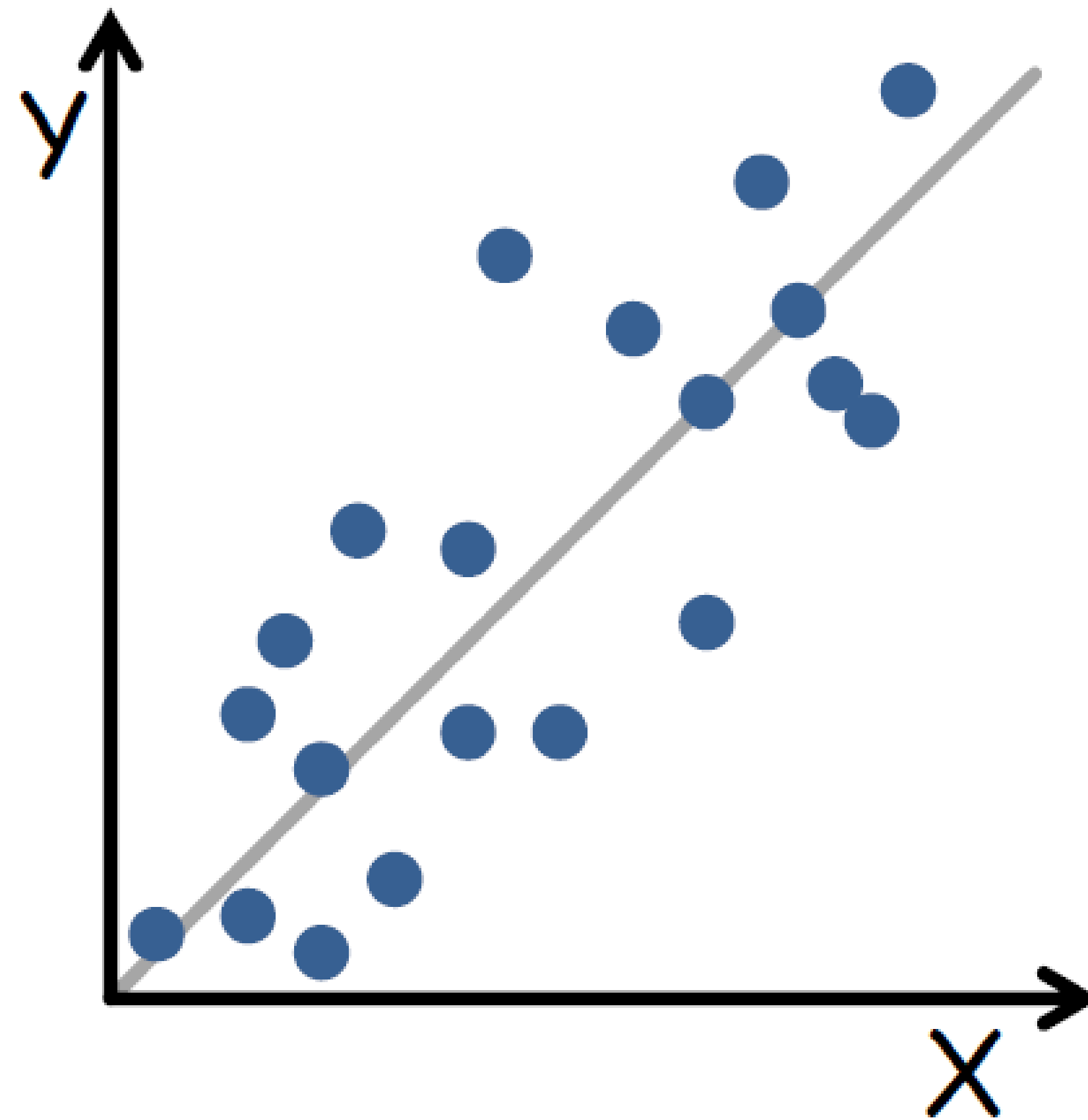


**Violin-plot of the Data**



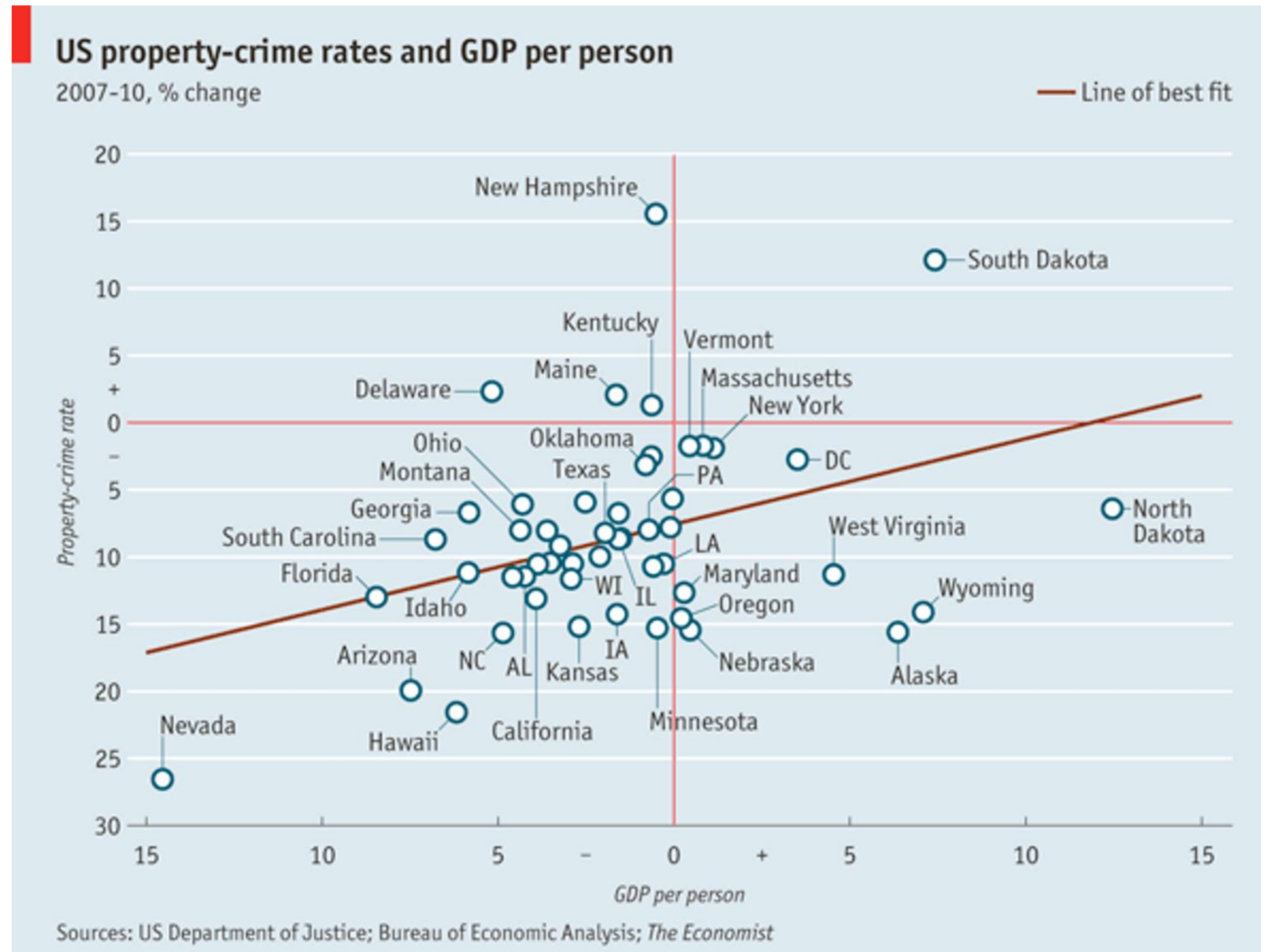


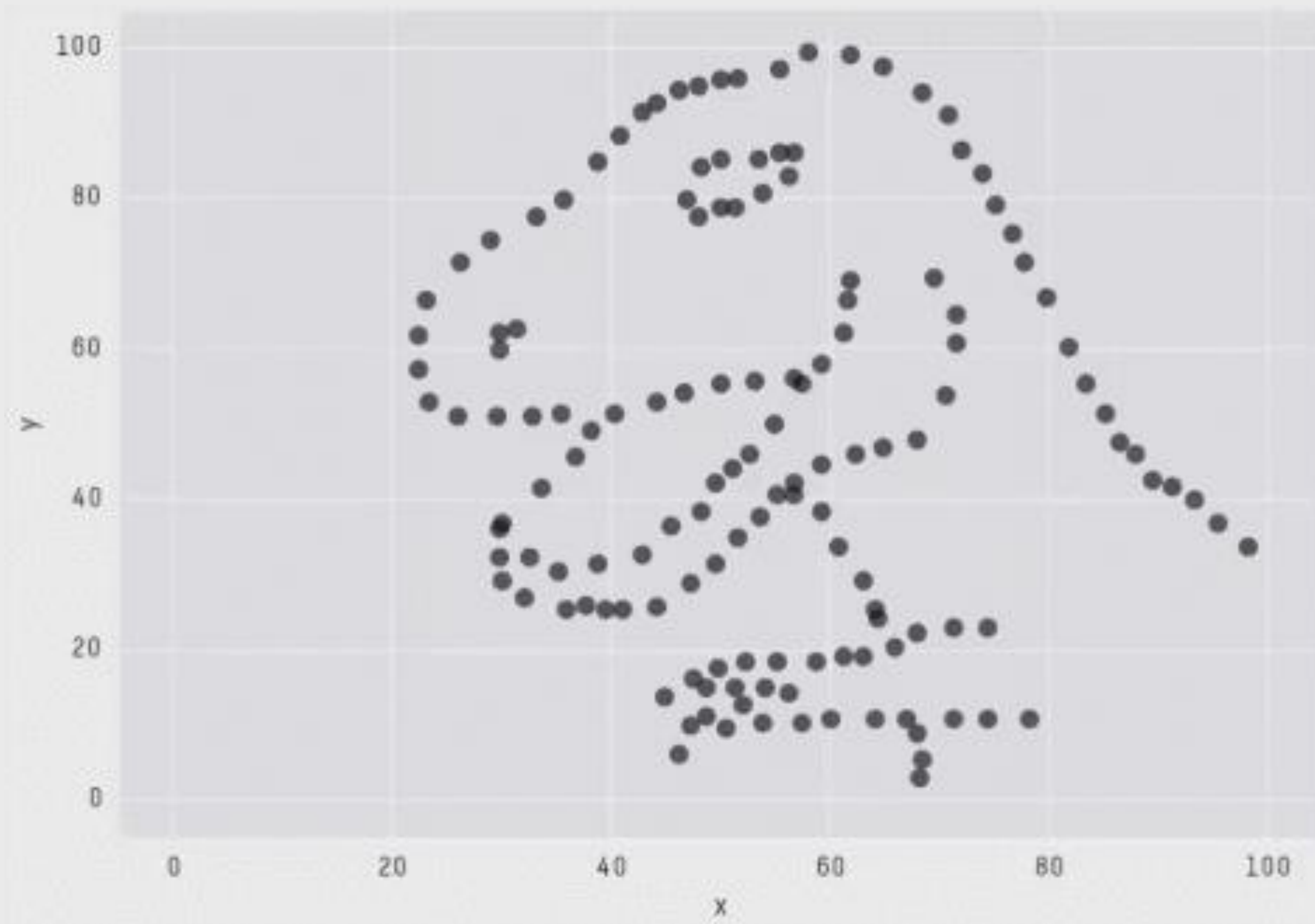
# Distributions & Correlations



TREND/CORRELATION LINE

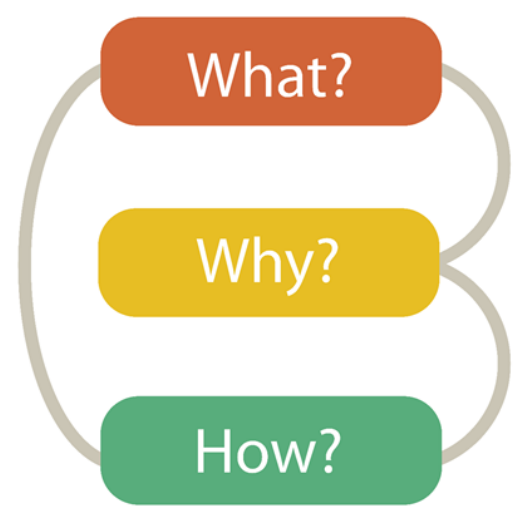
# Distributions & Correlations





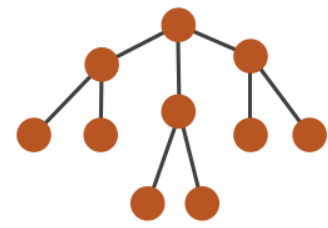
X Mean: 54.2659224  
Y Mean: 47.8313999  
X SD : 16.7649829  
Y SD : 26.9342120  
Corr. : -0.0642526





## What?

### → Tree



## Why?

### → Actions

→ Present → Locate → Identify



### → Targets

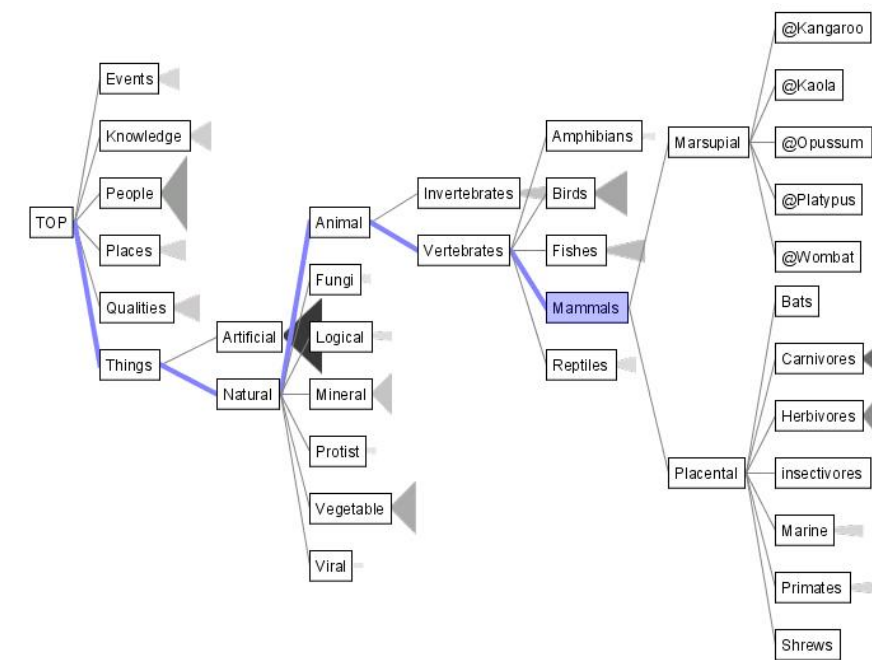
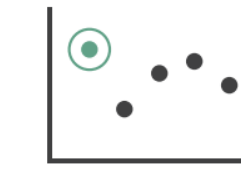
→ Path between two nodes



## How?

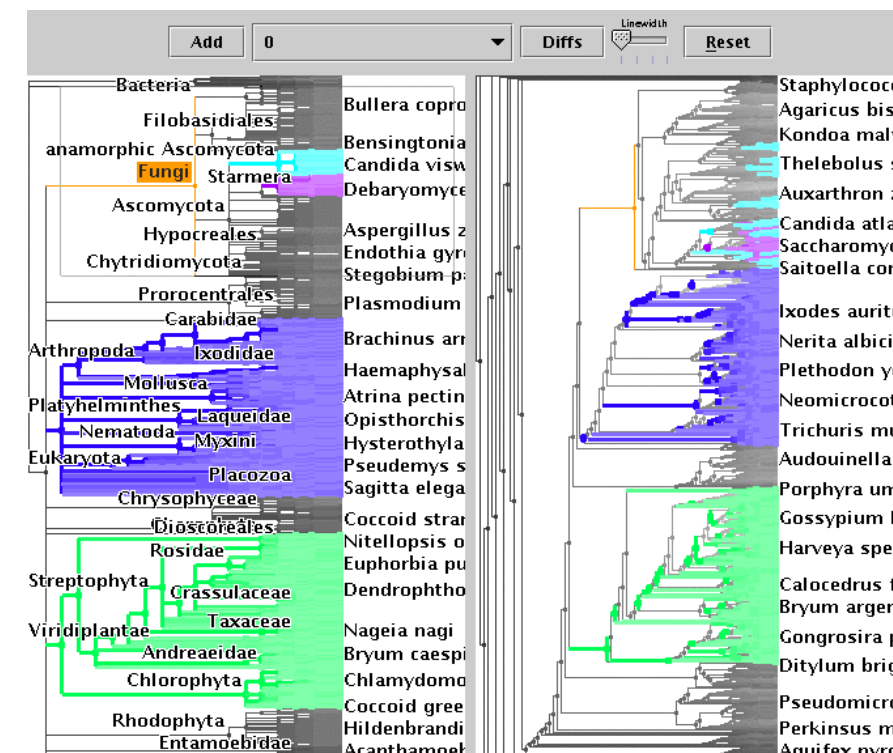
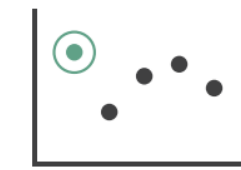
### → SpaceTree [SpaceTree \(Plaisant et al., 2002\) YouTube](#)

→ Encode → Navigate → Select → Filter → Aggregate



### → TreeJuxtaposer [TreeJuxtaposer \(Munzner et al., 2003\) YouTube](#)

→ Encode → Navigate → Select → Arrange







# Visualization Taxonomy

In order to address the variety of visualization types in the MassVis database, we created a taxonomy for static (i.e., non-interactive) visualizations. The taxonomy classifies static visualizations according to the underlying data structures, the visual encoding of the data, and the perceptual tasks enabled by these encodings. It contains twelve visualization categories and several popular subtypes for each category. In addition, we supply a set of properties that aid in the characterization of the visualizations. This taxonomy was created originally to classify the **2k dataset**, and we continue to use this terminology in our **papers**. For more information about the taxonomy, please read this document: **taxonomy details**

If you use this taxonomy, please cite this paper:  **Bibtex**

<http://massvis.mit.edu/>

Borkin, M., Vo, A., Bylinskii, Z., Isola, P., Sunkavalli, S., Oliva, A., & Pfister, H., 2013, "[What Makes a Visualization Memorable?](#)", IEEE Transactions on Visualization and Computer Graphics (Proceedings of InfoVis 2013), 19, 12, 2306-2315.

Great resource for categorizing visualizations, and brainstorming!



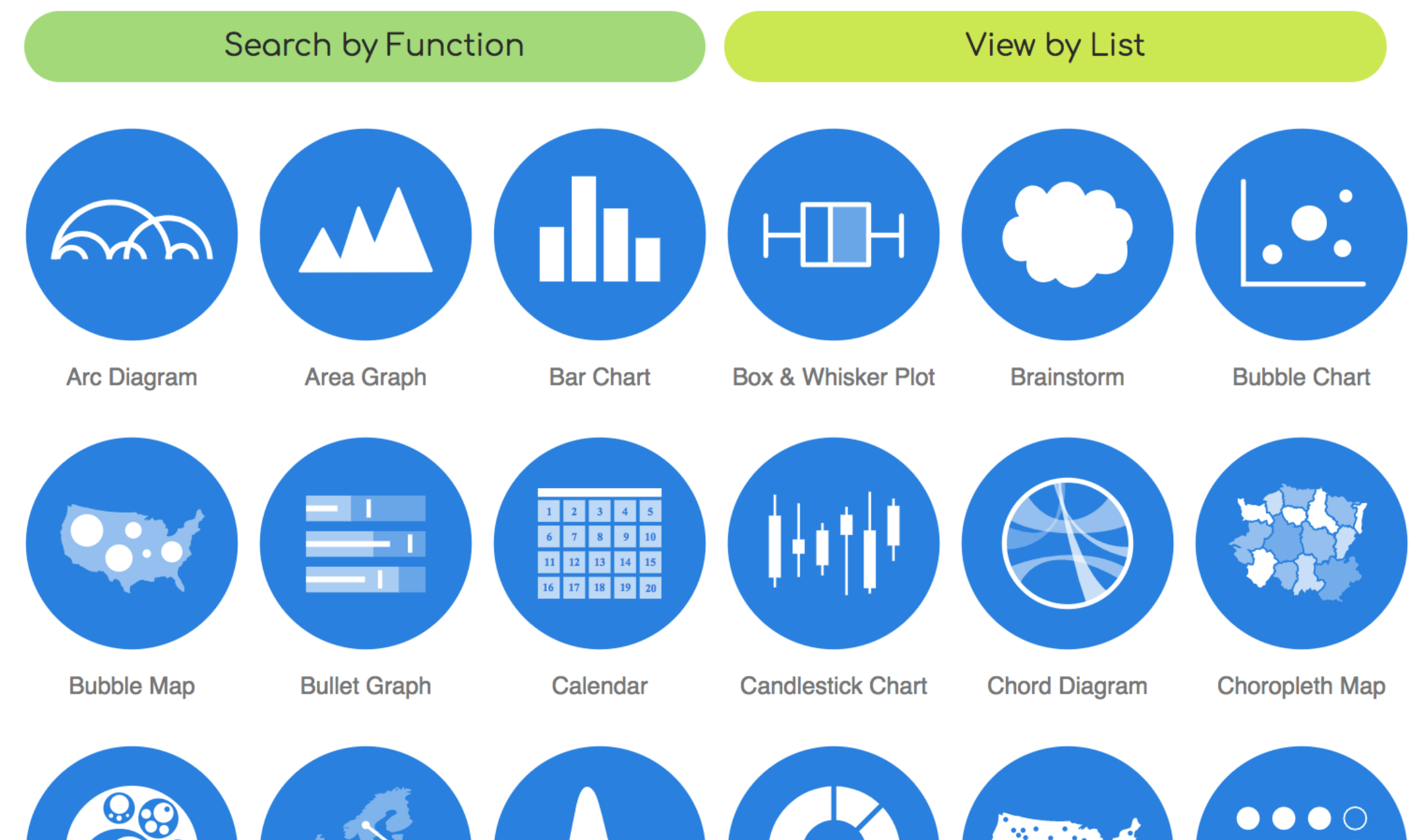
# More visualization “catalogs”

DataVizProject

<http://datavizproject.com/>

The Data Visualization Catalogue

<http://www.datavizcatalogue.com/>

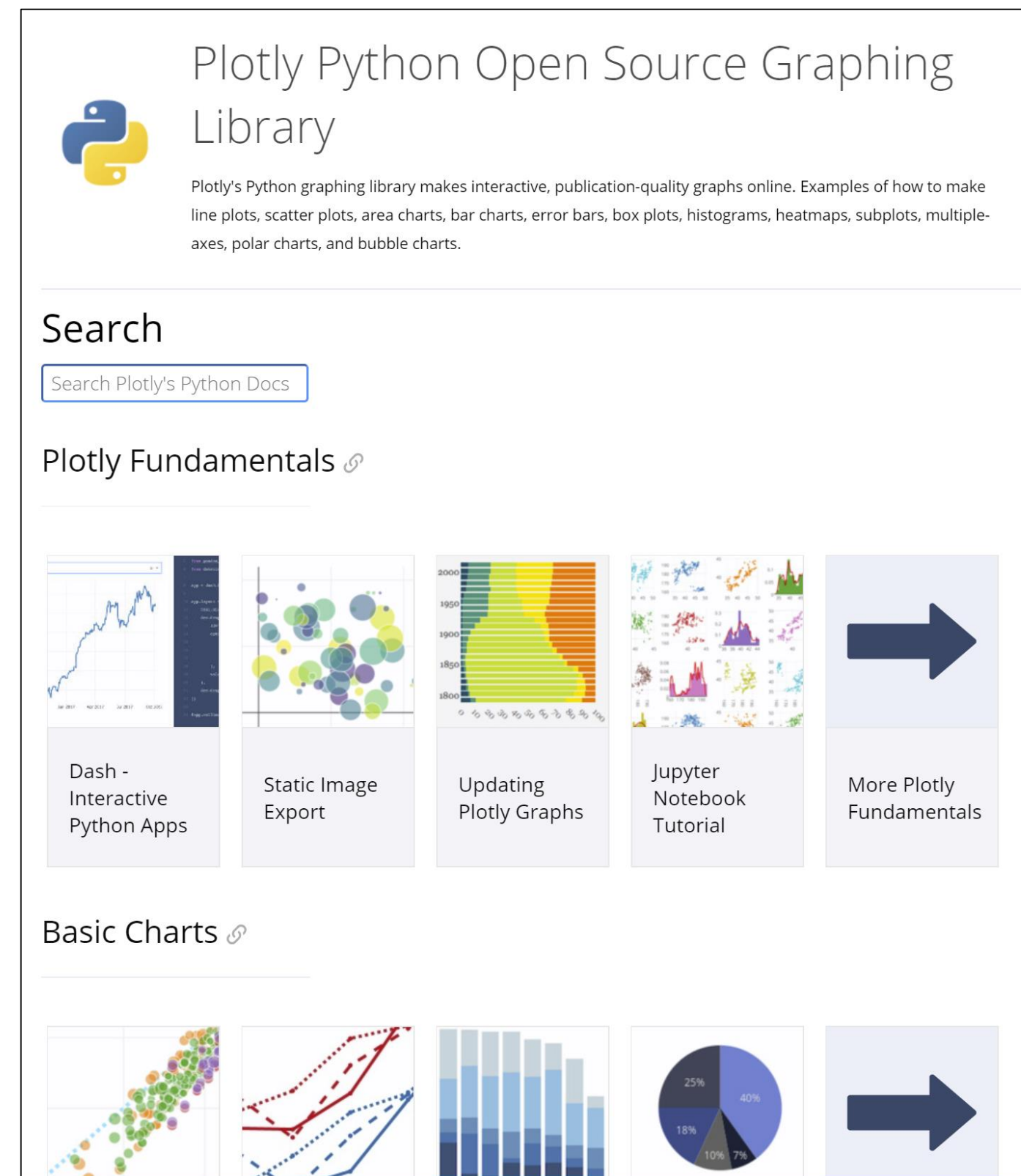


# More visualization ideas

<https://matplotlib.org/gallery.html>

<https://github.com/d3/d3/wiki/Gallery>

<https://plot.ly/python/>



Plotly Python Open Source Graphing Library

Plotly's Python graphing library makes interactive, publication-quality graphs online. Examples of how to make line plots, scatter plots, area charts, bar charts, error bars, box plots, histograms, heatmaps, subplots, multiple-axes, polar charts, and bubble charts.

Search

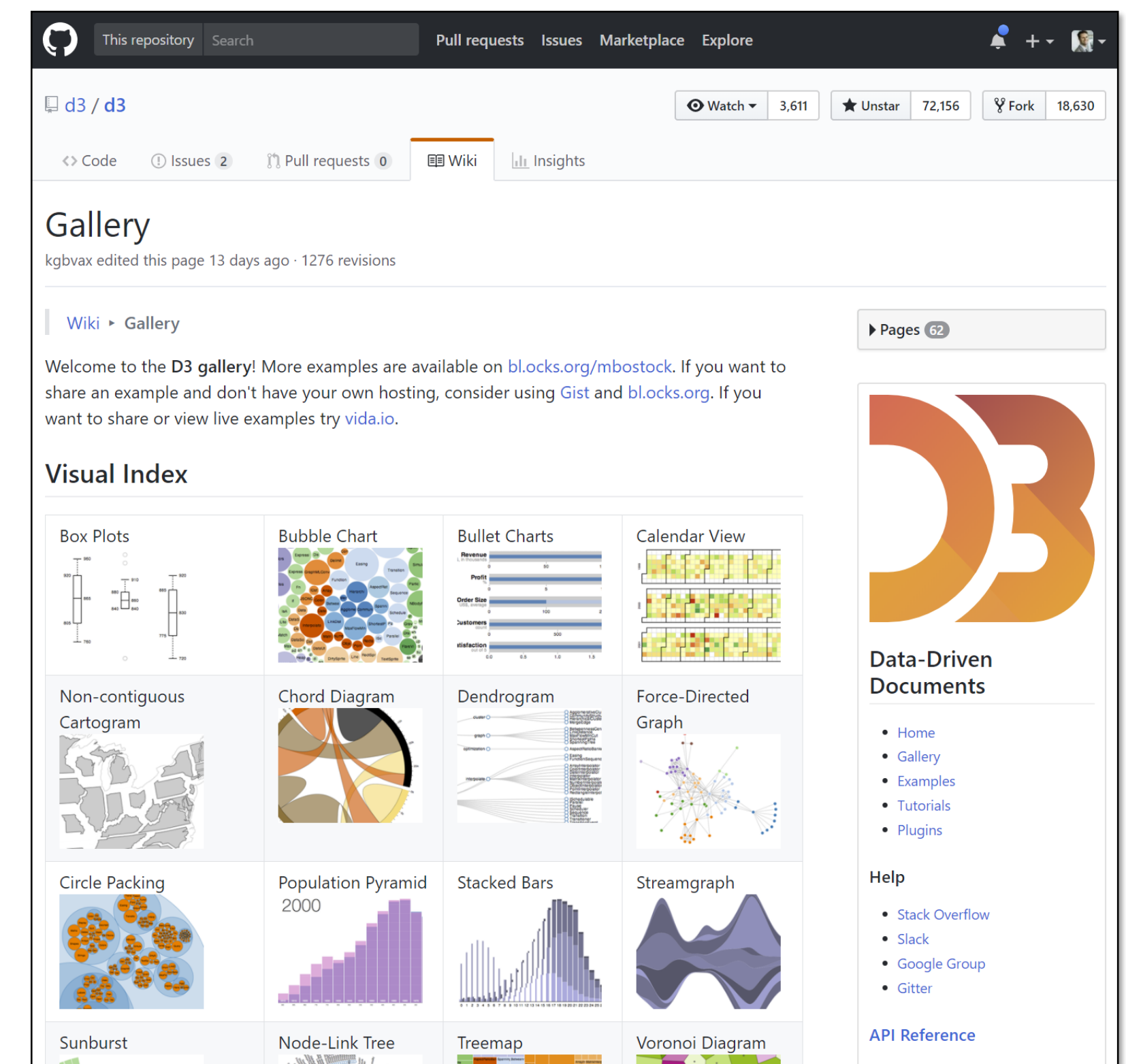
Search Plotly's Python Docs

Plotly Fundamentals

- Dash - Interactive Python Apps
- Static Image Export
- Updating Plotly Graphs
- Jupyter Notebook Tutorial
- More Plotly Fundamentals

Basic Charts

- Line plots
- Area charts
- Bar charts
- Pie charts
- More Basic Charts



This repository Search Pull requests Issues Marketplace Explore

d3 / d3

Watch 3,611 Unstar 72,156 Fork 18,630

Code Issues 2 Pull requests 0 Wiki Insights

## Gallery

kgbvax edited this page 13 days ago · 1276 revisions

Wiki > Gallery

Pages 62

Welcome to the D3 gallery! More examples are available on [bl.ocks.org/mbostock](https://bl.ocks.org/mbostock). If you want to share an example and don't have your own hosting, consider using [Gist](https://gist.github.com) and [bl.ocks.org](https://bl.ocks.org). If you want to share or view live examples try [vida.io](https://vida.io).

### Visual Index

- Box Plots
- Bubble Chart
- Bullet Charts
- Calendar View
- Non-contiguous Cartogram
- Chord Diagram
- Dendrogram
- Force-Directed Graph
- Circle Packing
- Population Pyramid 2000
- Stacked Bars
- Streamgraph
- Sunburst
- Node-Link Tree
- Treemap
- Voronoi Diagram

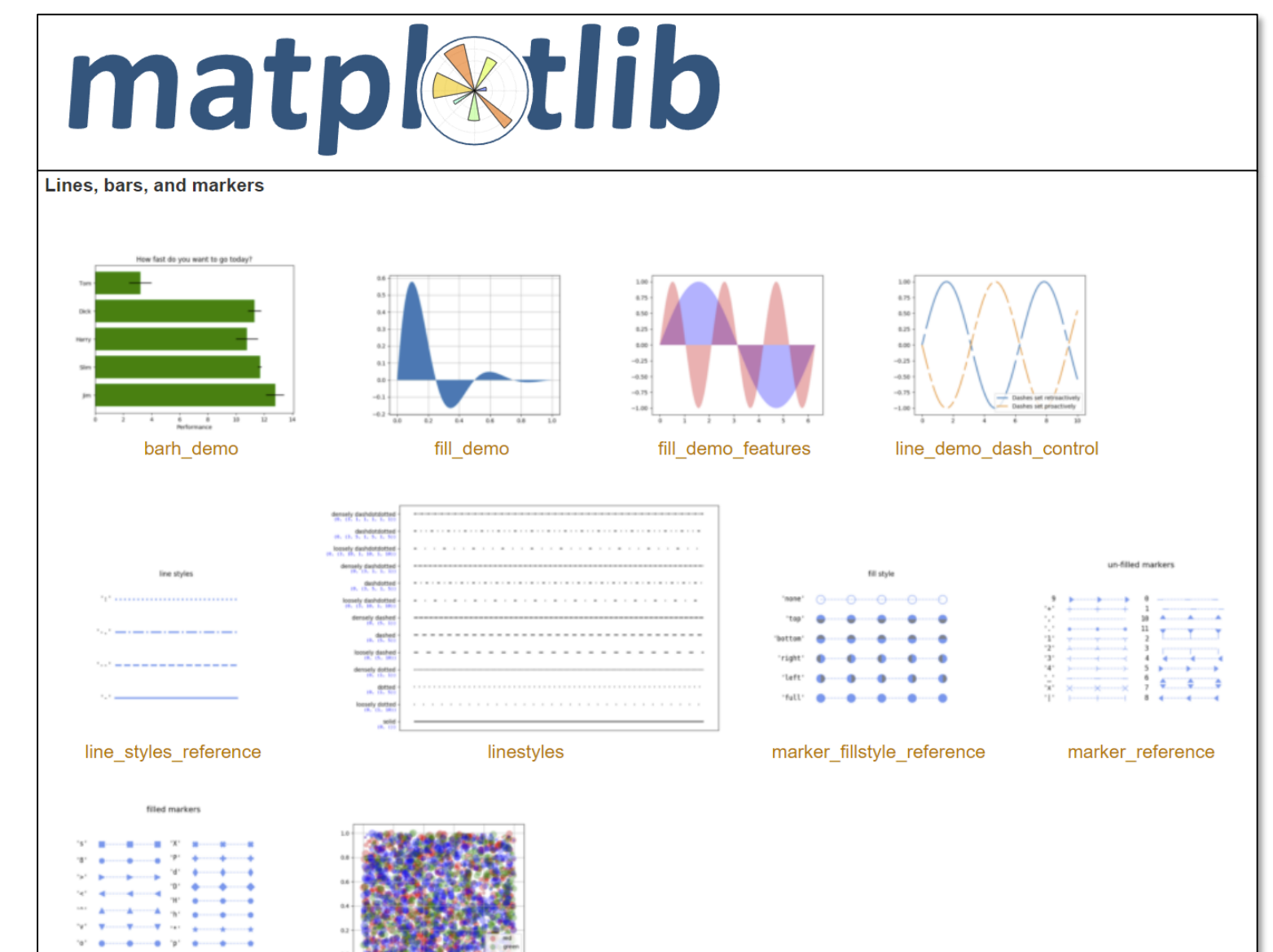
Data-Driven Documents

- Home
- Gallery
- Examples
- Tutorials
- Plugins

Help

- Stack Overflow
- Slack
- Google Group
- Gitter

API Reference



# matplotlib

Lines, bars, and markers

- barh\_demo
- fill\_demo
- fill\_demo\_features
- line\_demo\_dash\_control
- line\_styles\_reference
- linestyles
- marker\_fillstyle\_reference
- marker\_reference
- filled markers

COLOR

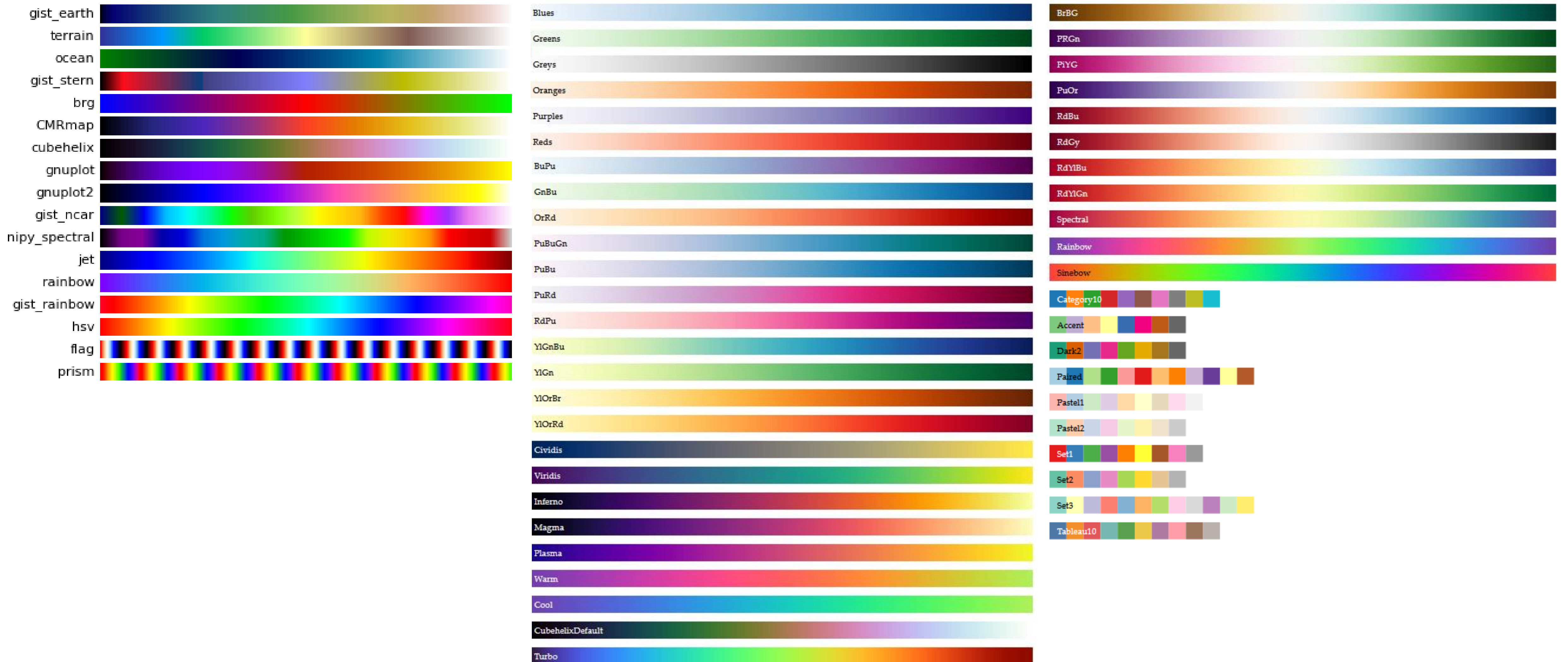


# GOALS FOR TODAY: LEARN HOW...

- ...to effectively use color as a channel for visual encodings including different colormap types.
- ...we process color in the visual system.
- ...individual color differences (i.e., colorblindness) should be accommodated in visualizations.
- ...interactions can occur between colors and with lighting.
- ...illusions and tricks can affect perception.

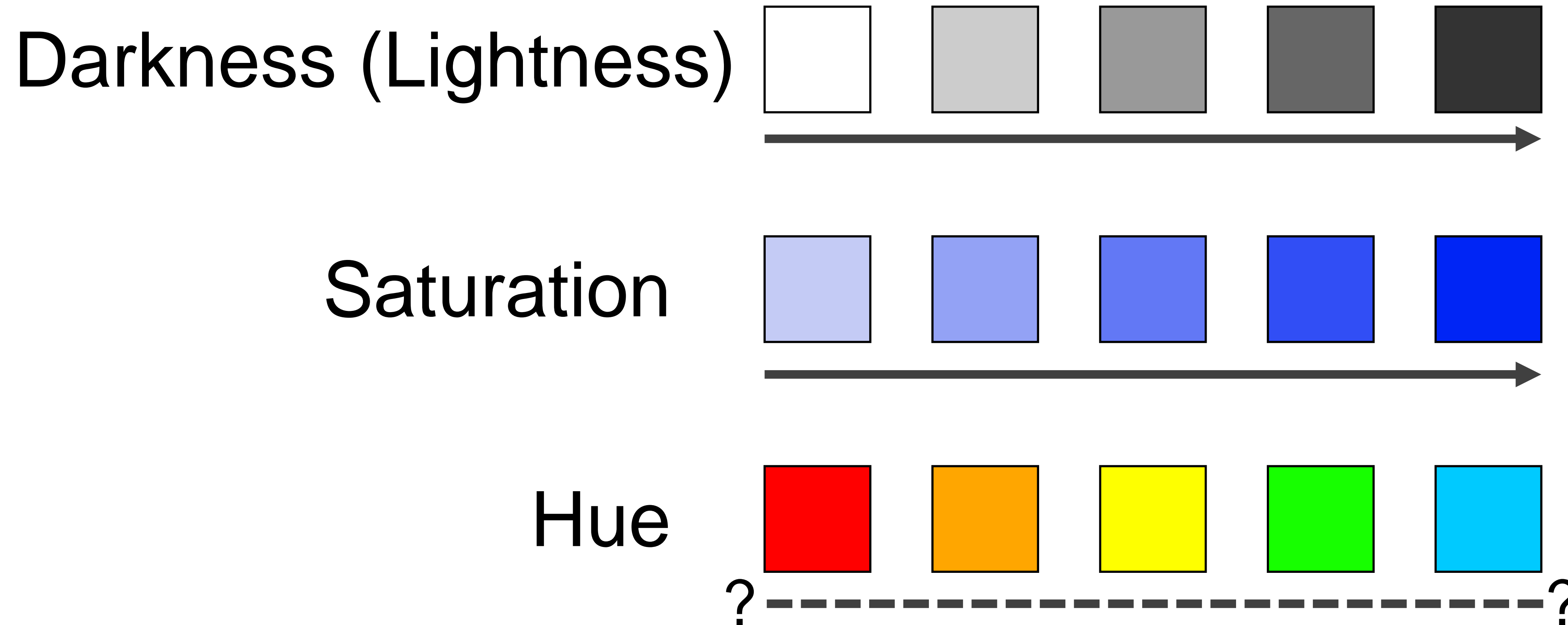
# Color Maps

Color Map = map between value (domain) and color (range)



“...avoiding catastrophe becomes the first principle in bringing color to information: above all, do no harm.”  
-Edward Tufte

# Color Vocabulary and Perceptual Ordering



# Encode > Map

## ➔ Color

➔ Color Encoding

➔ Hue



➔ Saturation



➔ Luminance



≈ Darkness  
(Lightness)

➔ Color Map

➔ Categorical



➔ Ordered

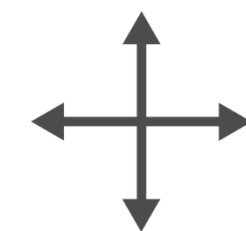
➔ Sequential



➔ Diverging



➔ Bivariate



## ➔ Size, Angle, Curvature, ...

➔ Length



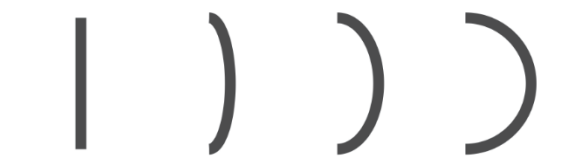
➔ Angle



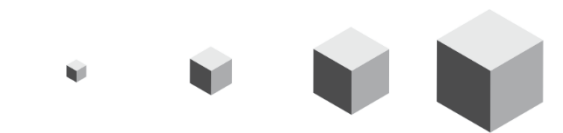
➔ Area



➔ Curvature



➔ Volume



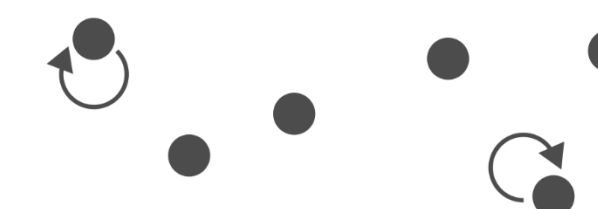
## ➔ Shape



## ➔ Motion

➔ Motion

Direction, Rate,  
Frequency, ...





# Color Maps

## THREE MAIN TYPES:

### Categorical

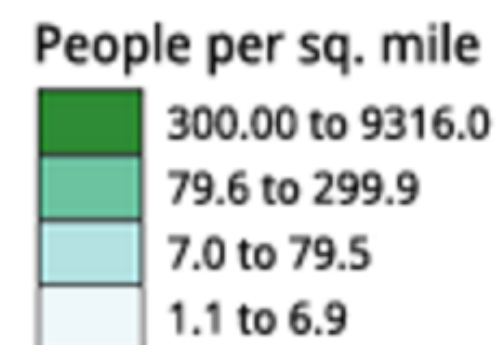


Does not imply magnitude differences (categorical/nominal data)

Distinct hues with similar emphasis

---

### Sequential

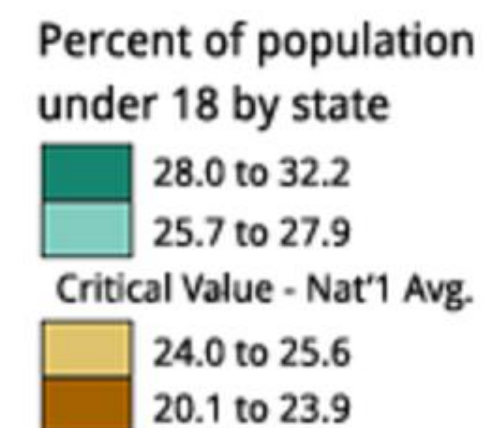


Best for ordered data that progresses from low to high (ordinal, quantitative data)

Darkness (lightness) channel effectively employed

---

### Diverging



For data with a “diverging” (mid) point (quantitative data)

Equal emphasis on mid-range critical values and extremes at both ends of the data range

# Color Maps

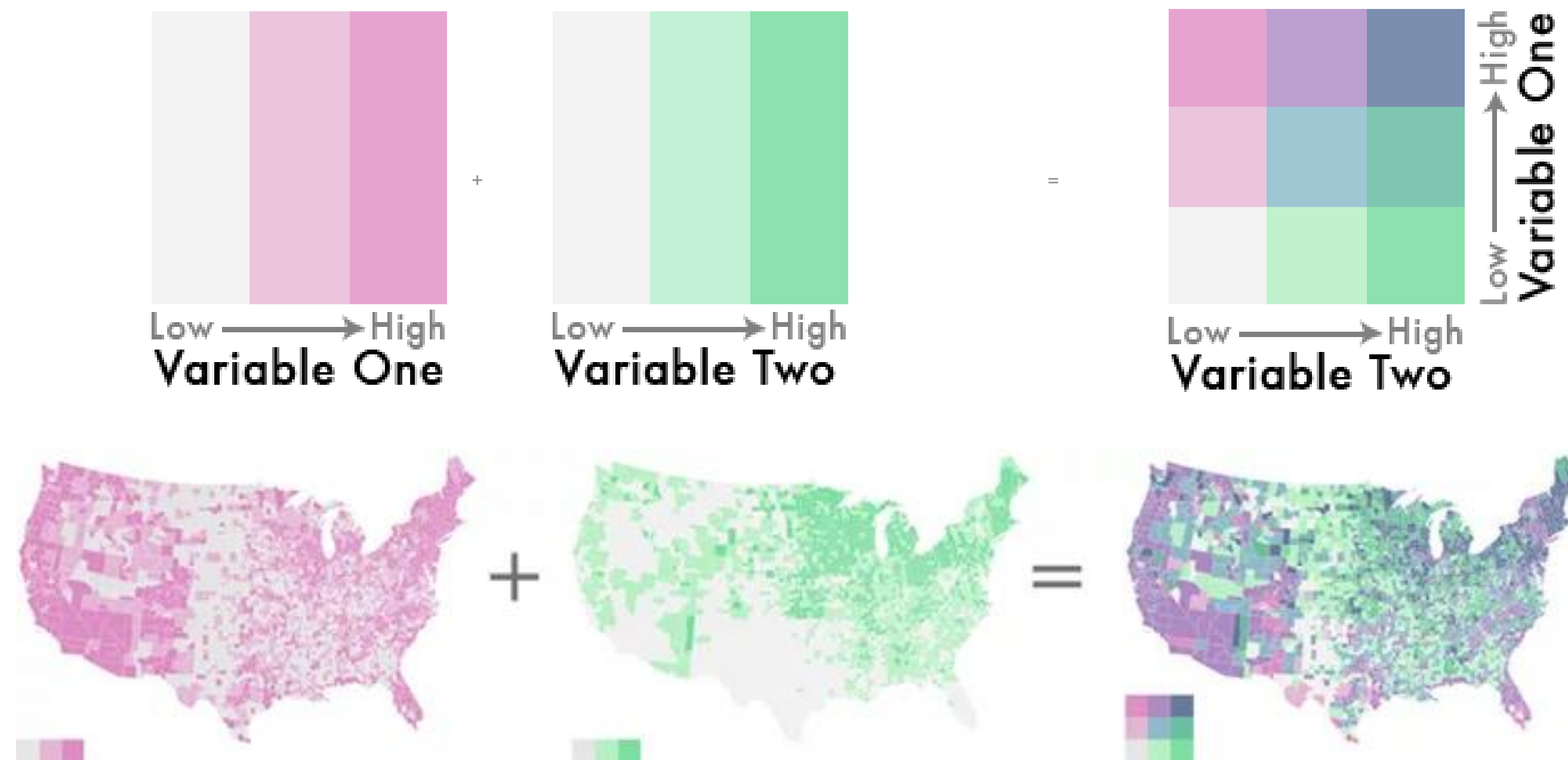
ALSO...

Bivariate

Displays two variables

Combination of two sequential color schemes

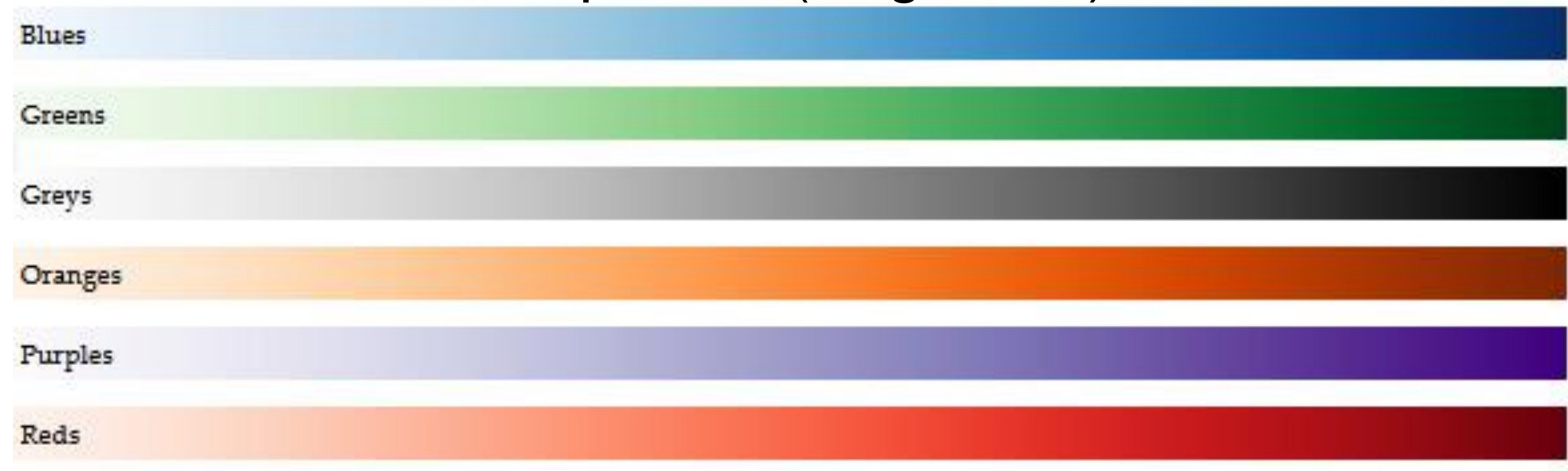
*These are very difficult to design effectively, make intelligible, and be color blind friendly.*





# Types of Color Maps

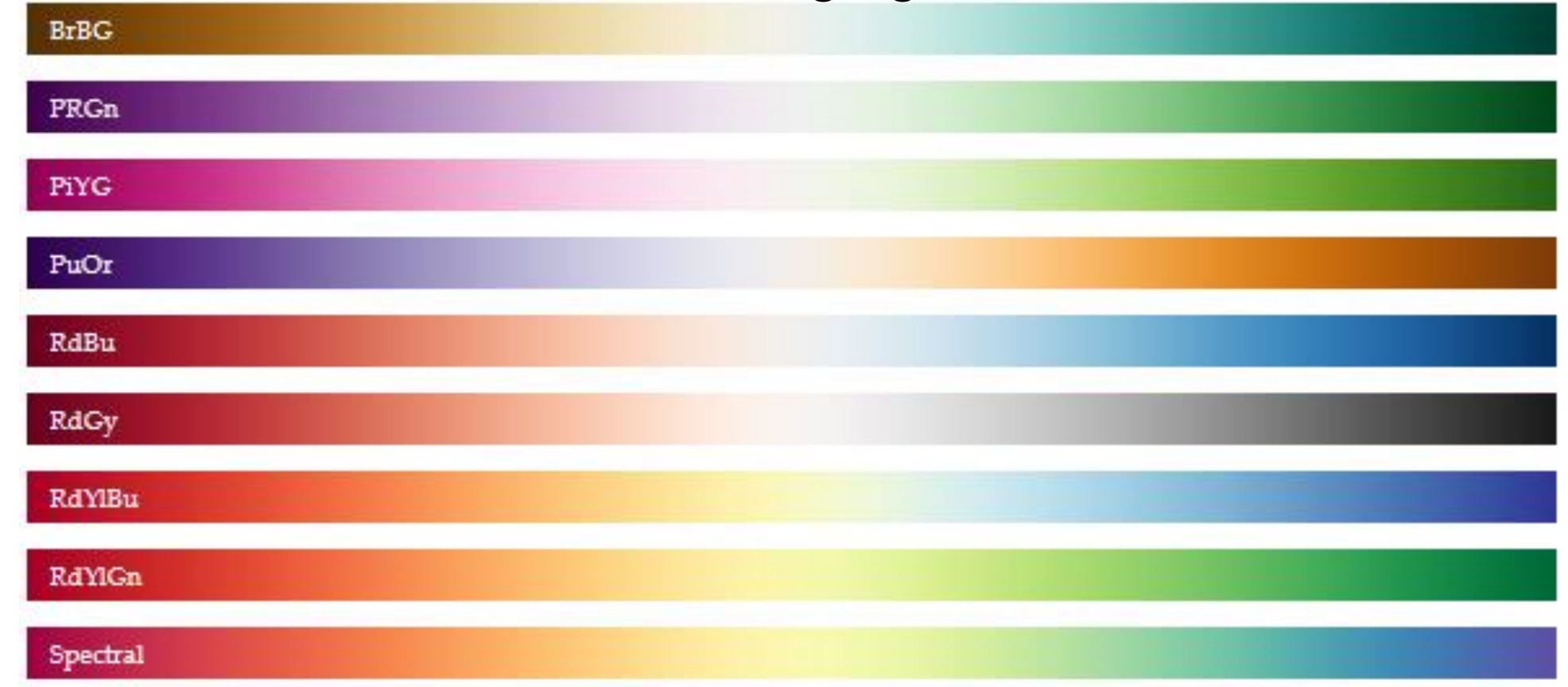
Sequential (single hue)



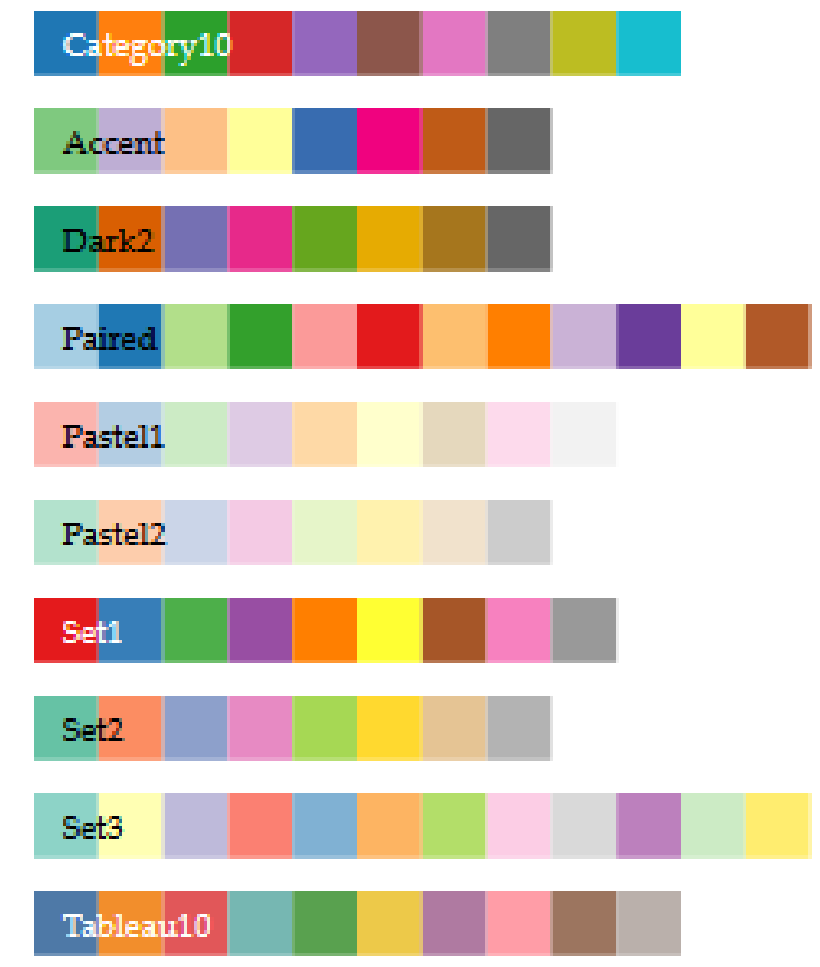
Sequential (multiple hue)



Diverging



Categorical

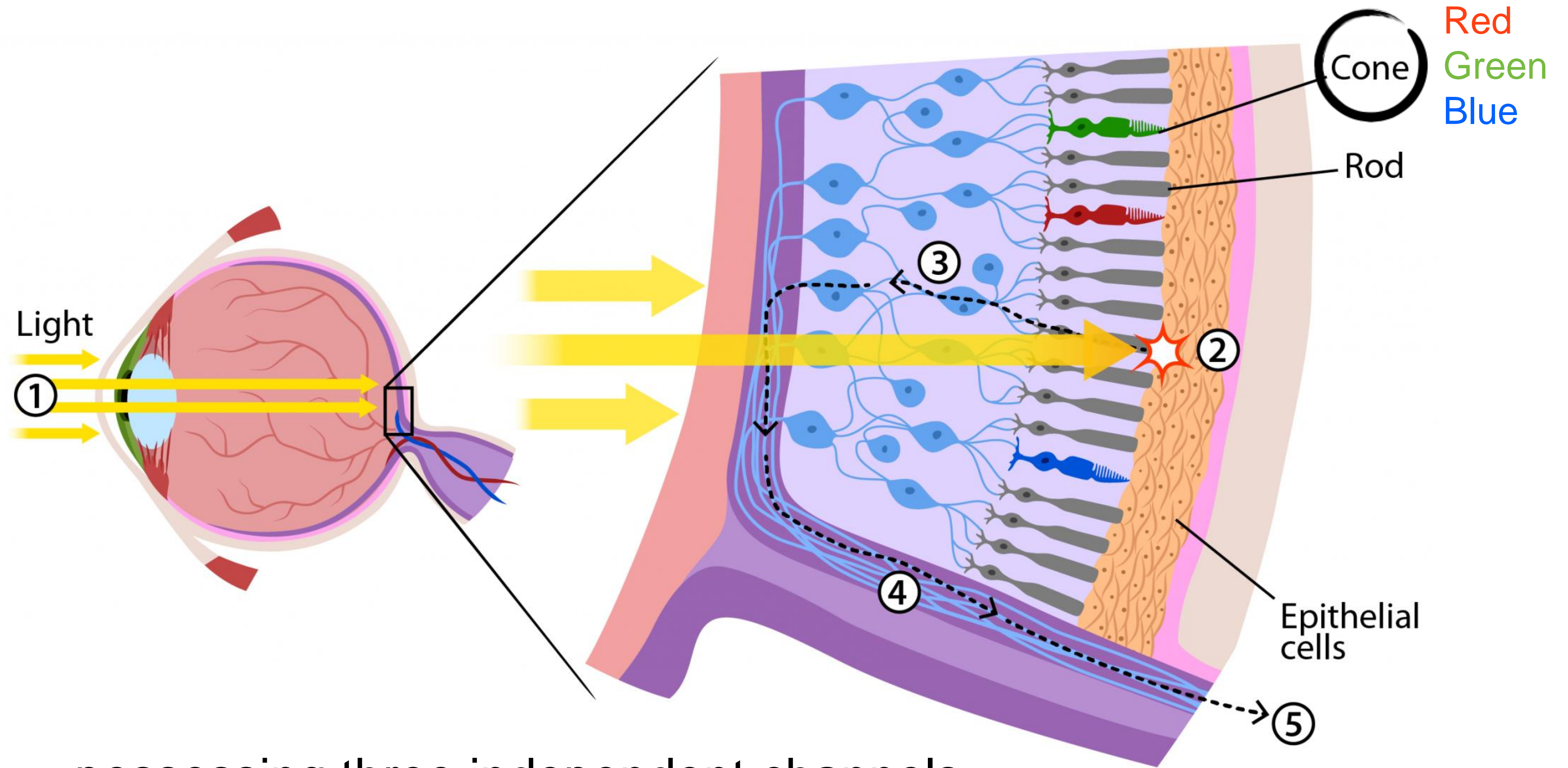


Cyclical





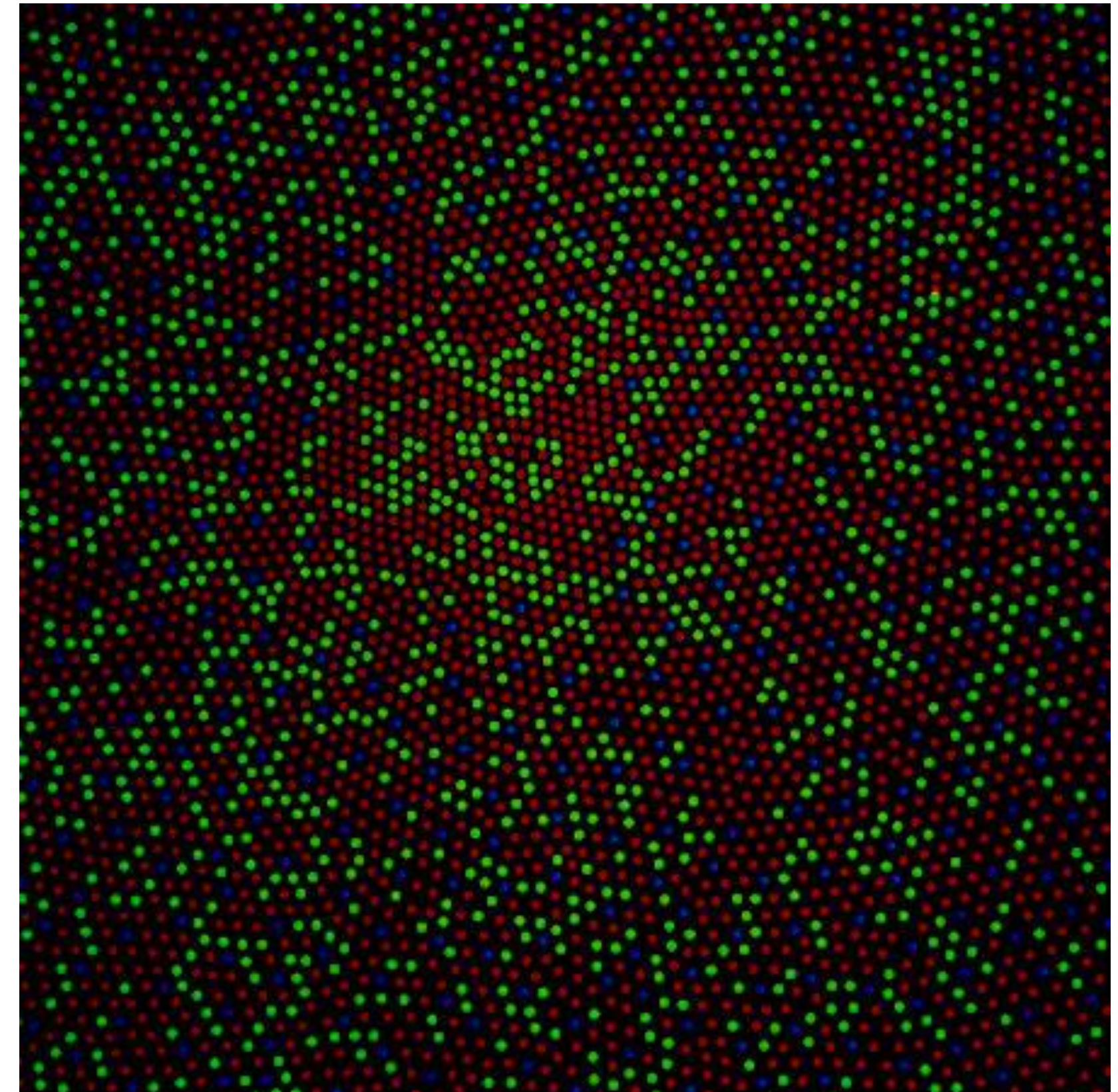
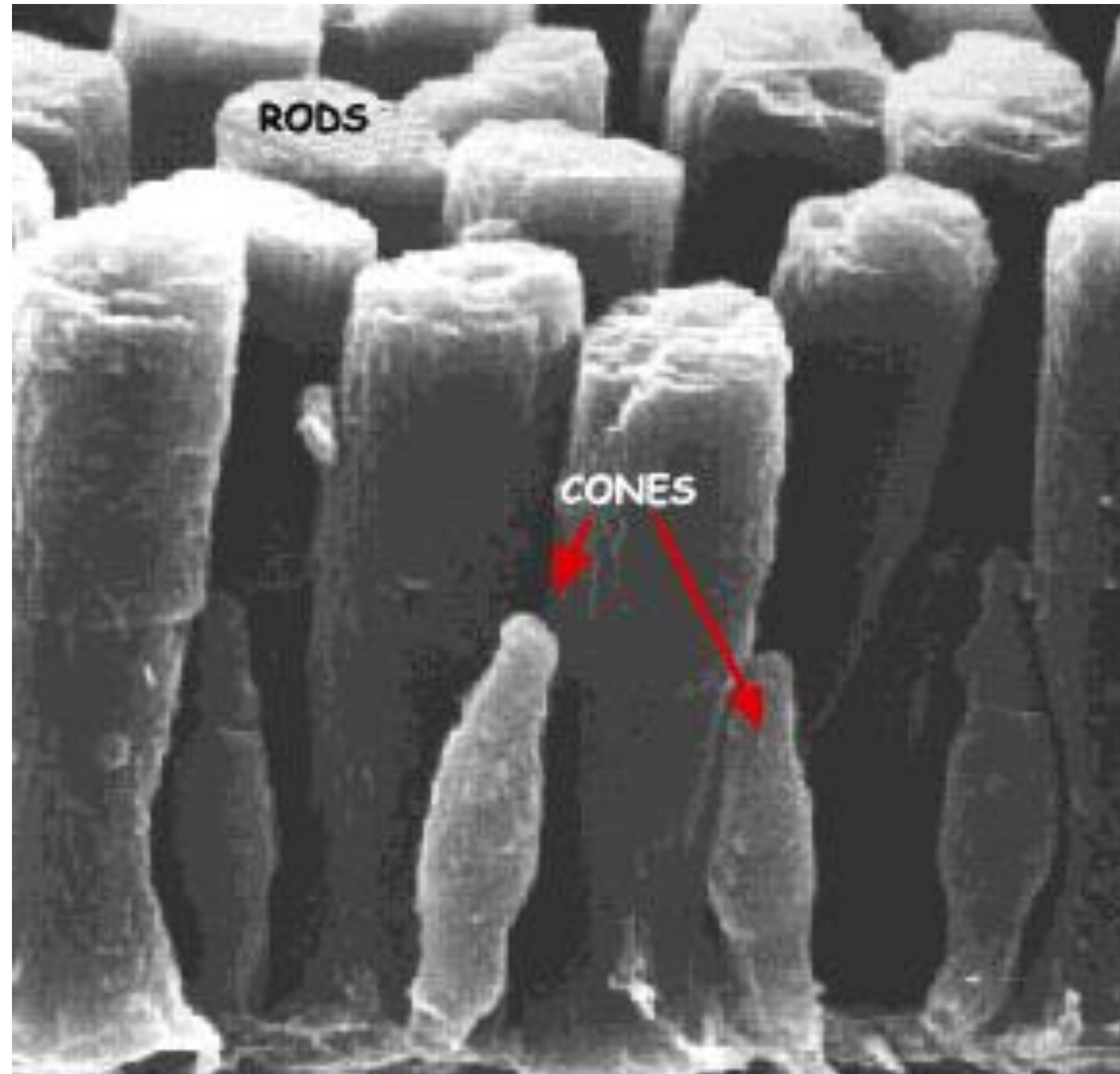
# RODS & CONES



trichromacy = possessing three independent channels for conveying color information

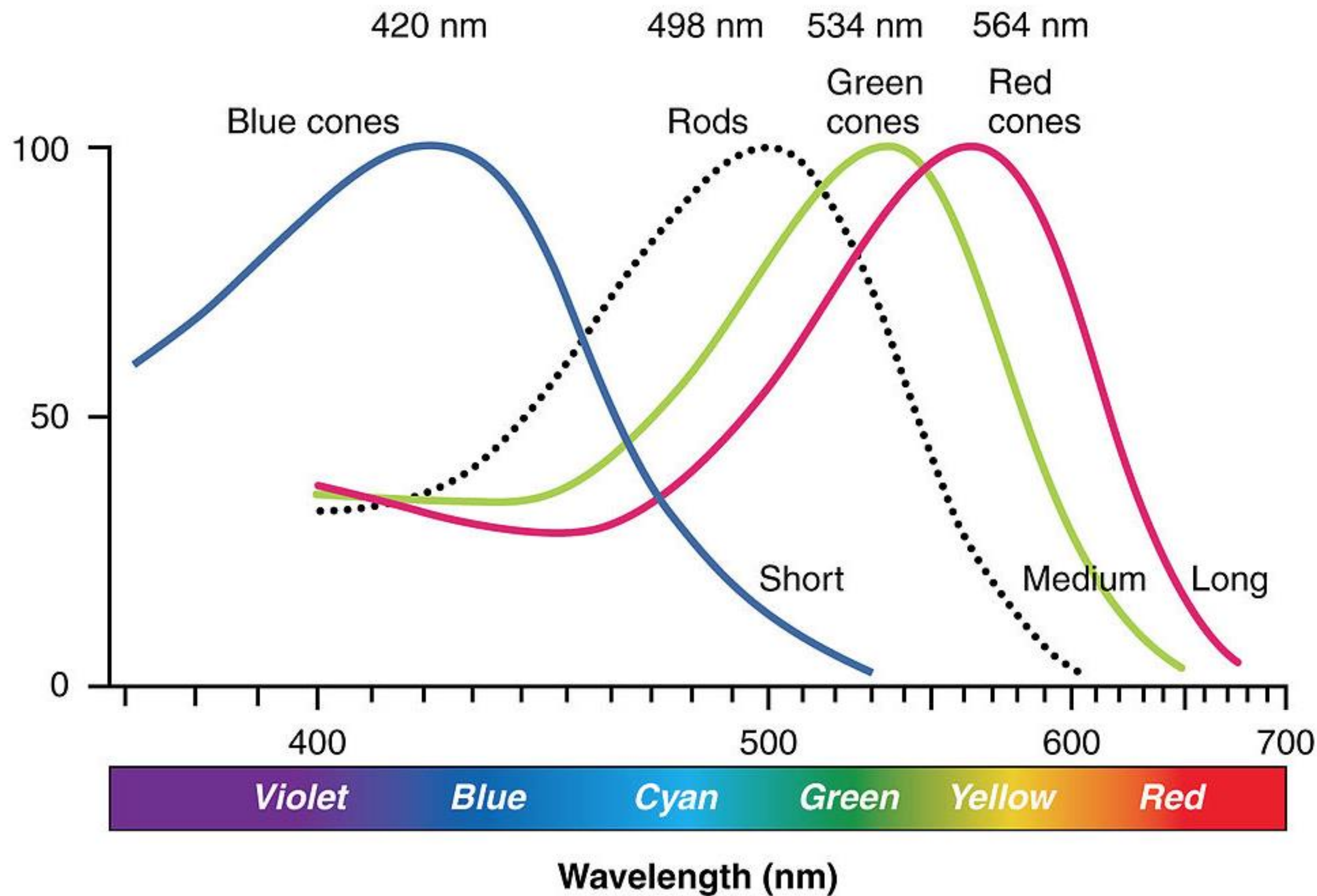


# RODS & CONES





# CONES & RODS



This is why darkness (lightness) is an effective encoding channel!

Rods: 120 million

Cones: 5-6 million

This is why we are so sensitive to red!

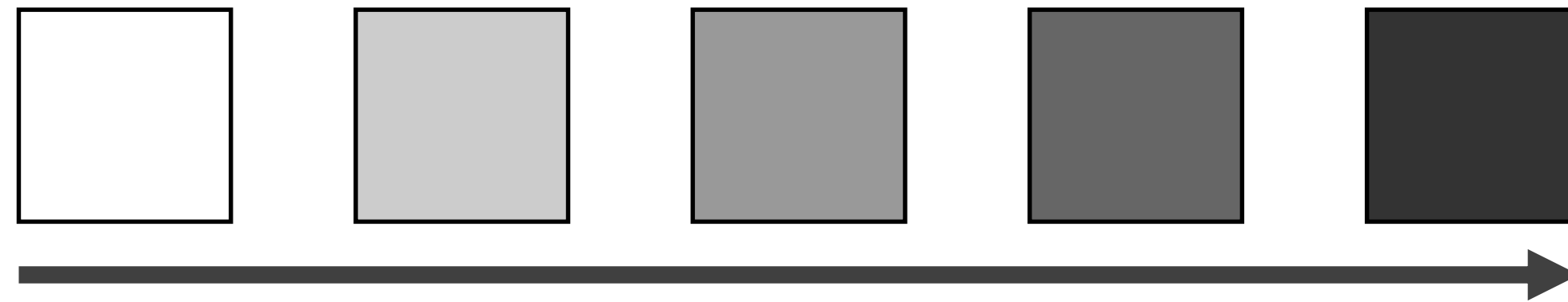
Cones:

64% red-sensitive

32% green-sensitive

2% blue-sensitive.

# Darkness (Lightness) Channel



- No edges without darkness difference
- No shading without darkness variation
- Has higher spatial sensitivity than color channels
- Contrast defines legibility, attention, layering
- Controlling darkness is primary rule of design

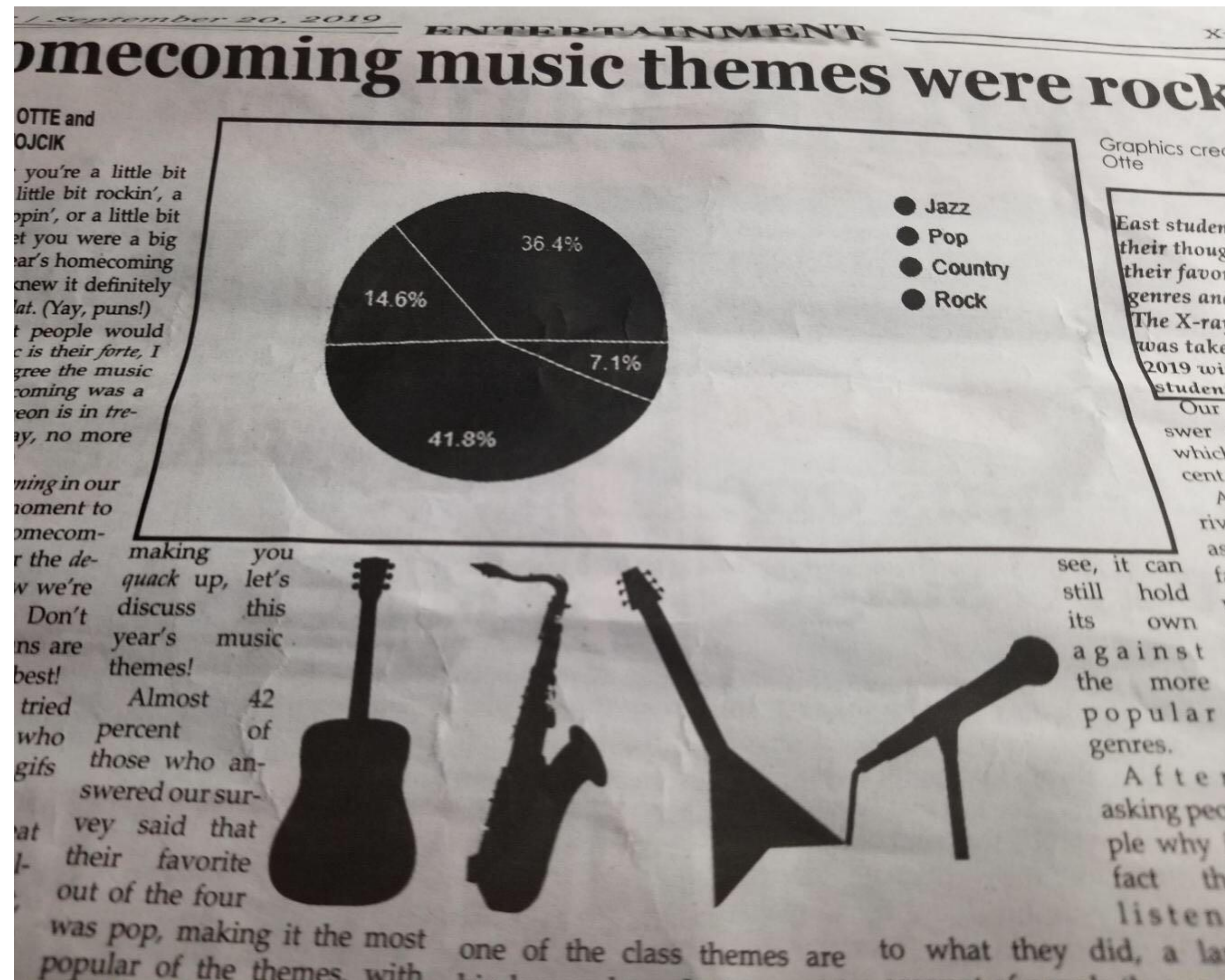


“Get it right in black and white.”

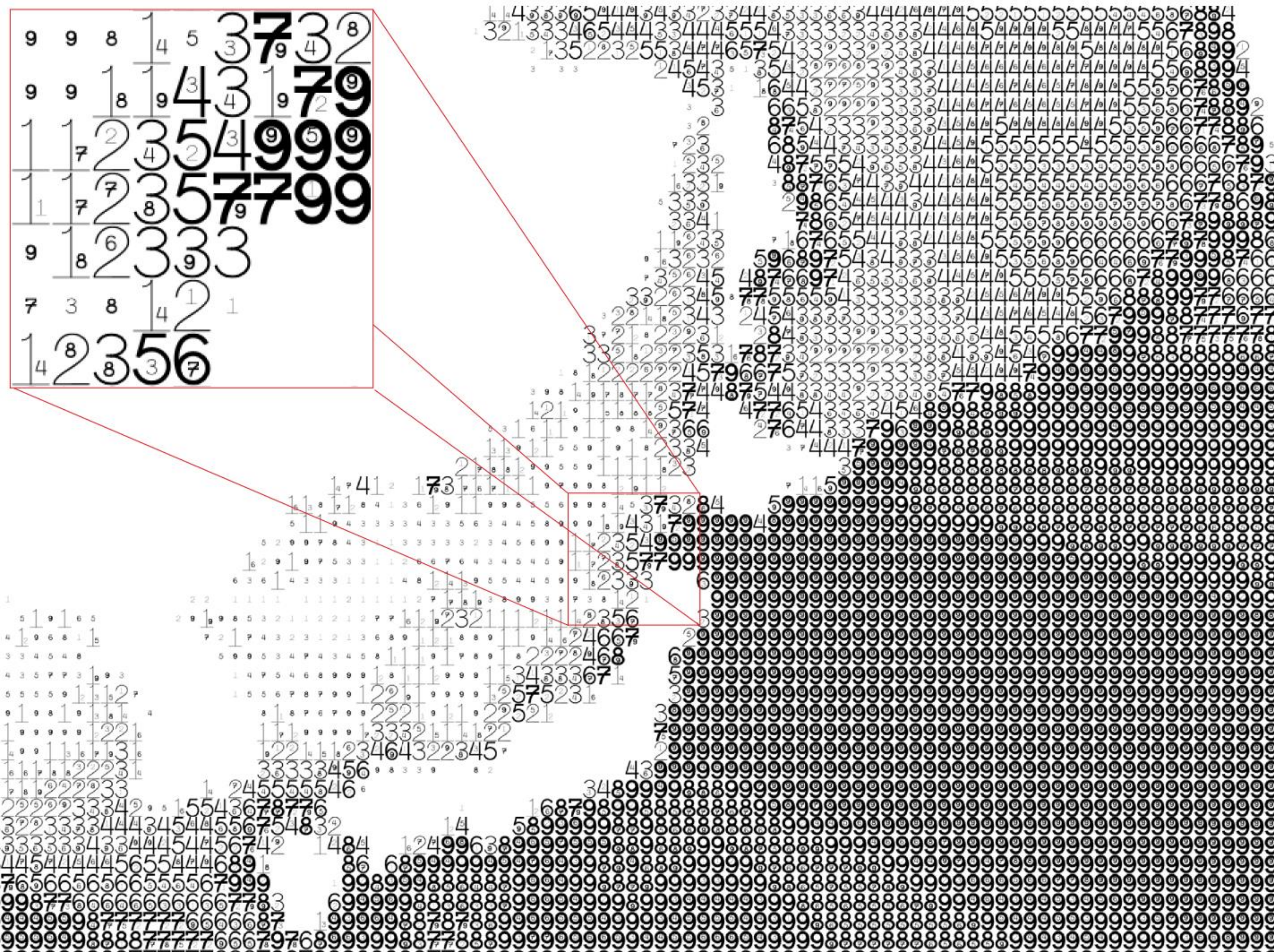
-Maureen Stone



# Understanding your medium matters







# FatFonts

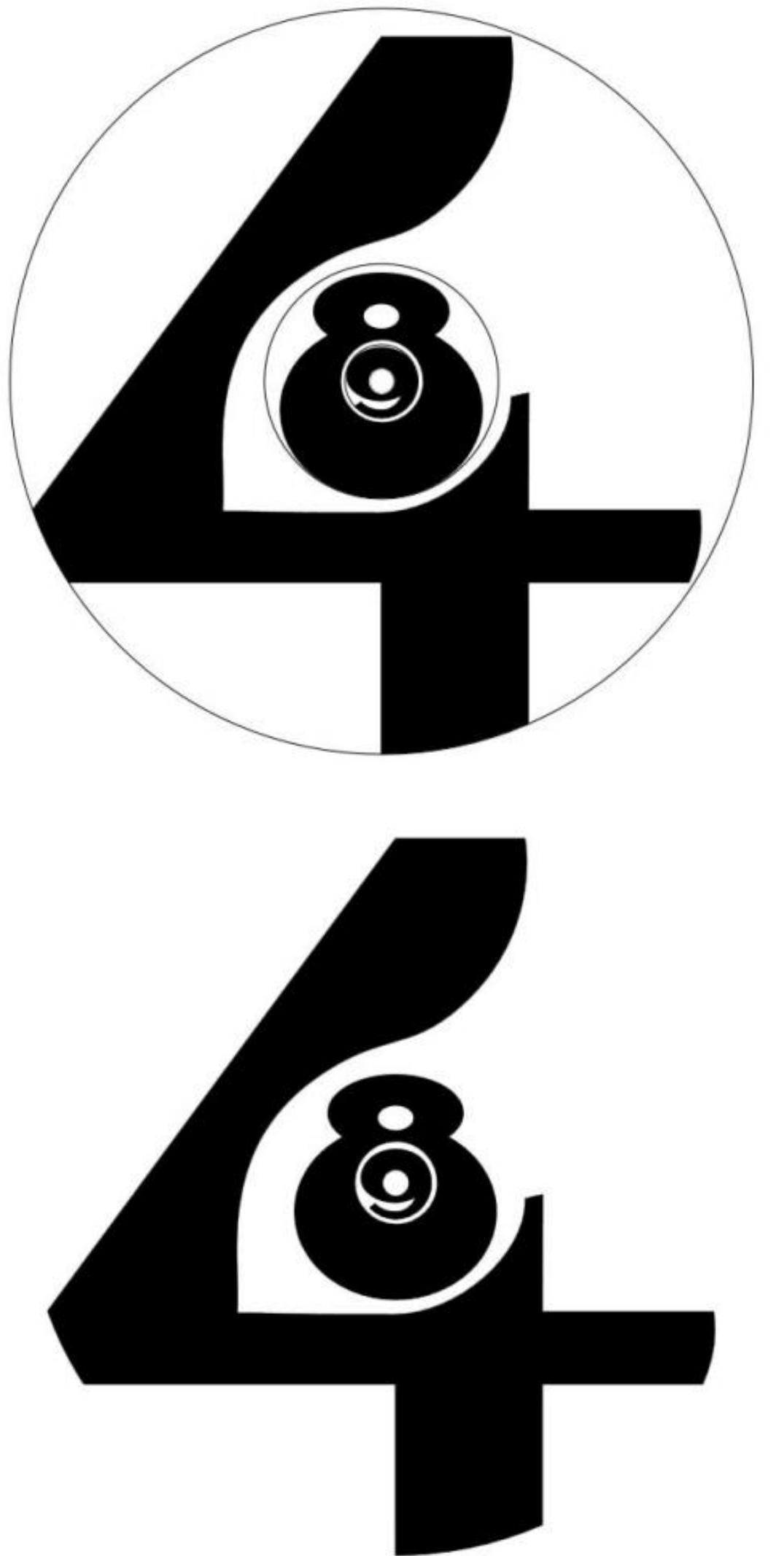


Figure 8: Maximum wave amplitudes for the Japan 2011 tsunami. Amplitudes were clipped at 99cm. Data adapted from NOAA; <http://www.noaa.gov/>.