

DESIGN+VISUALIZATION STRATEGIES

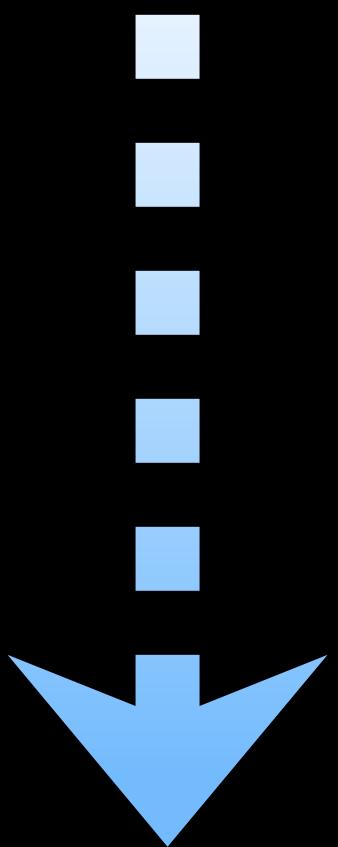
ASTROINFORMATICS|2019

artcenter | caltech

SANTIAGO LOMBEYDA

WHAT IS DATA VISUALIZATION?

DATA

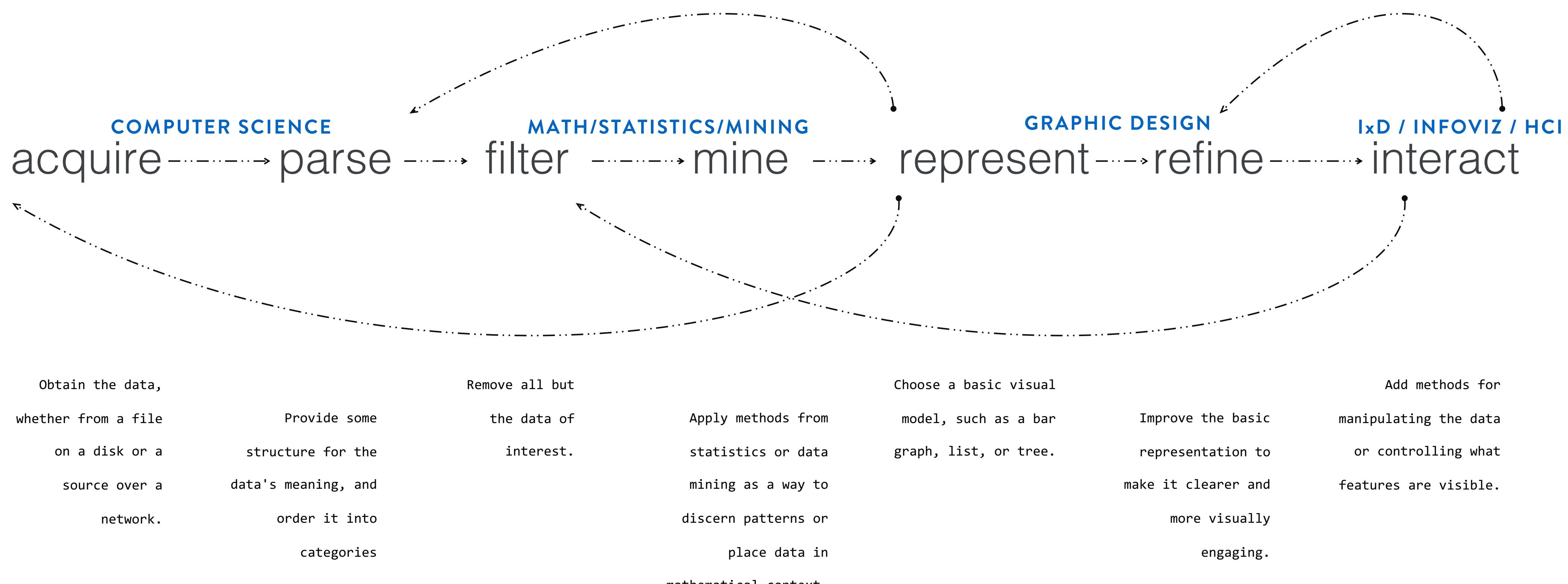


MORE UNDERSTANDABLE REPRESENTATION





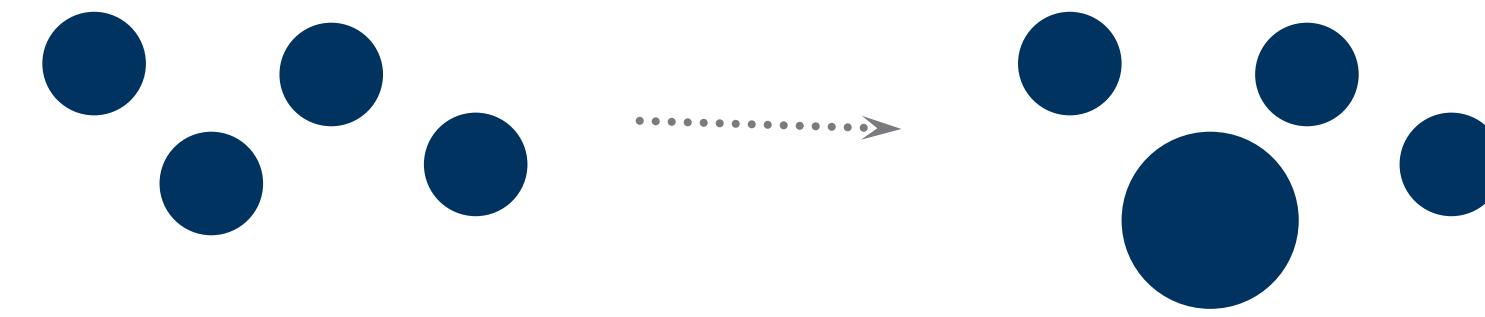
VISUALIZATION PIPELINE



Ben Fry

HOW DO WE REPRESENT DATA?

SCALE



position | orientation

SHAPE



distinctive glyphs | bumps | points | whiskers

DATA ENCODING

COLOR

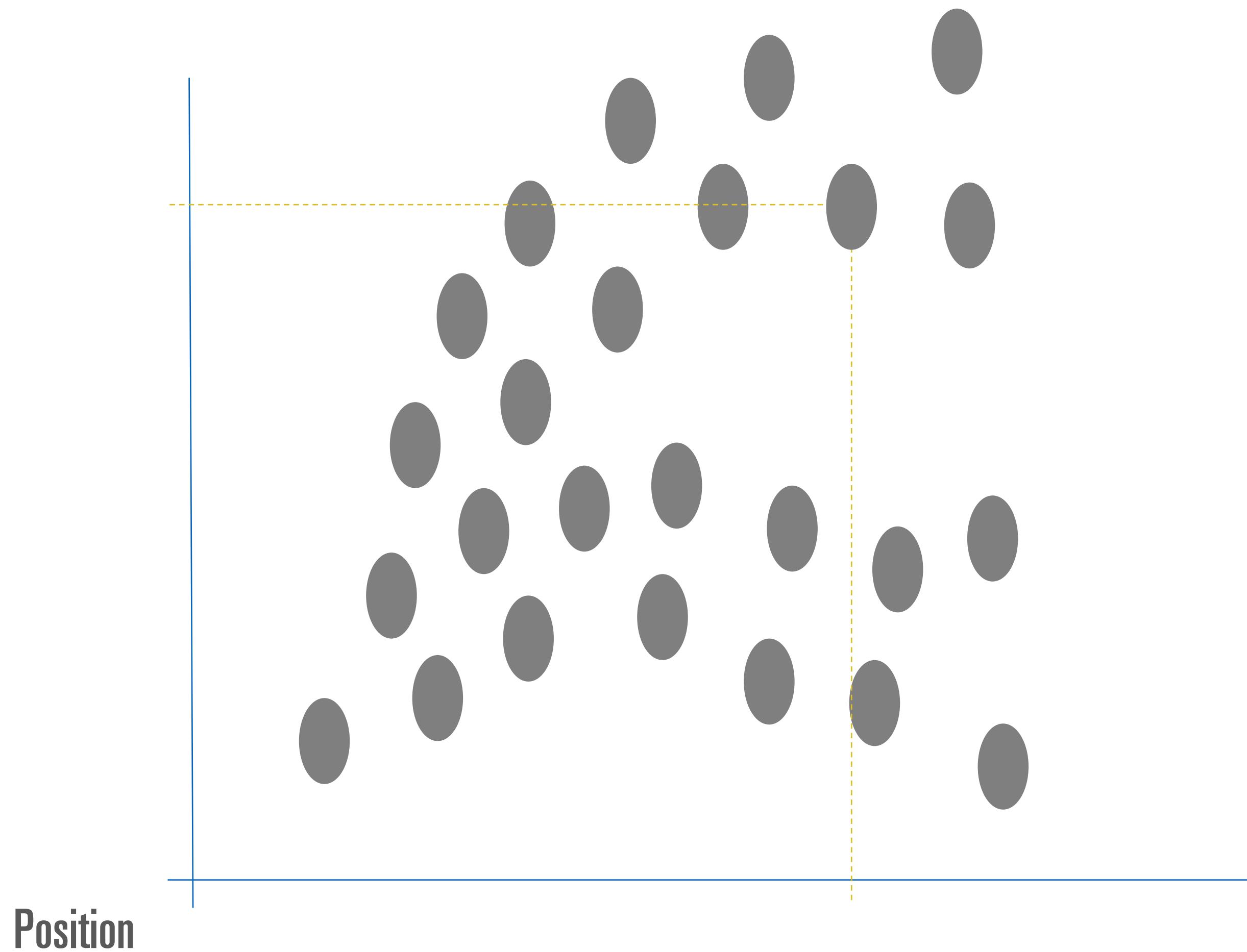


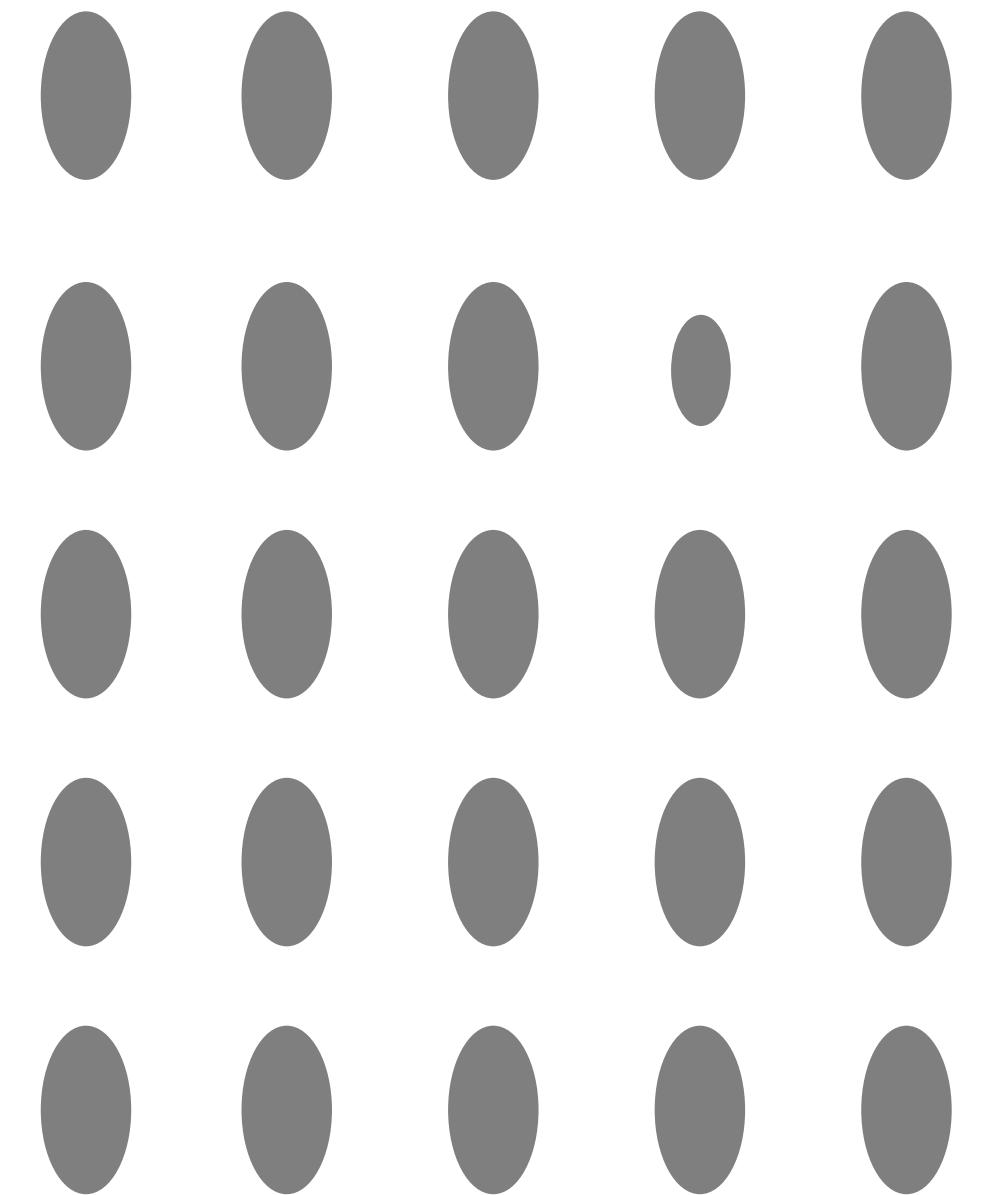
luminosity | hue | saturation | texture

MOTION

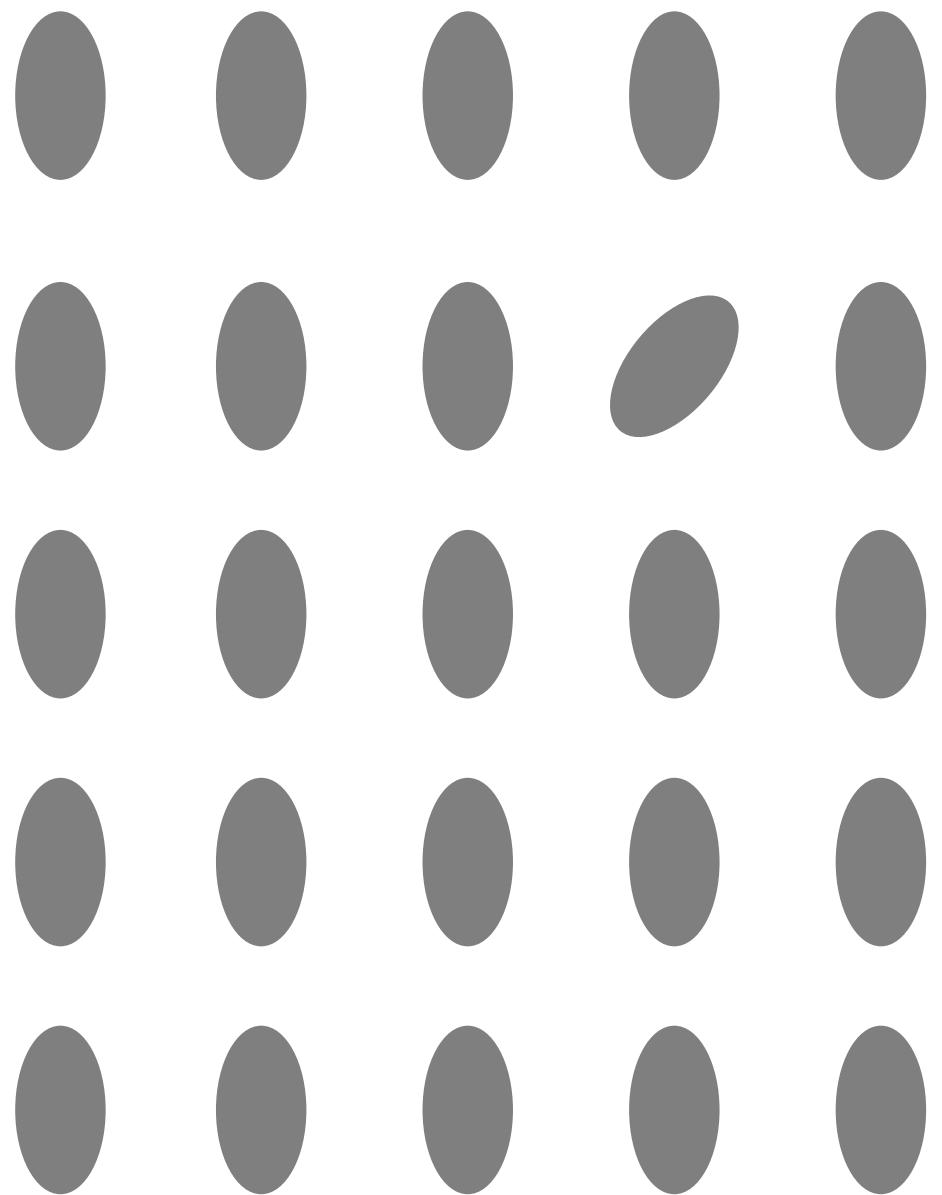


vibration | rotation | deformation

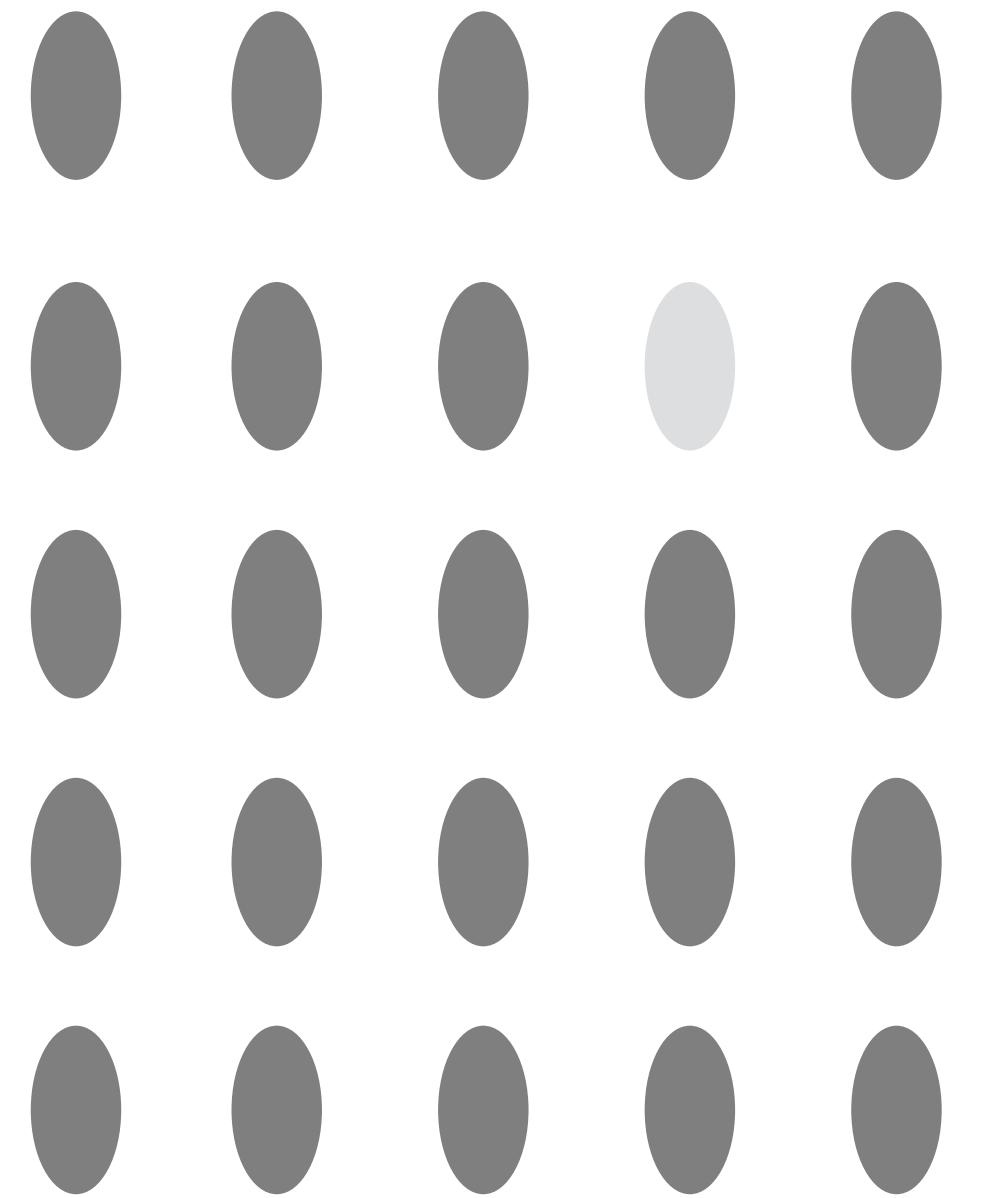




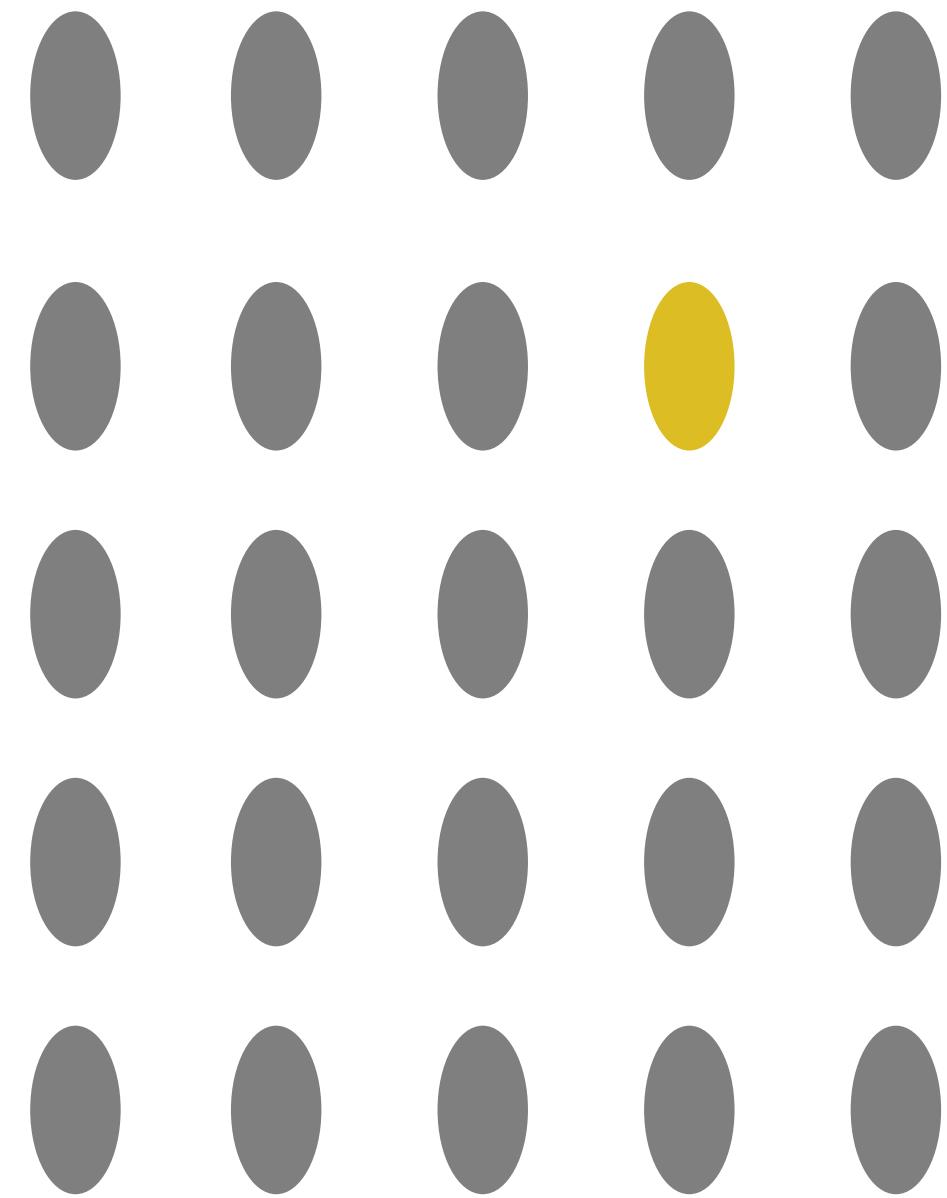
Scale



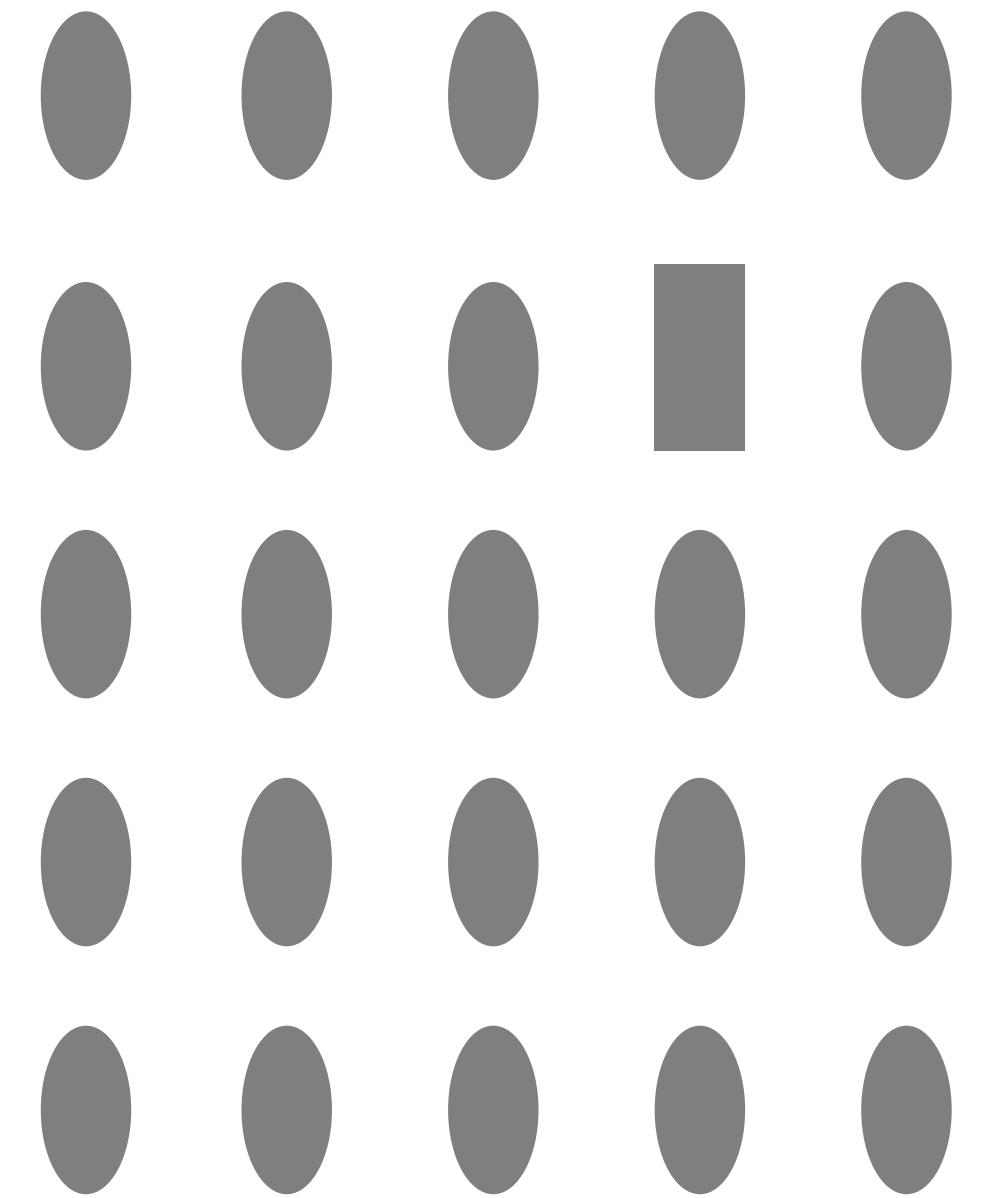
Orientation



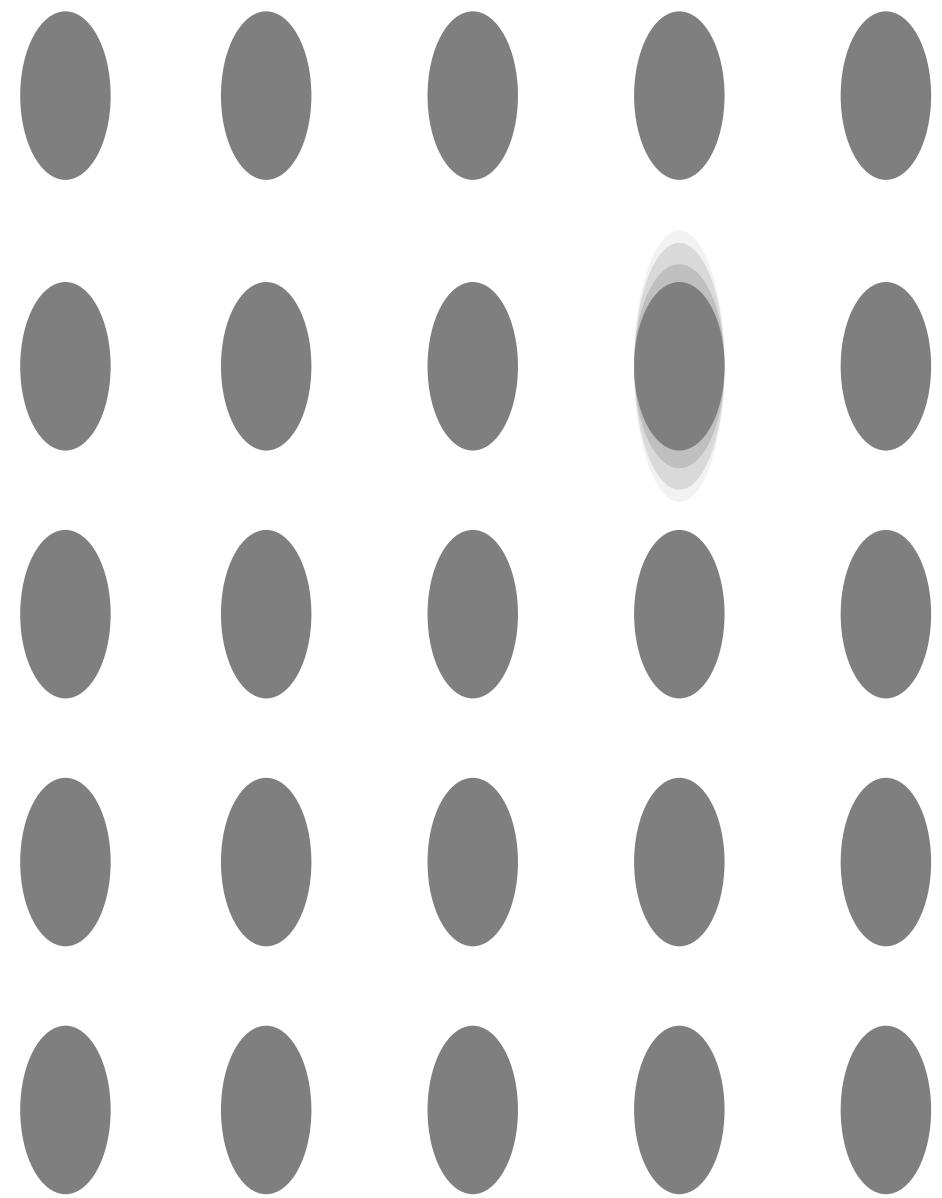
Luminosity



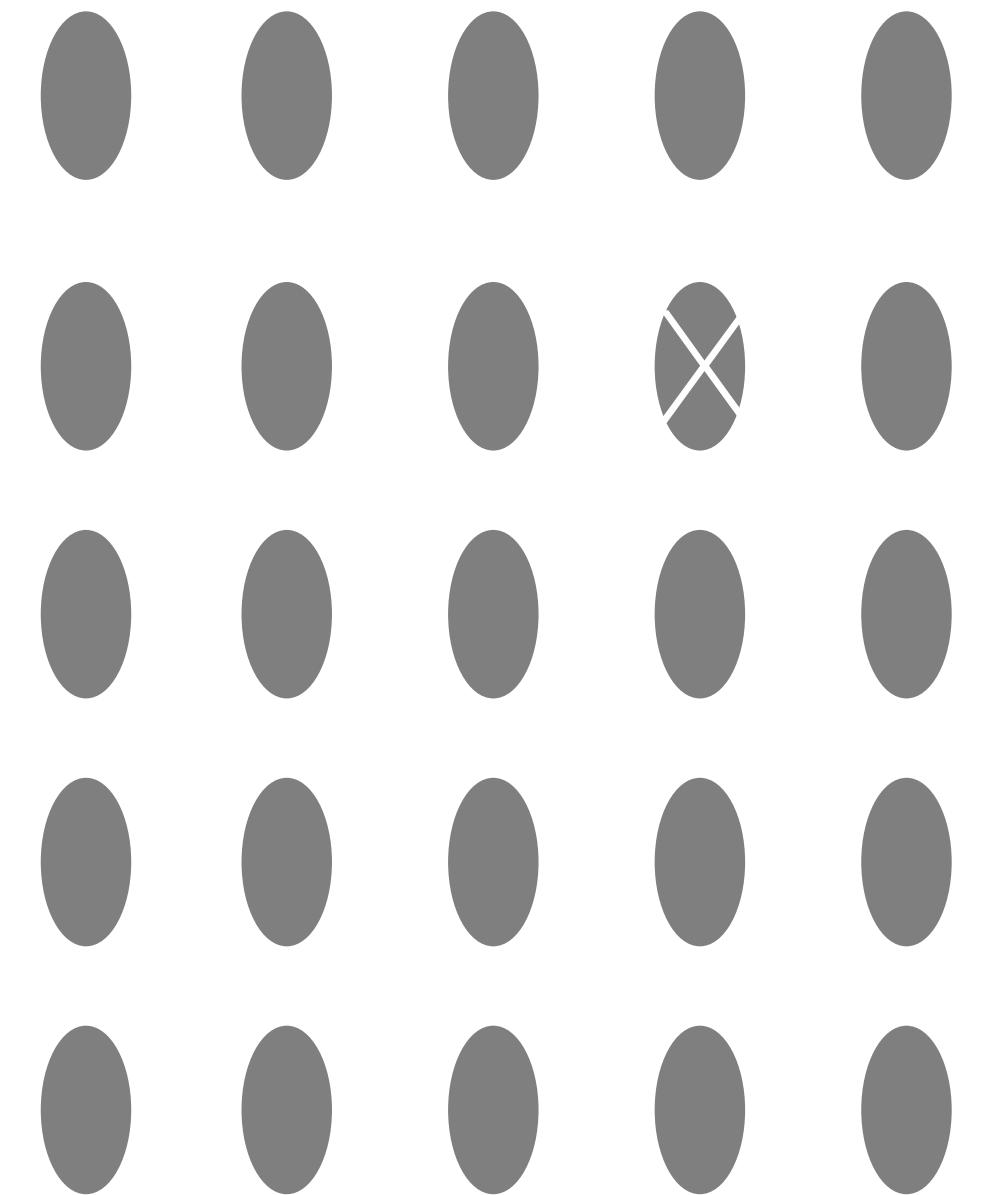
Hue



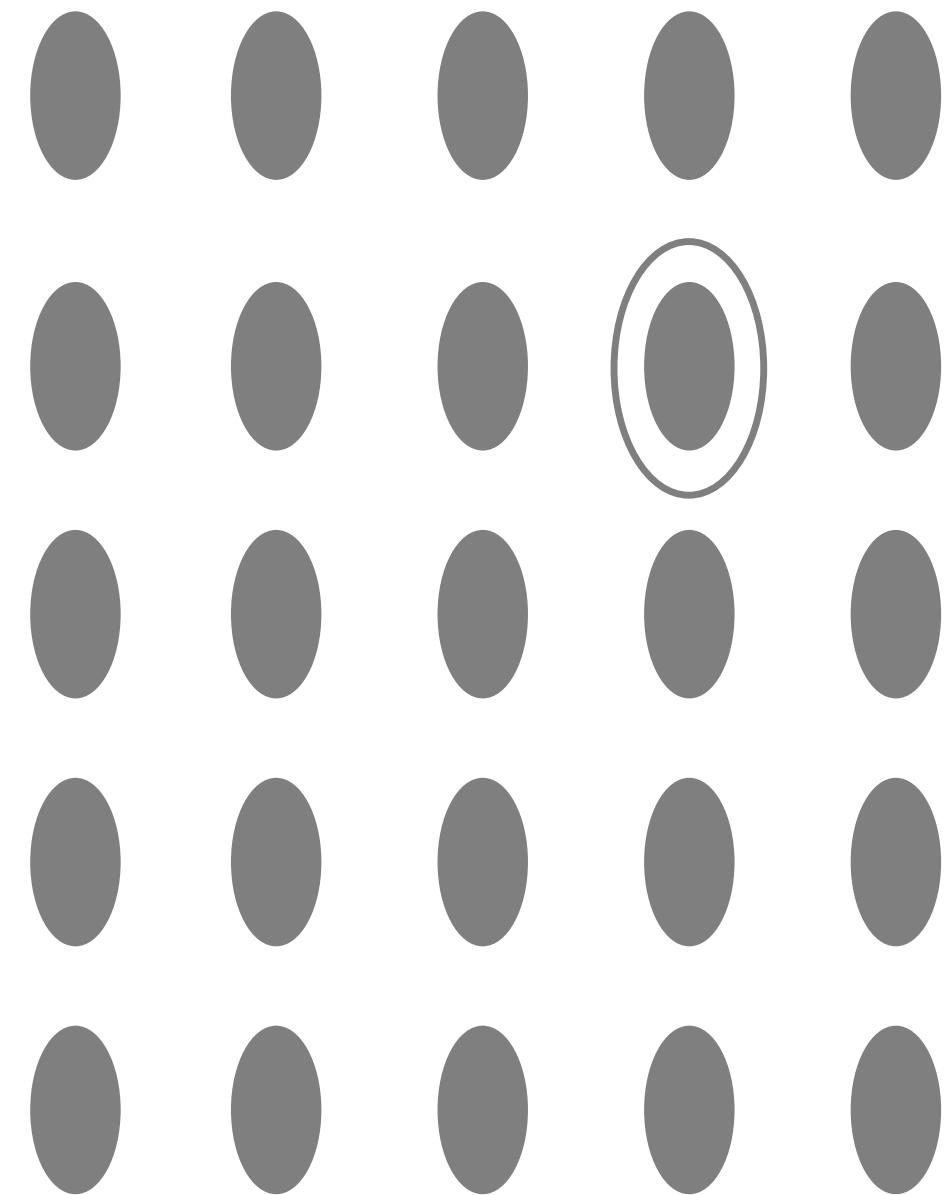
Shape



Motion



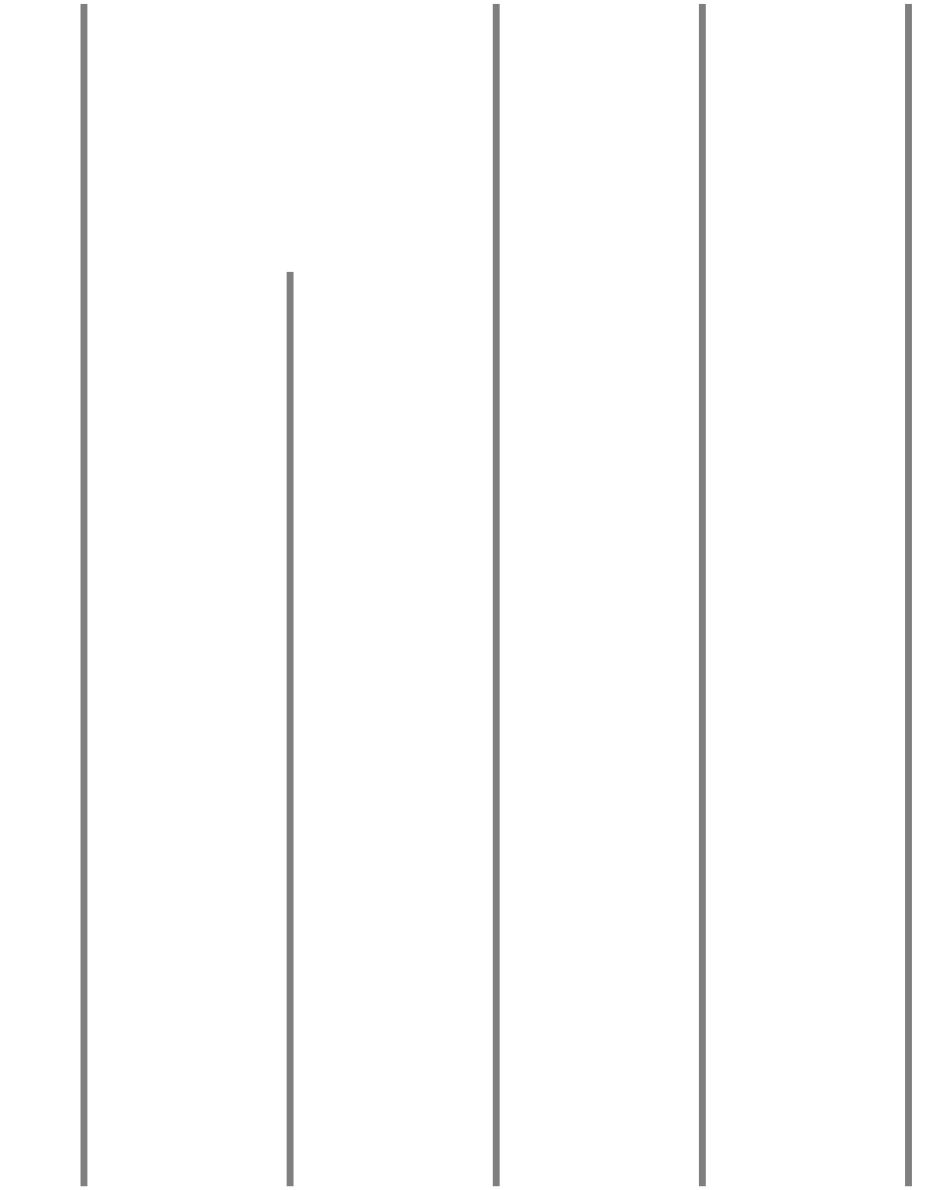
Markings



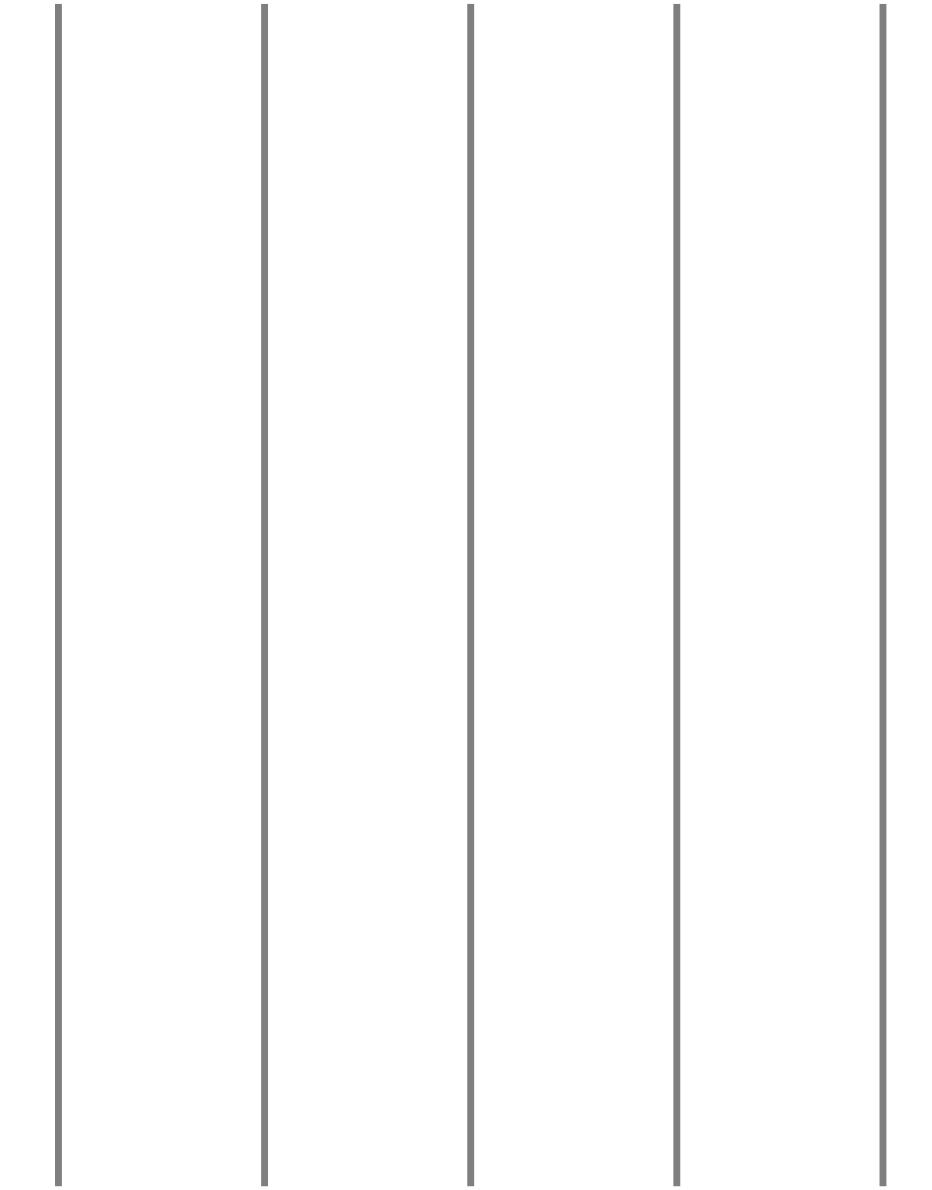
Enclosure



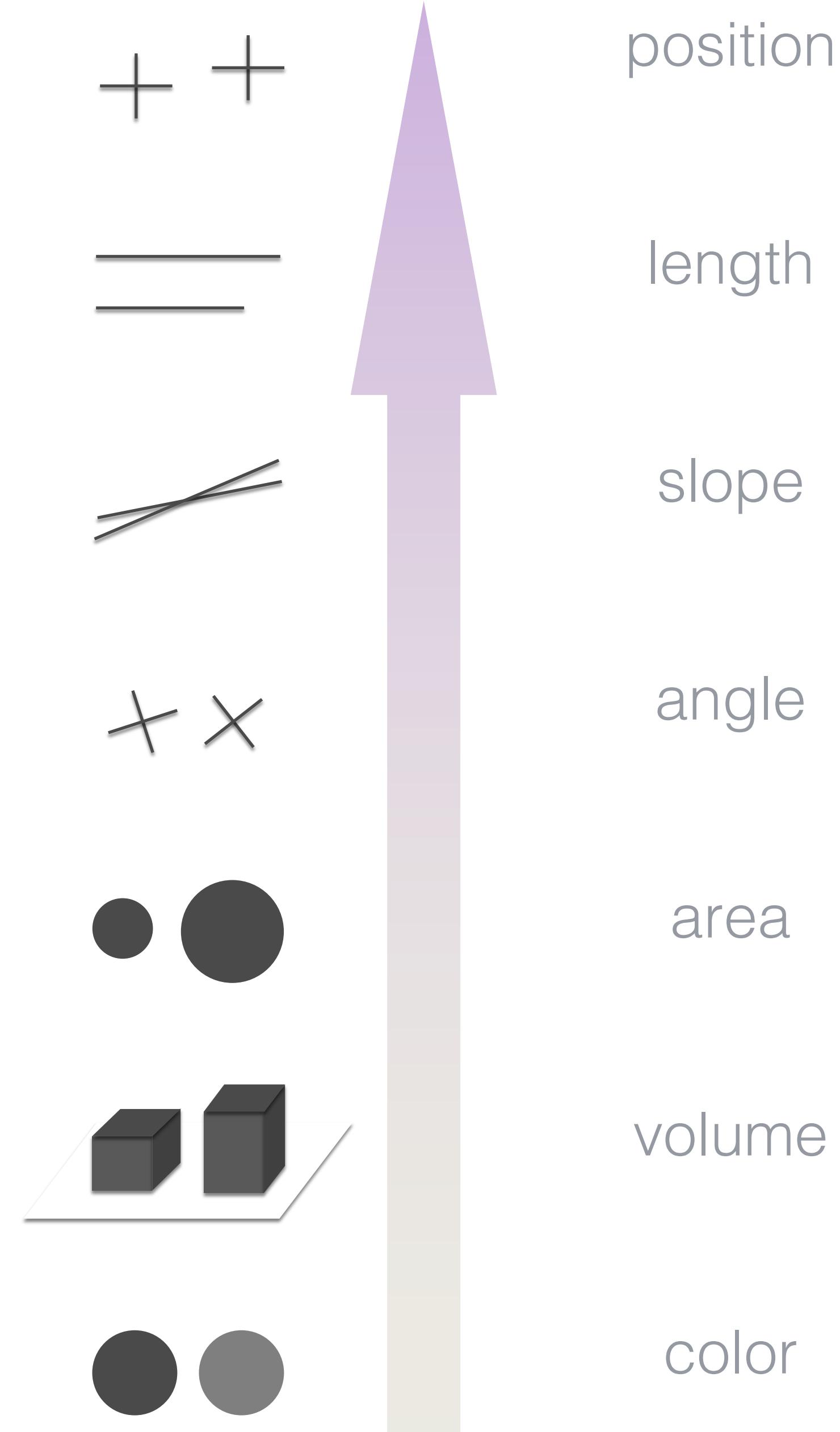
Line Length



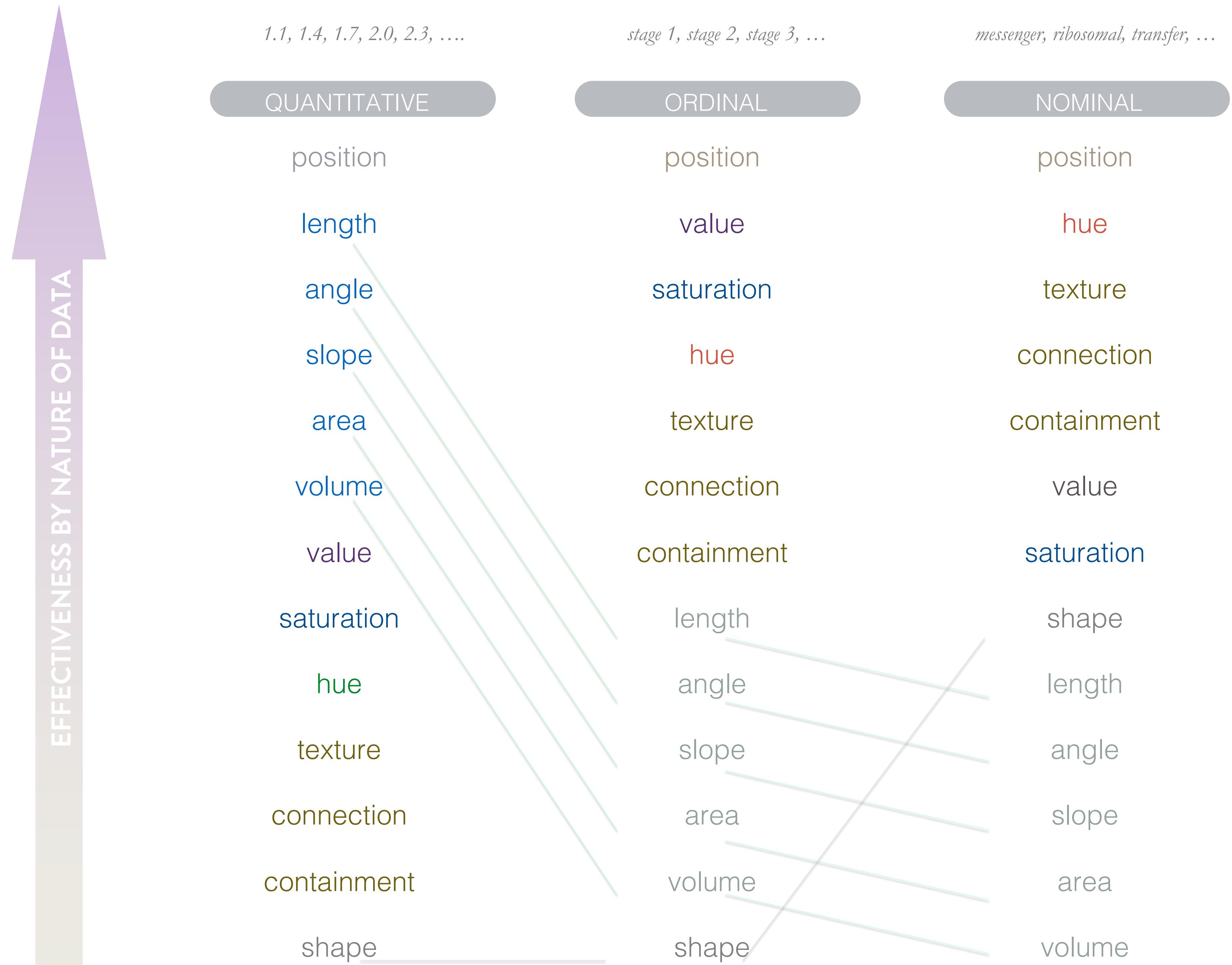
Line Width



ACCURACY IN PERCEPTION

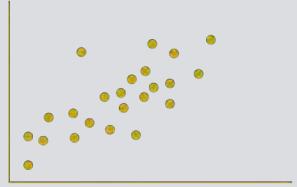


EFFECTIVENESS BY NATURE OF DATA

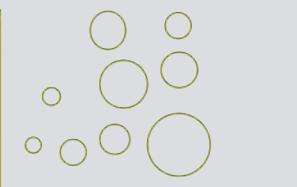




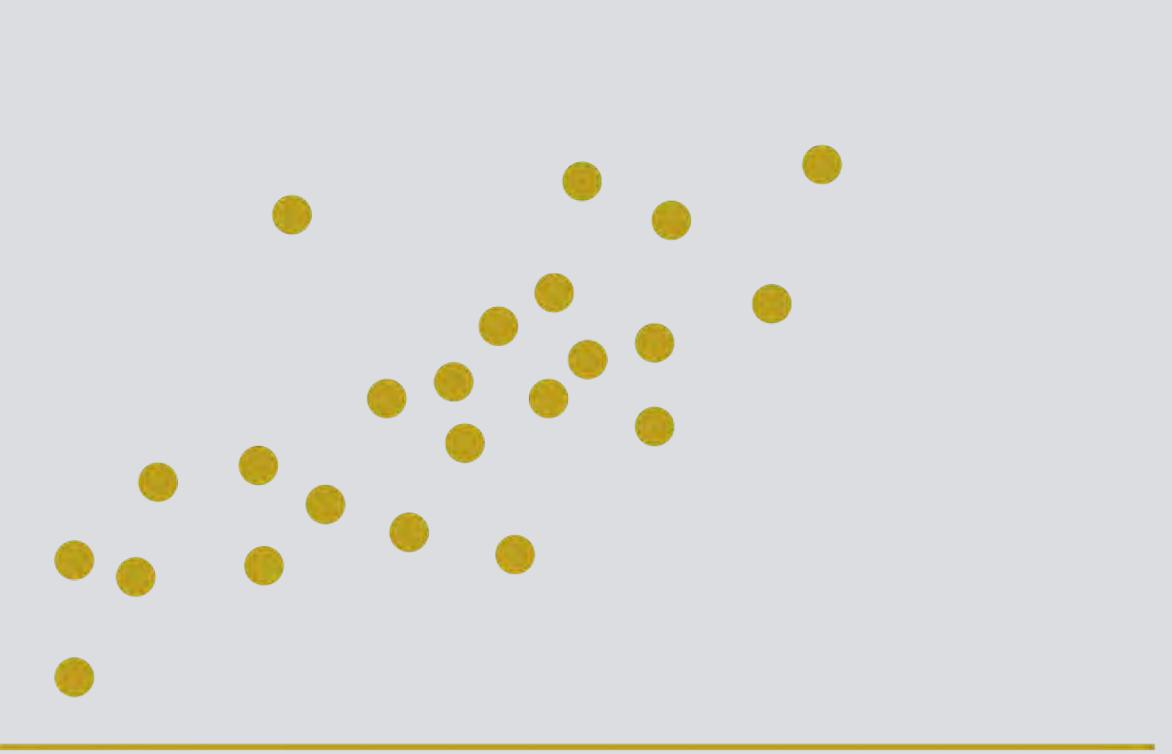
SCATTER CHART



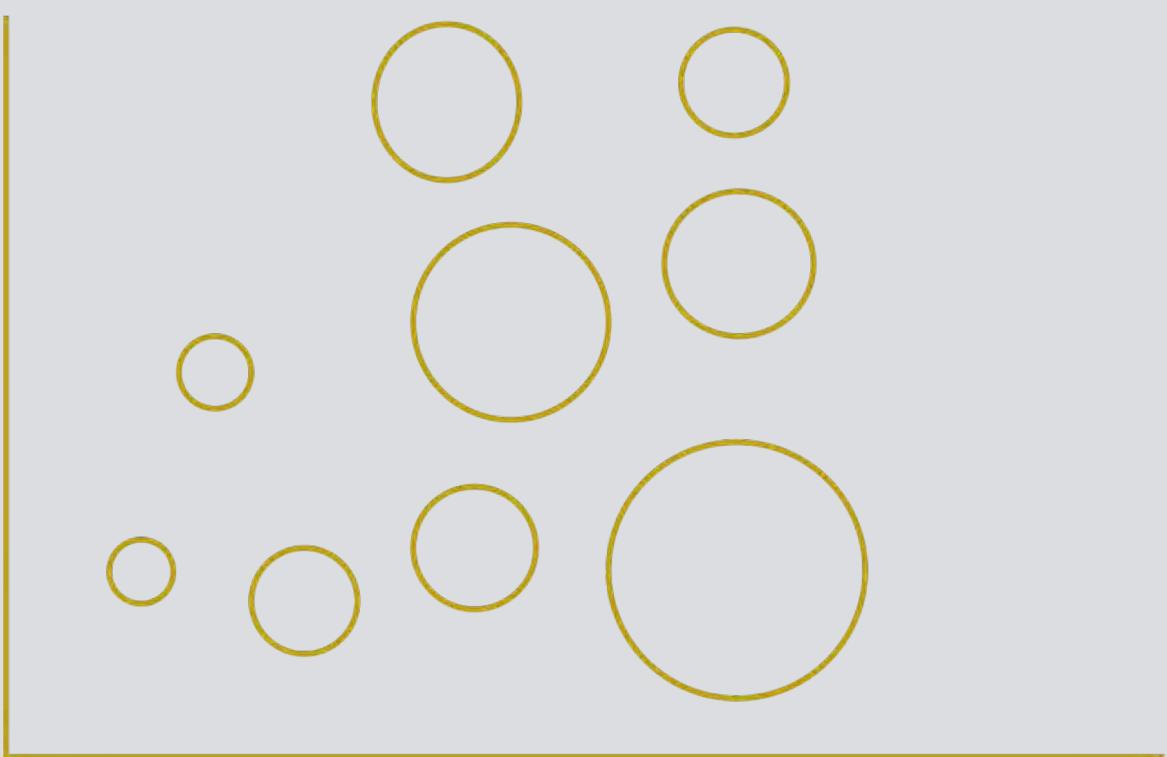
BUBBLE CHART



SCATTER CHART

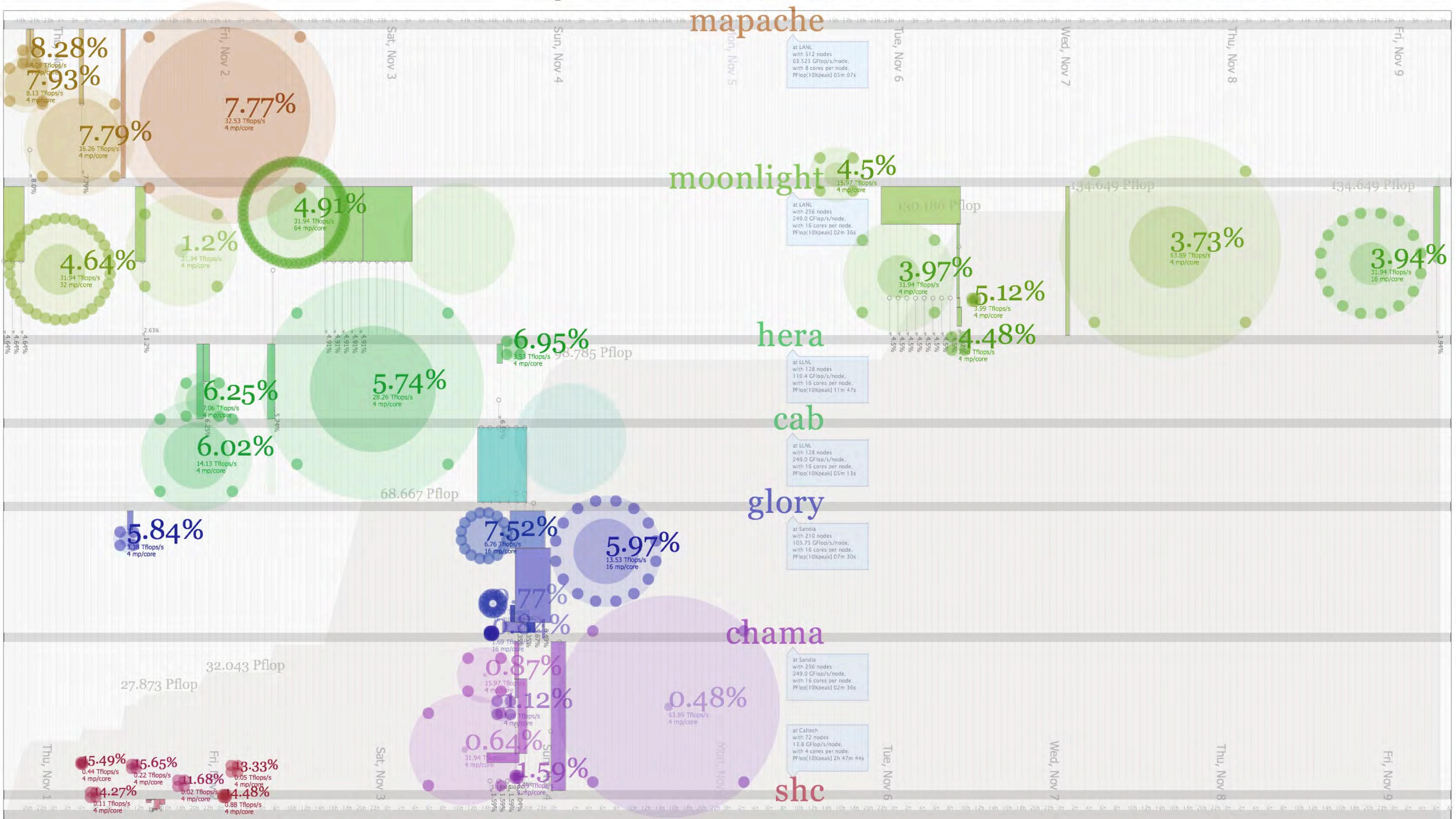


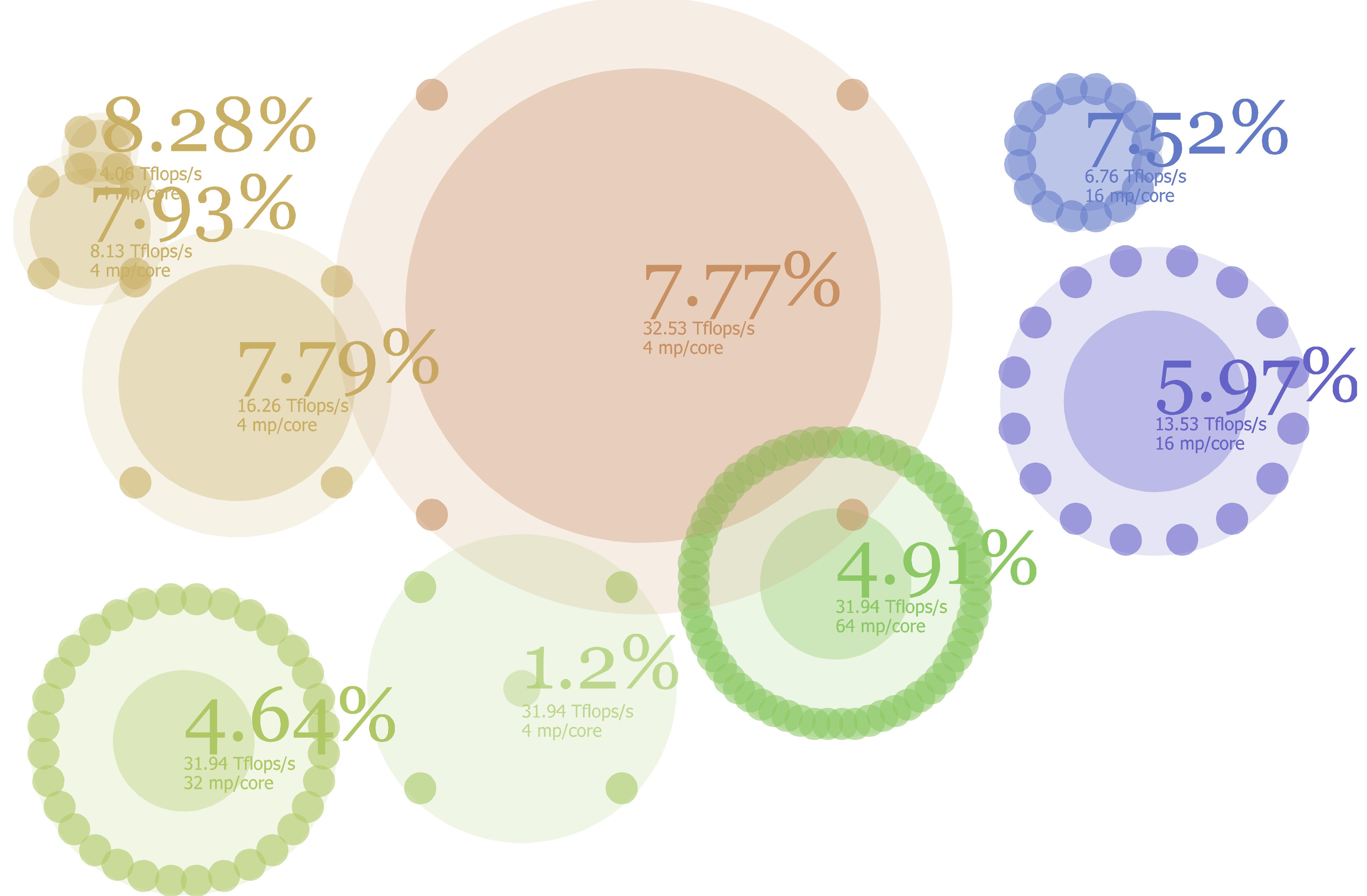
BUBBLE CHART

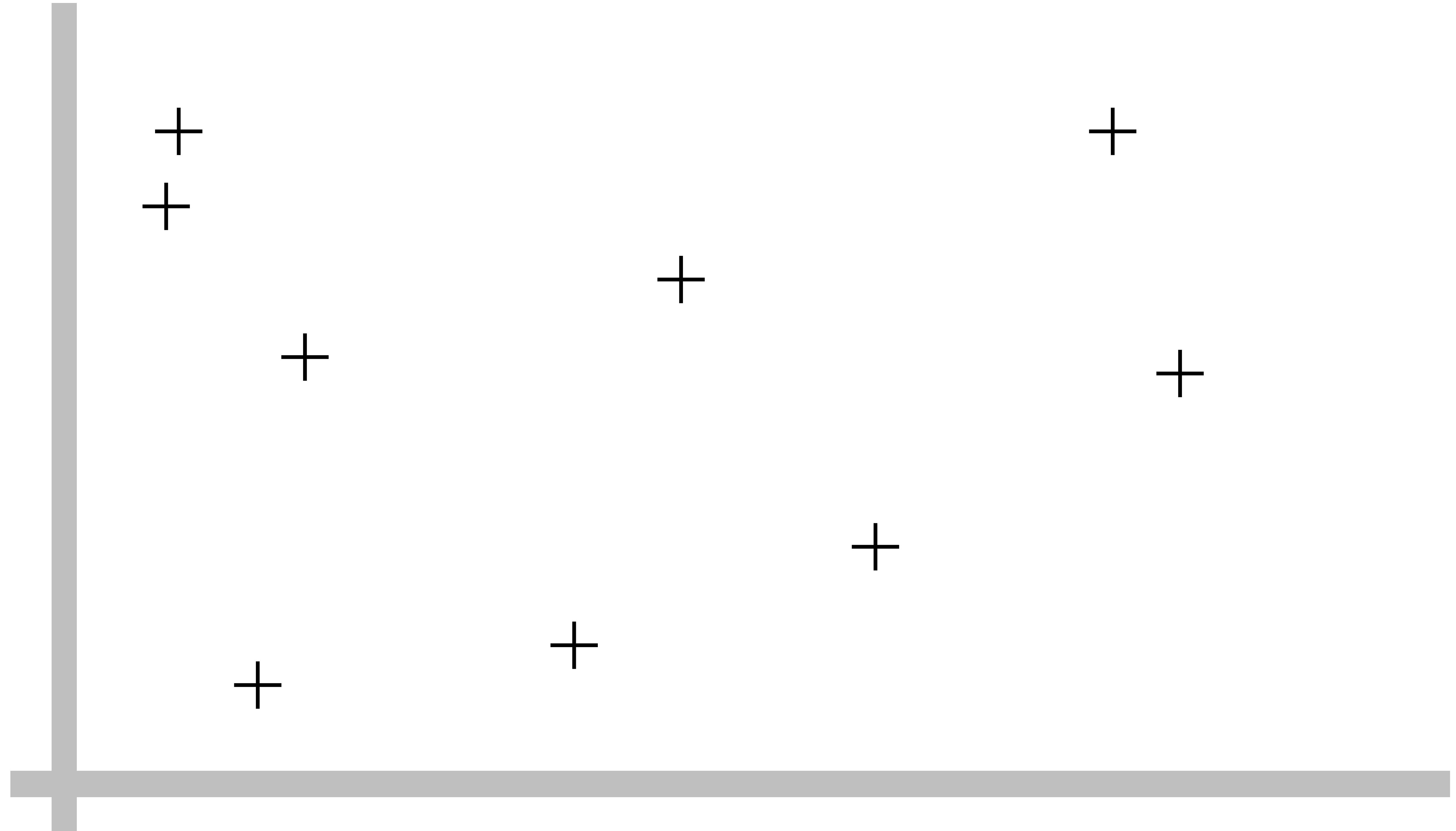


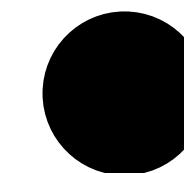
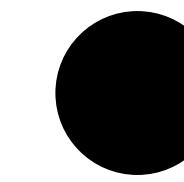
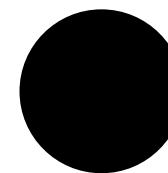
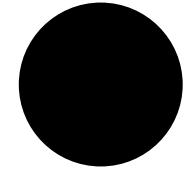
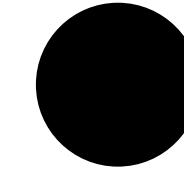
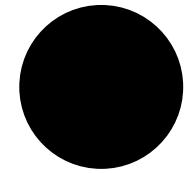
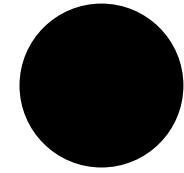
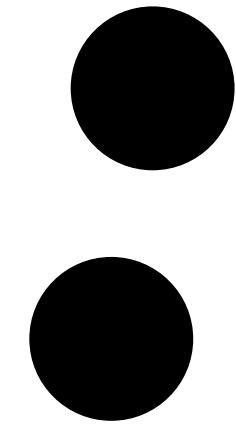
U Q C A M P A I G N M O N I T O R

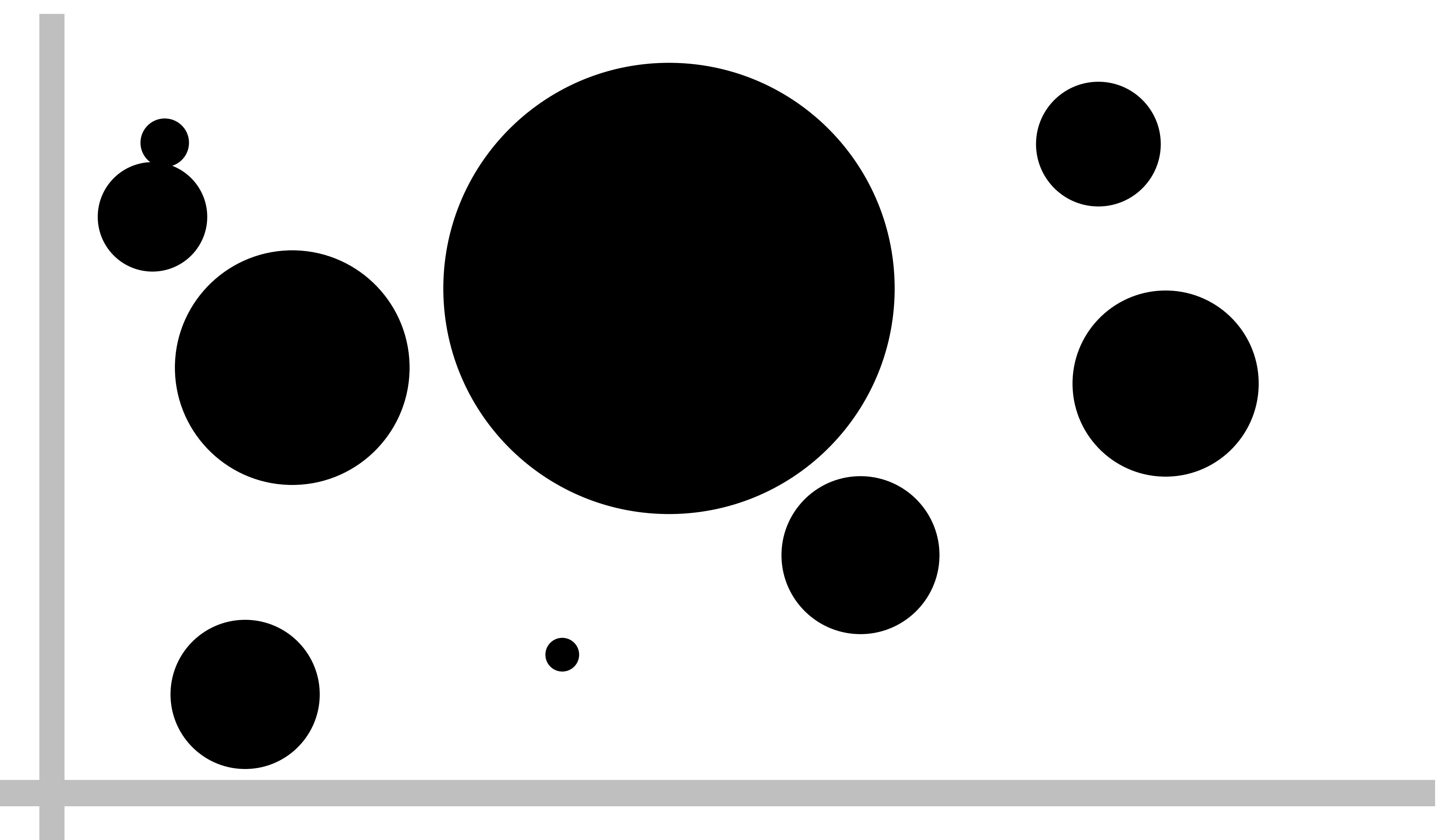
Total system usage in 8d 14h 43m 05s: 138.578 Pflop

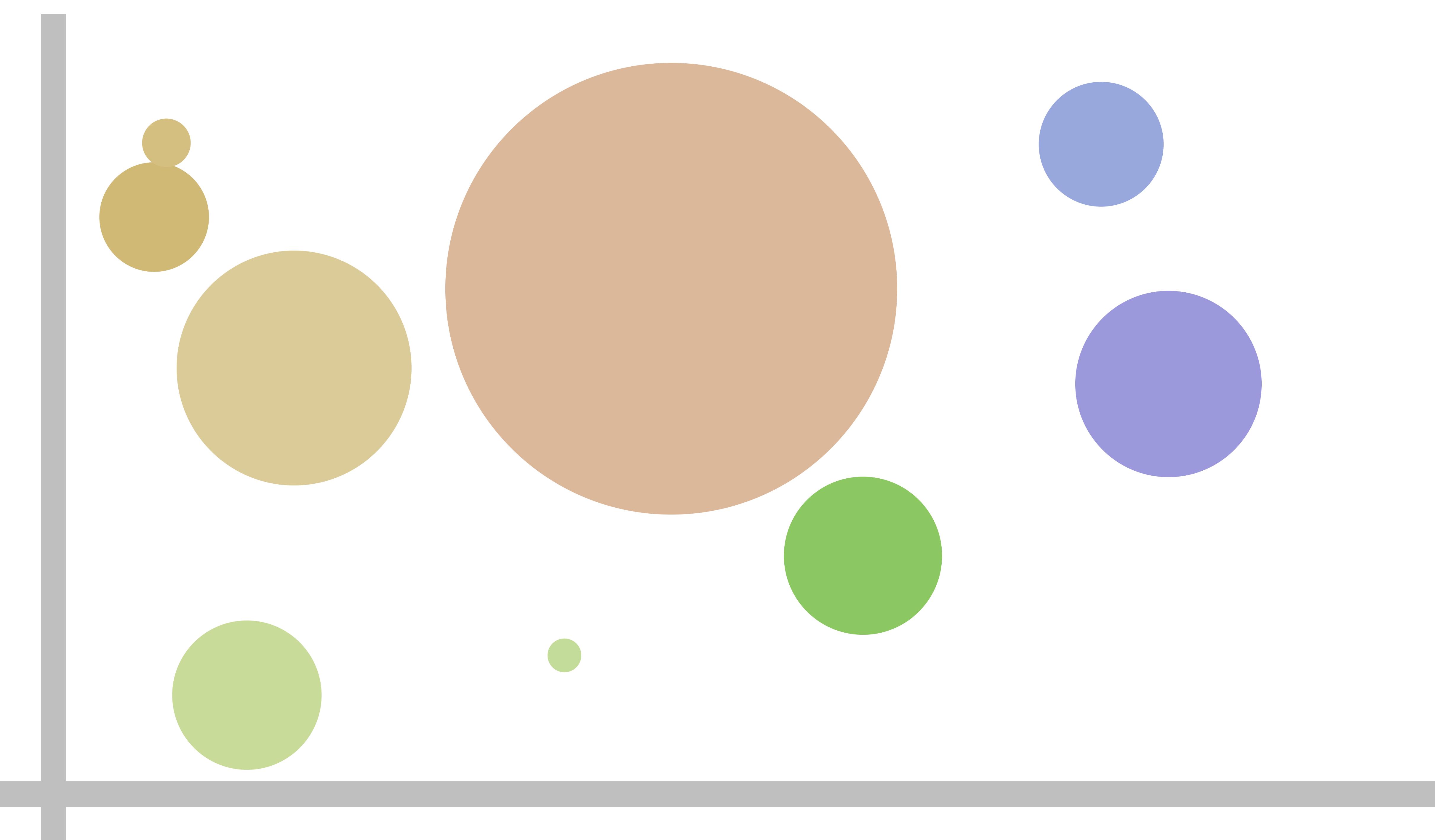


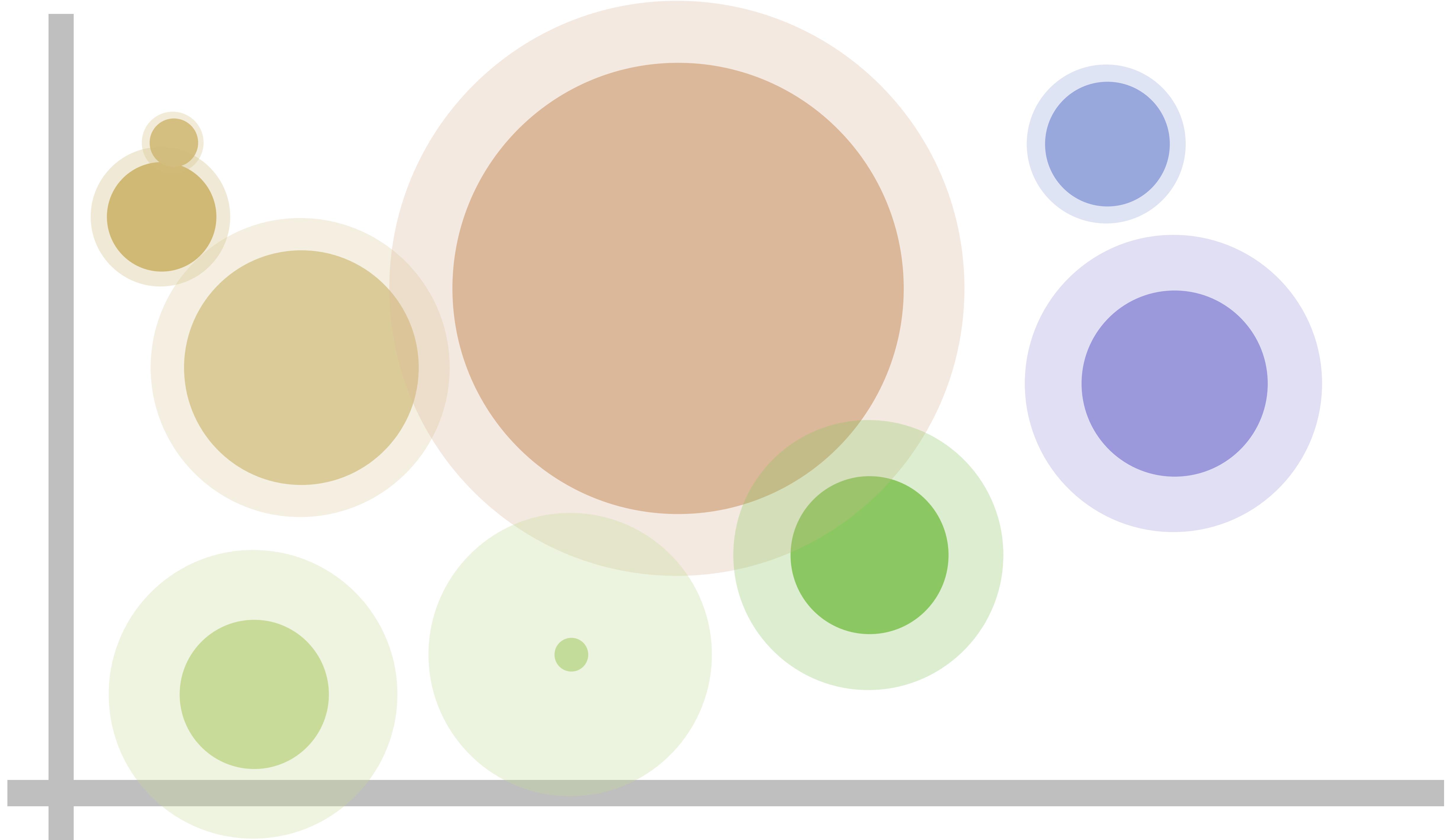


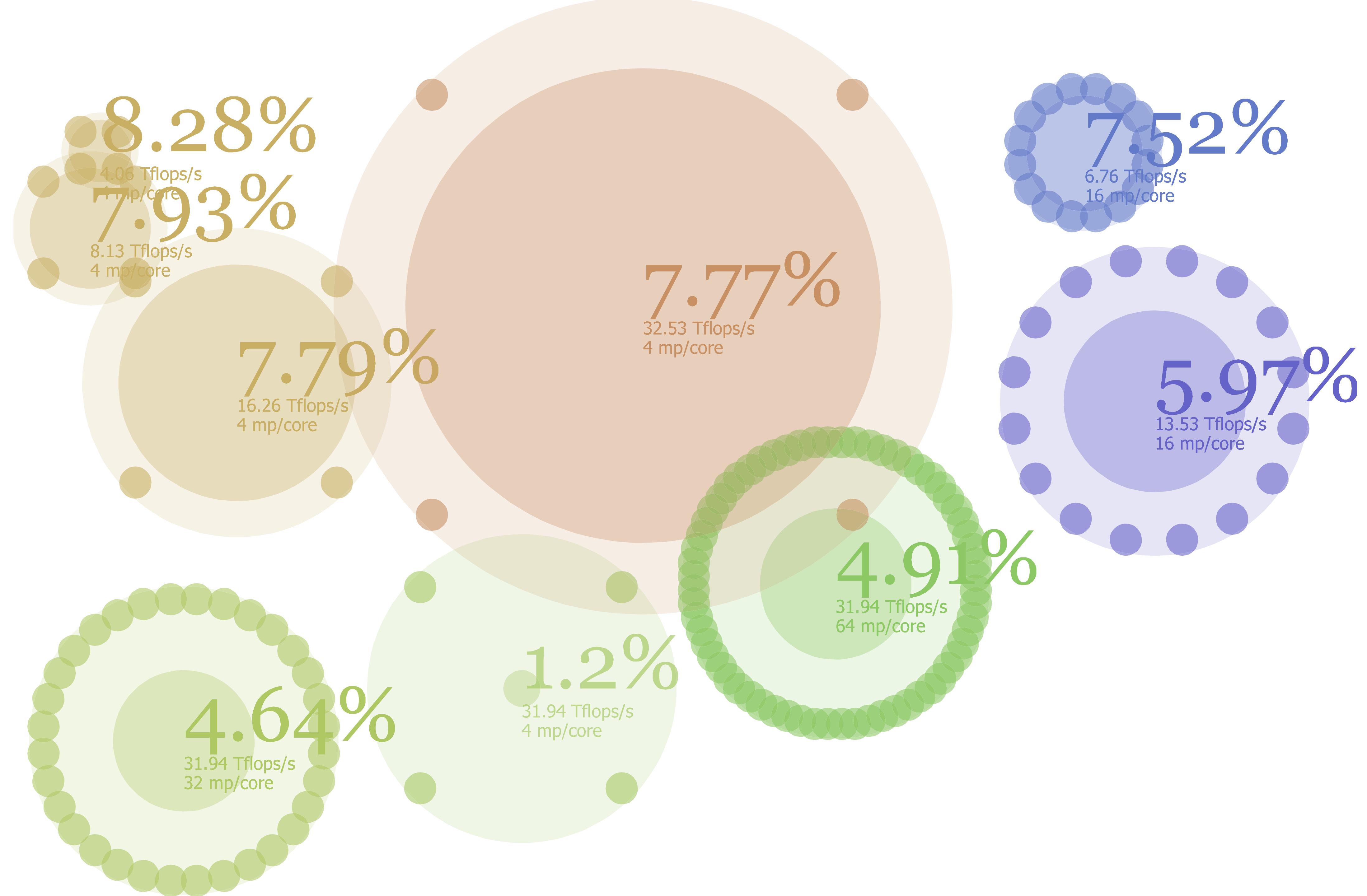












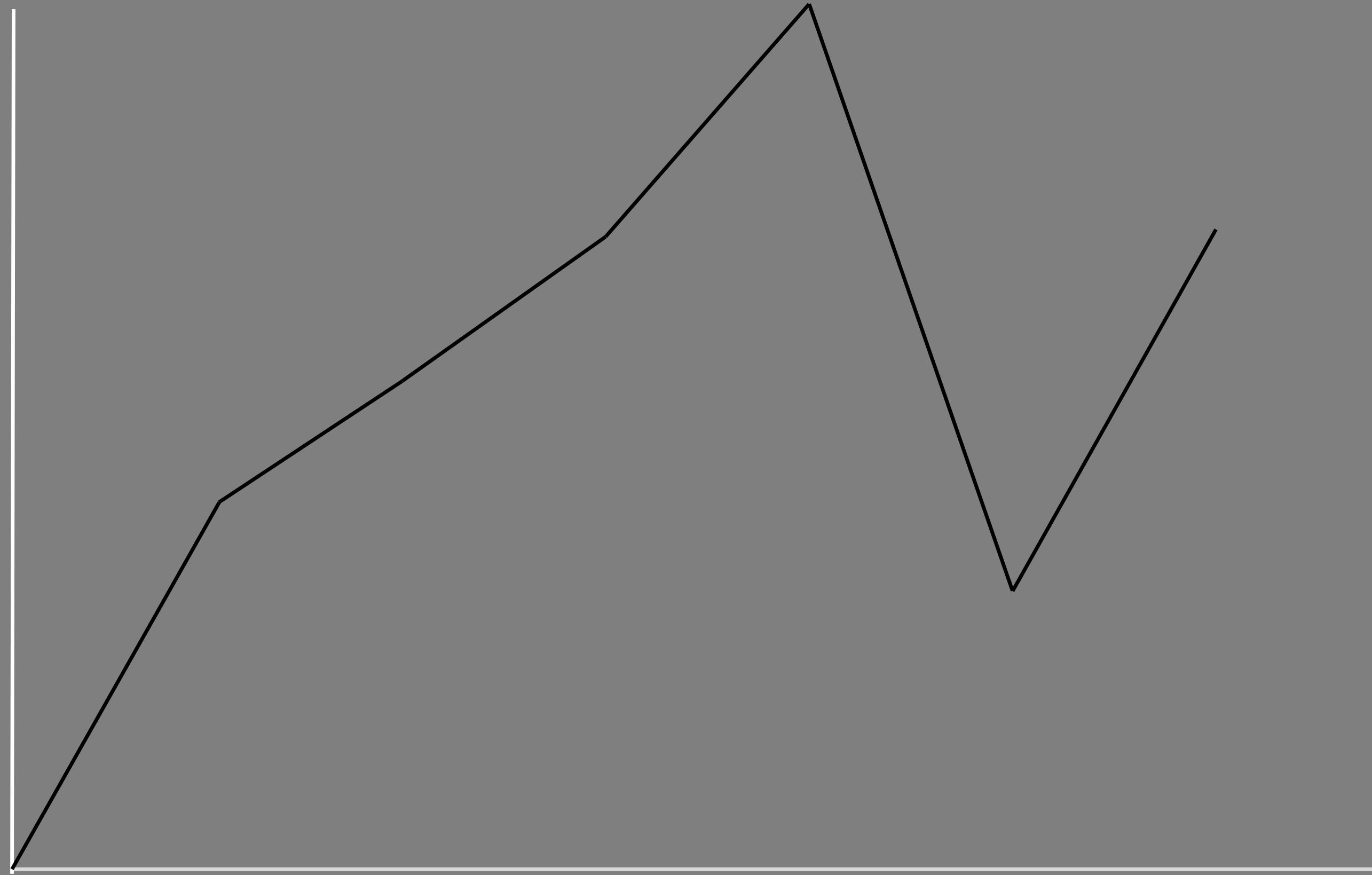
LAYERS
LAYERS
LAYERS

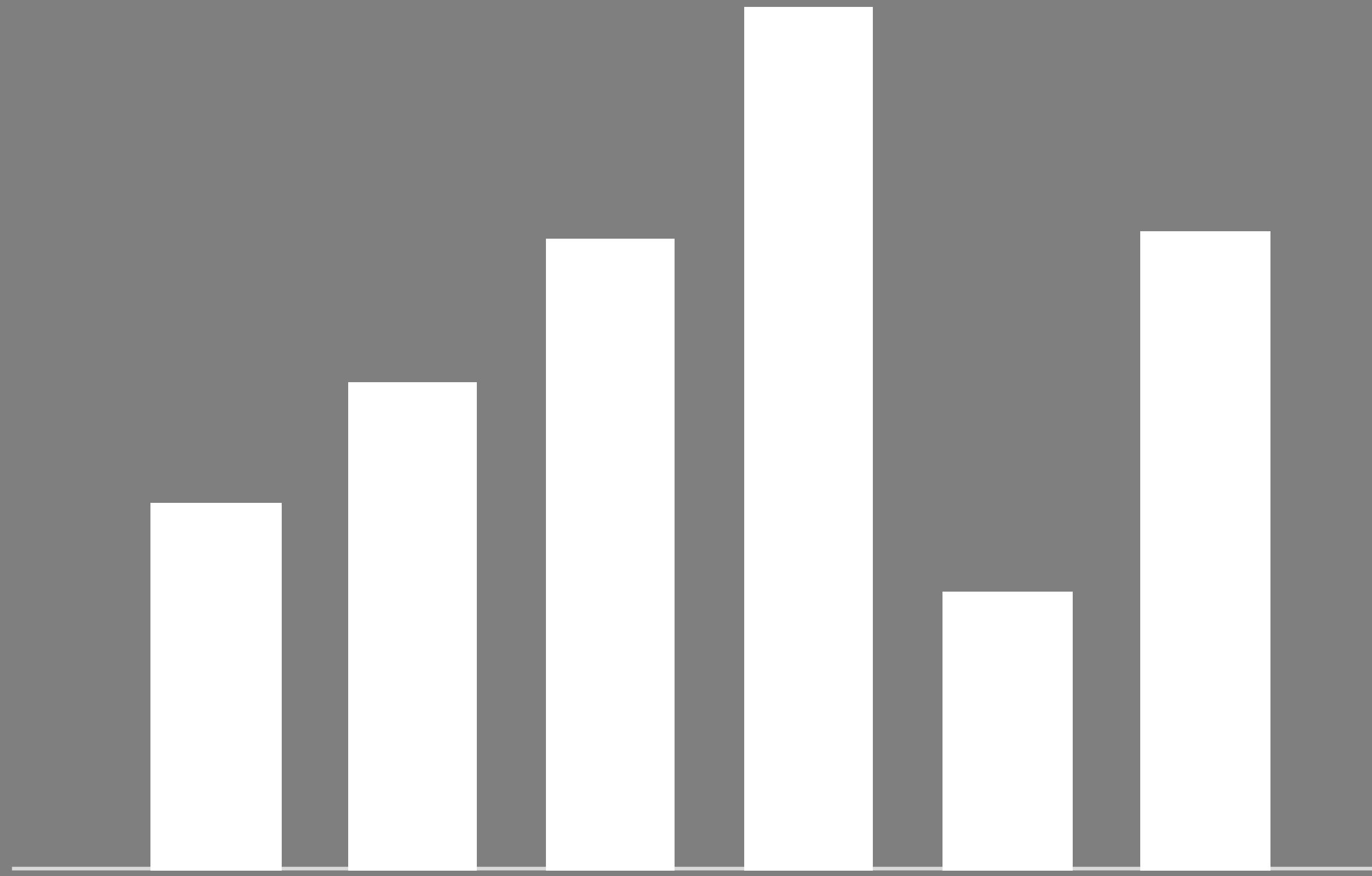
PLAYERS

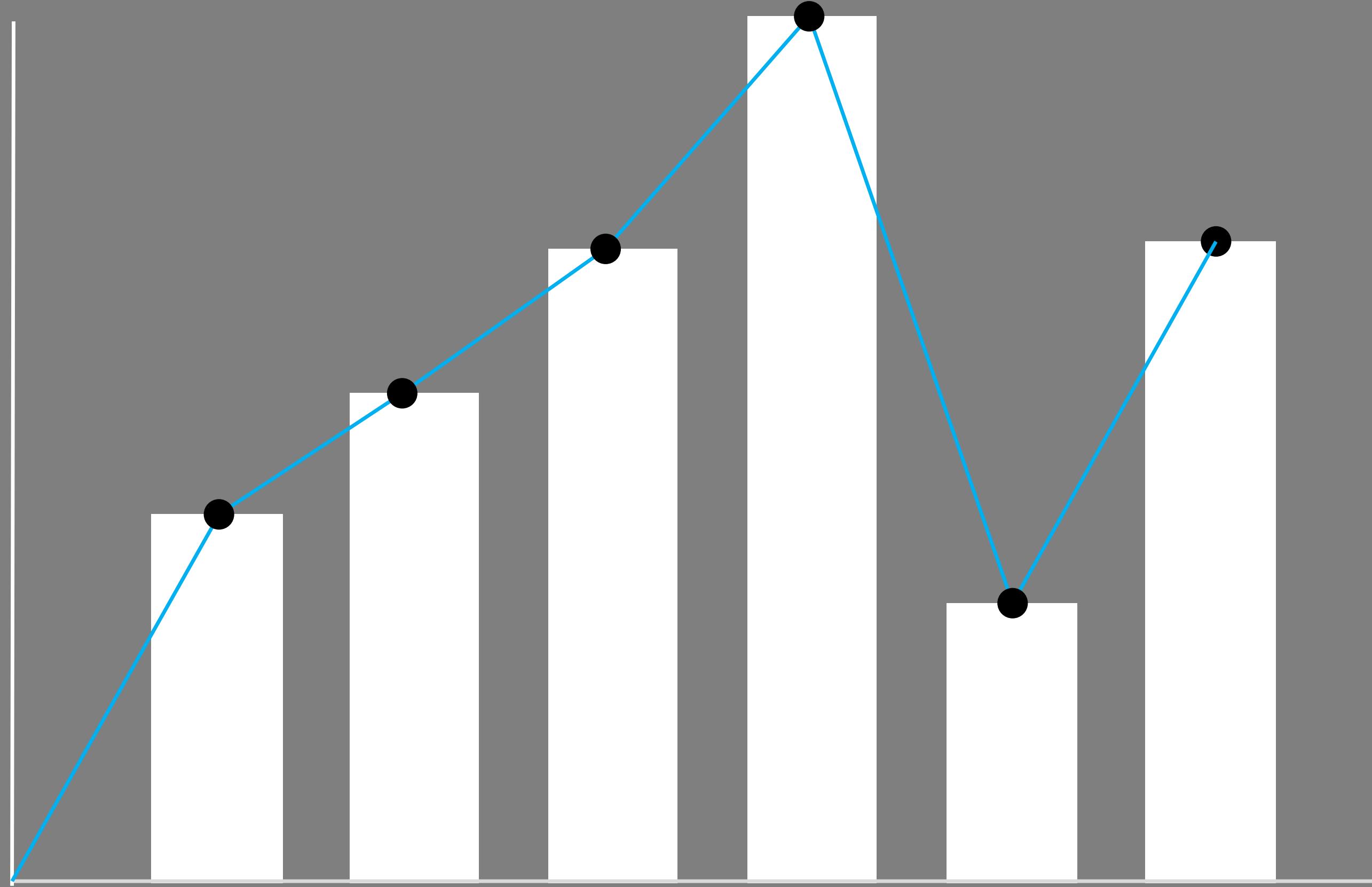
PLAYERS

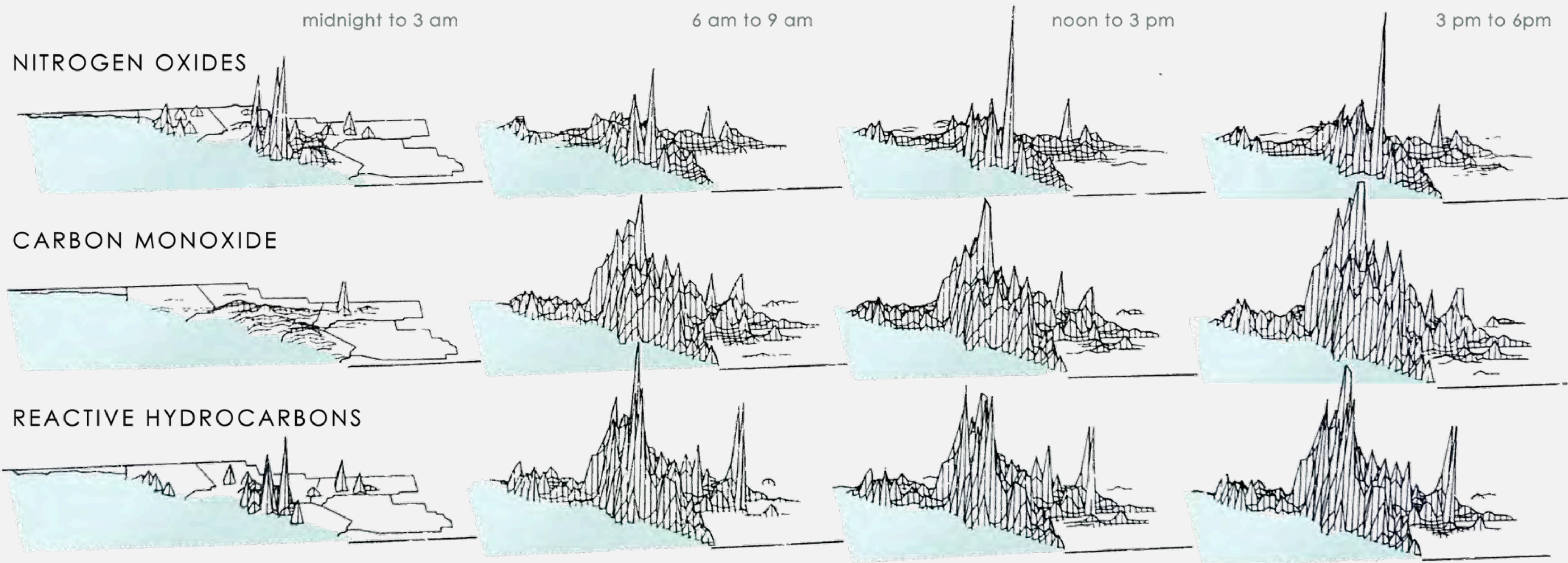
PLAYERS

L A Y E S P C









VARIABLE WIDTH COLUMN CHART



Two Variables per Item

TABLE OR TABLE WITH EMBEDDED CHARTS



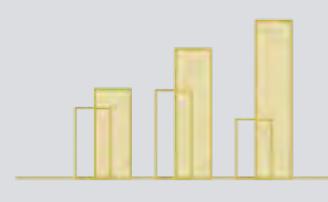
Many Categories

BAR CHART



Many Items

COLUMN CHART



Few Items

CIRCULAR AREA CHART



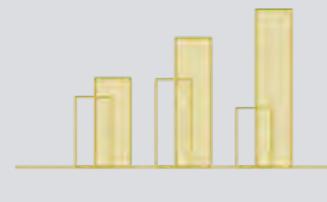
Cyclical Data

LINE CHART



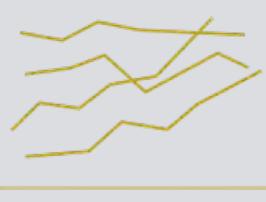
Non-Cyclical Data

COLUMN CHART



Single or Few Categories

LINE CHART



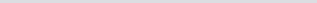
Many Categories

SCATTER CHART



Two Variables

BUBBLE CHART



Three Variables

Few Periods

Changing Over Time

Many Periods

Only Relative Differences Matter

Relative and Absolute Differences Matter

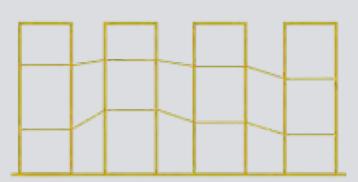
Only Relative Differences Matter

Relative and Absolute Differences Matter

Simple Share of Total

Accumulation or Subtraction to Total

Components of Components



STACKED 100% COLUMN CHART



STACKED COLUMN CHART



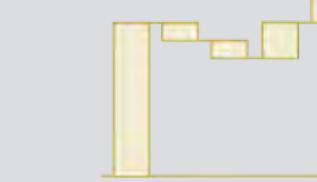
STACKED 100% AREA CHART



STACKED AREA CHART



PIE CHART

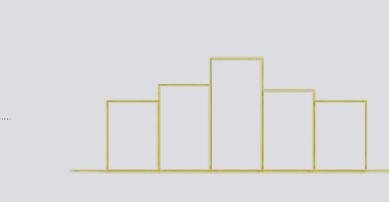


WATERFALL CHART



STACKED 100% COLUMN CHART WITH SUBCOMPONENTS

COLUMN HISTOGRAM



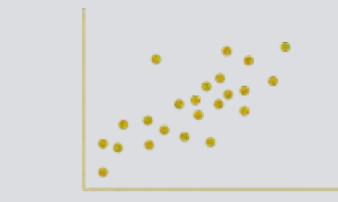
Few Data Points

LINE HISTOGRAM



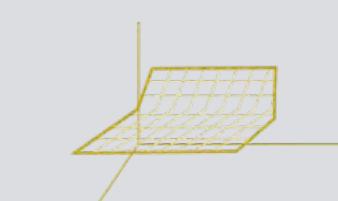
Many Data Points

SCATTER CHART



Two Variables

3D AREA CHART



Three Variables

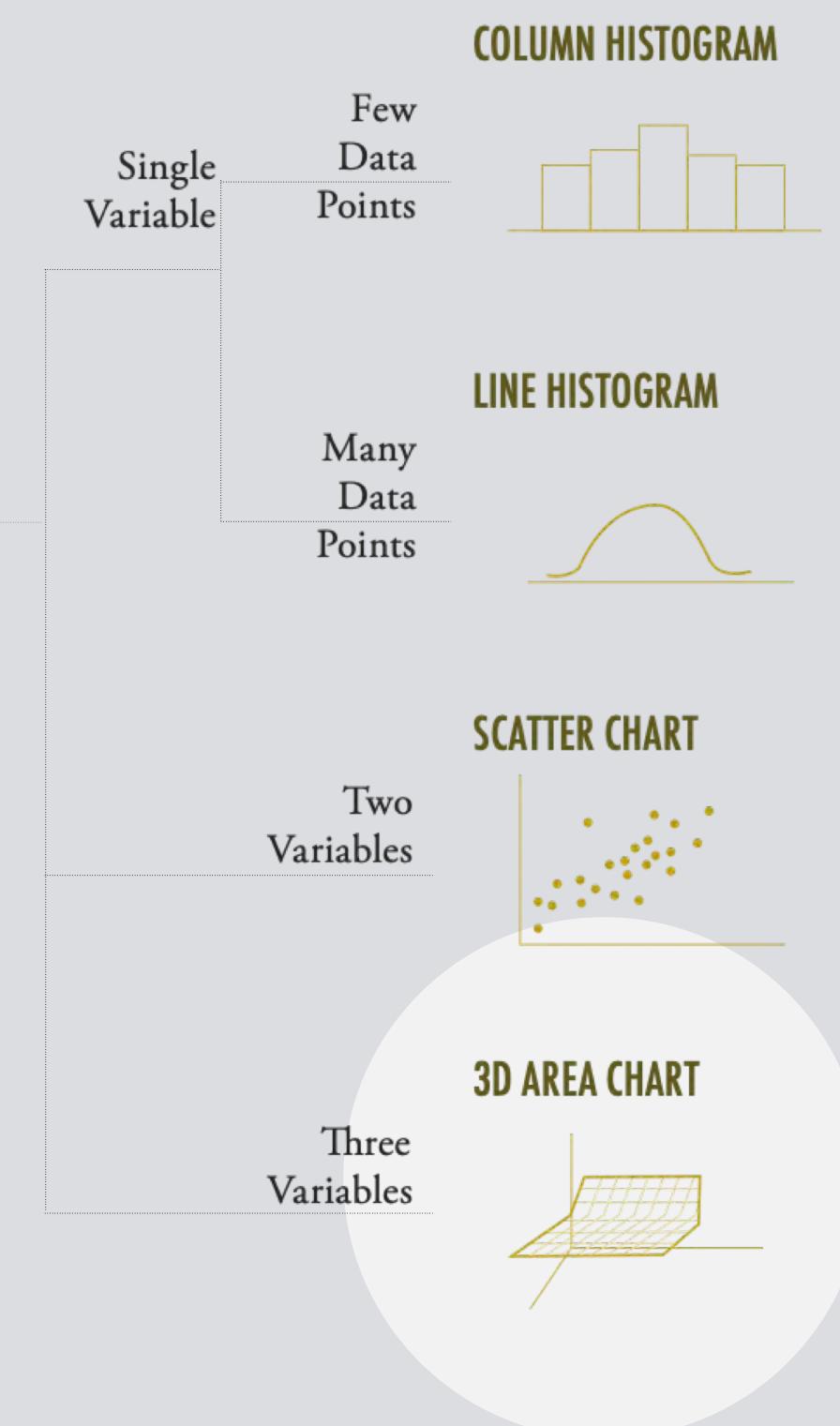
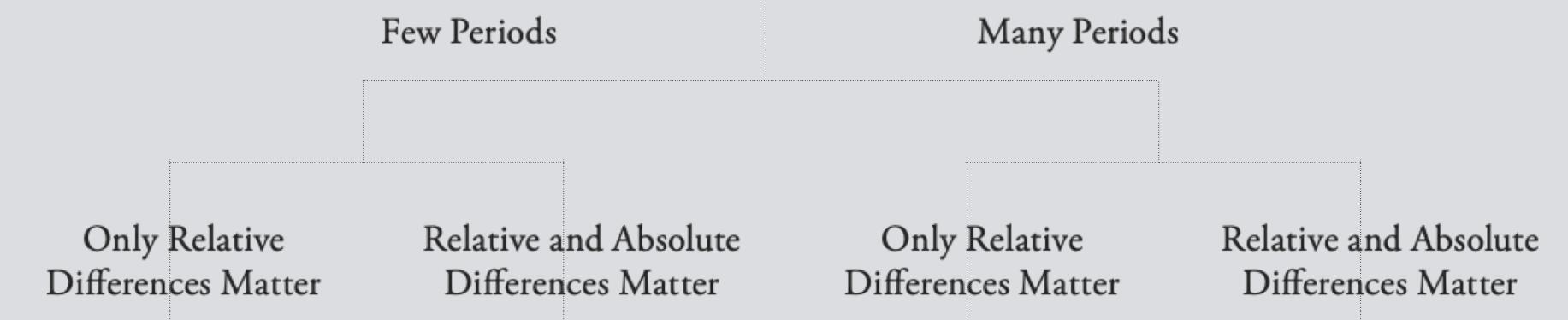
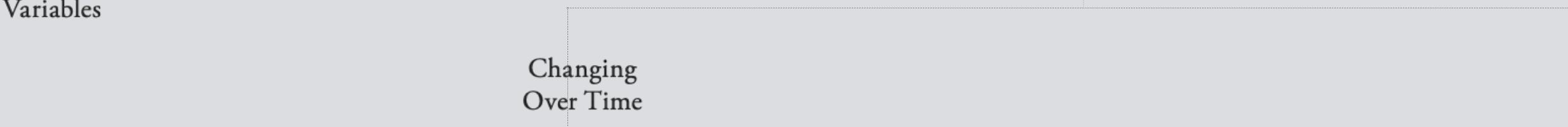
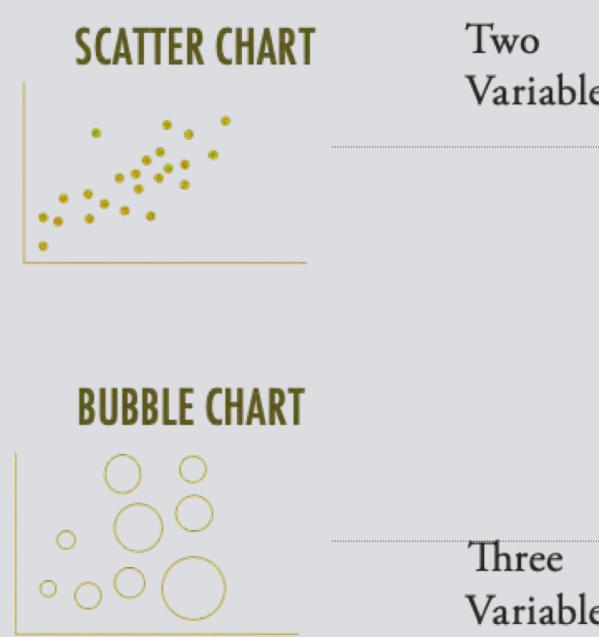
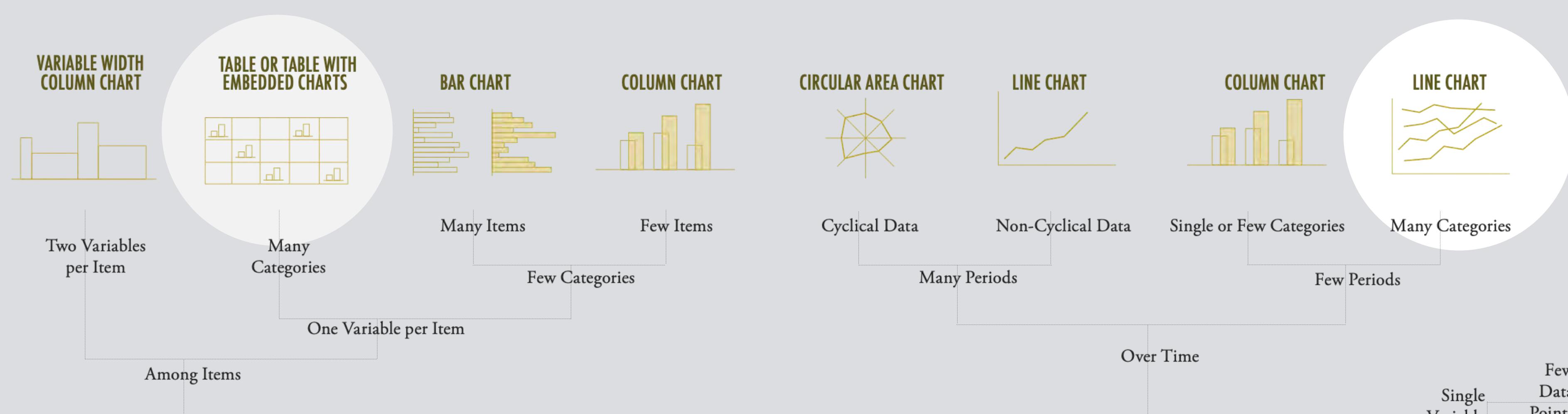
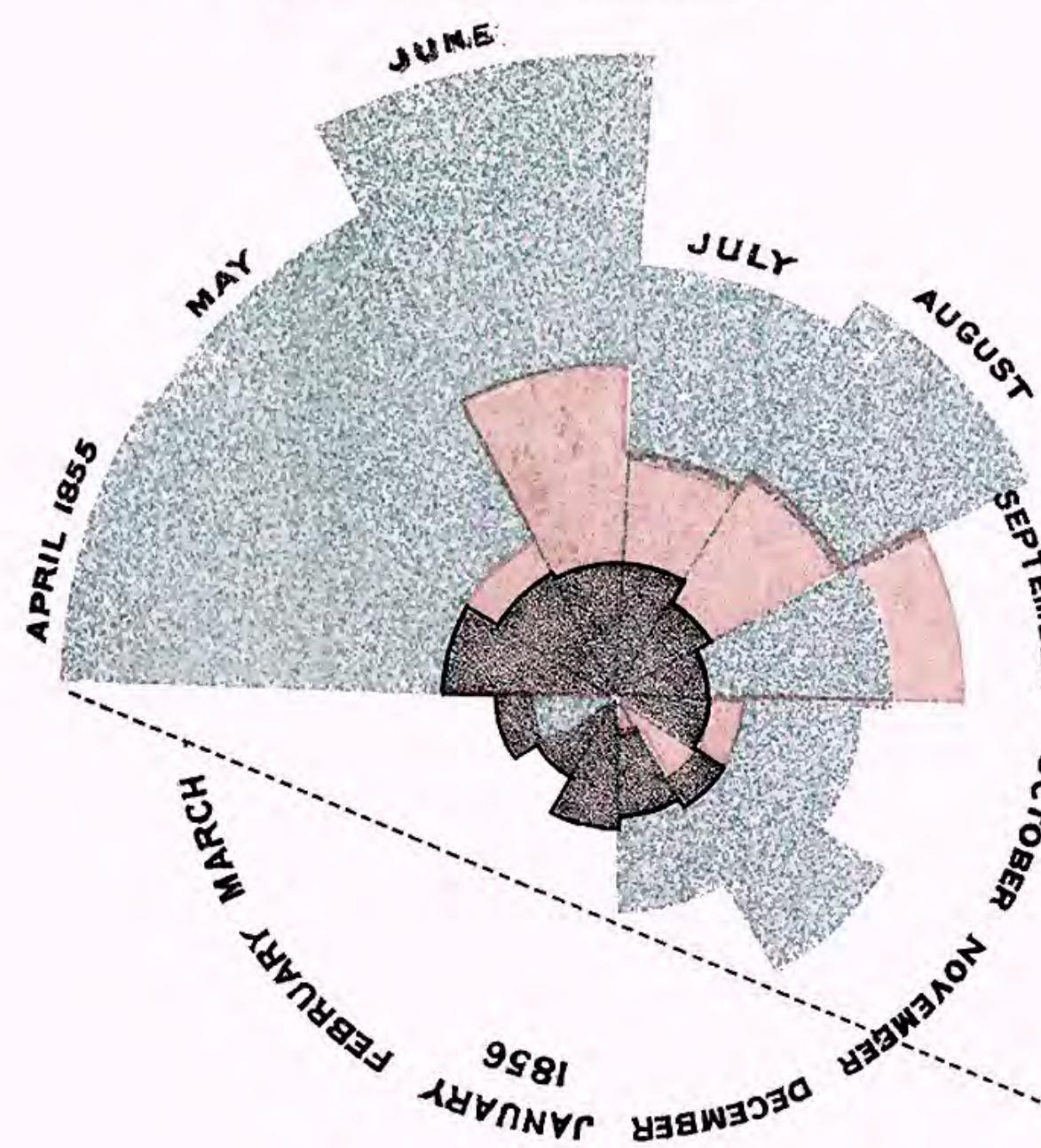


DIAGRAM OF THE CAUSES OF MORTALITY
IN THE ARMY IN THE EAST.

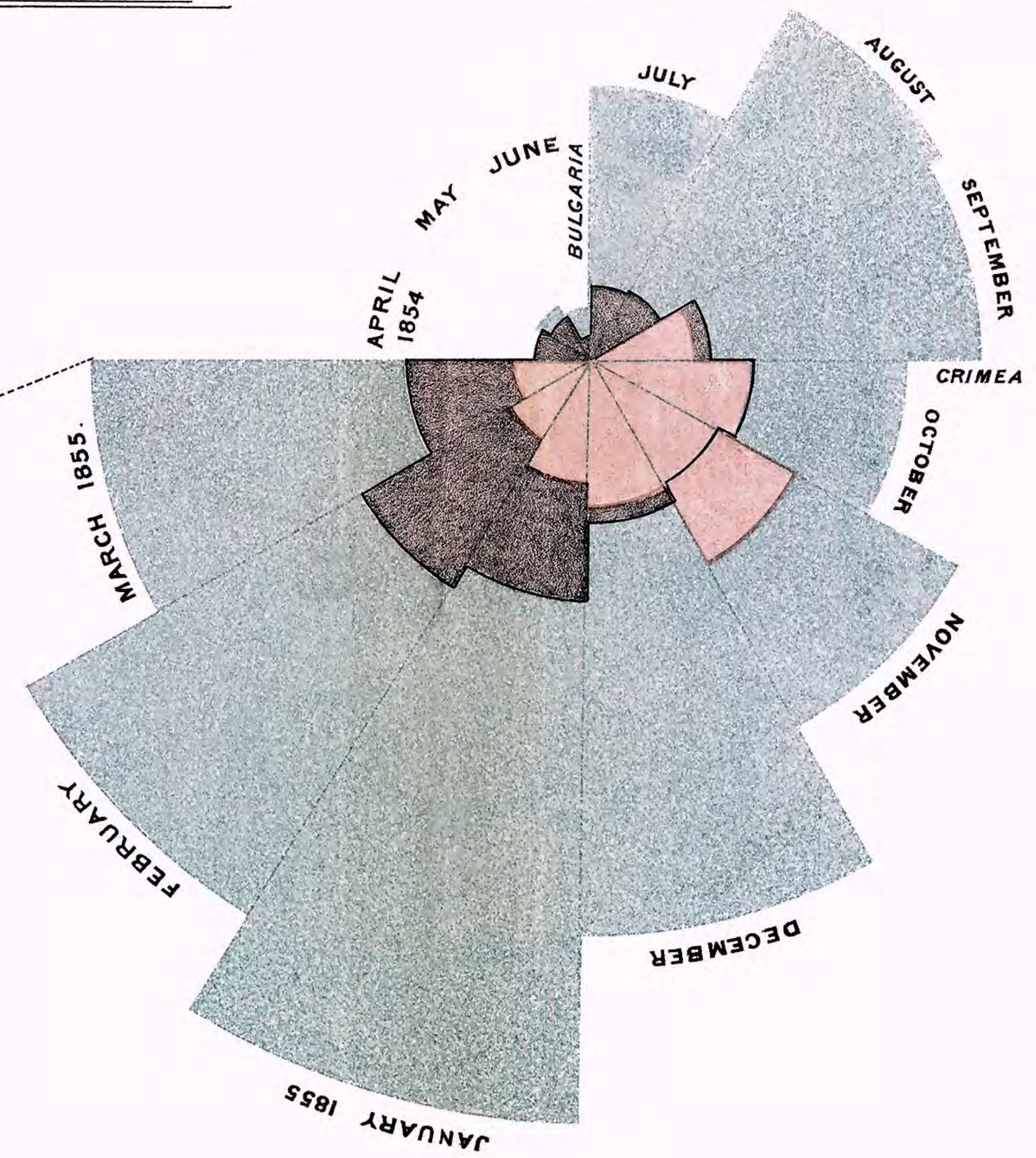
2.

APRIL 1855 TO MARCH 1856.



1.

APRIL 1854 TO MARCH 1855.



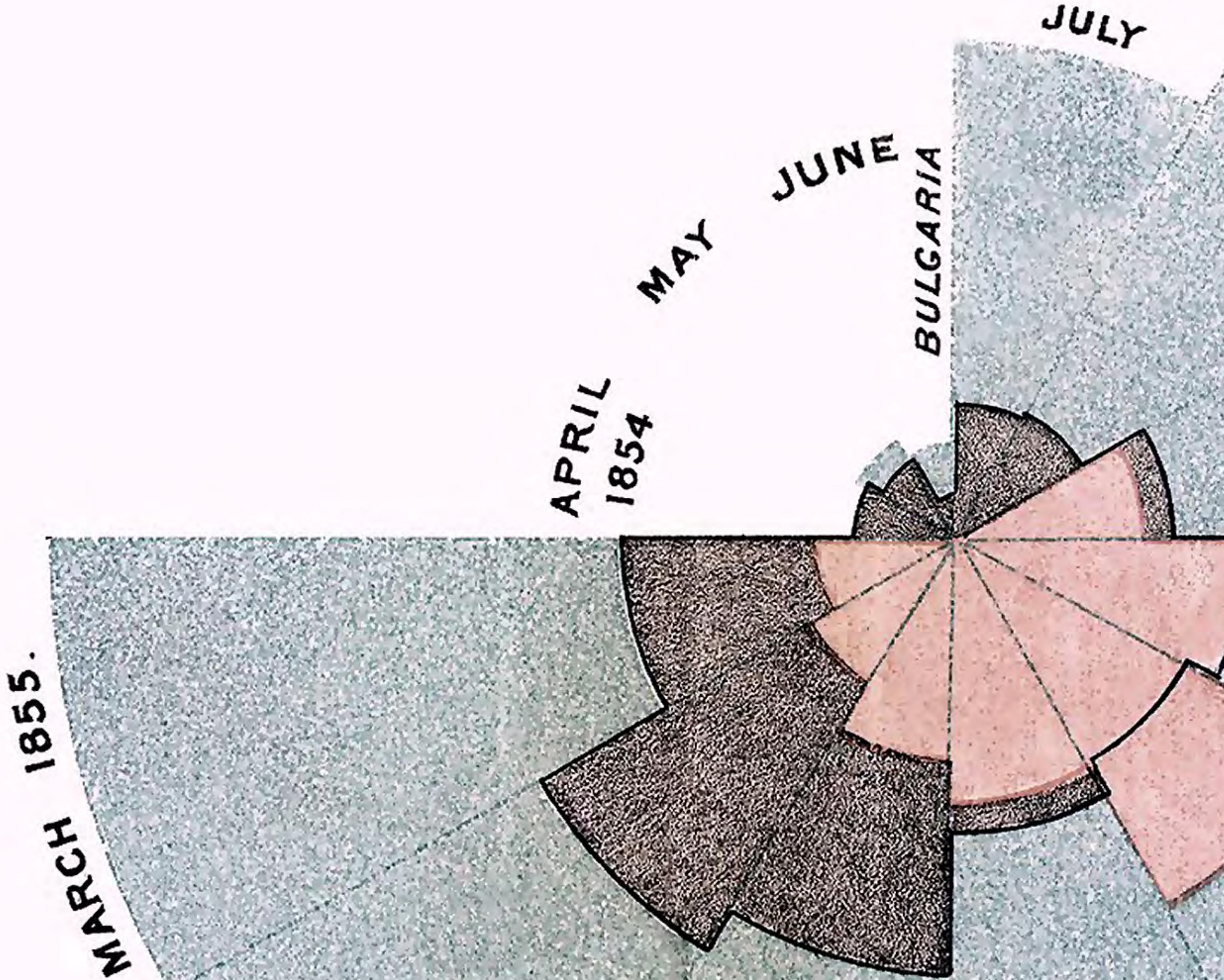
The Areas of the blue, red, & black wedges are each measured from the centre as the common vertex.

The blue wedges measured from the centre of the circle represent area for area the deaths from Preventible or Mitigable Zymotic diseases; the red wedges measured from the centre the deaths from wounds; & the black wedges measured from the centre the deaths from all other causes.

The black line across the red triangle in Nov.^r 1854 marks the boundary of the deaths from all other causes during the month.

In October 1854, & April 1855, the black area coincides with the red; in January & February 1856, the blue coincides with the black.

The entire areas may be compared by following the blue, the red & the black lines enclosing them.



VARIABLE WIDTH COLUMN CHART



Two Variables per Item

TABLE OR TABLE WITH EMBEDDED CHARTS



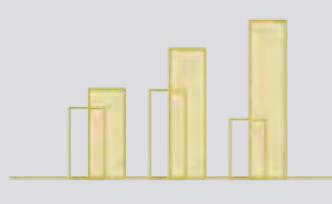
Many Categories

BAR CHART



Many Items

COLUMN CHART



Few Items

CIRCULAR AREA CHART



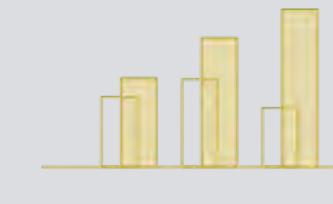
Cyclical Data

LINE CHART



Non-Cyclical Data

COLUMN CHART



Single or Few Categories

LINE CHART



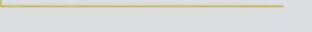
Many Categories

SCATTER CHART



Two Variables

BUBBLE CHART



Three Variables

Few Periods

Changing Over Time

Many Periods

Only Relative Differences Matter

Relative and Absolute Differences Matter

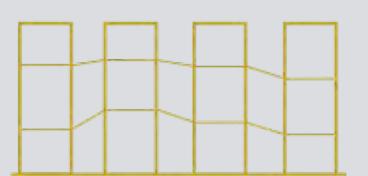
Only Relative Differences Matter

Relative and Absolute Differences Matter

Simple Share of Total

Accumulation or Subtraction to Total

Components of Components



STACKED 100% COLUMN CHART



STACKED COLUMN CHART



STACKED 100% AREA CHART



STACKED AREA CHART



PIE CHART



WATERFALL CHART



STACKED 100% COLUMN CHART WITH SUBCOMPONENTS

COLUMN HISTOGRAM



Few Data Points

LINE HISTOGRAM



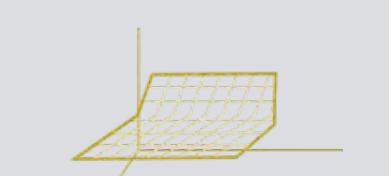
Many Data Points

SCATTER CHART



Two Variables

3D AREA CHART



Three Variables

VARIABLE WIDTH COLUMN CHART

Two Variables per Item

TABLE OR TABLE WITH EMBEDDED CHARTS

Many Categories

BAR CHART

Many Items

COLUMN CHART

Few Items

CIRCULAR AREA CHART

Cyclical Data

LINE CHART

Non-Cyclical Data

COLUMN CHART

Single or Few Categories

LINE CHART

Many Categories

SCATTER CHART

Two Variables

BUBBLE CHART

Three Variables

Few Periods

Changing Over Time

Many Periods

Only Relative Differences Matter

Relative and Absolute Differences Matter

Only Relative Differences Matter

Relative and Absolute Differences Matter

Simple Share of Total

Accumulation or Subtraction to Total

Components of Components

**STACKED 100% COLUMN CHART****STACKED COLUMN CHART****STACKED 100% AREA CHART****STACKED AREA CHART****PIE CHART****WATERFALL CHART****STACKED 100% COLUMN CHART WITH SUBCOMPONENTS****COLUMN HISTOGRAM**

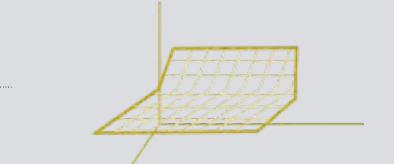
Single Variable

LINE HISTOGRAM

Many Data Points

SCATTER CHART

Two Variables

3D AREA CHART

Three Variables

Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

Dessiné par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.

Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. Chiers, de Segur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avaient été détachés sur Minsk et Mohilow et qui rejoignirent Oroscha et Witebsk, avaient toujours marché avec l'armée.

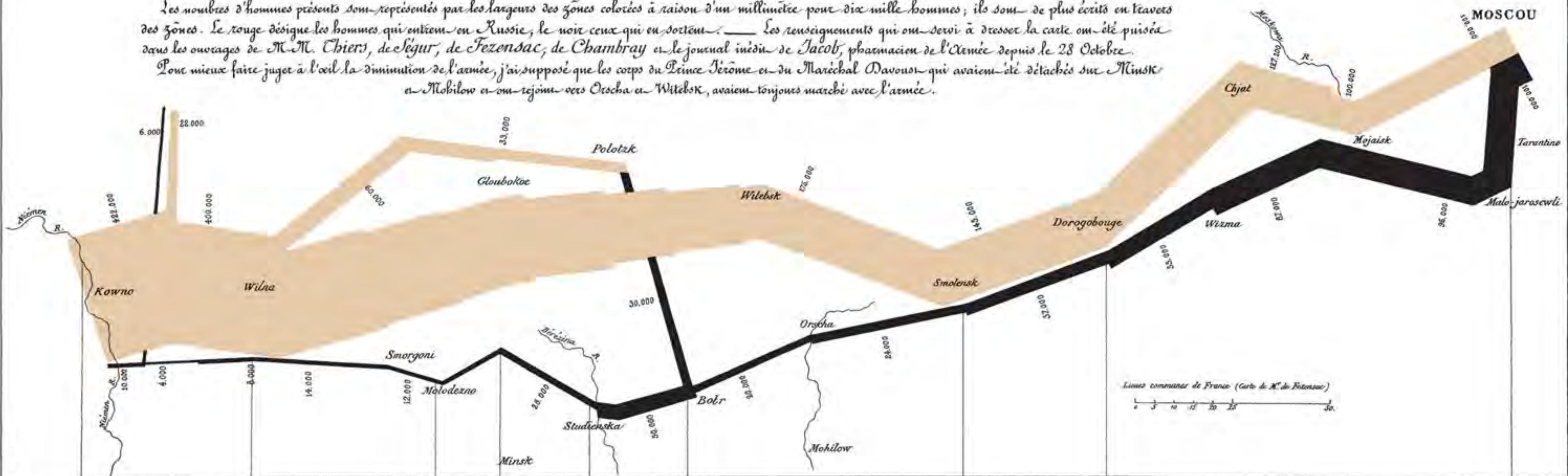
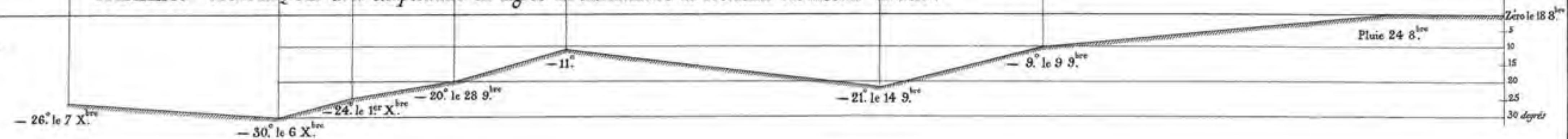
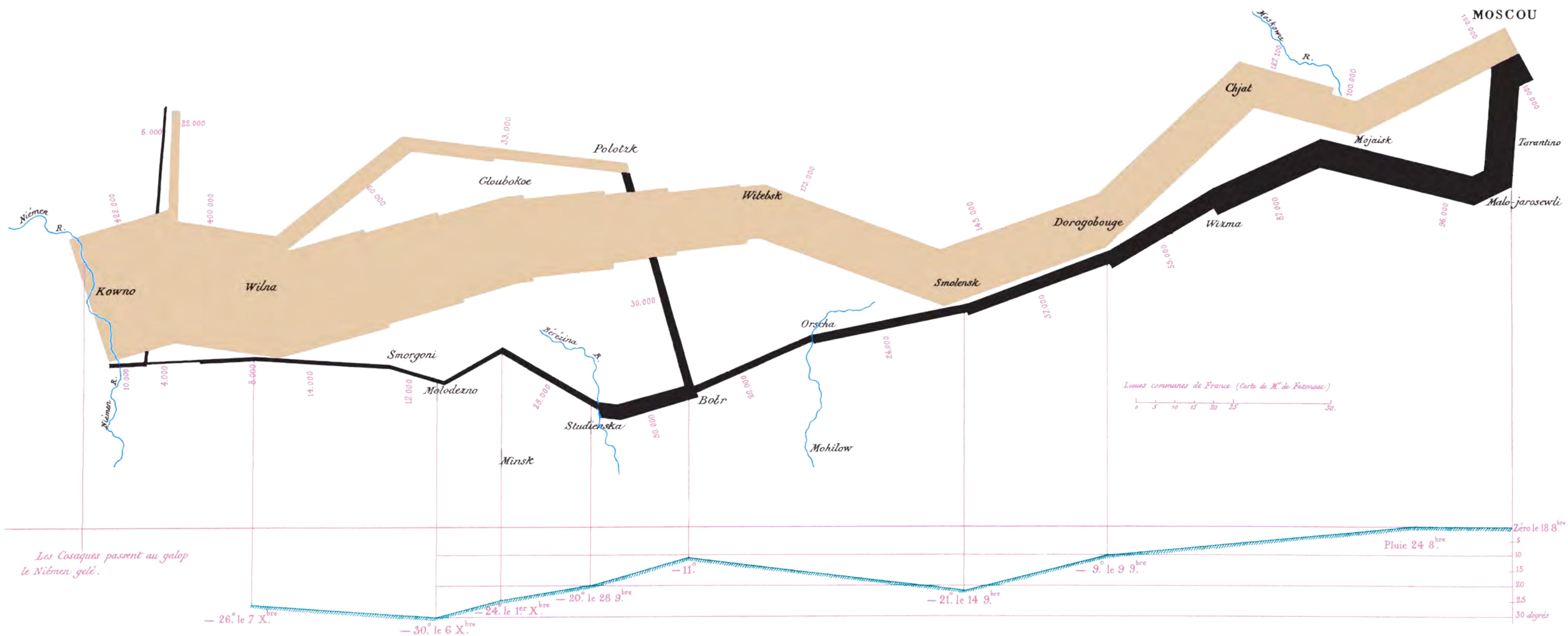


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les cosaques passent au galop
le Niemen gelé.





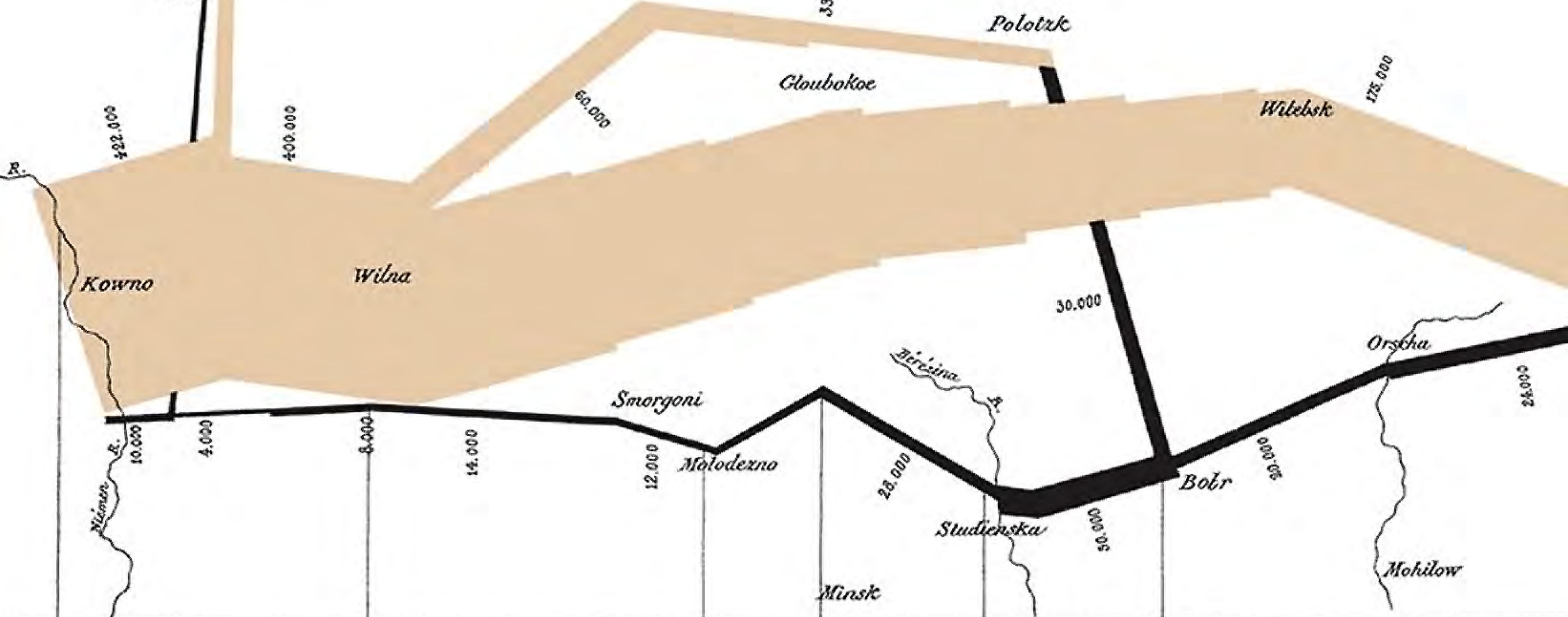


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au de-

Cosaques passent au galop
en gelé.

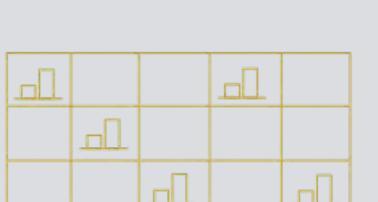
-24° le 1^{er} X^{brc} -20° le 28 9^{bre} -11°

VARIABLE WIDTH COLUMN CHART



Two Variables per Item

TABLE OR TABLE WITH EMBEDDED CHARTS



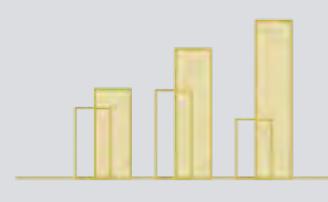
Many Categories

BAR CHART



Many Items

COLUMN CHART



Few Items

CIRCULAR AREA CHART



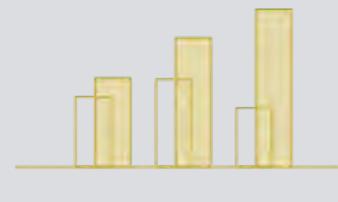
Cyclical Data

LINE CHART



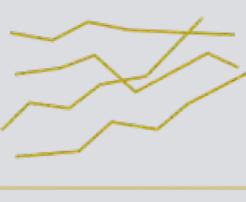
Non-Cyclical Data

COLUMN CHART



Single or Few Categories

LINE CHART



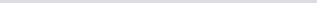
Many Categories

SCATTER CHART



Two Variables

BUBBLE CHART



Three Variables

Few Periods

Changing Over Time

Many Periods

Only Relative Differences Matter

Relative and Absolute Differences Matter

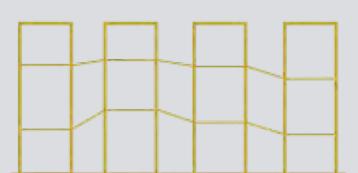
Only Relative Differences Matter

Relative and Absolute Differences Matter

Simple Share of Total

Accumulation or Subtraction to Total

Components of Components



STACKED 100%
COLUMN CHART



STACKED
COLUMN CHART



STACKED 100%
AREA CHART



STACKED AREA CHART



PIE CHART

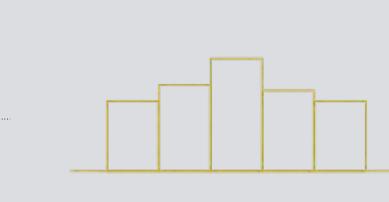


WATERFALL CHART



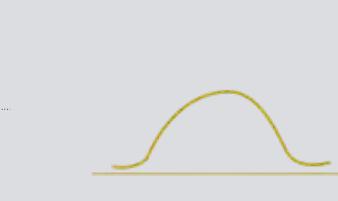
STACKED 100% COLUMN CHART
WITH SUBCOMPONENTS

COLUMN HISTOGRAM



Few Data Points

LINE HISTOGRAM



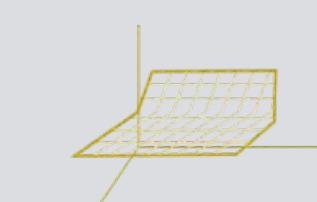
Many Data Points

SCATTER CHART

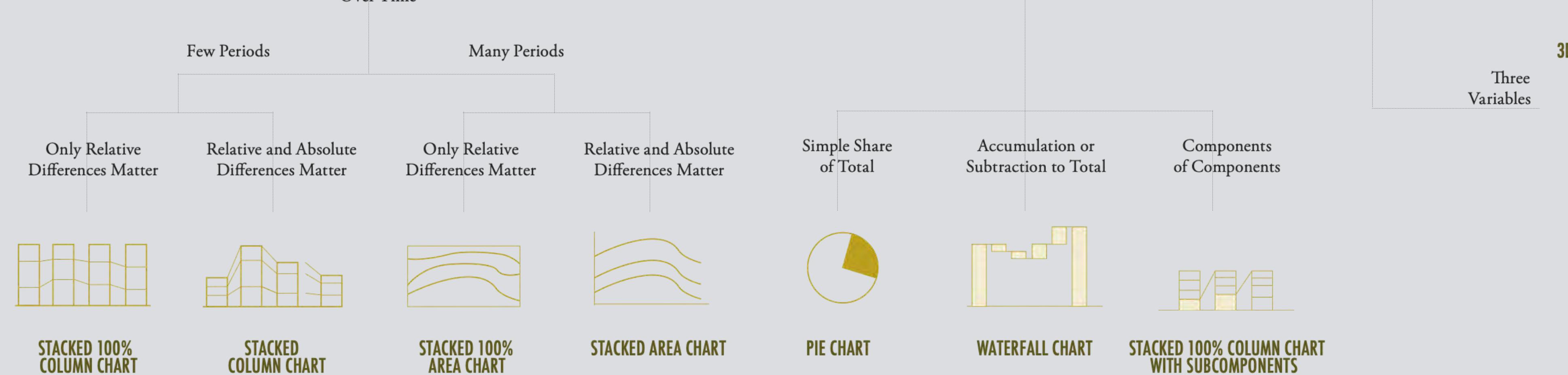
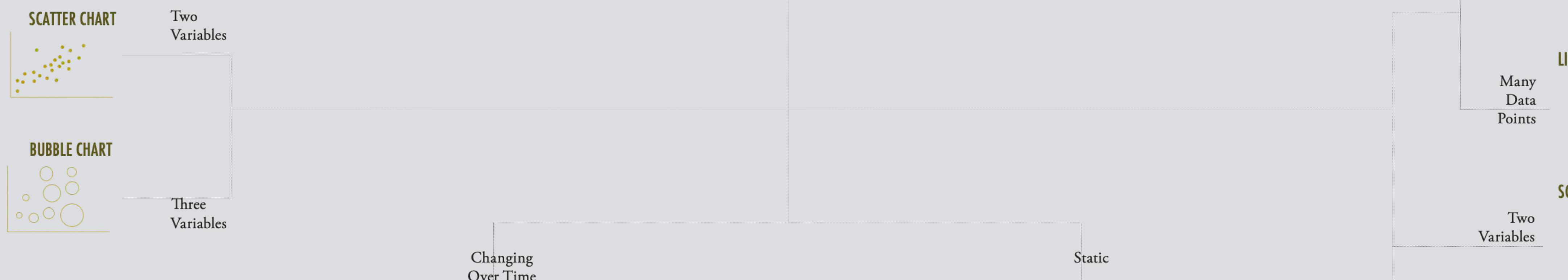
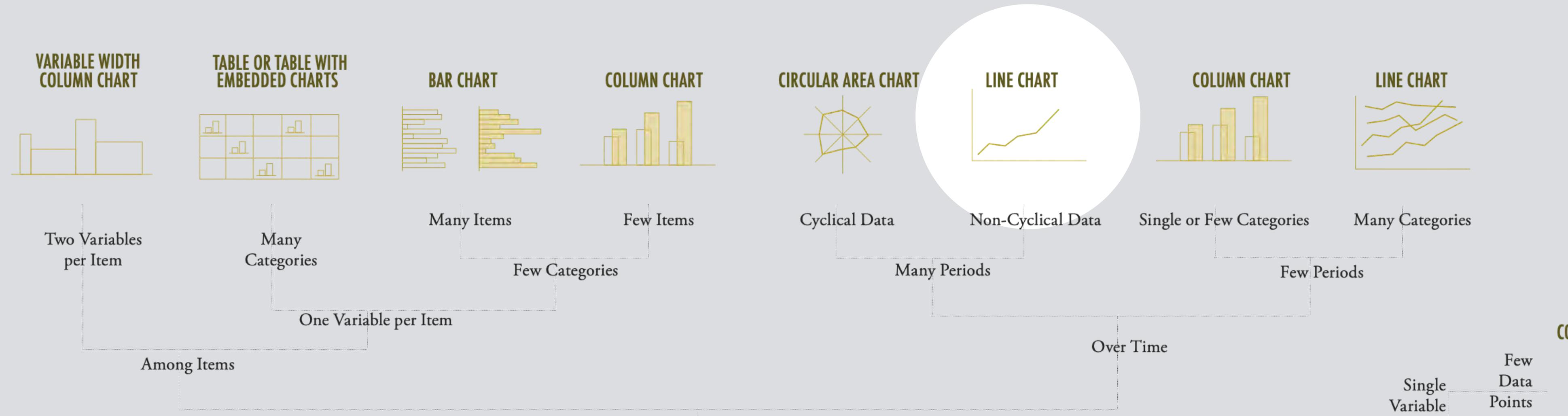


Two Variables

3D AREA CHART



Three Variables

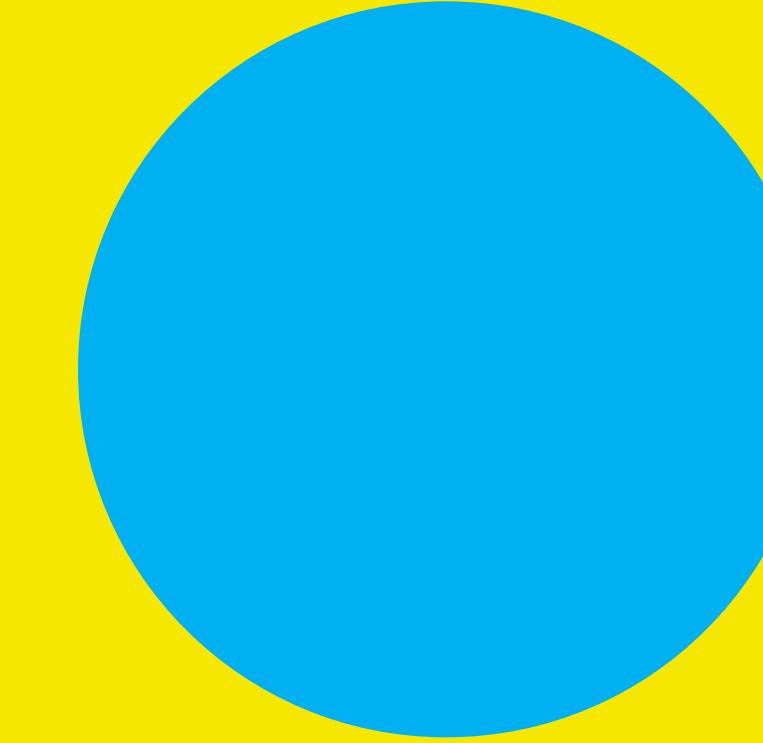


COLUMN HISTOGRAM

LINE HISTOGRAM

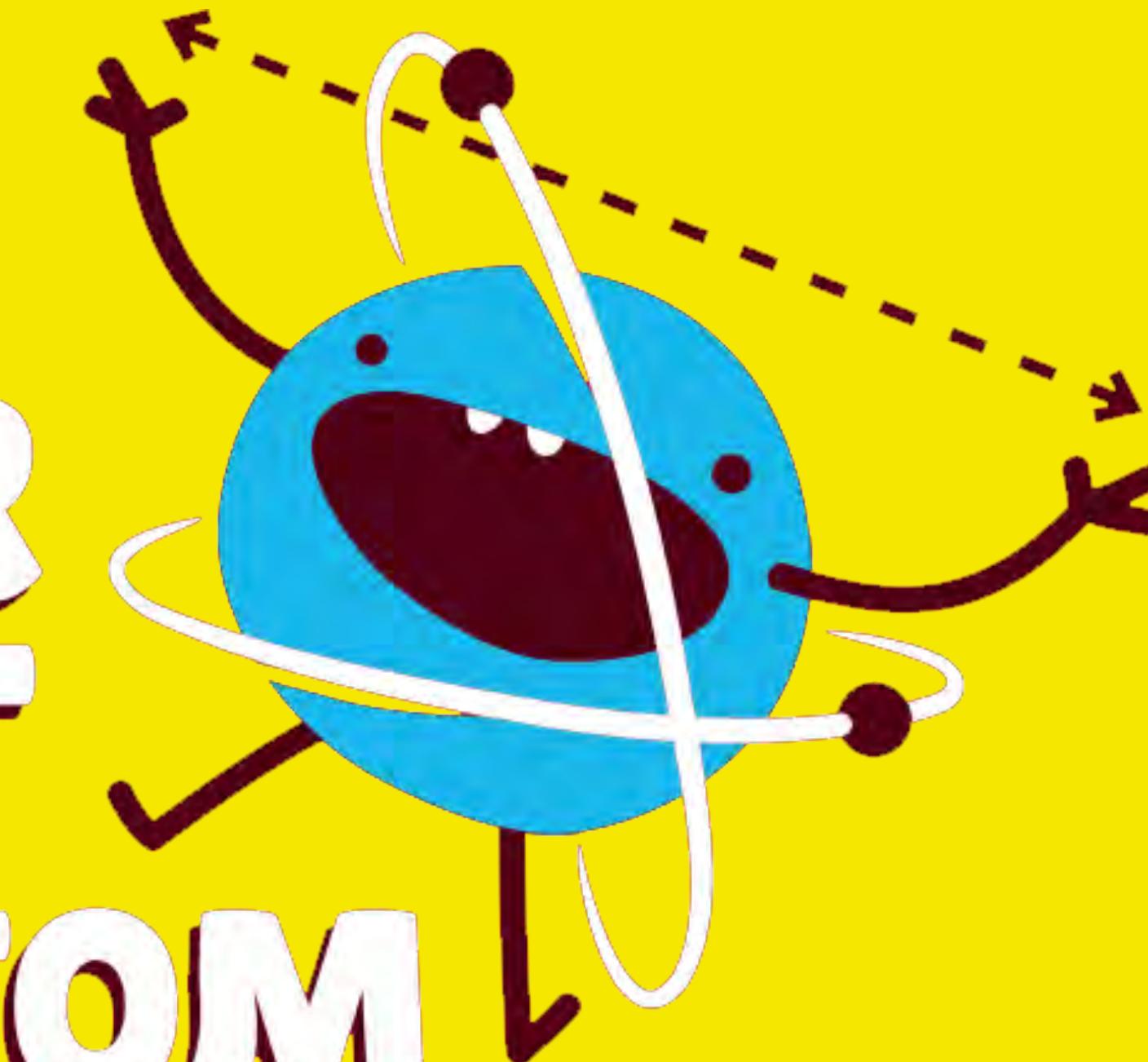
SCATTER CHART

3D AREA CHART



ATOMS

**NEVER
TRUST
AN ATOM**
*They make up
Everything*

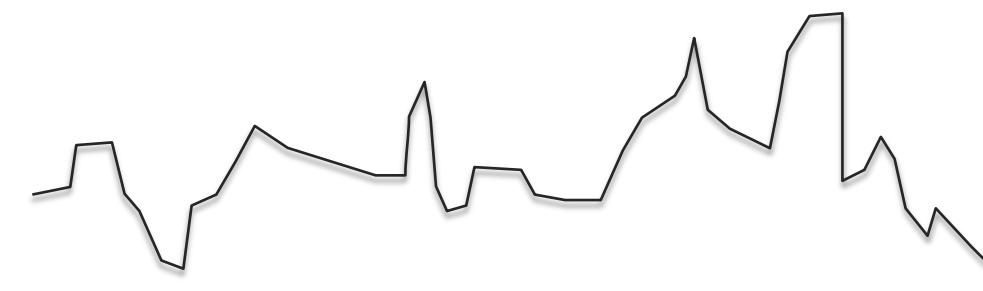


6.6

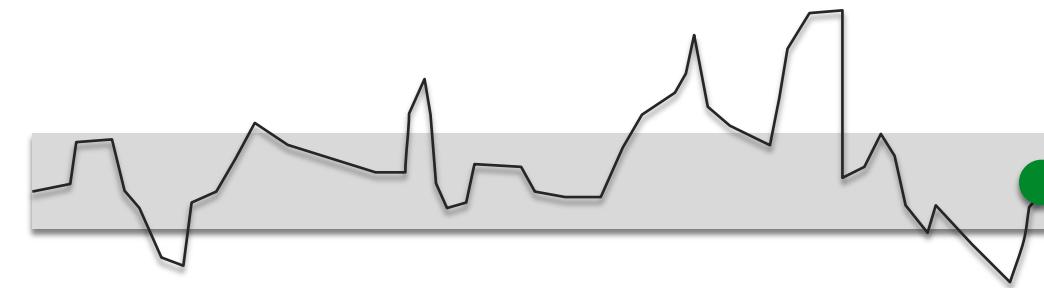
glucose 6.6



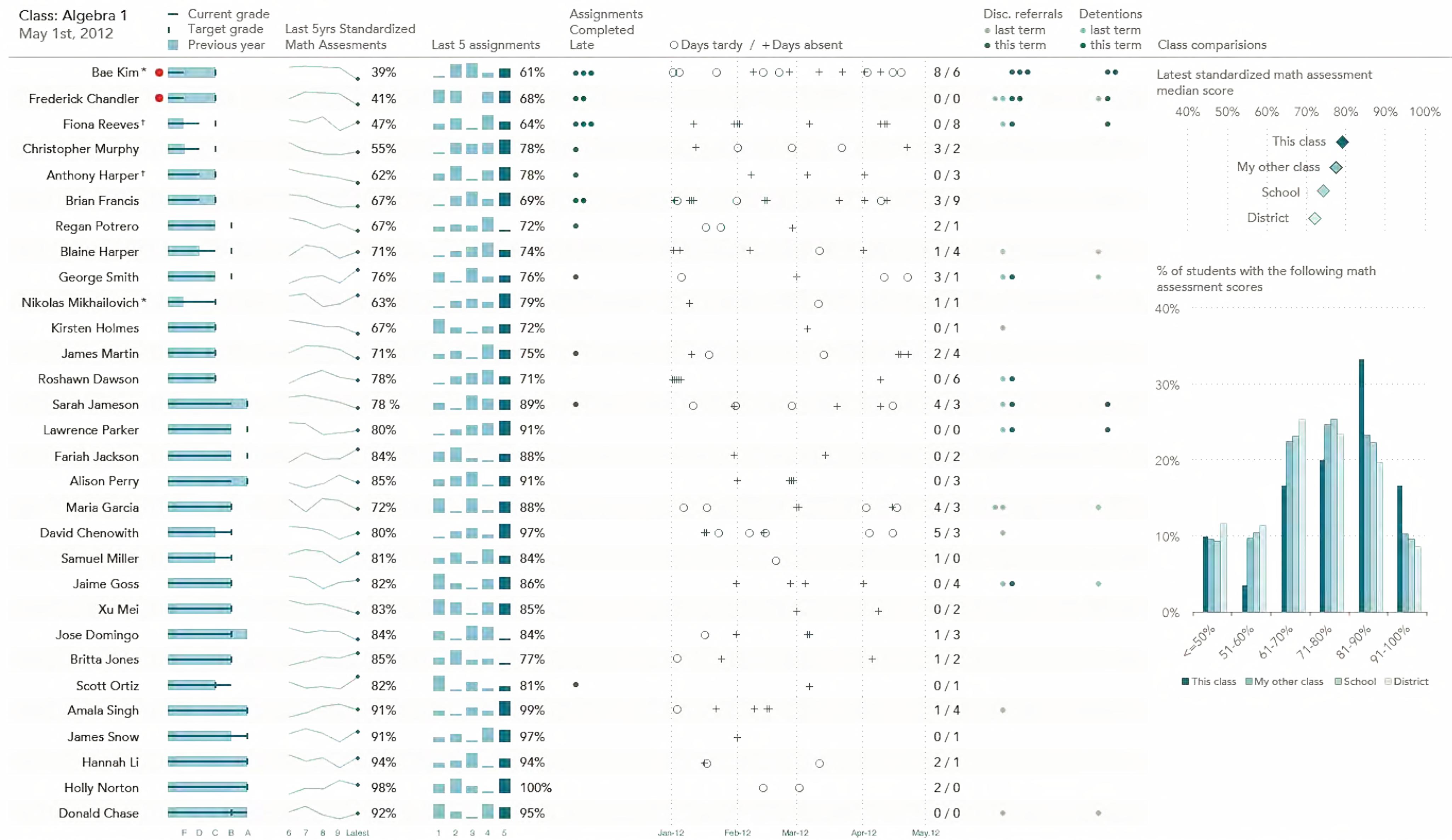
glucose 6.6



glucose 6.6



glucose 6.6



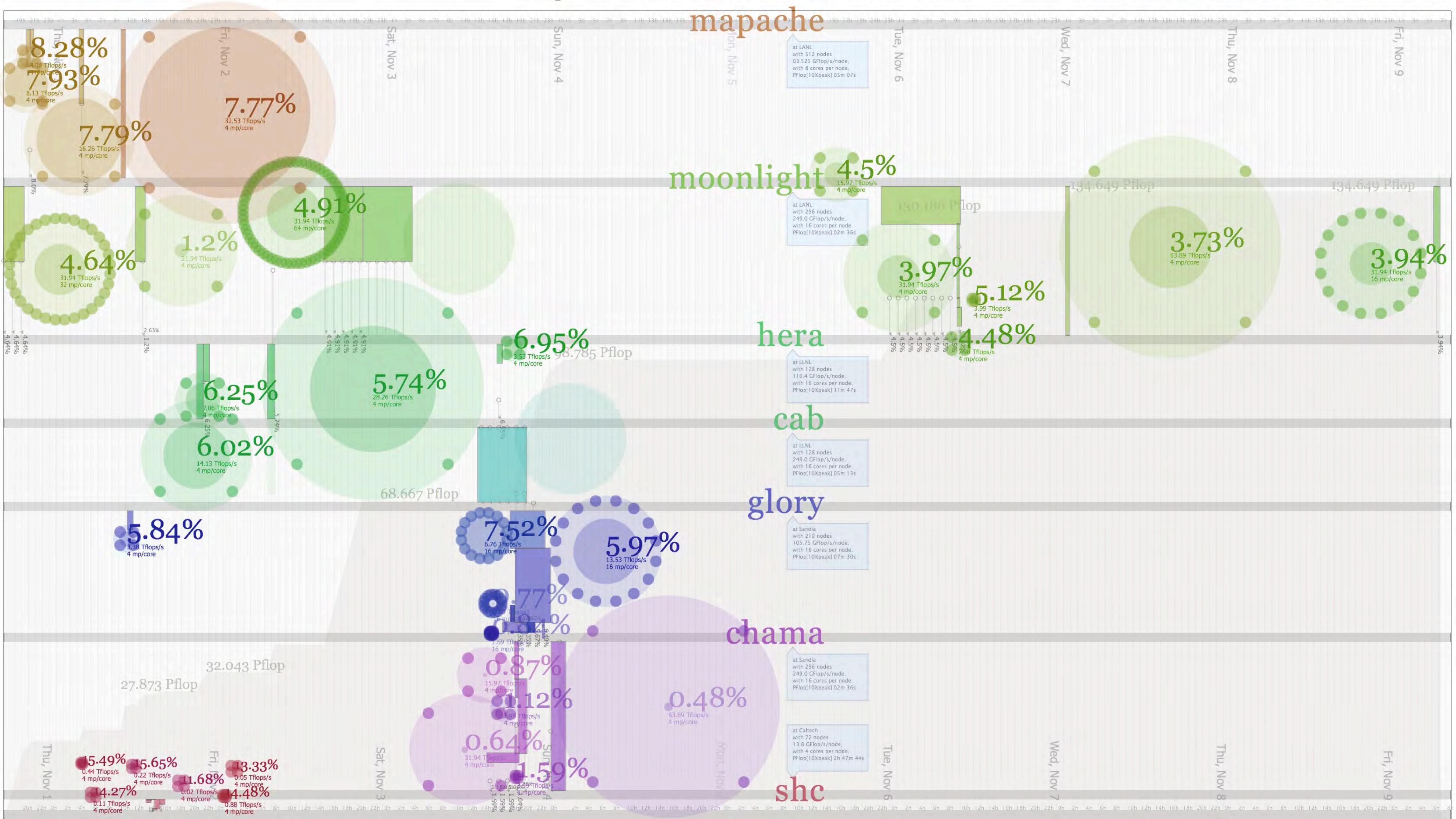
* No english language proficiency

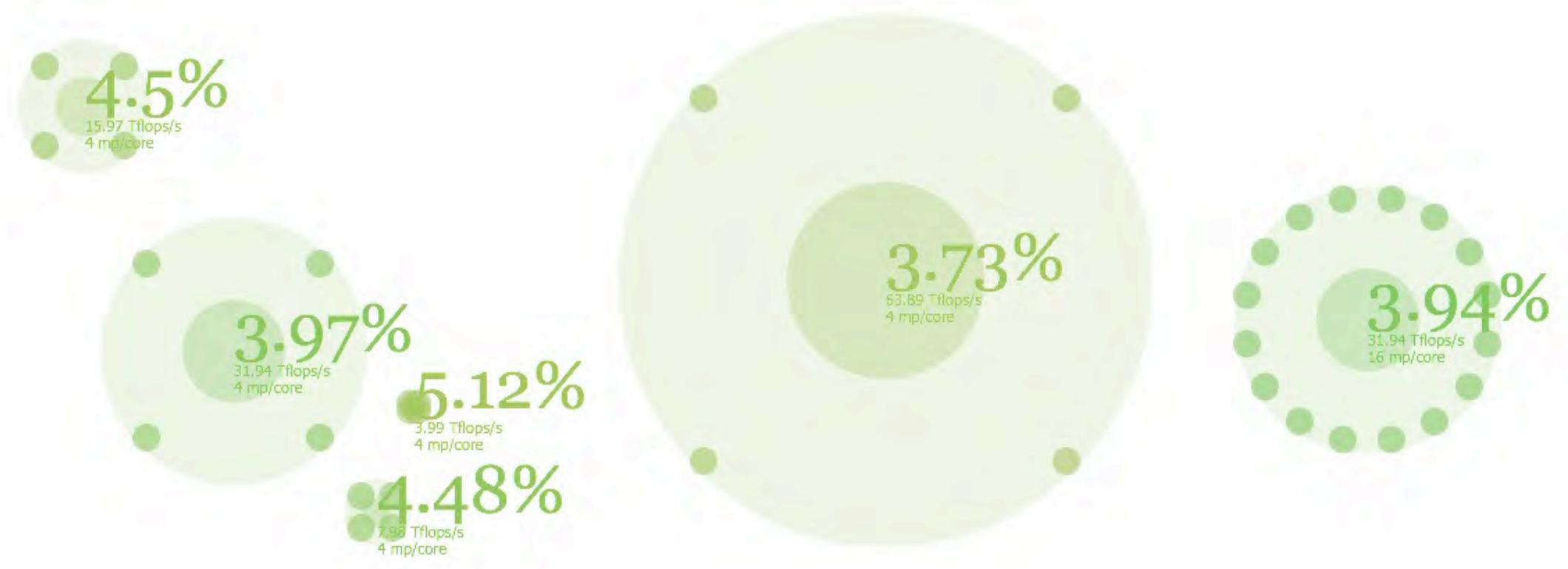
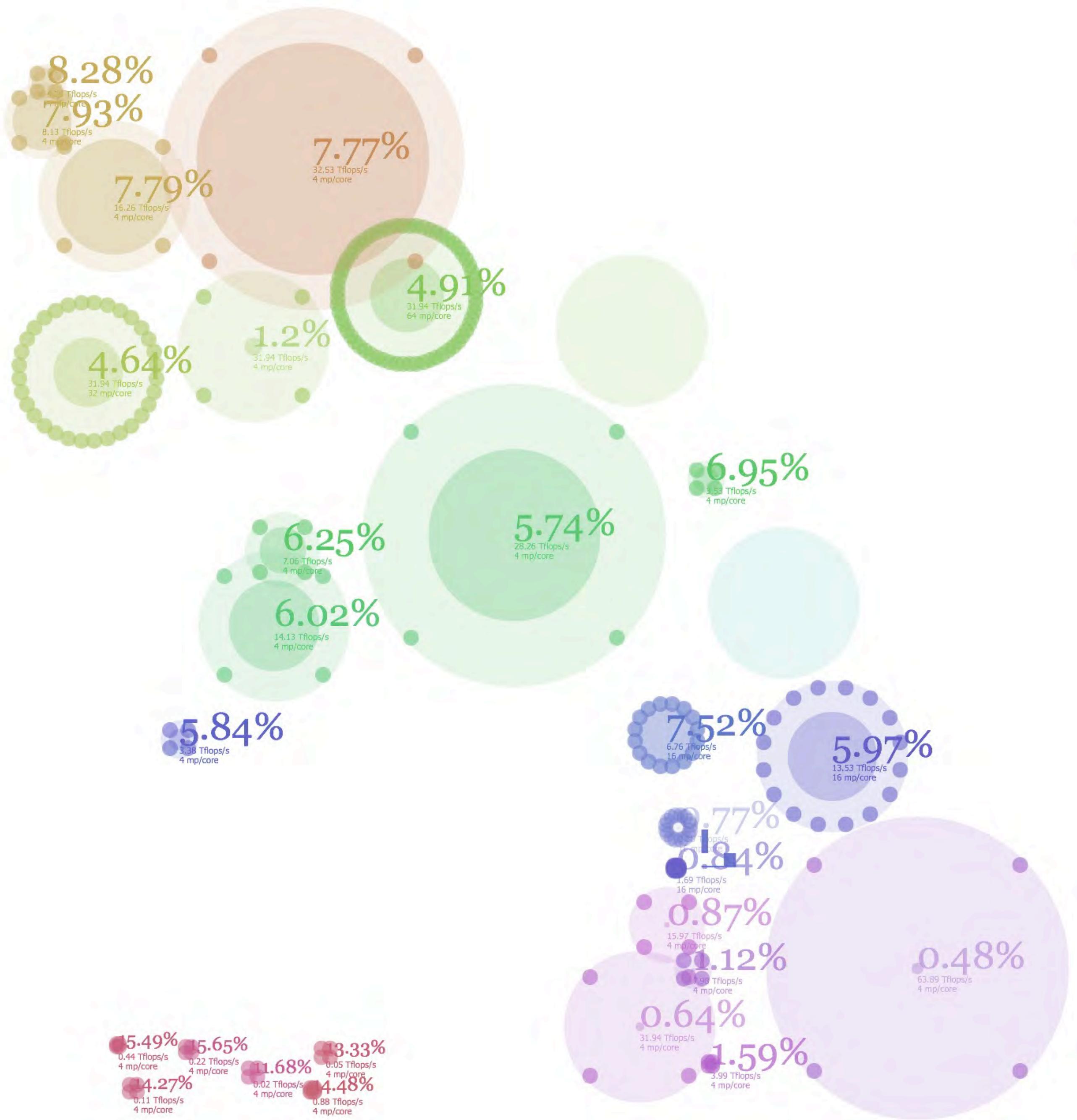
† Special education

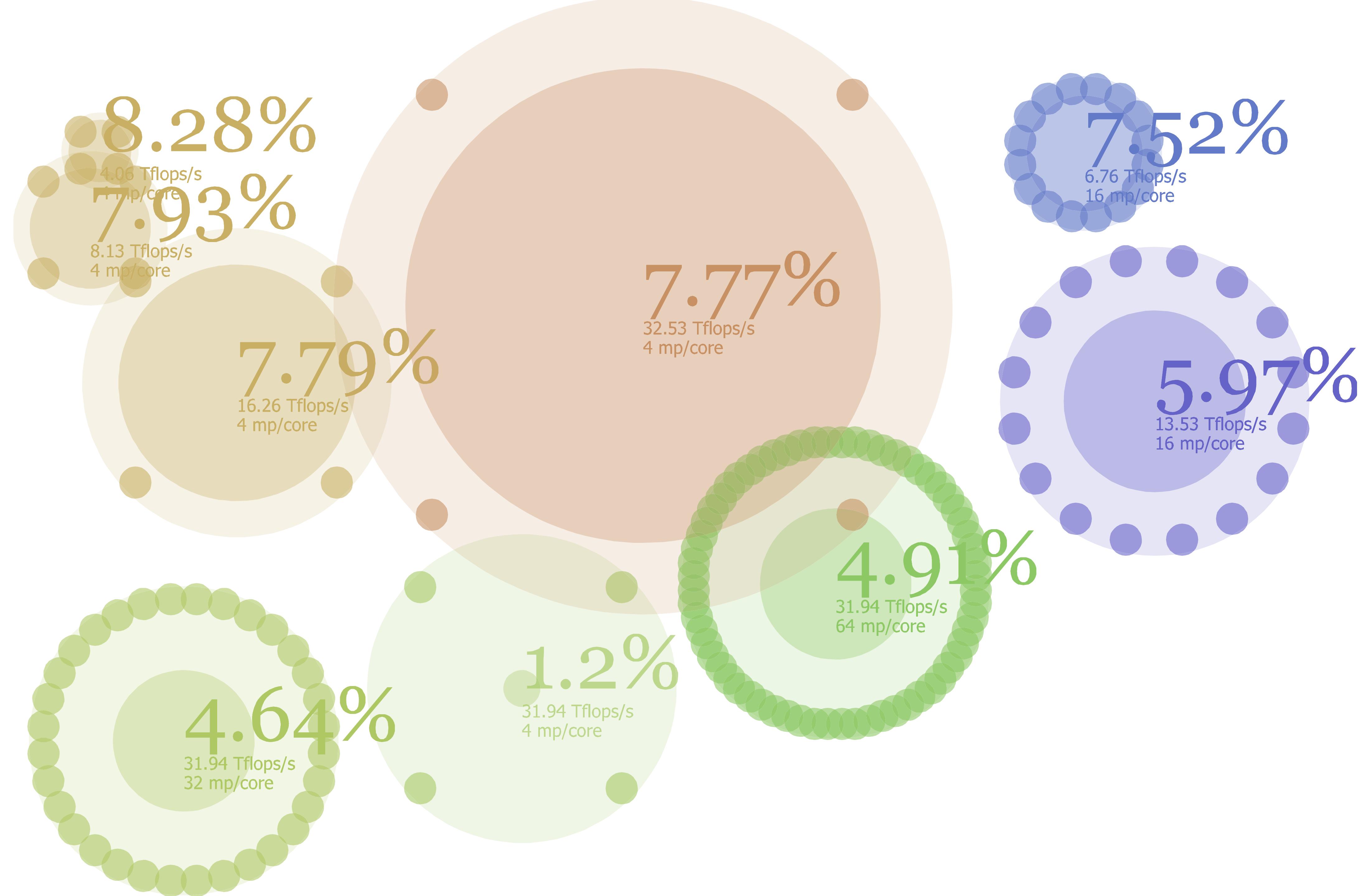
Note: Assessment and assignment scores are being expressed as the percentage of points that were earned out of the total points possible.

U Q C A M P A I G N M O N I T O R

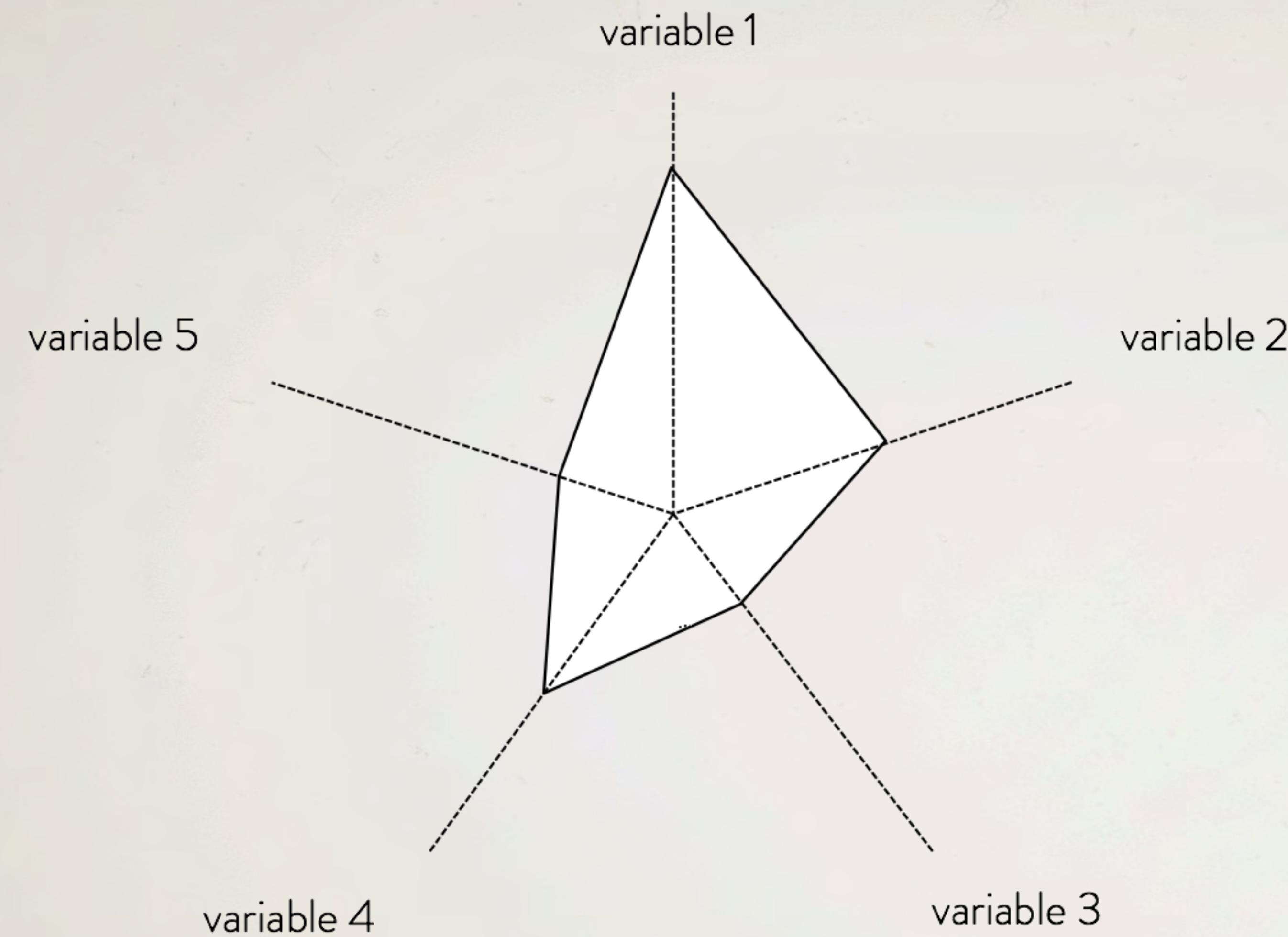
Total system usage in 8d 14h 43m 05s: 138.578 Pflop



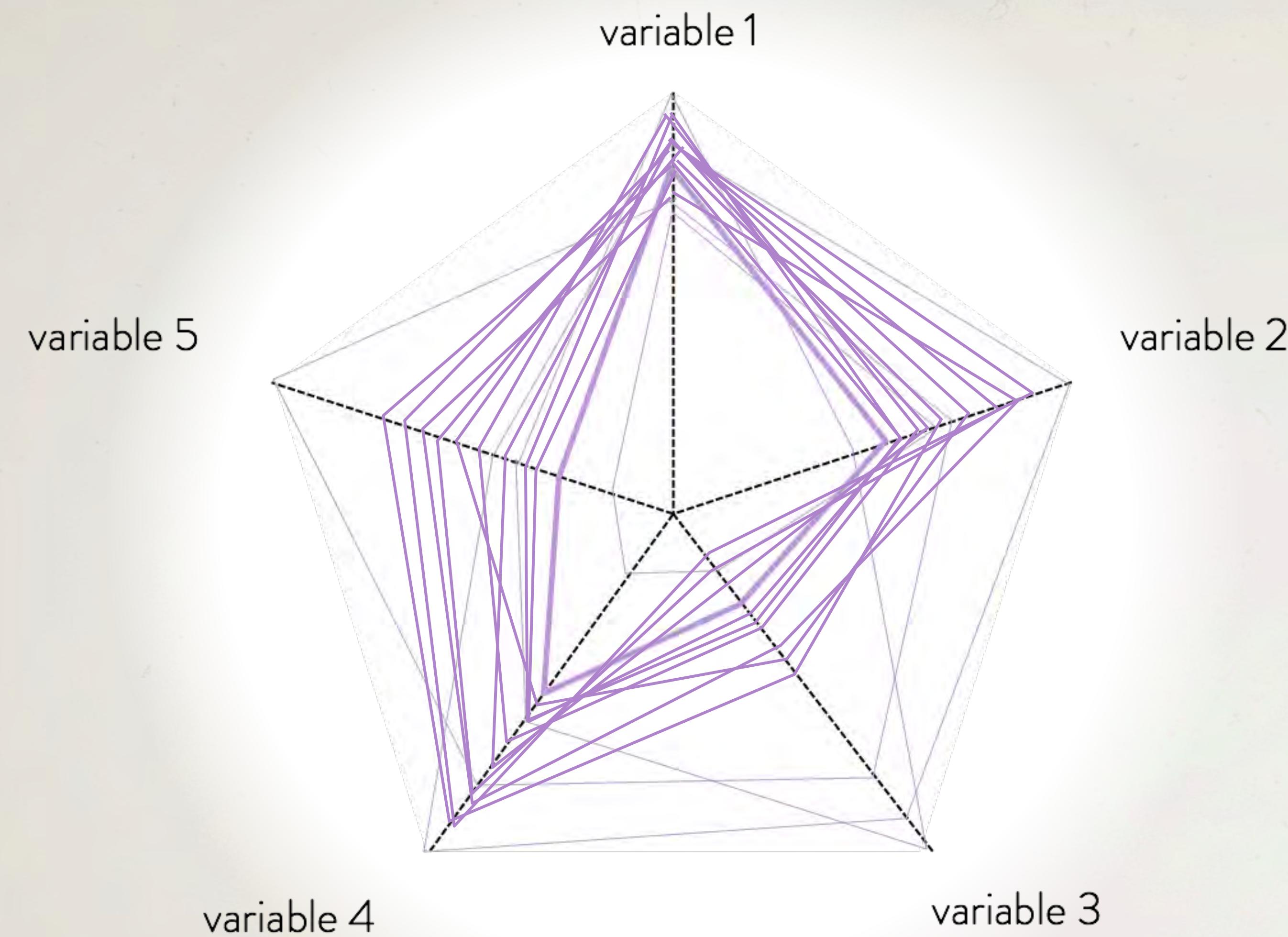




STAR PLOT

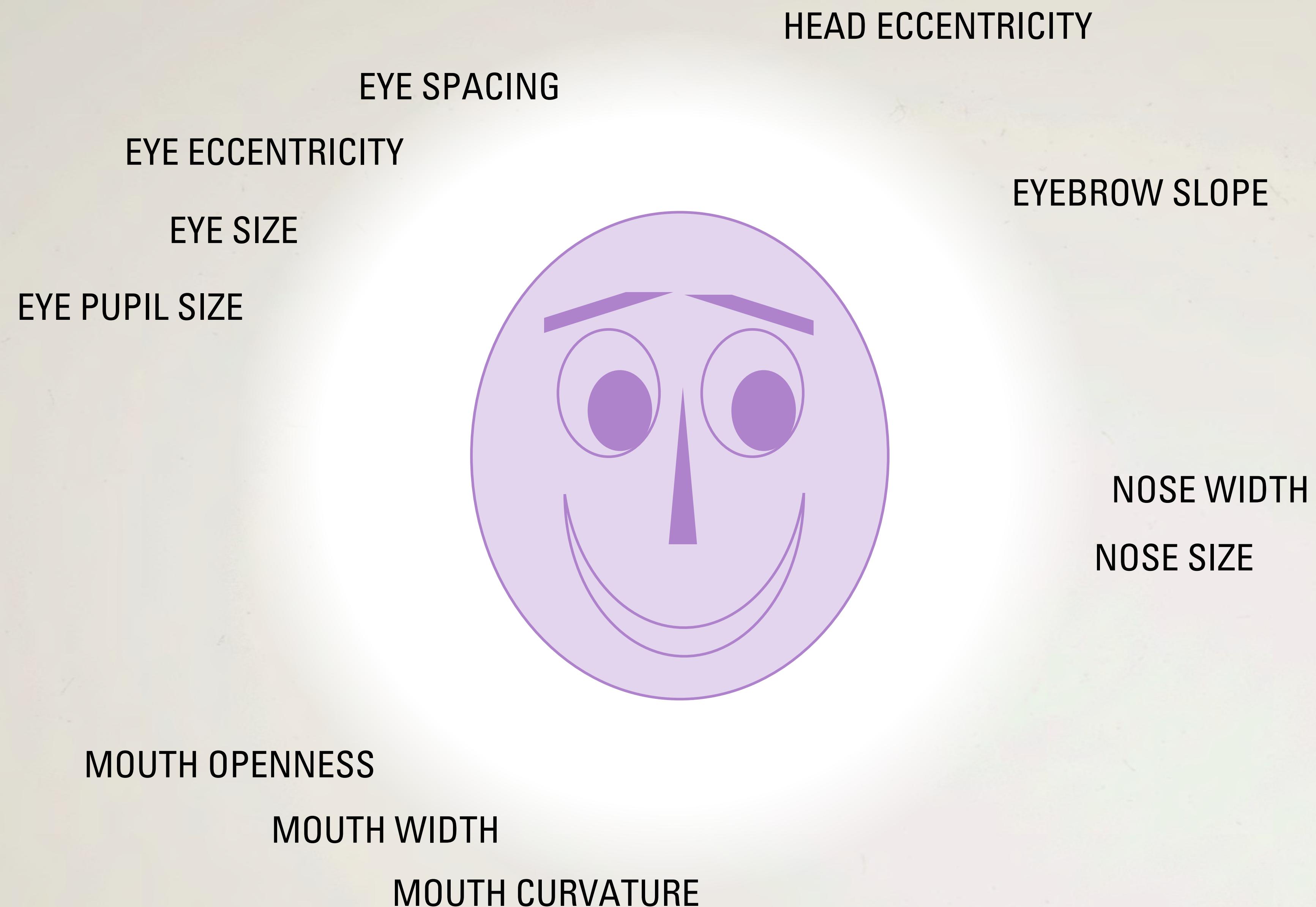


STAR PLOTS



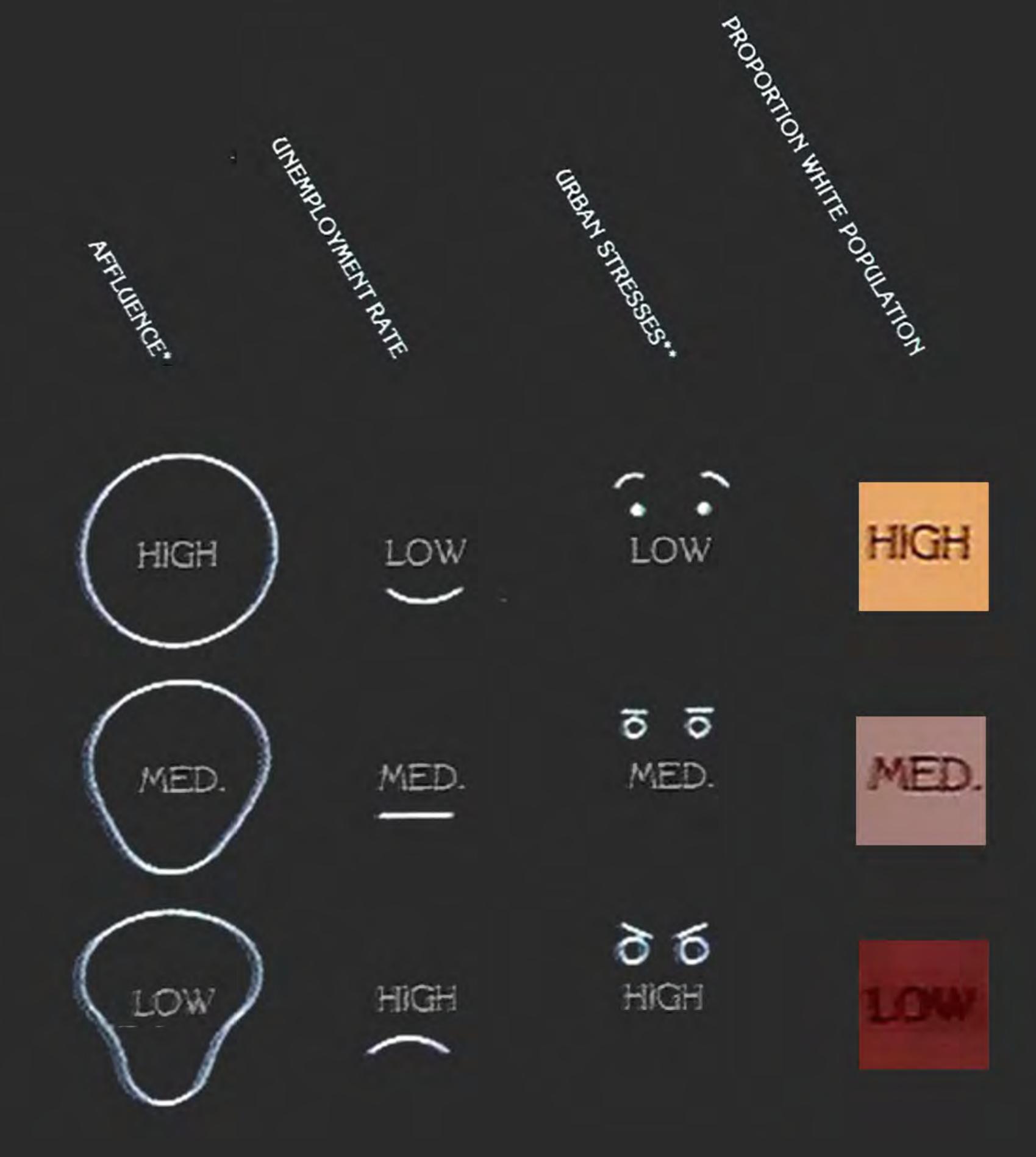
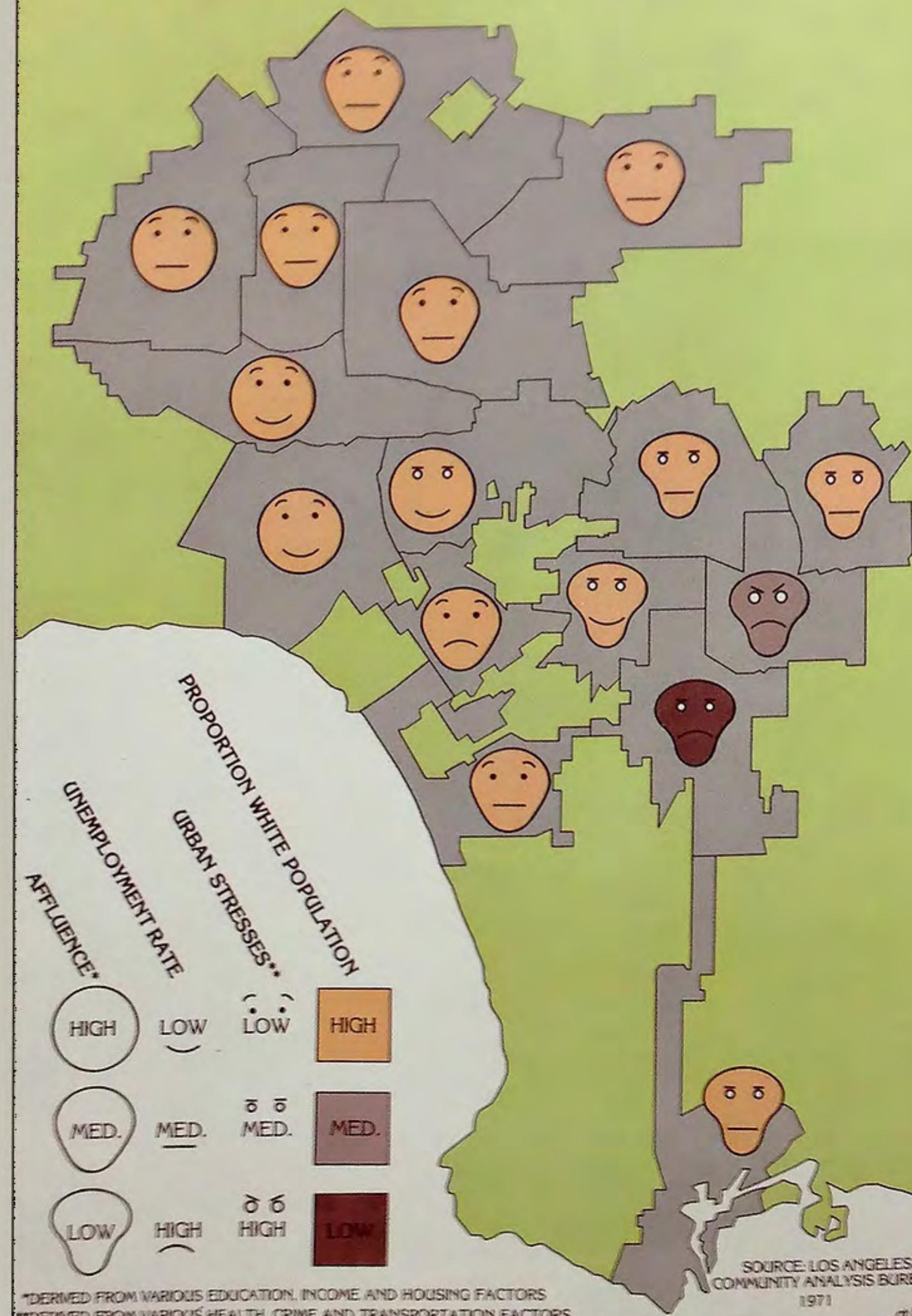
STAR PLOTS
AS GLYPHS

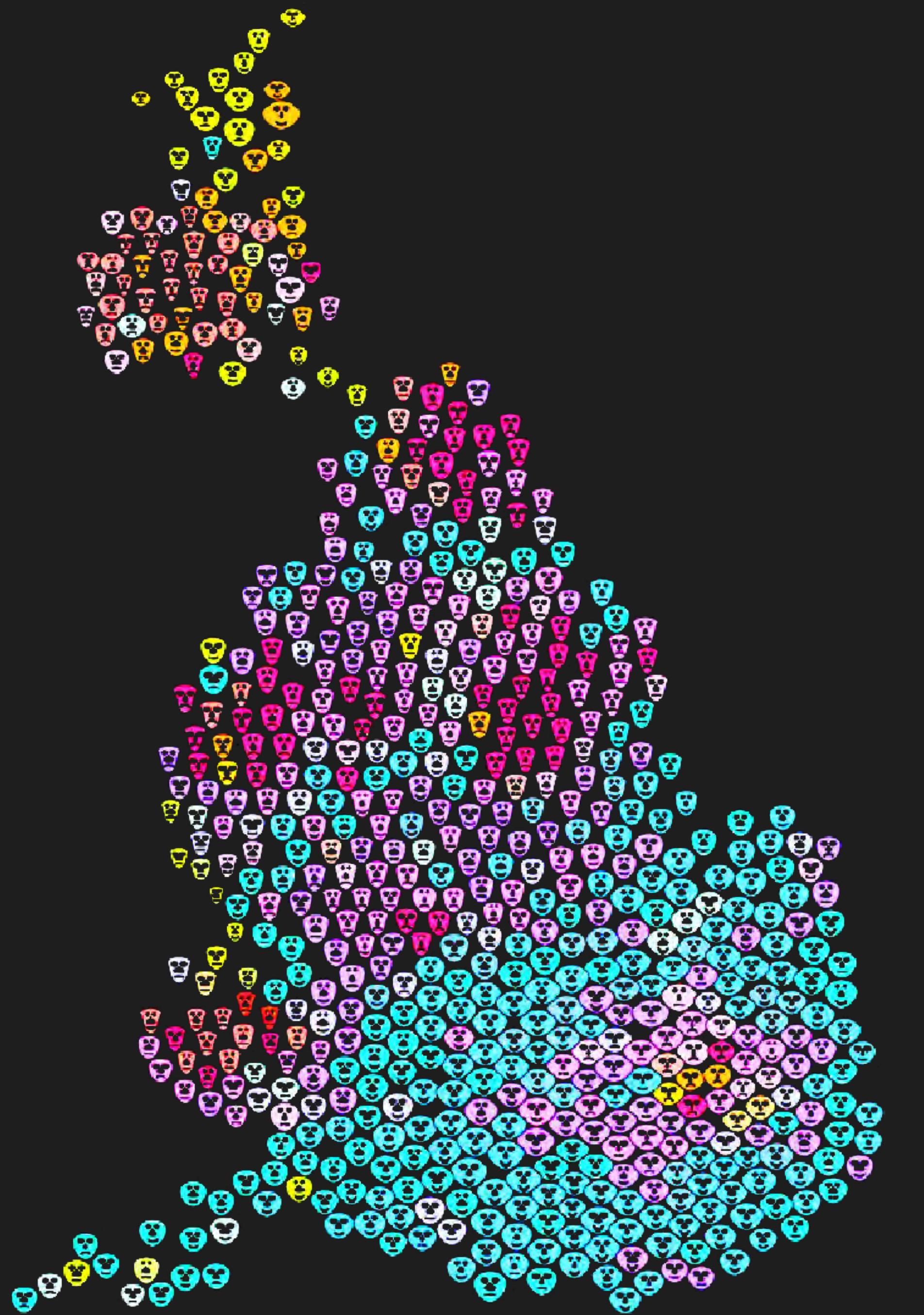


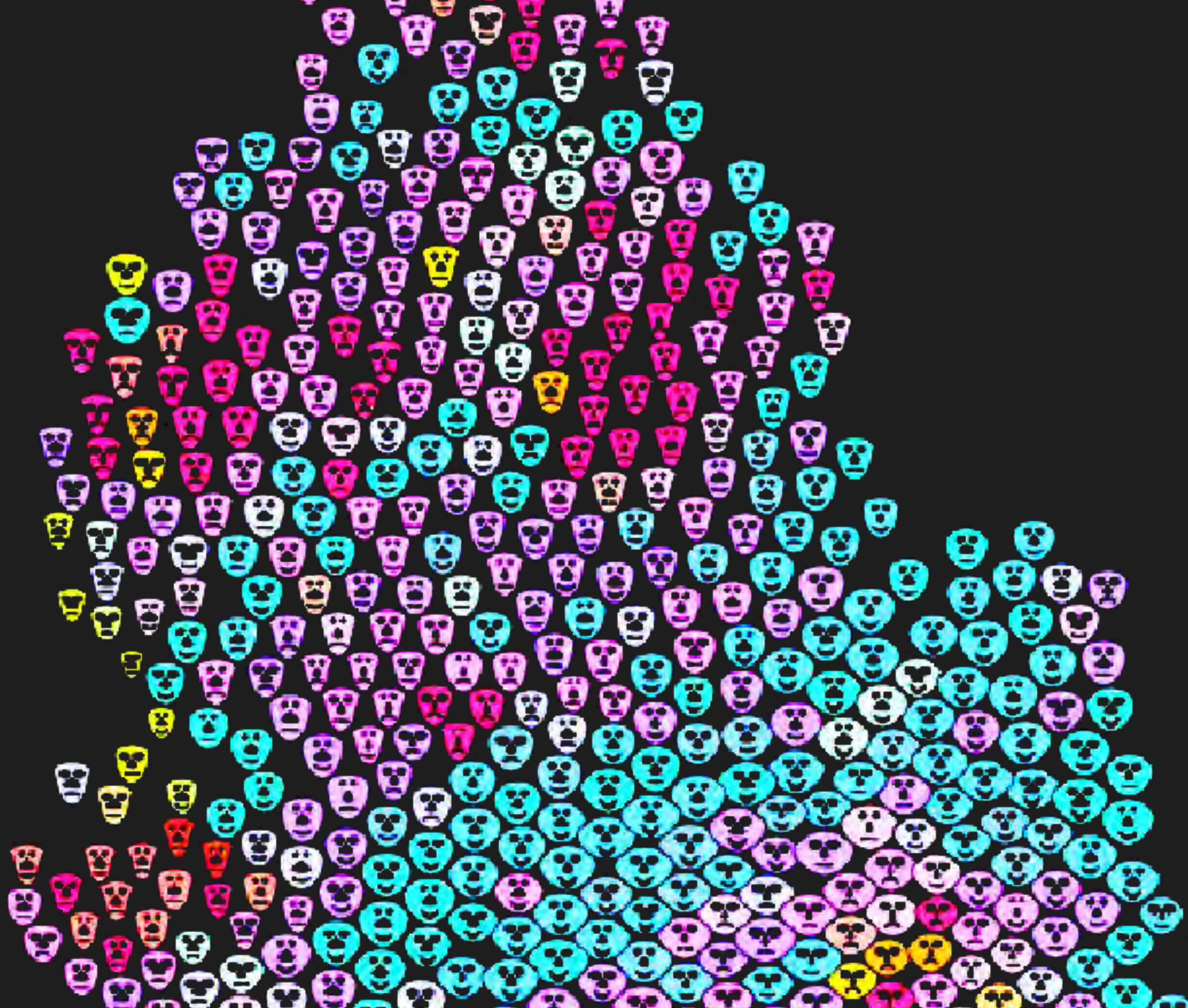


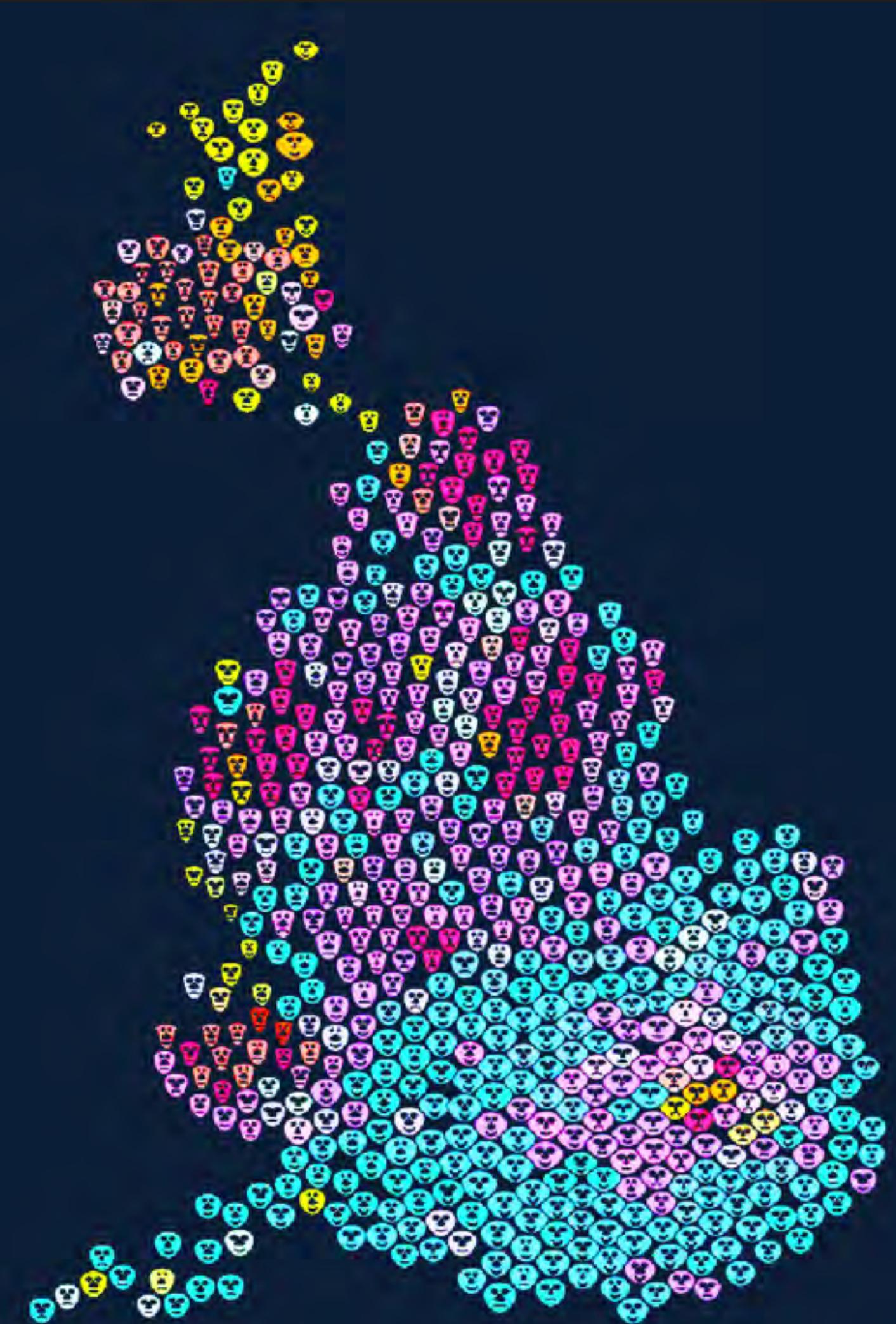


Life in Los Angeles



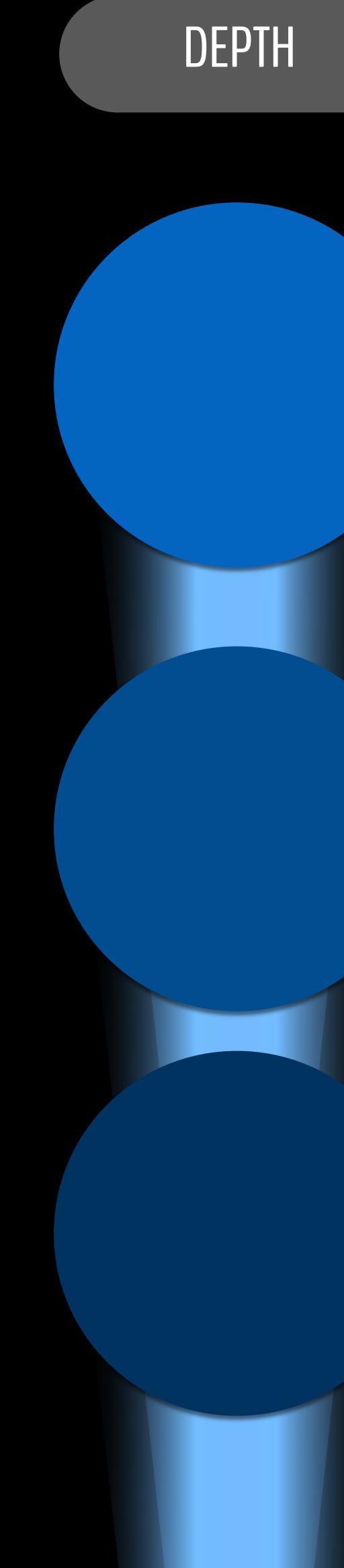








[GEORGE UNDERWOOD]



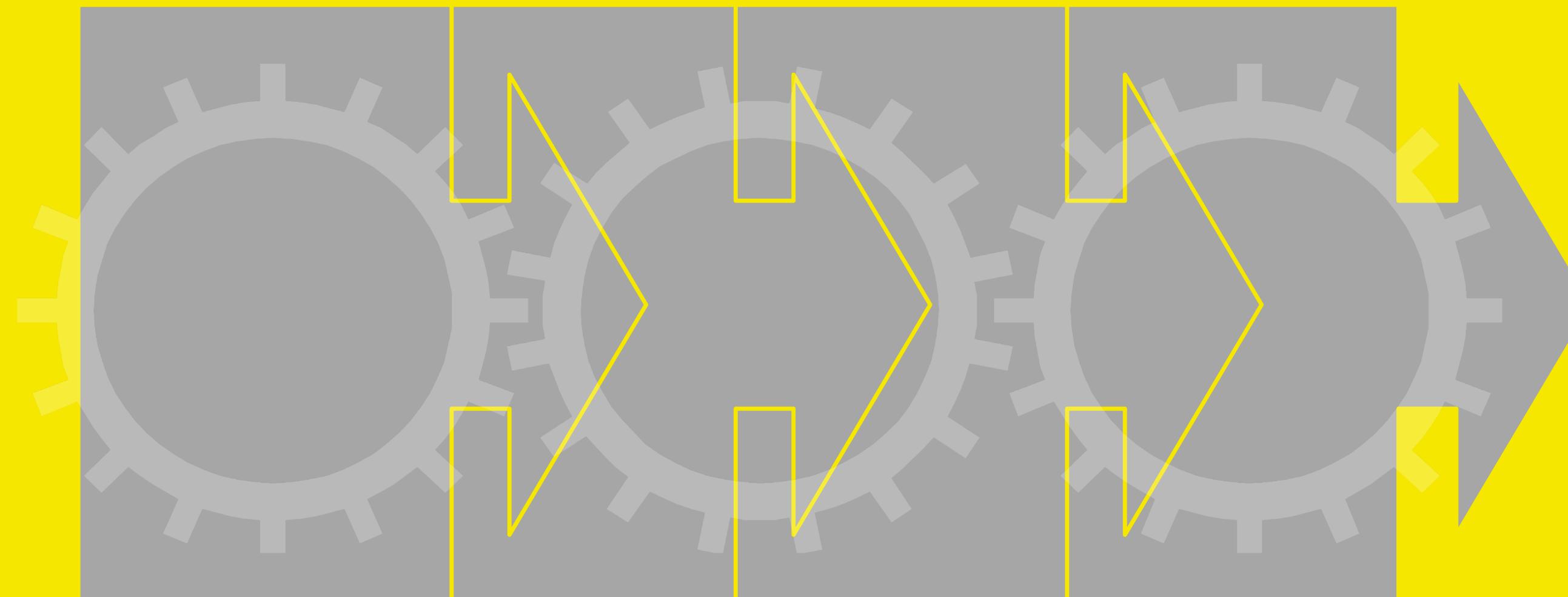
DEPTH

QUICK INSPECTION

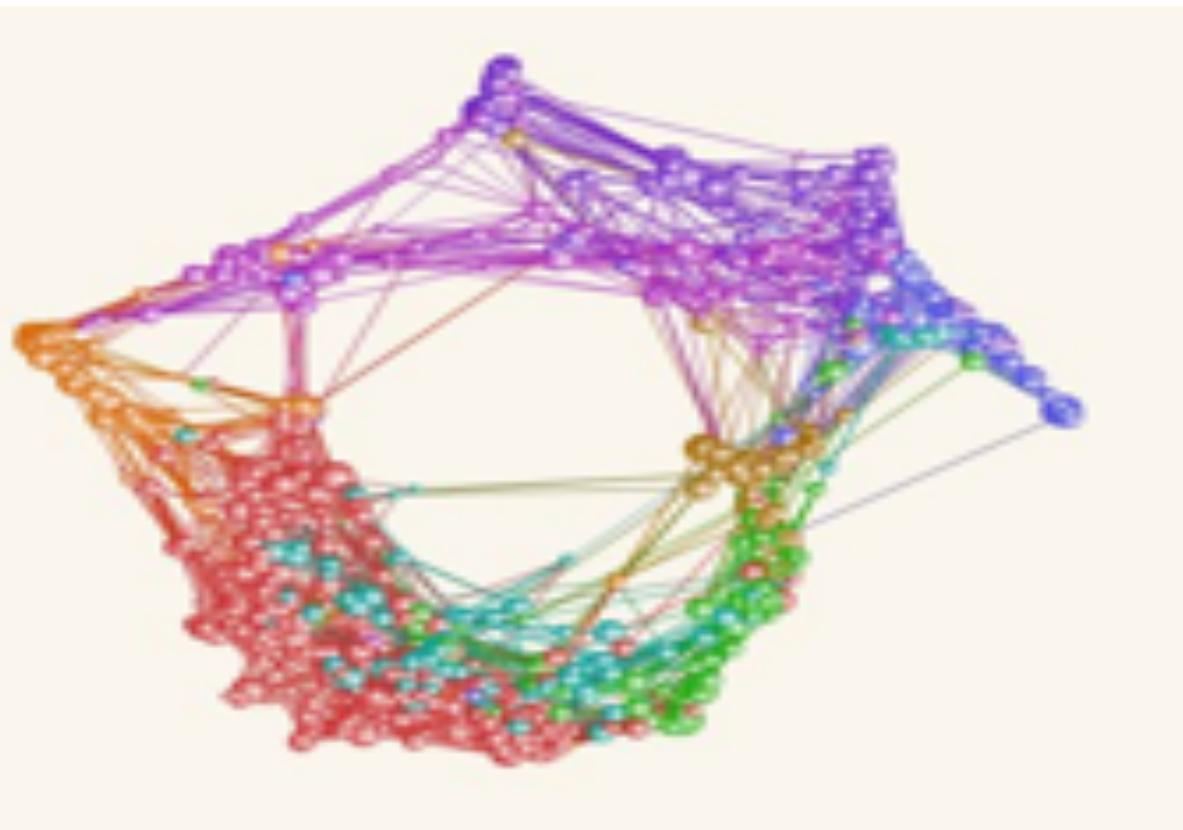
ANALYSIS TOOL

BATCH/DISCRIMINATION TOOL

data + goal



→ viz engine →

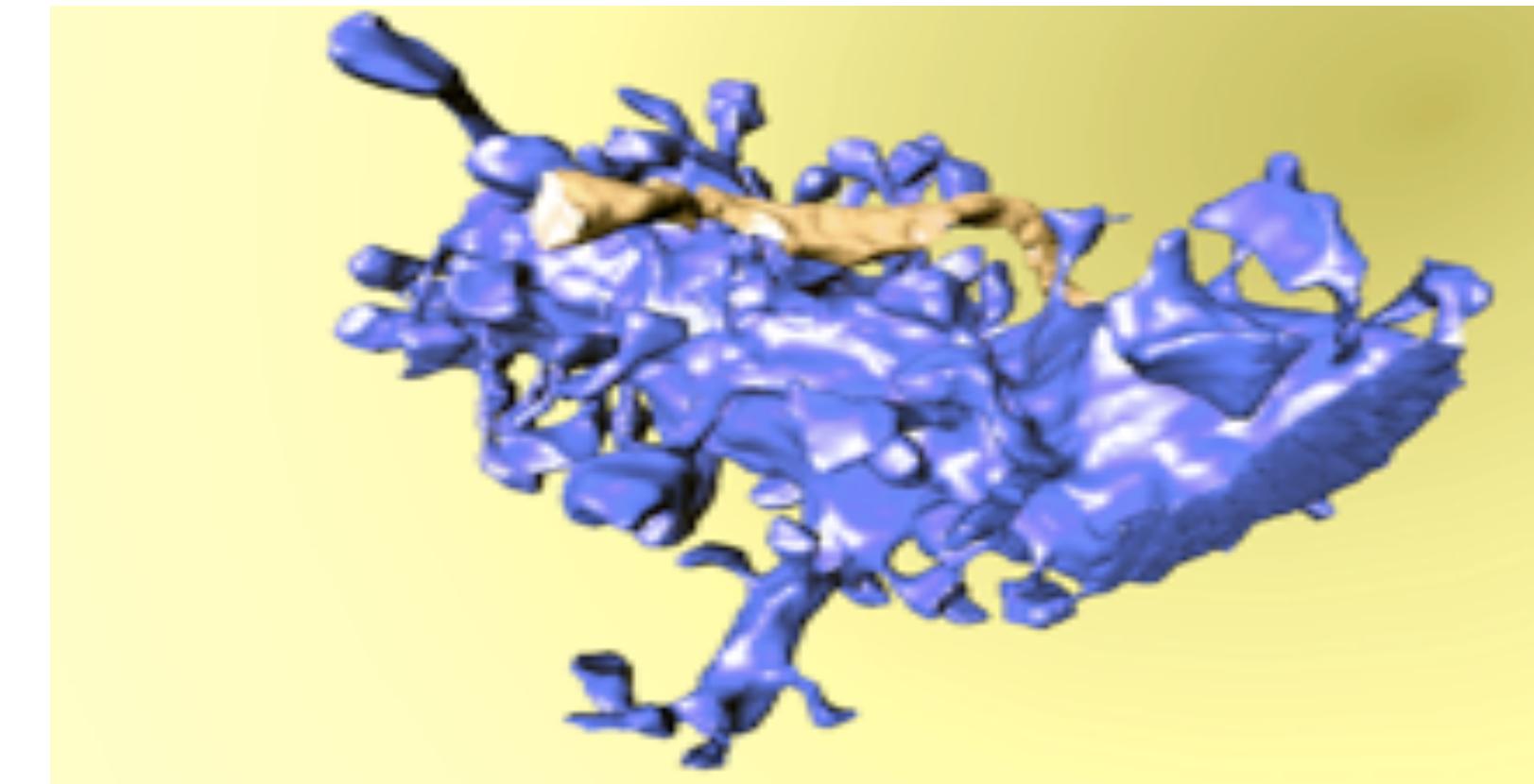


ABSTRACT DATA

multi-dimensional data RECORDS

infoviz

GEOMETRIC STRUCTURE



2D/3D DATA

scalar/vector/tensor + time

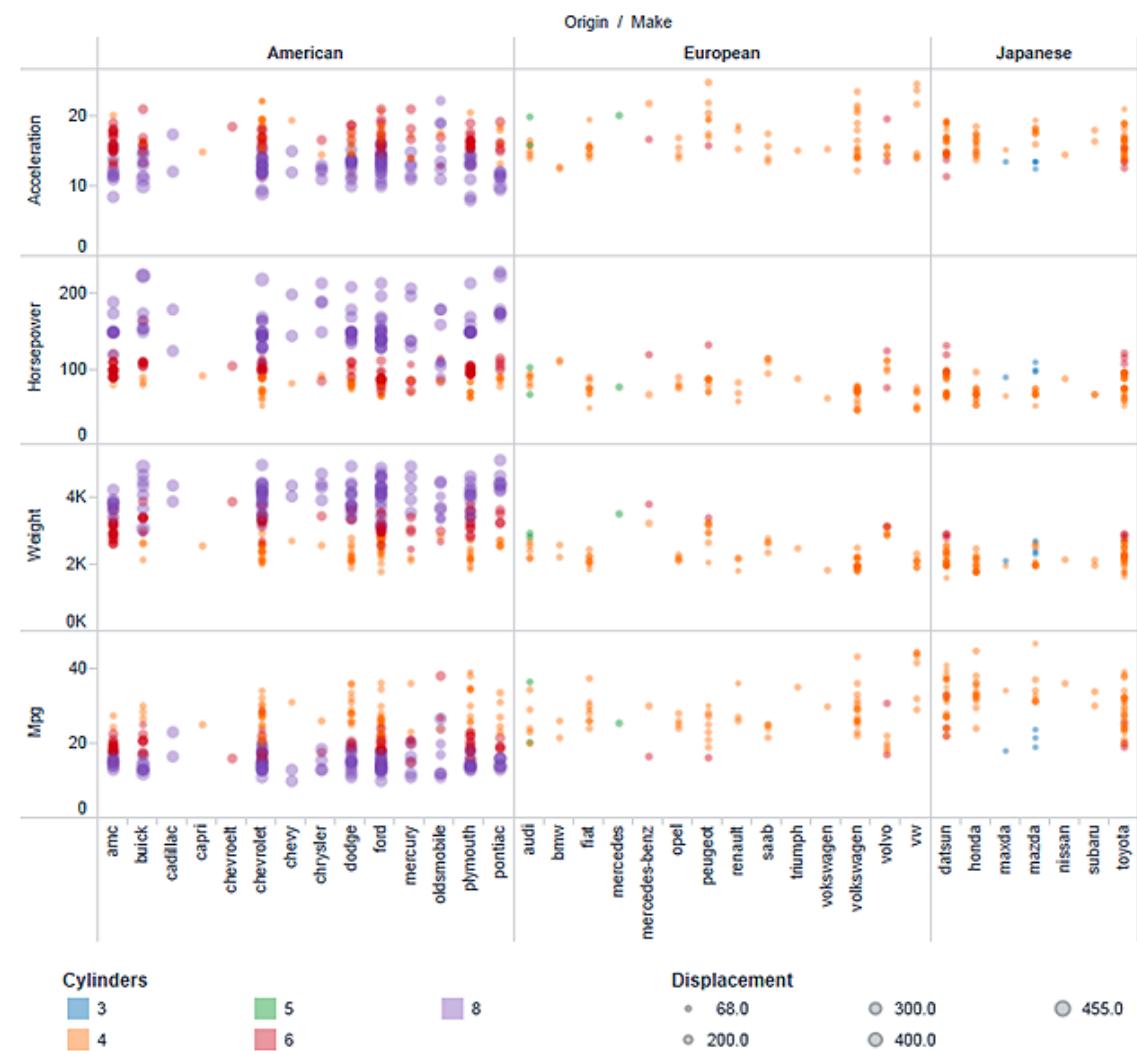
sciviz

MPG Cylinders Horsepower Weight Acceleration Year Origin

```

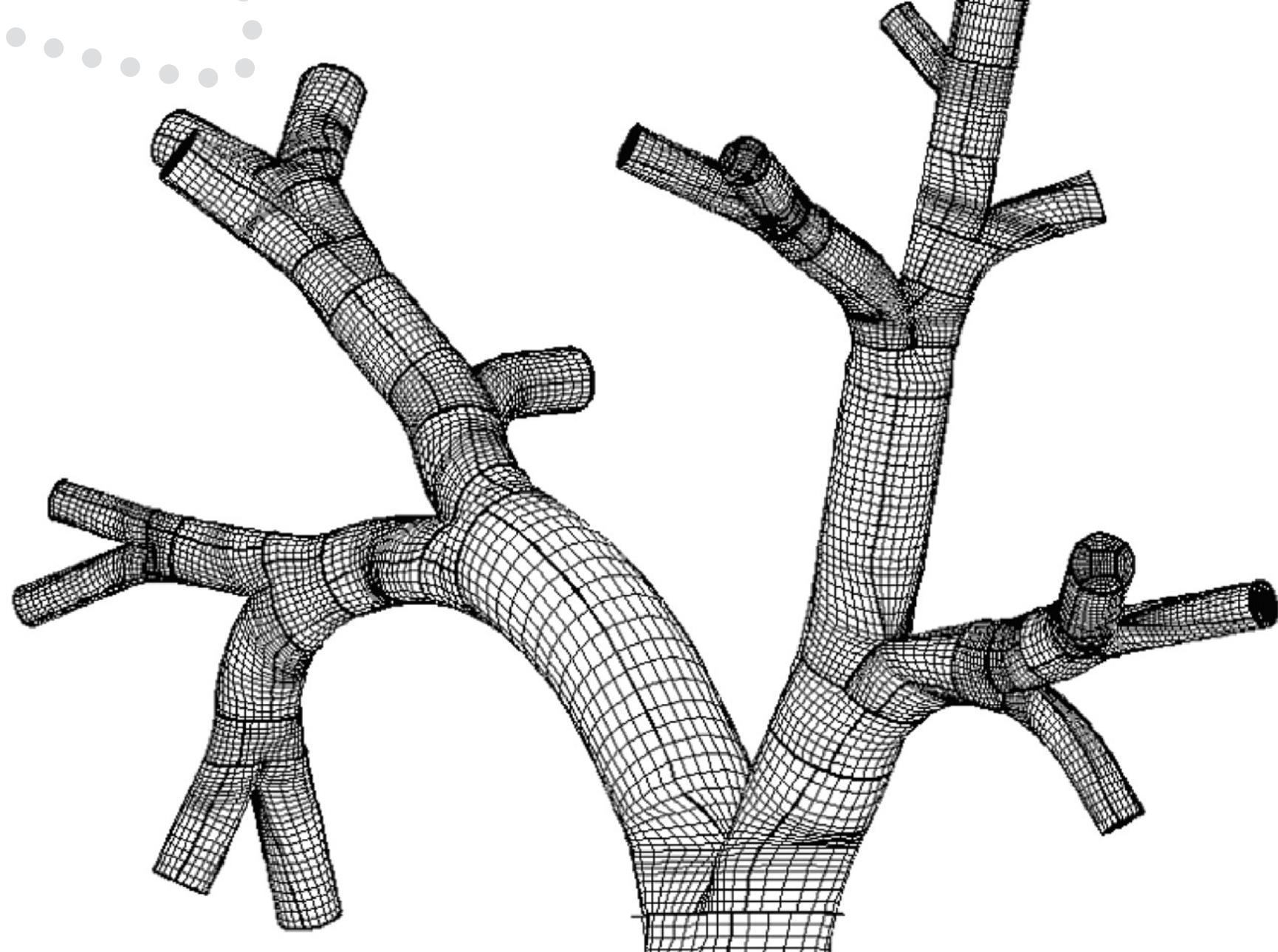
8.5 0.4 2.8 8.2 4 40.2 250.4 1500.5 500.4 5.3 30.4 69.5 82.5 4.8 3.2 3
18.000000 8.000000 130.000000 3504.000000 12.000000 70.000000 1.000000
15.000000 8.000000 165.000000 3693.000000 11.500000 70.000000 1.000000
18.000000 8.000000 150.000000 3436.000000 11.000000 70.000000 1.000000
16.000000 8.000000 150.000000 3433.000000 12.000000 70.000000 1.000000
17.000000 8.000000 140.000000 3449.000000 10.500000 70.000000 1.000000
...

```

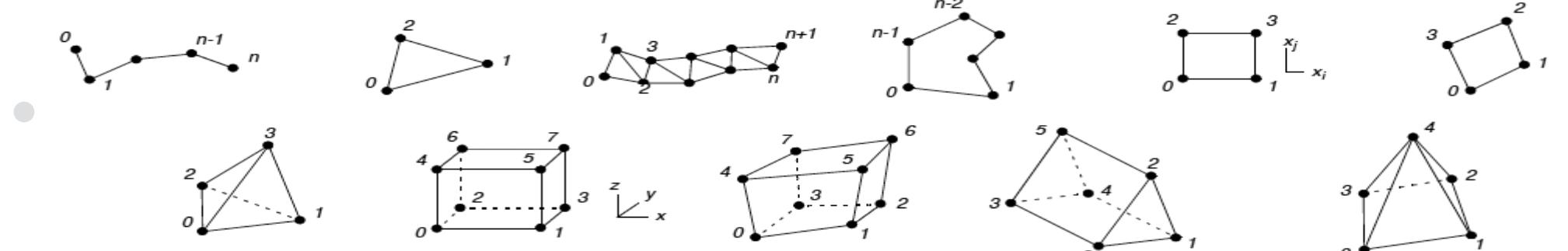


ABSTRACT DATA

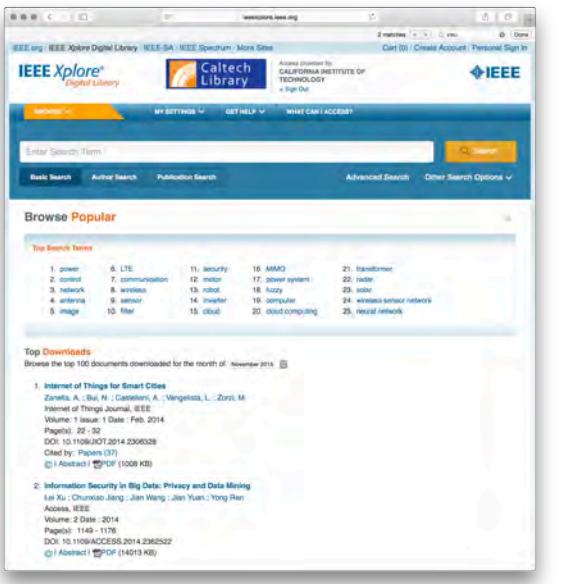
GEOMETRIC STRUCTURE



2D/3D DATA



RESOURCES

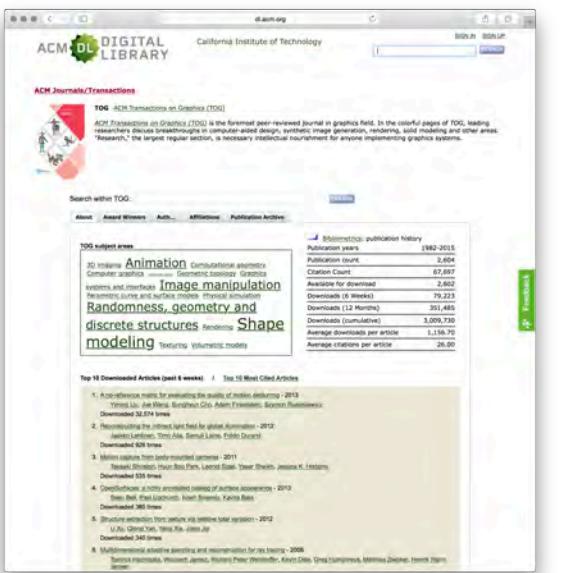


IEEE VIS CONFERENCE

SciVis | InfoVis | VAST

IEEE Xplore

<https://clsproxy.library.caltech.edu/login?url=http://ieeexplore.ieee.org/Xplore/DynWel.jsp>



ACM Siggraph Conference

ACM Digital Library

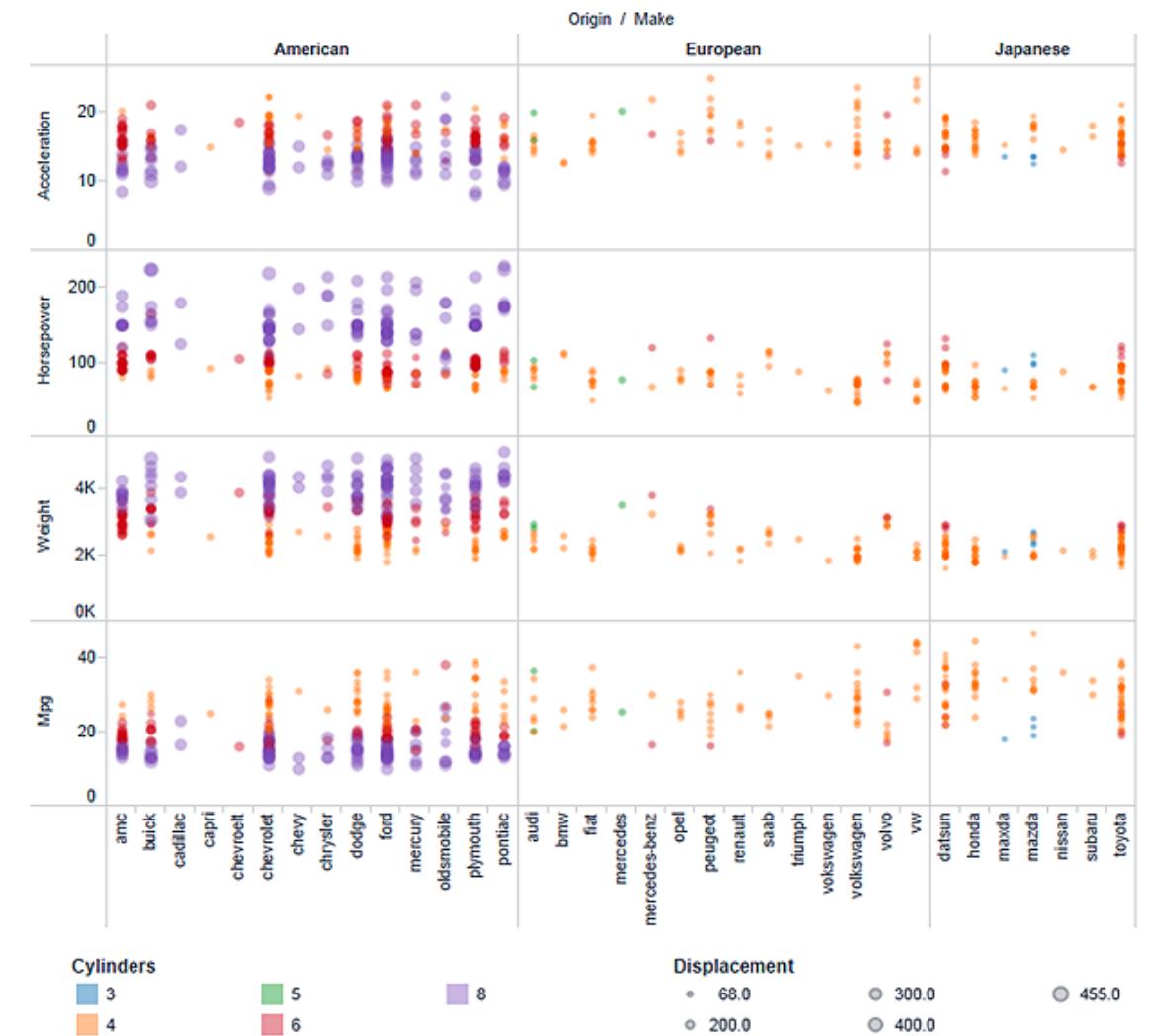
<https://clsproxy.library.caltech.edu/login?url=http://portal.acm.org/dl.cfm>

MPG Cylinders Horsepower Weight Acceleration Year Origin

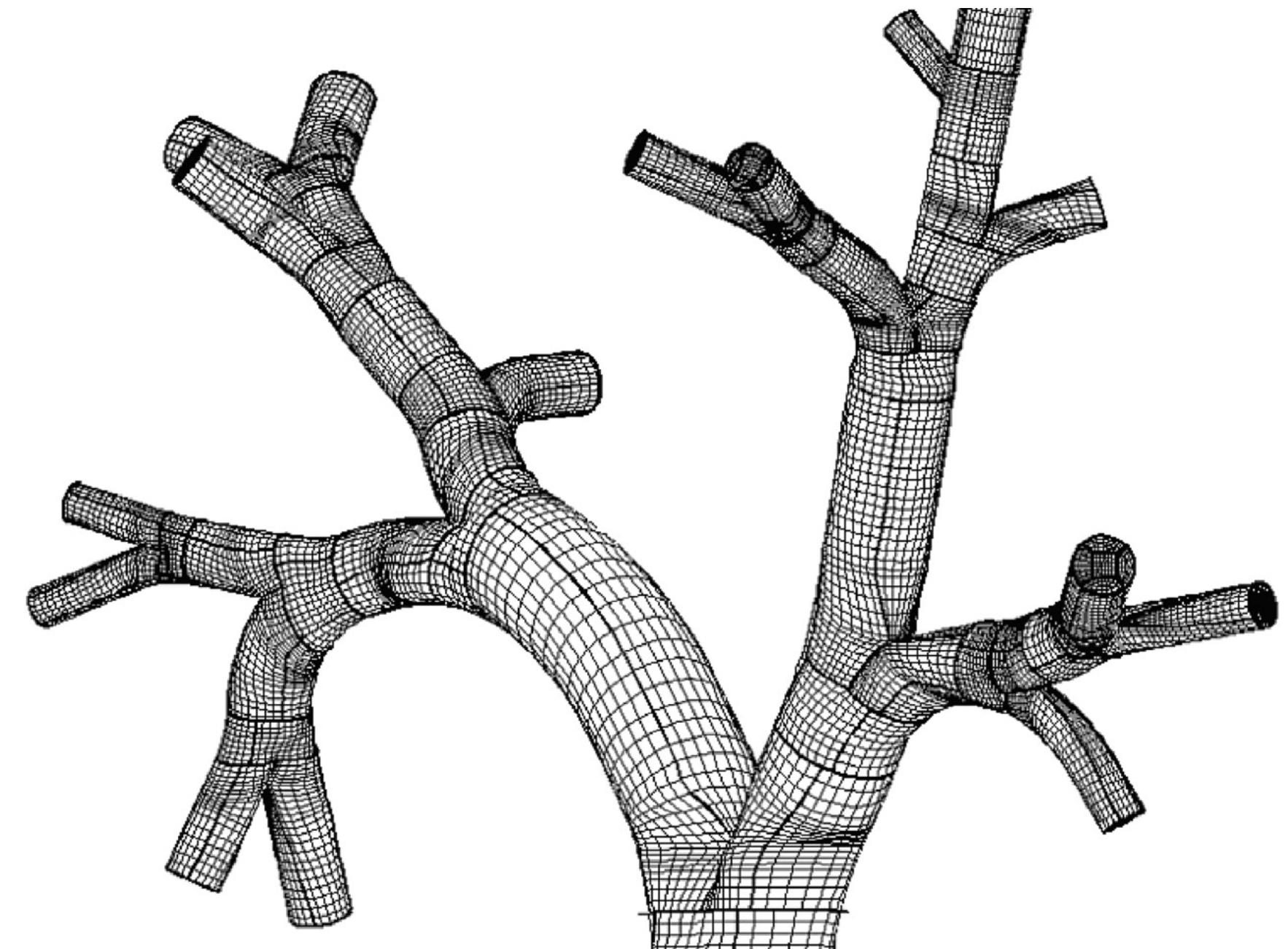
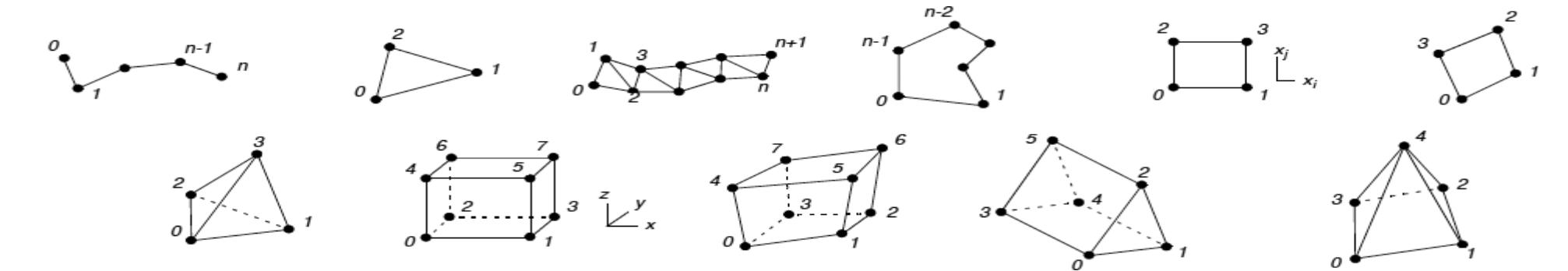
```

8.5 0.4 2.8 8.2 4 40.2 250.4 1500.5 500.4 5.3 30.4 69.5 82.5 4.8 3.2 3
18.000000 8.000000 130.000000 3504.000000 12.000000 70.000000 1.000000
15.000000 8.000000 165.000000 3693.000000 11.500000 70.000000 1.000000
18.000000 8.000000 150.000000 3436.000000 11.000000 70.000000 1.000000
16.000000 8.000000 150.000000 3433.000000 12.000000 70.000000 1.000000
17.000000 8.000000 140.000000 3449.000000 10.500000 70.000000 1.000000
...

```

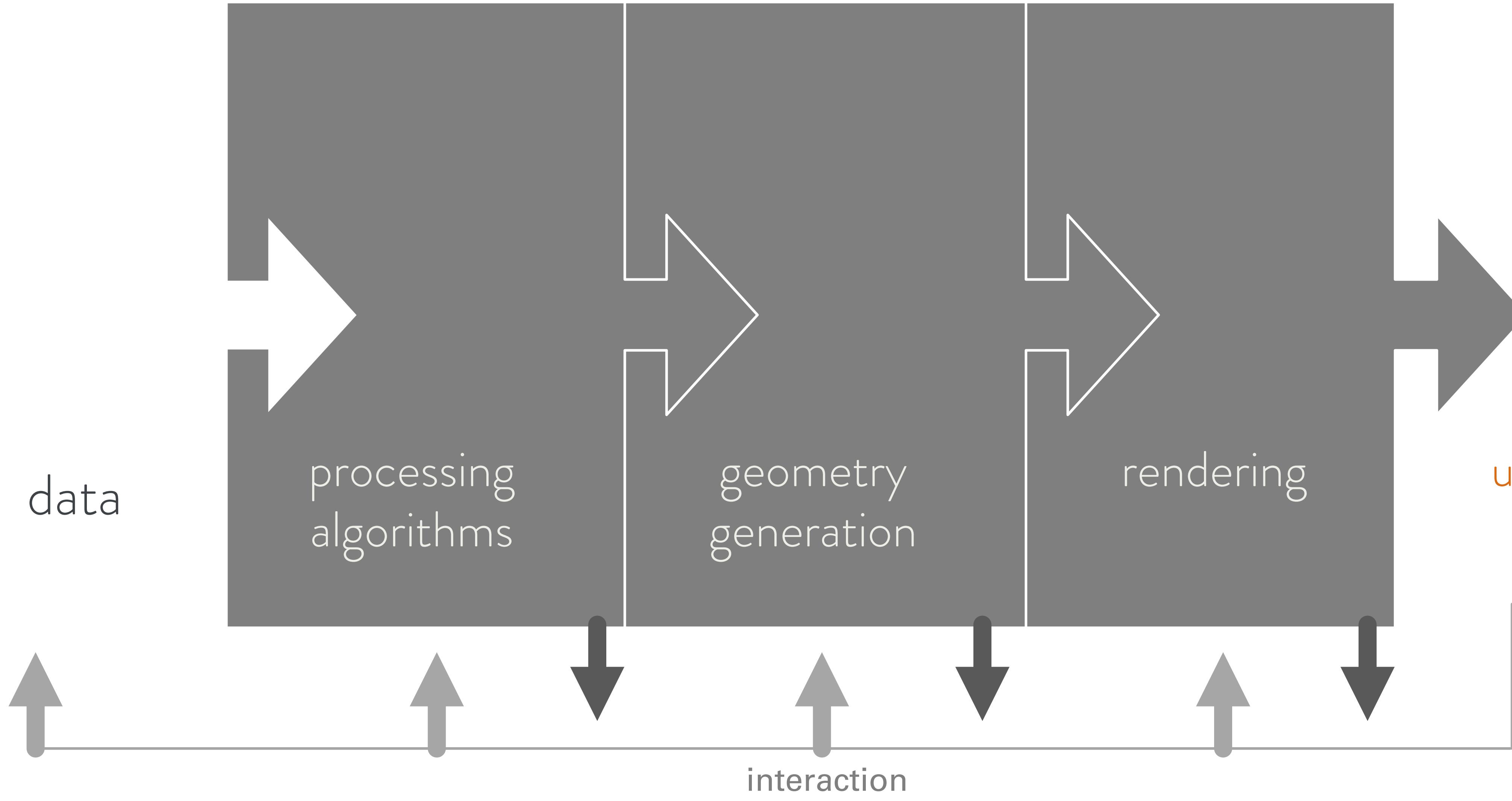


ABSTRACT DATA

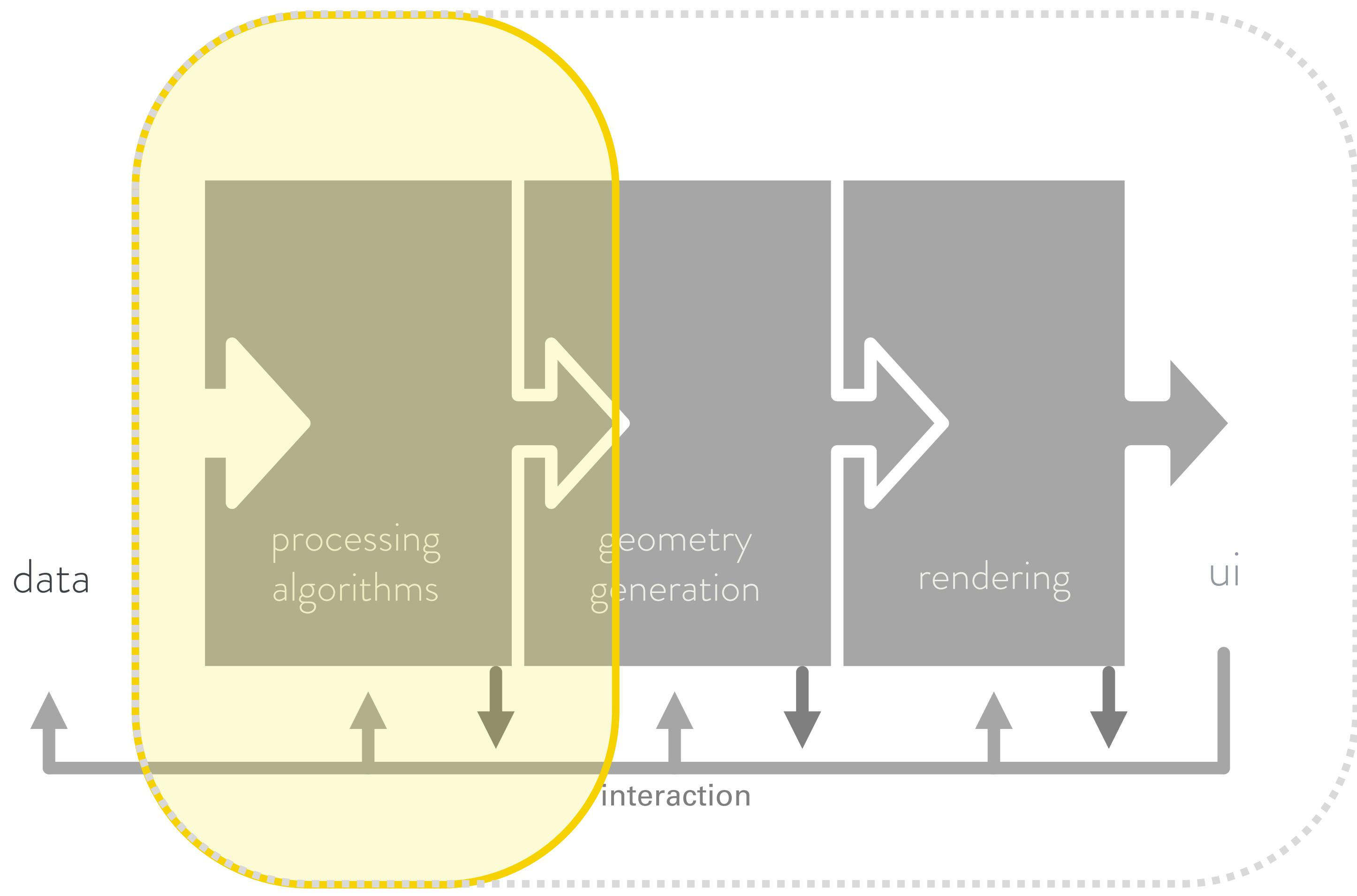


2D/3D DATA

GEOMETRIC STRUCTURE

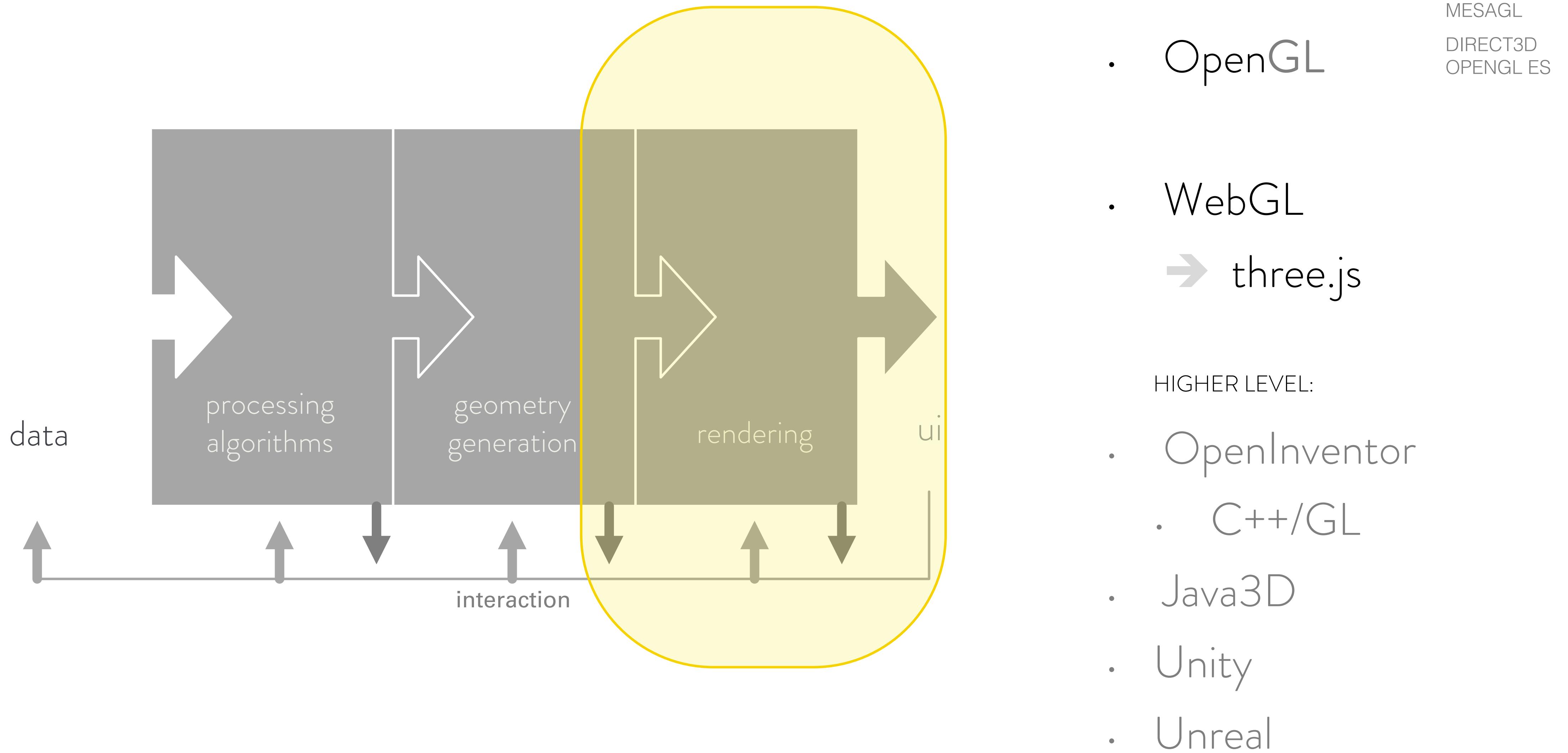


USUAL VISUALIZATION ENGINE

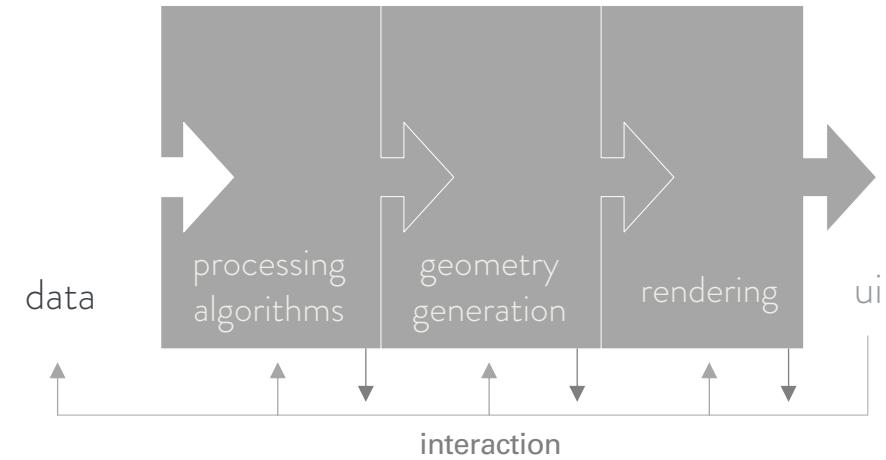


- VTK
- c/c++
- tcl/tk
- python/qt
- java
- R

INTERACTIVE RENDERERS

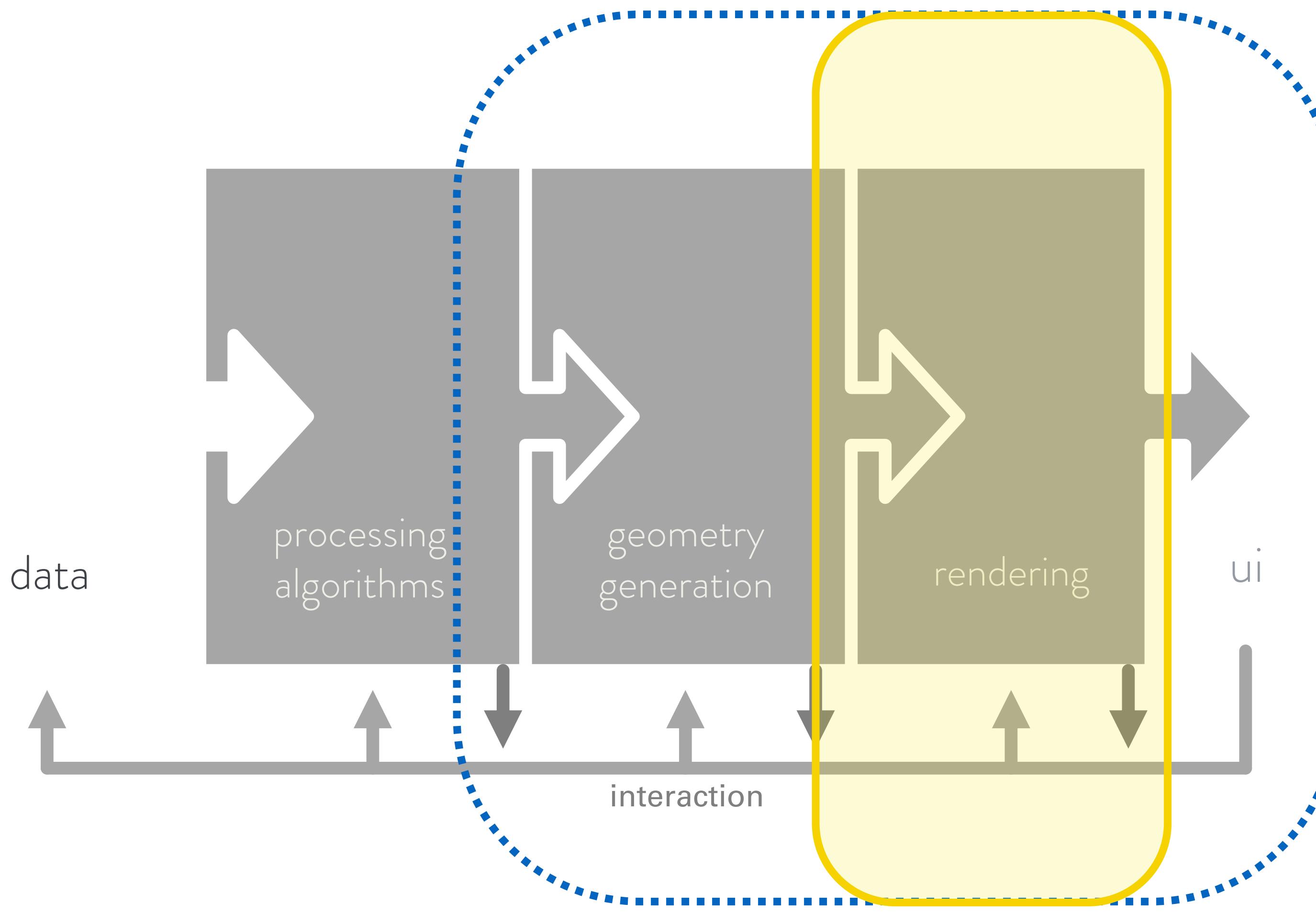


MODERN PROGRAMMING LANGUAGES/ENVIRONMENTS

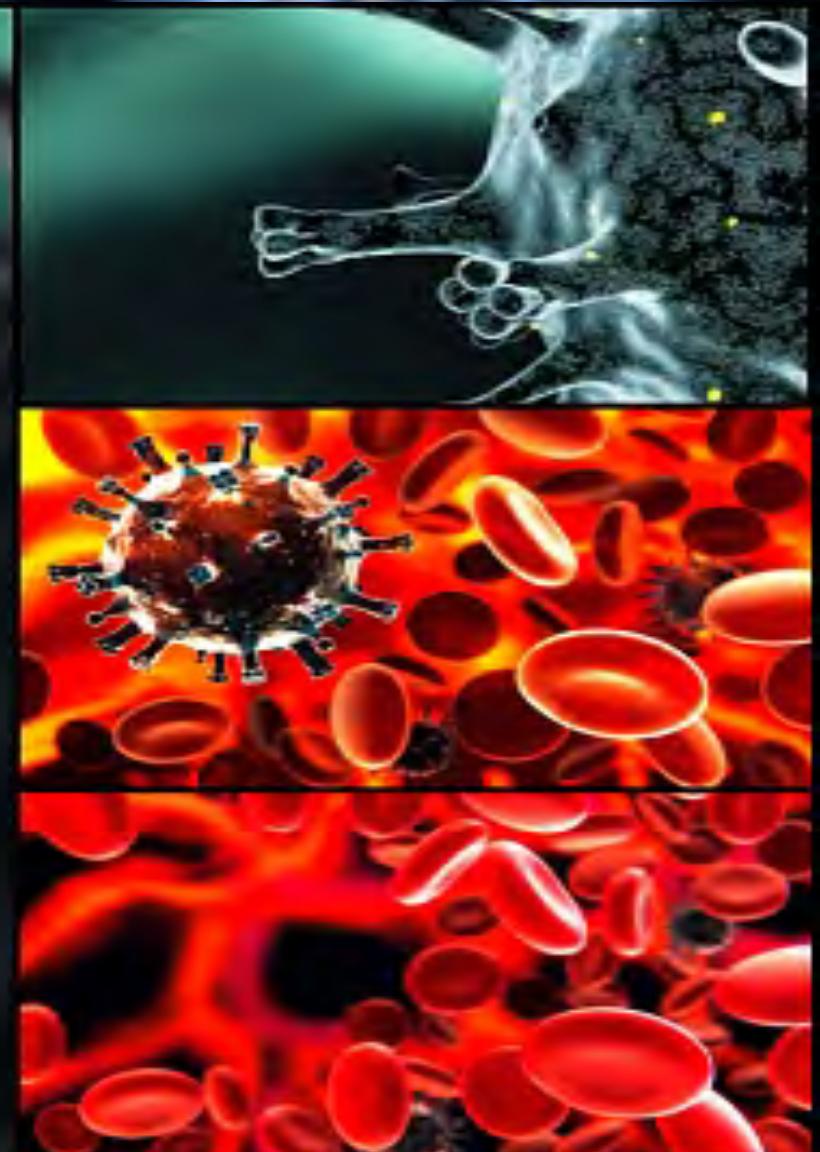
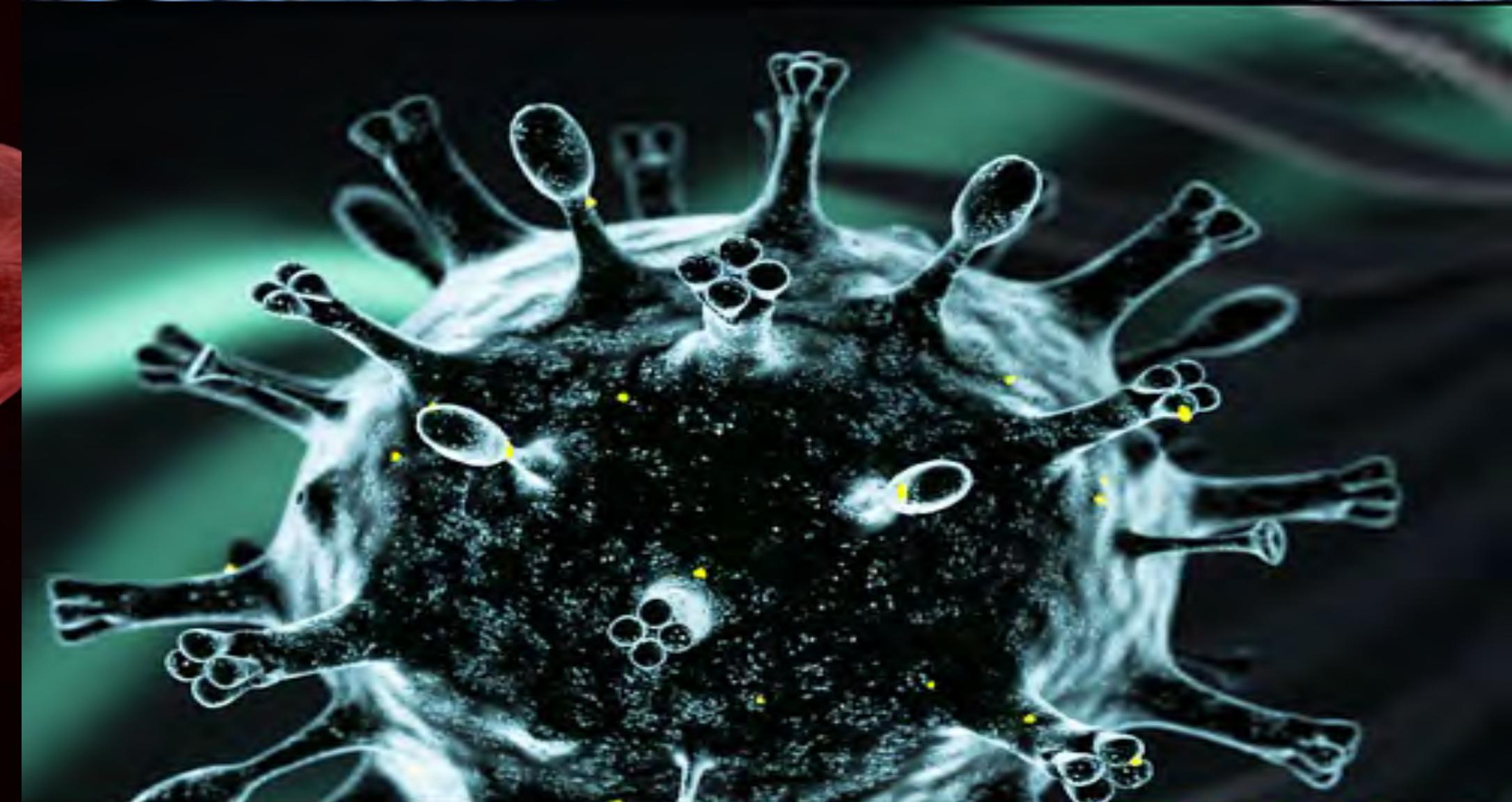
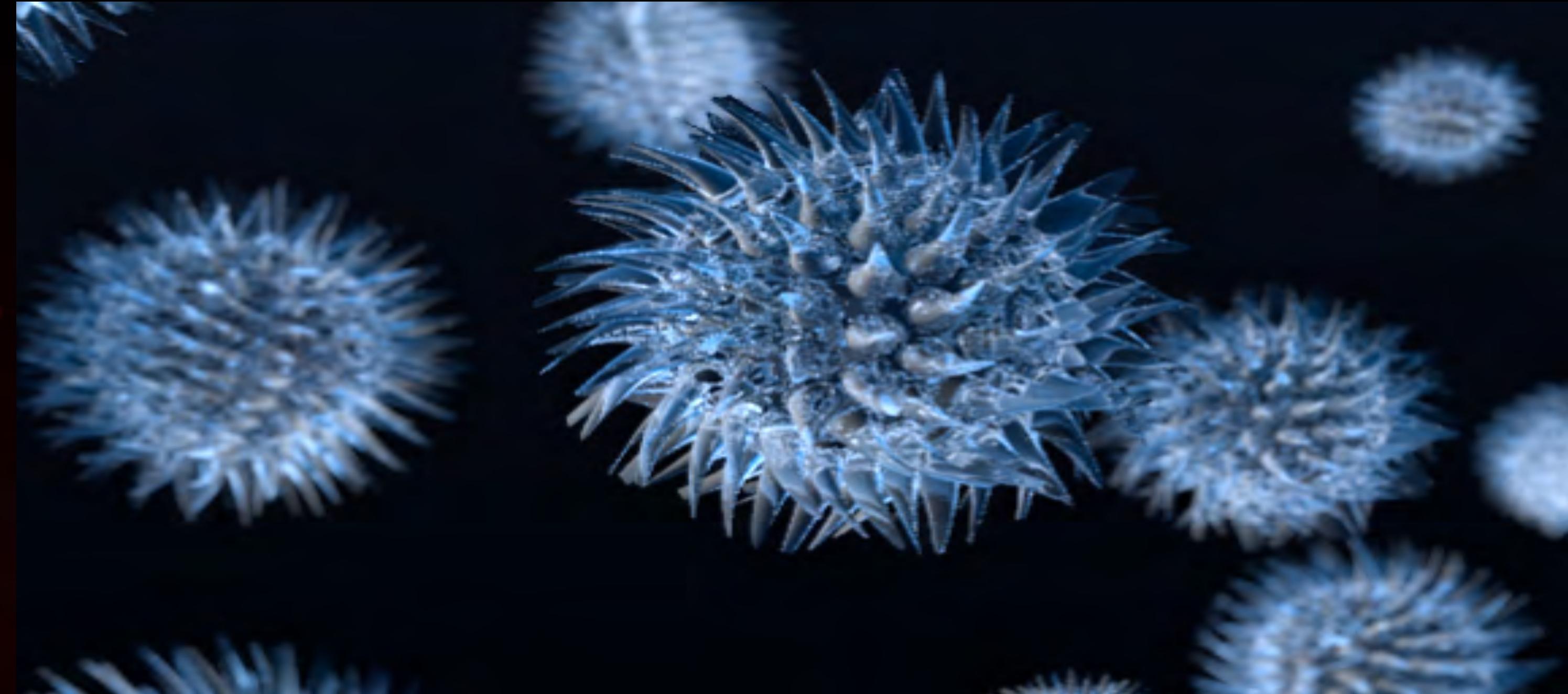
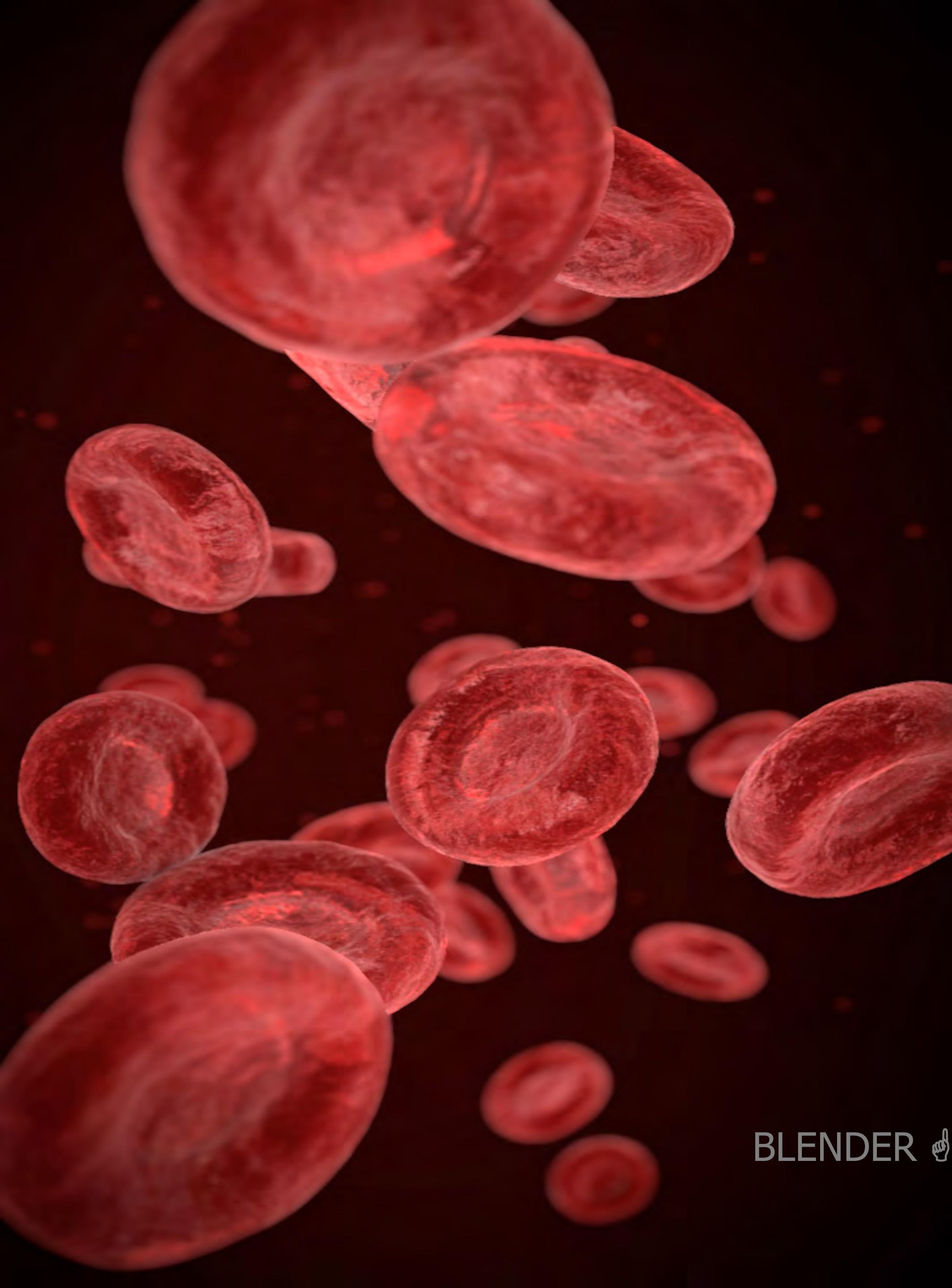


- C++ Cinder, Open Framework
- Java Processing
- Lua Löve (Moai, ...)
- Objective-C Swift
- JavaScript PLOTLY, D3, VEGA
- C# Unity

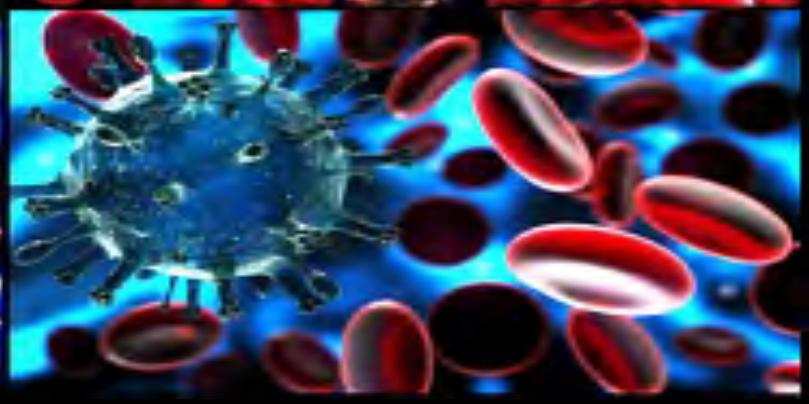
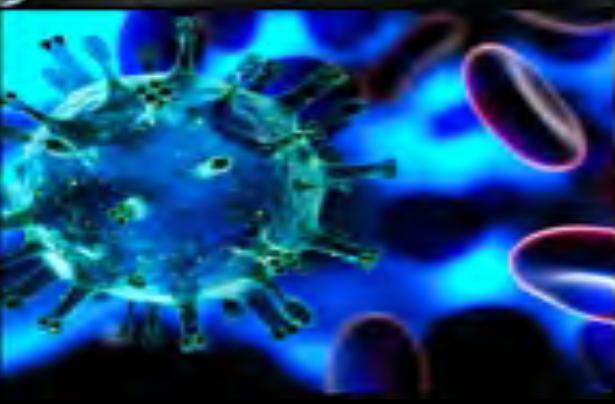
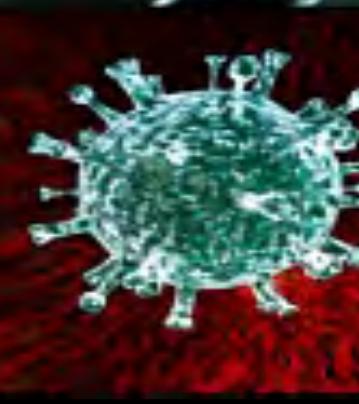
RAY TRACERS

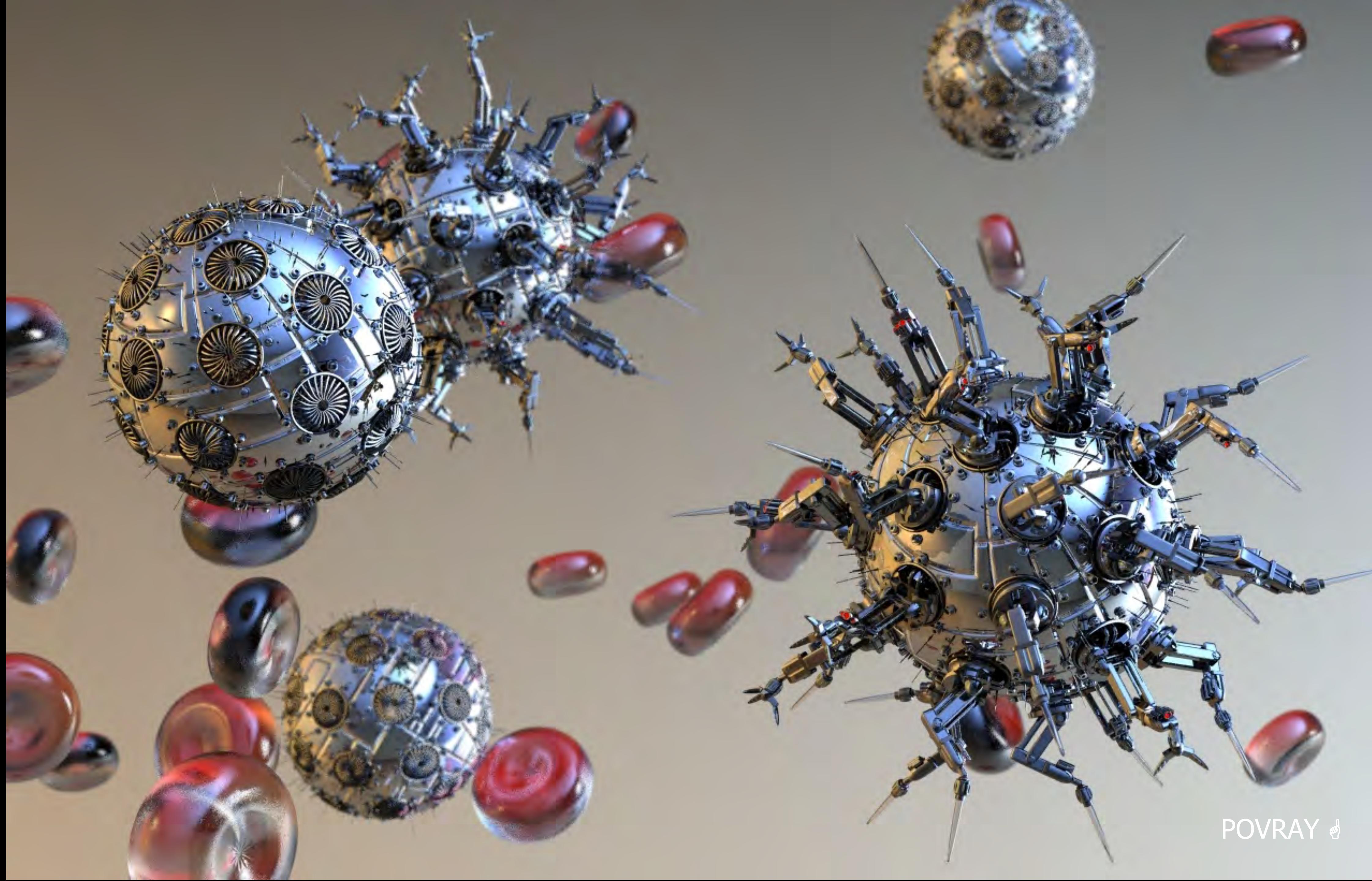


- POVRay
 - RenderMan^{\$\$}
- MODELLERS:
- Blender
 - Maya^{\$\$}

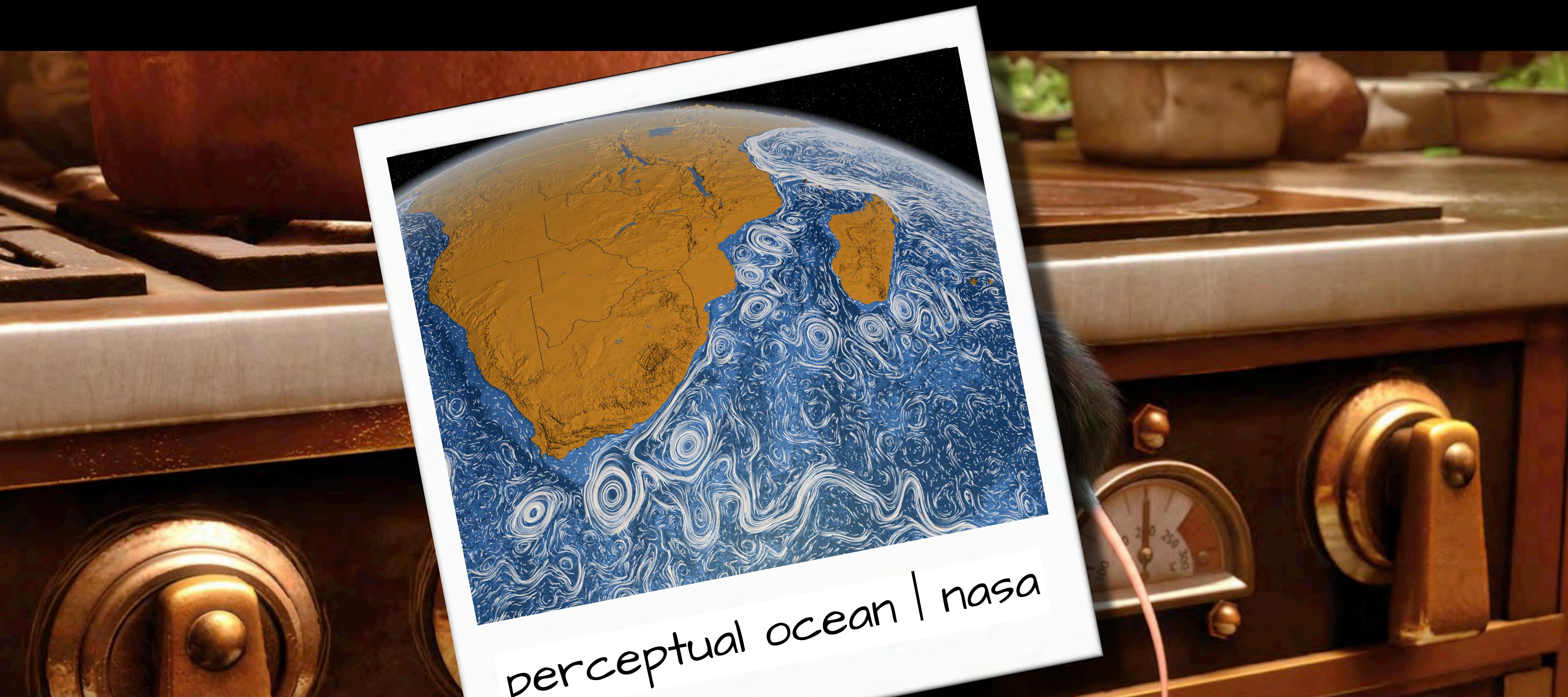


BLENDER ↗



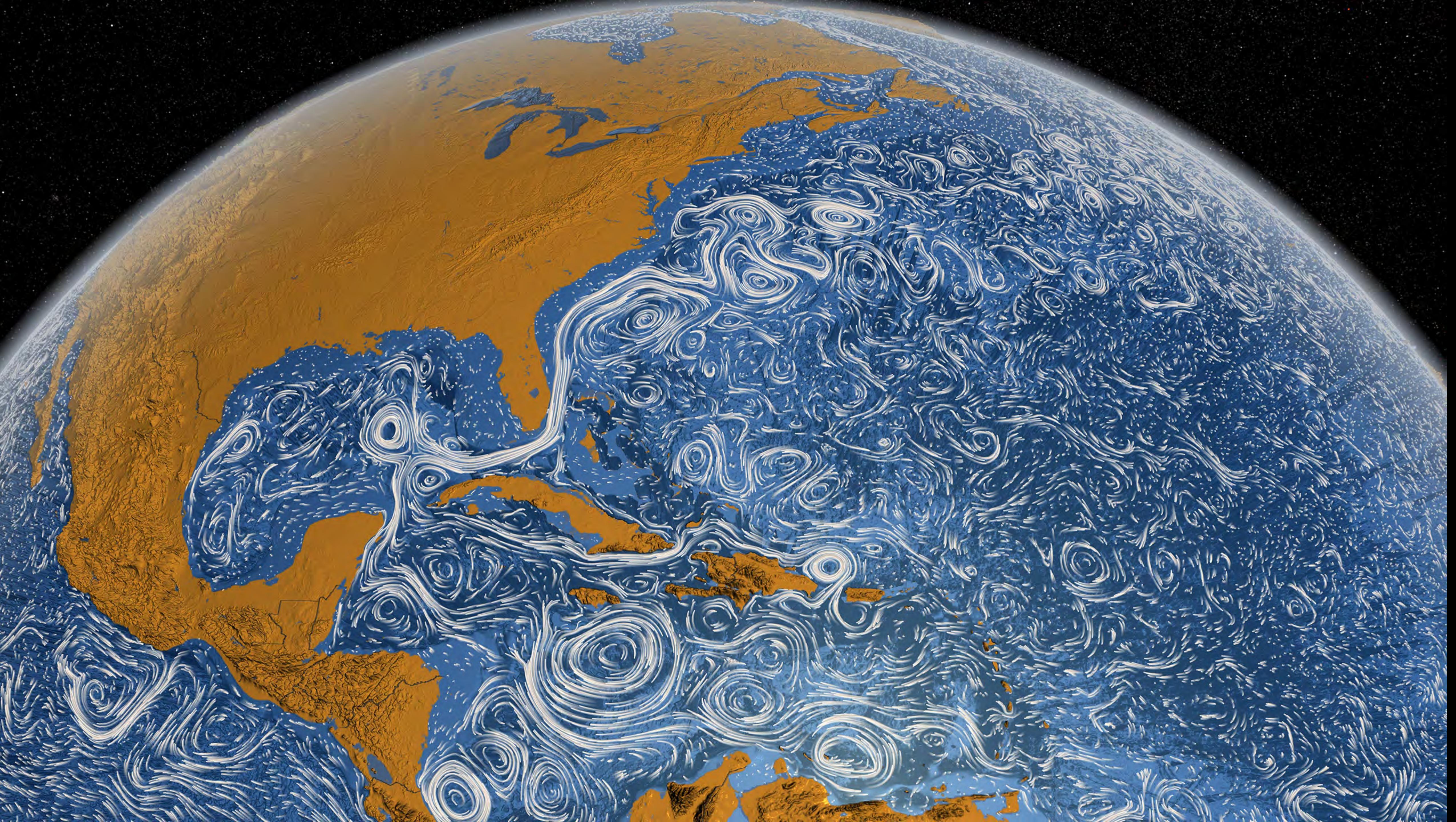


POVRAY ↗

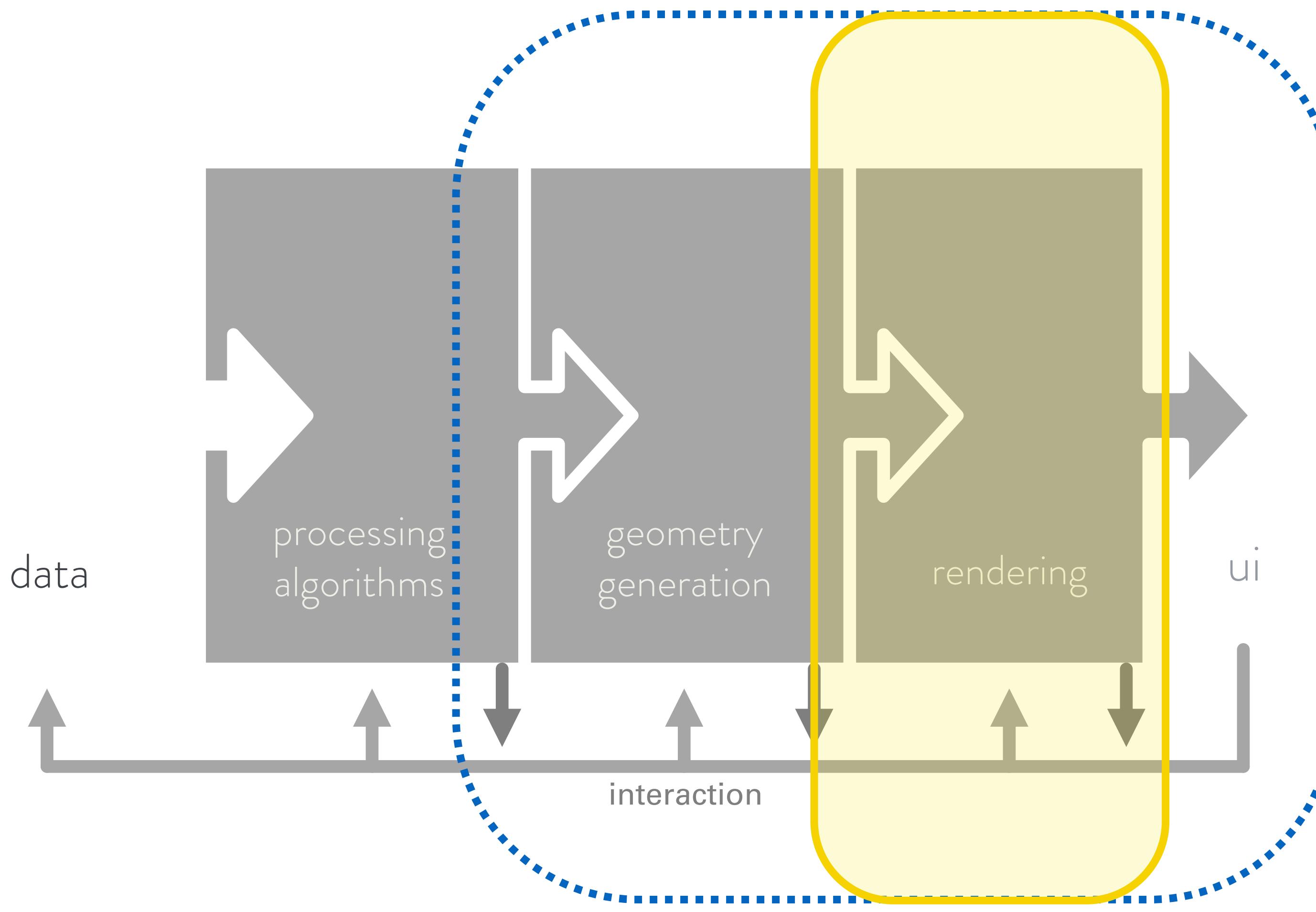


perceptual ocean | nasa

RENDERMAN Ⓜ

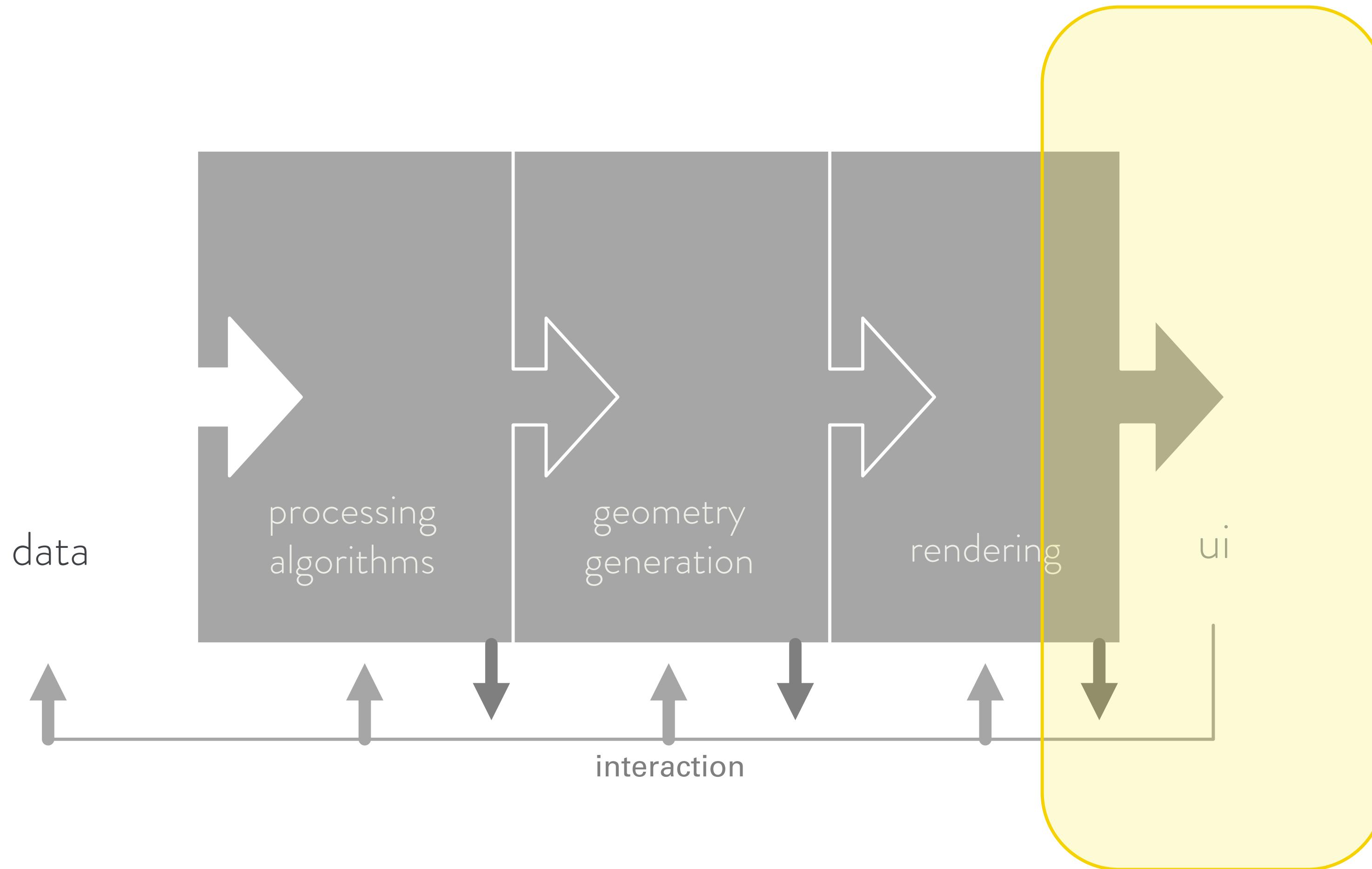


RAY TRACERS



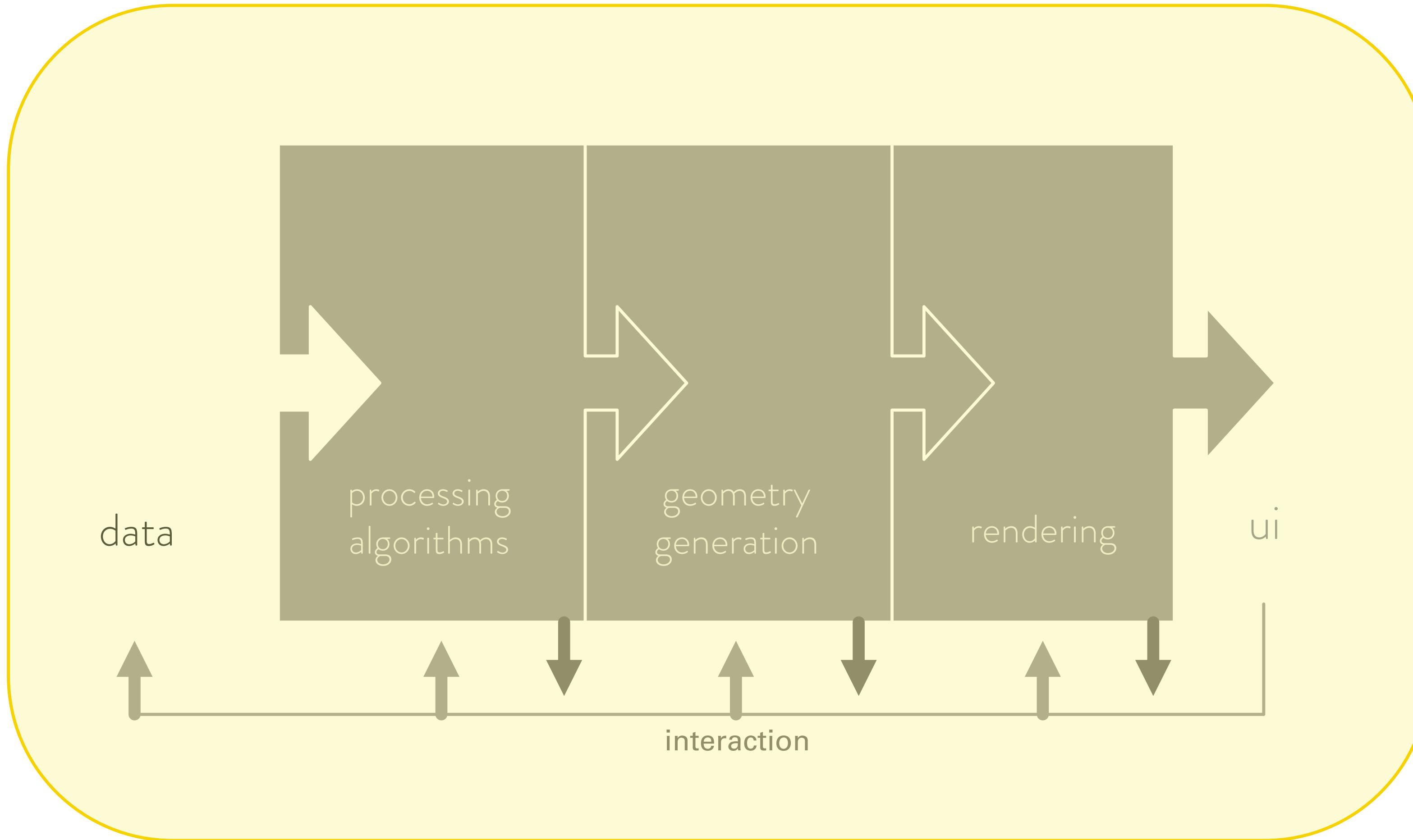
- POVRay
 - RenderMan^{\$\$}
- MODELLERS:
- Blender
 - Maya^{\$\$}

GUI TOOLKITS

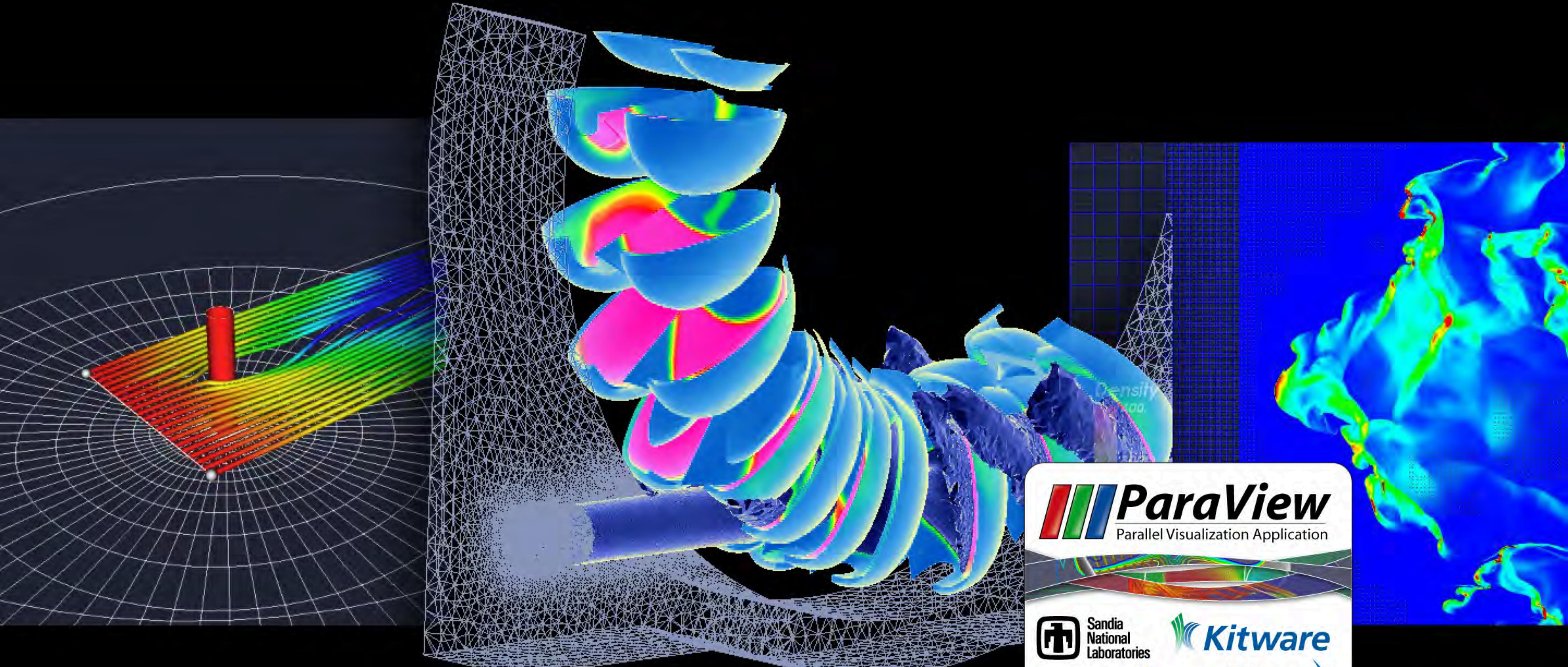


- WWW/HTML
- QT (python)
- GTK+ (python)
- TK ([TCL/TK](#))
- KIVY (python)
- iOS, Android
- Java Swing
- Cocoa, Motif...

VISUALIZATION SYSTEMS



- Paraview^{VTK}
- LLNL VisIt^{VTK}
- EnSight^{\$}
- tableau^{\$}
- D3js^{WWW}
 - Many Eyes^{WWW}
- Modrian^R,
- TopCat, ...



 **ParaView**
Parallel Visualization Application

 Sandia
National
Laboratories

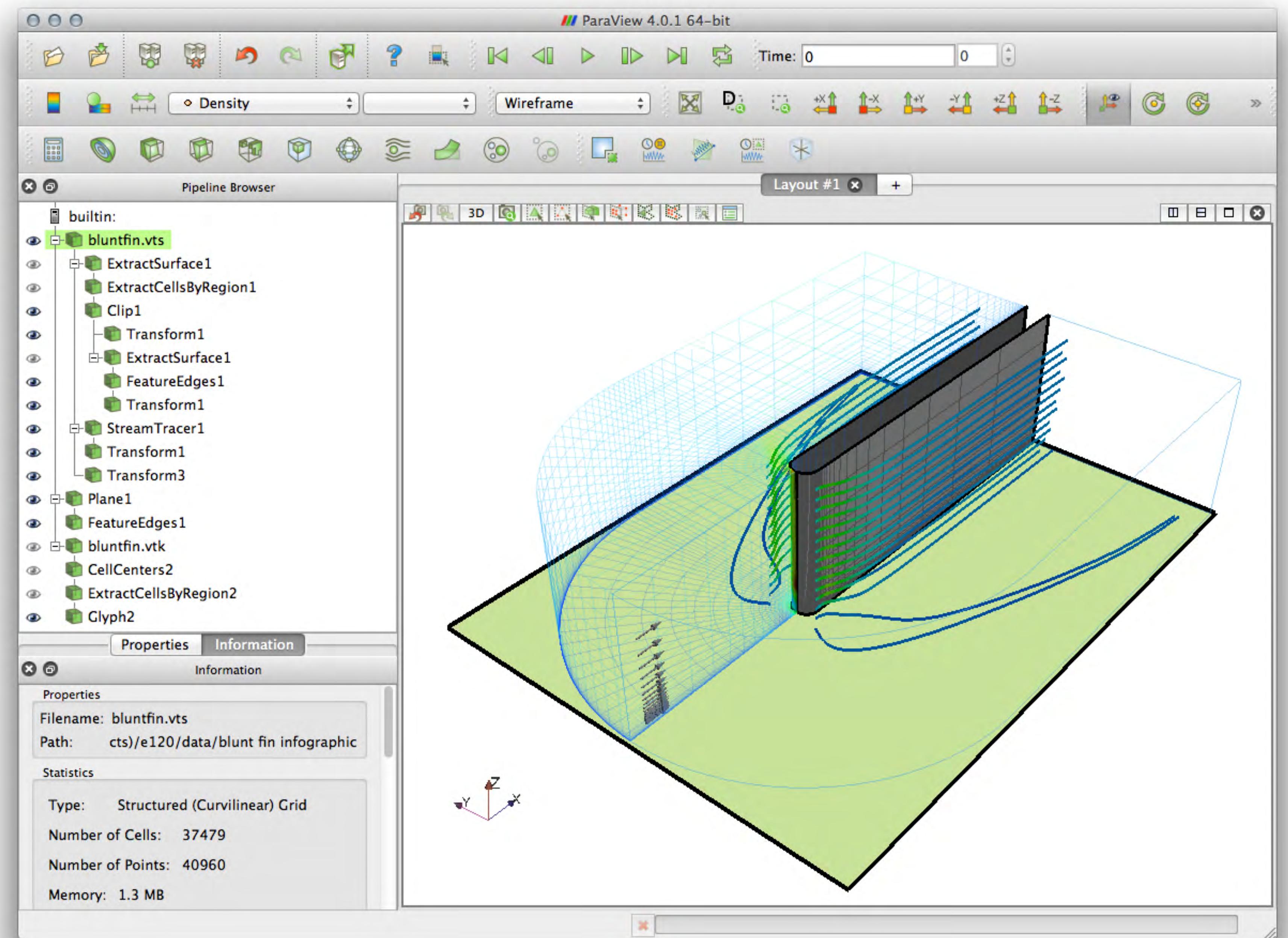
 **Kitware**

 **csimsoft**

 Los Alamos
NATIONAL LABORATORY

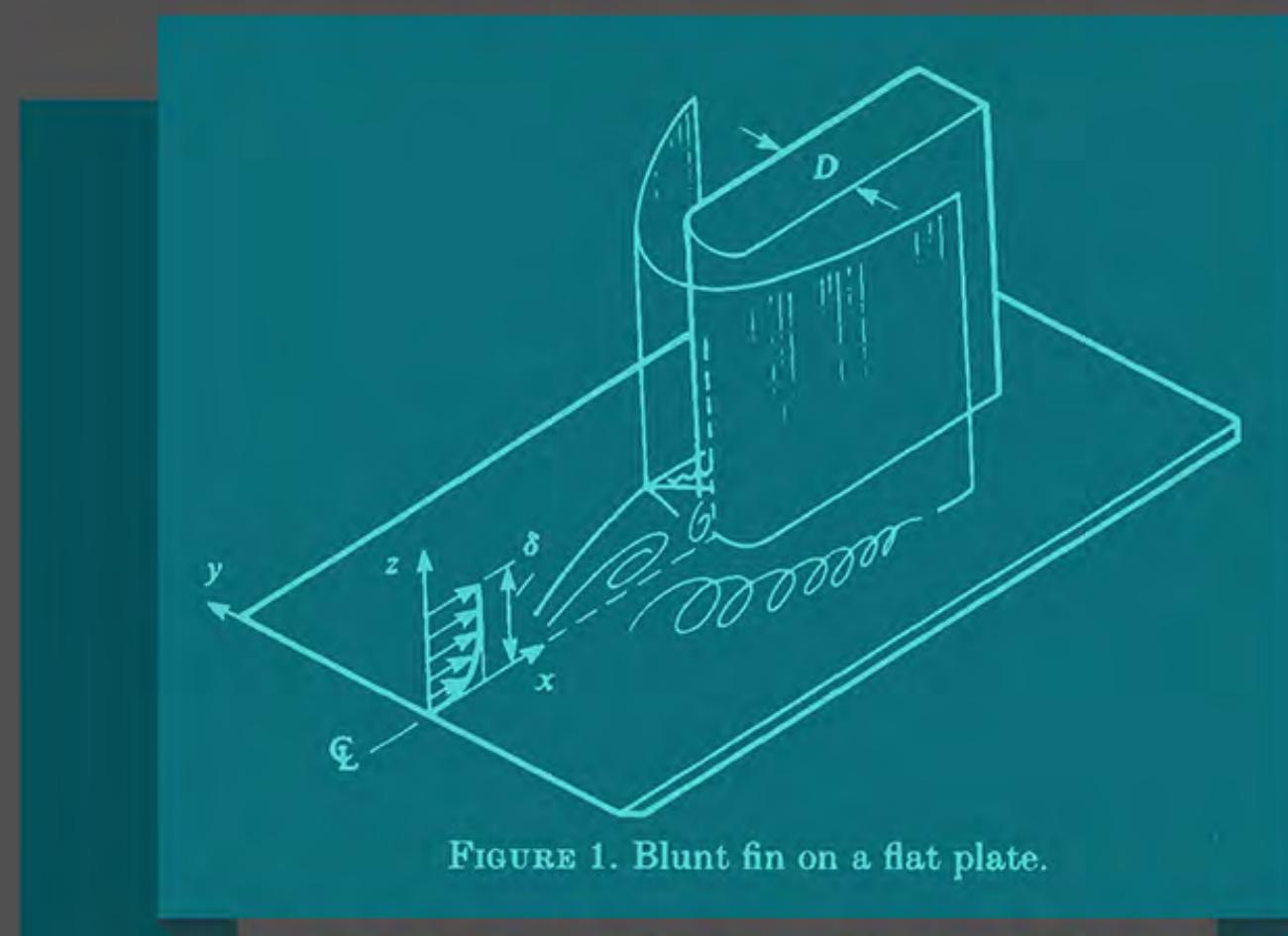
 U.S. Army Research Laboratory

 **ASC**





MACH NUMBER AT VARIOUS
CONSTANT ($z=$) PLANES



BLUNT-FIN-INDUCED SHOCK-WAVE AND TURBULENT BOUNDARY-LAYER INTERACTION

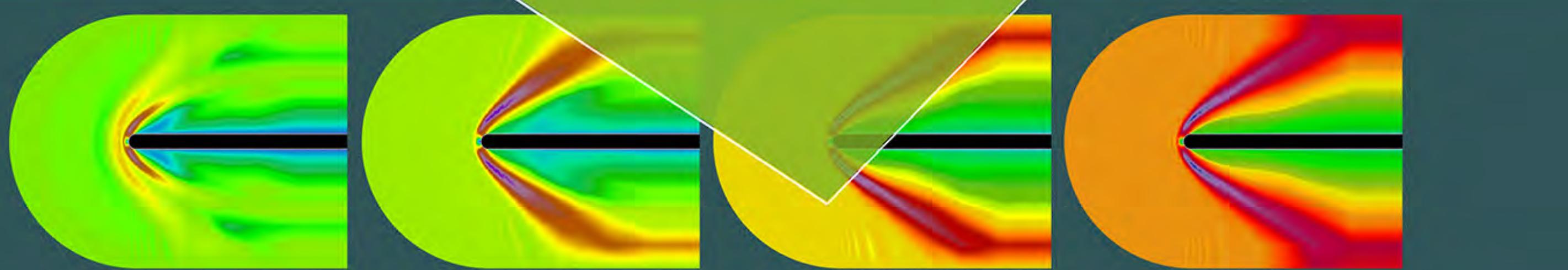
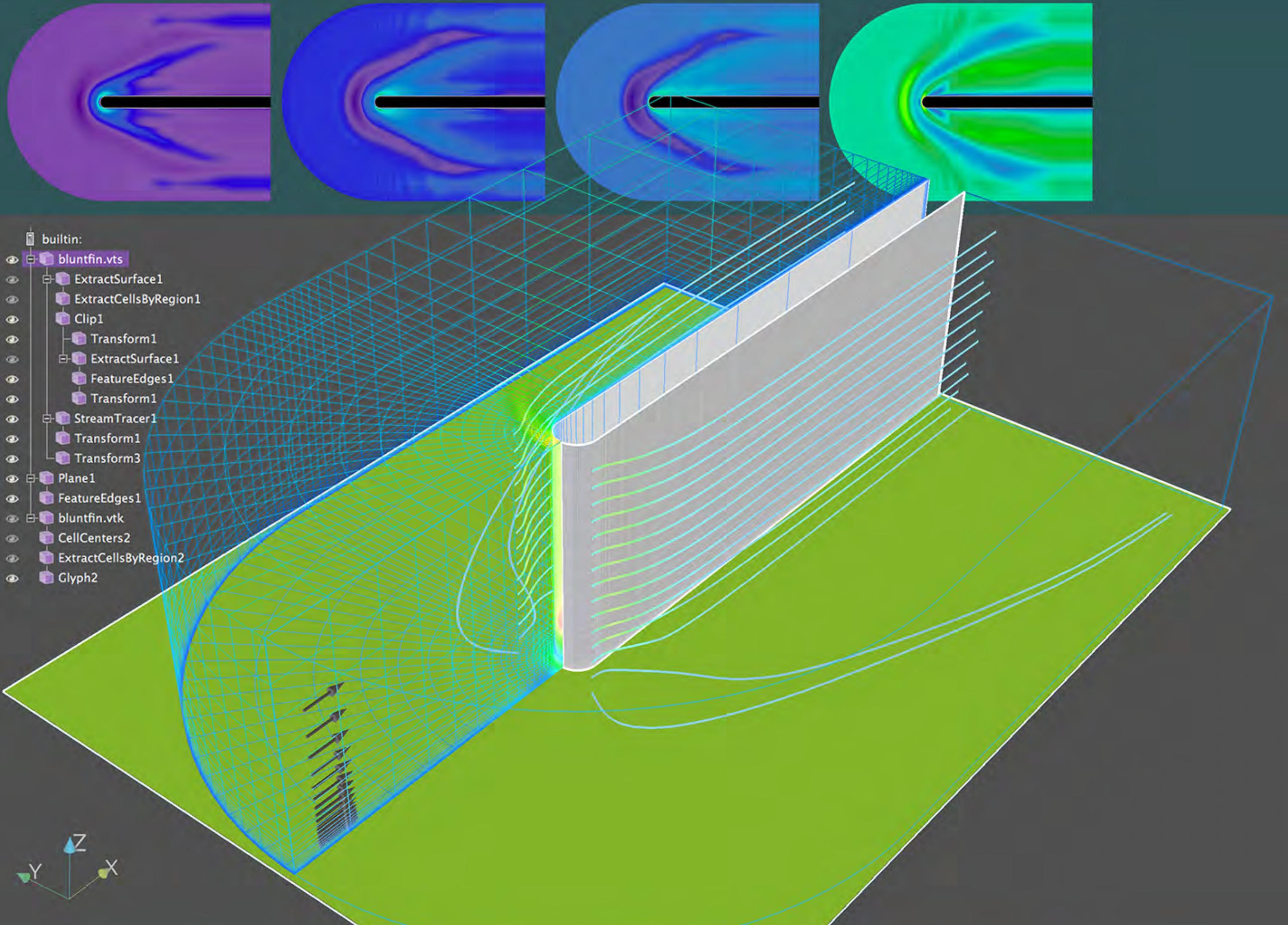
visualized with

PARAVIEW

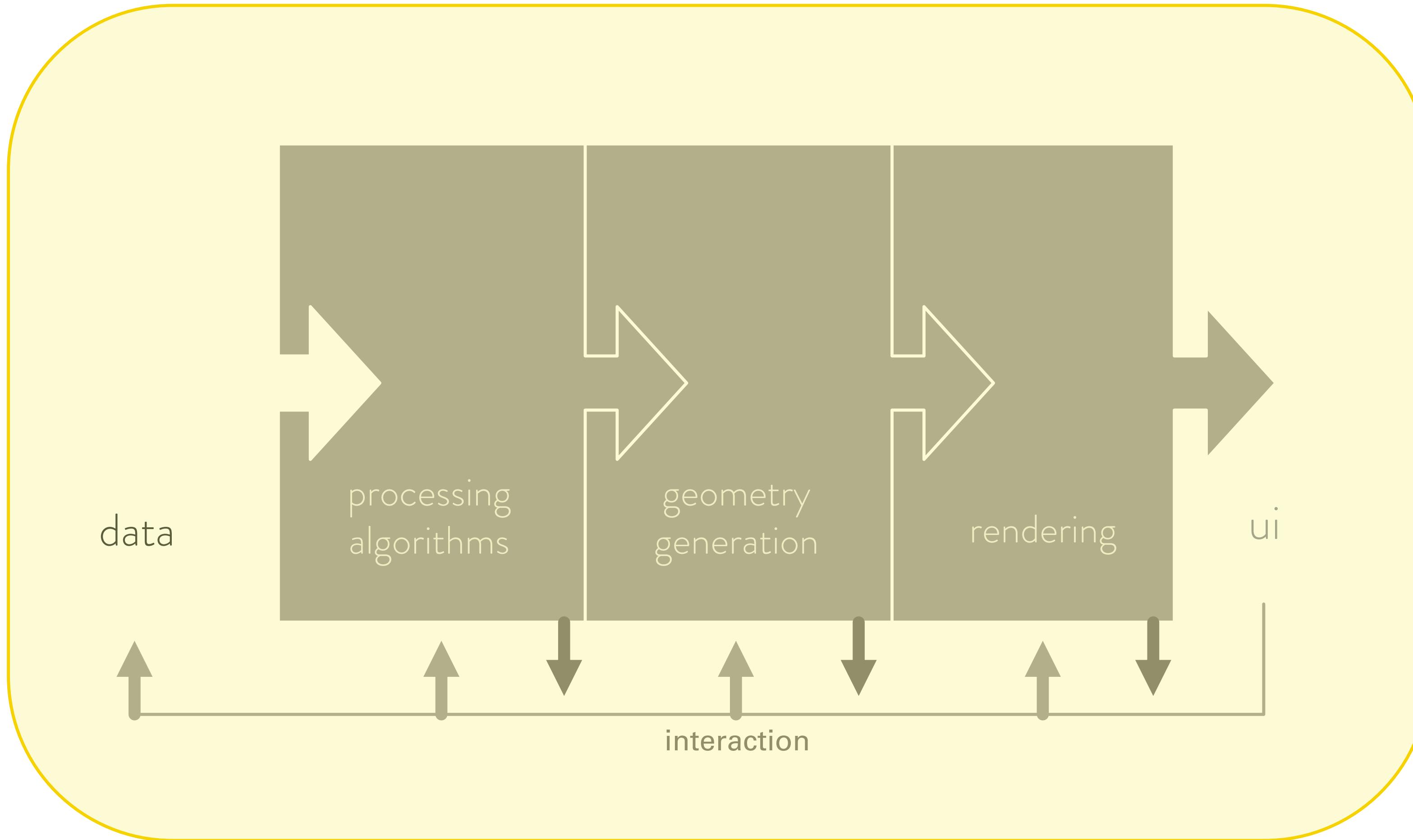
```

builtin:
  - bluntfin.vts
  - ExtractSurface1
  - ExtractCellsByRegion1
  - Clip1
  - Transform1
  - ExtractSurface1
  - FeatureEdges1
  - Transform1
  - StreamTracer1
  - Transform1
  - Transform3
  - Plane1
  - FeatureEdges1
  - bluntfin.vtk
  - CellCenters2
  - ExtractCellsByRegion2
  - Glyph2

```

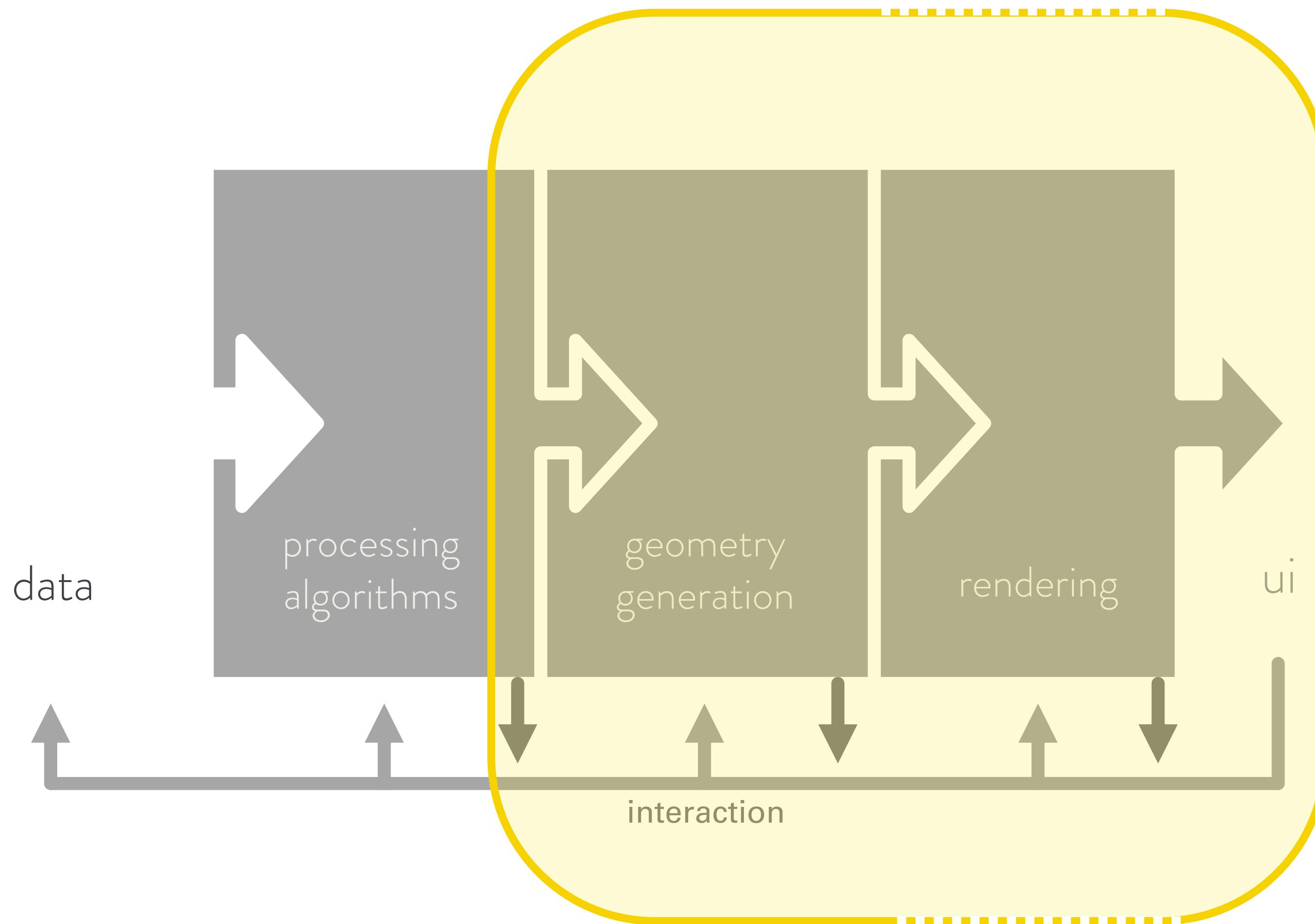


VISUALIZATION SYSTEMS

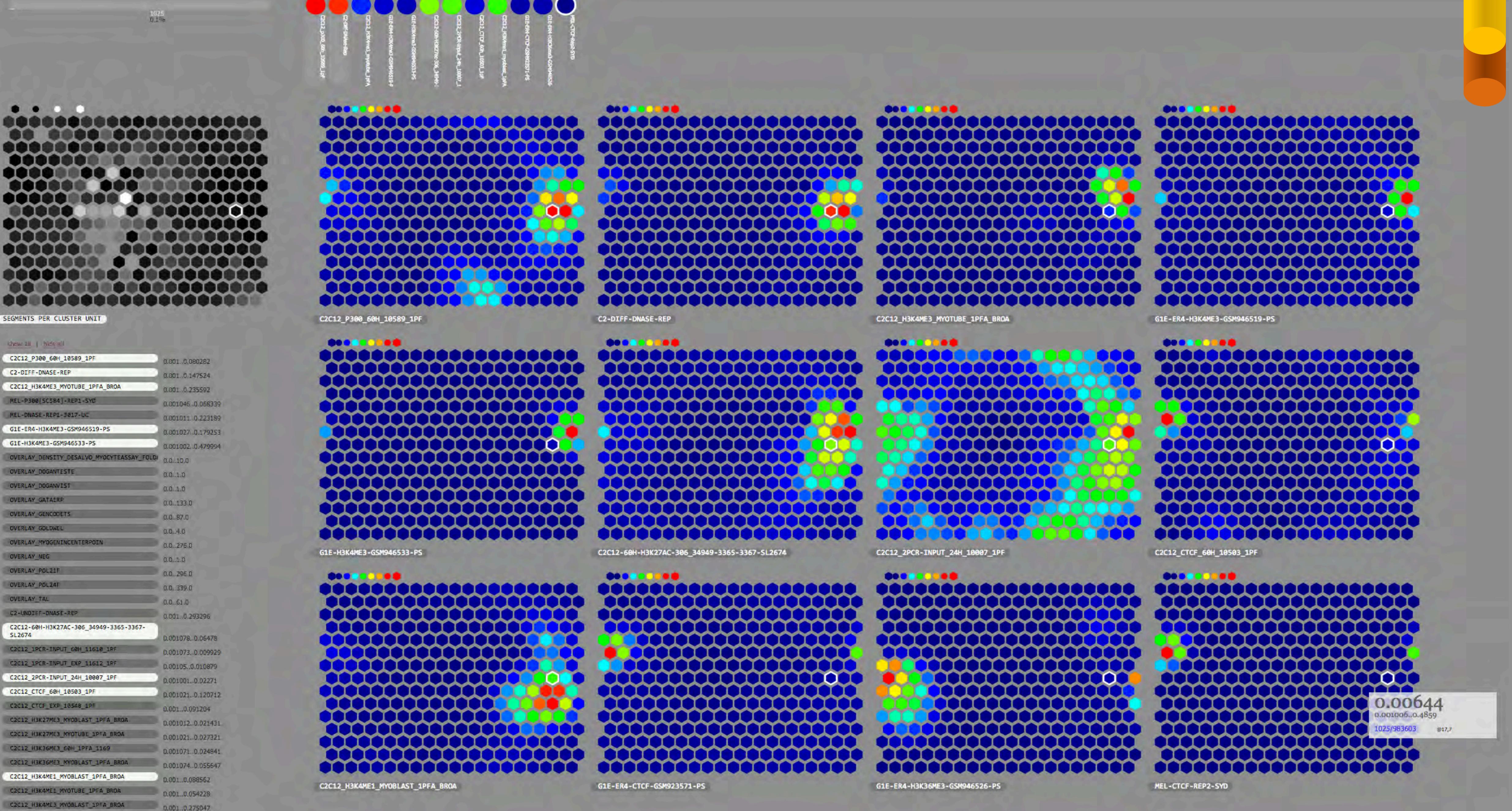


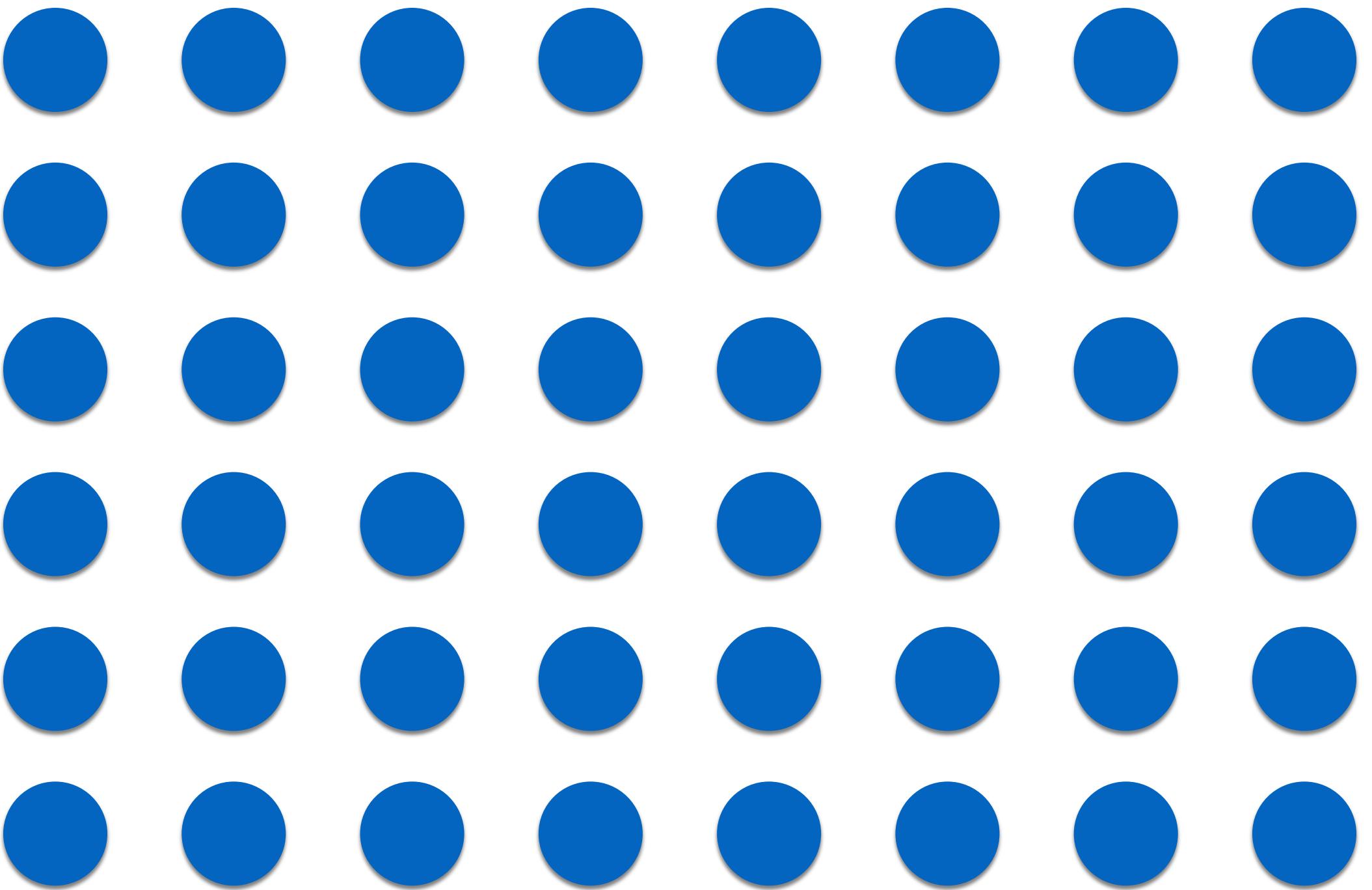
- Paraview^{VTK}
- LLNL VisIt^{VTK}
- EnSight^{\$}
- tableau^{\$}
- D3js^{WWW}
 - Many Eyes^{WWW}
- Modrian^R,
- TopCat, ...

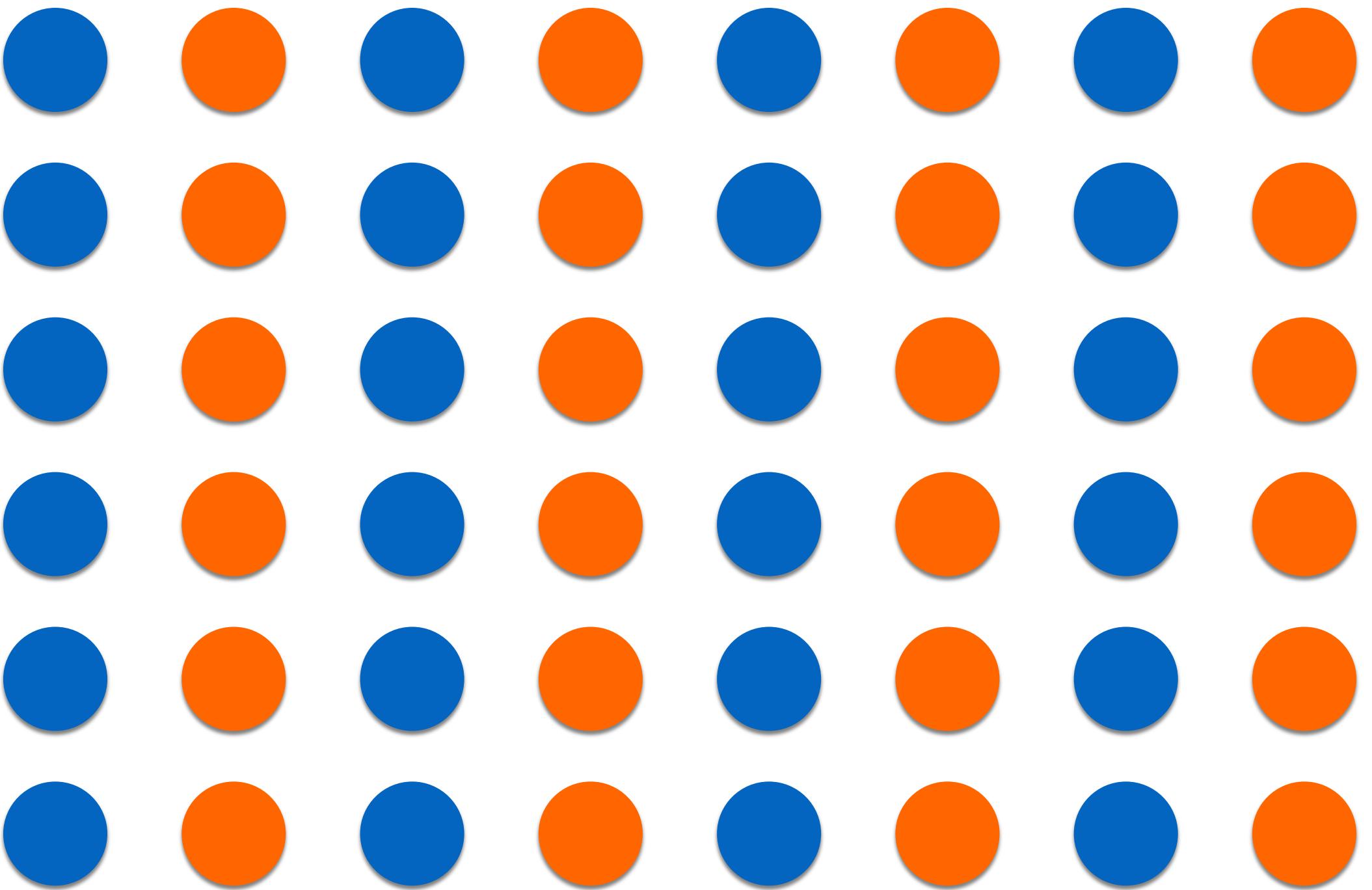
DATA TO GEOMETRY

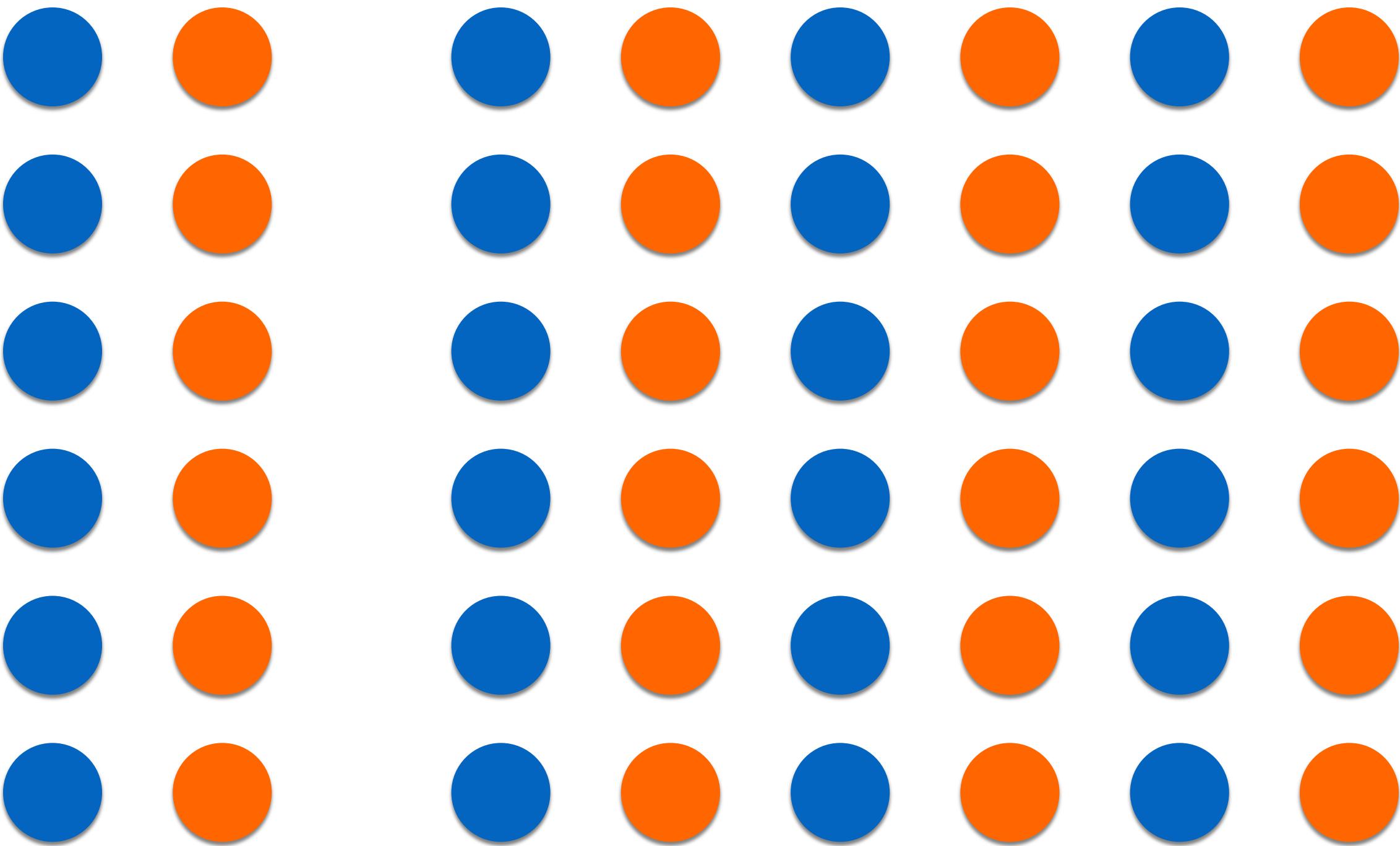


- D3.js^{WWW}
- VEGA.json^{WWW}

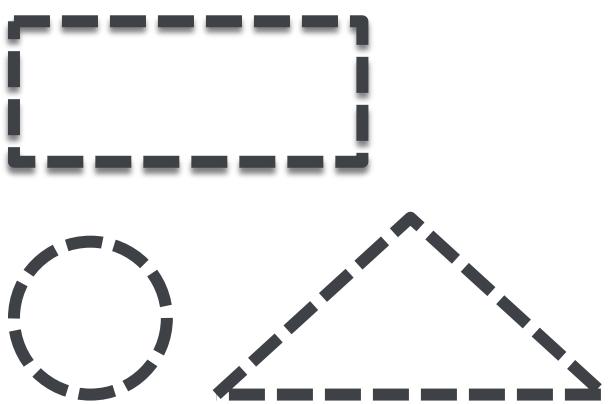




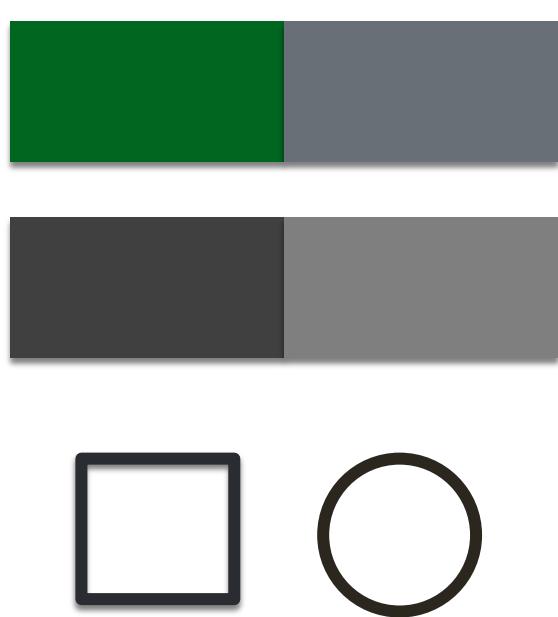




REPETITION

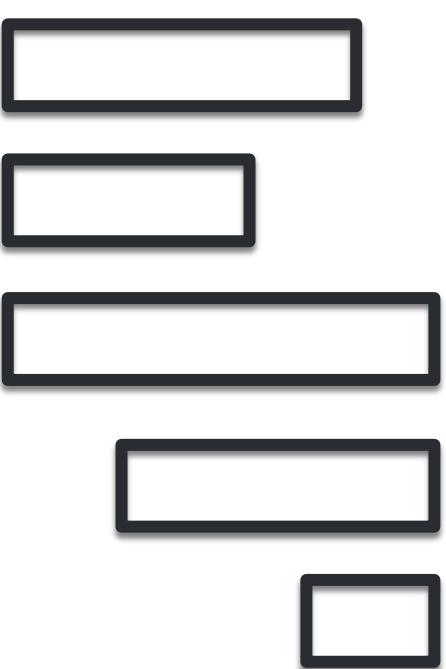


CONTRAST

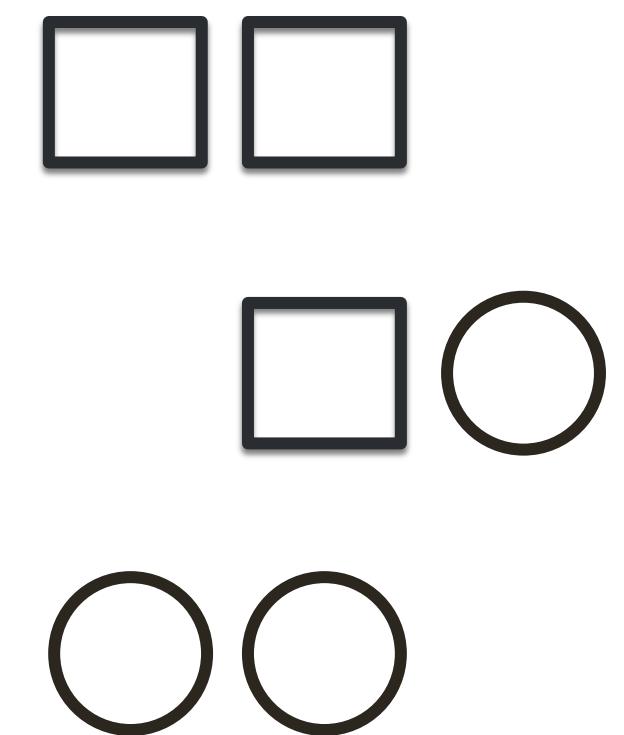


USE DESIGN TO SHOW RELATIONSHIPS

ALIGNMENT



PROXIMITY



DOMINANCE



USE DESIGN TO PURPOSEFULLY
CONVEY IMPORTANCE

READ ORDER

HUE



SATURATION



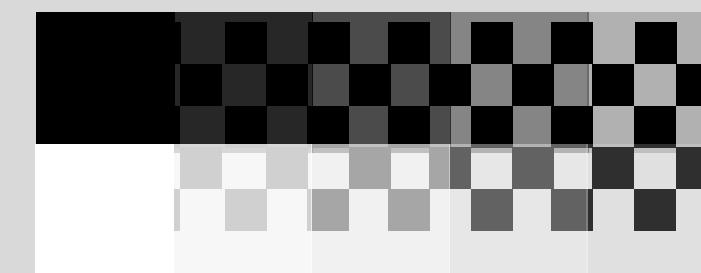
VALUE



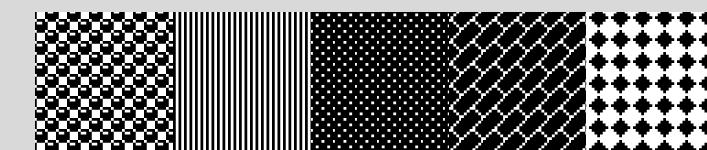
BALANCE



OPACITY



TEXTURE



SIZE



DESIGN

2D DESIGN

CAVEATS

CHART JUNK

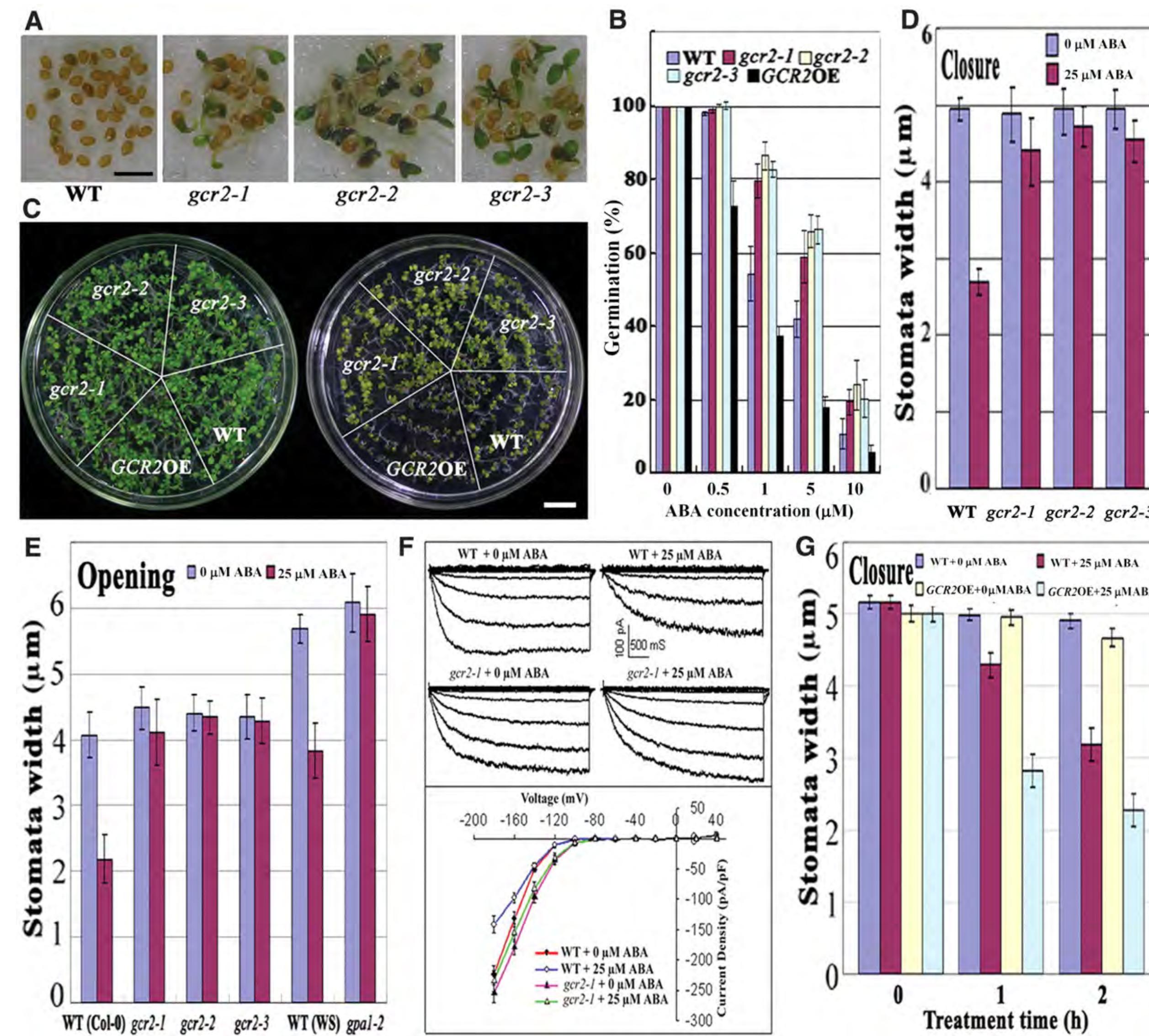


Fig. 2. The *gcr2* mutants exhibit all known ABA defects.

SIMPLIFY

_ REMOVE JUNK

_ RE-PLACE REPETITIVE ELEMENTS

_ USING DESIGN TO MAKE MEANING CLEAR AT A GLANCE

Sales per Salesperson (Aug vs Sep)

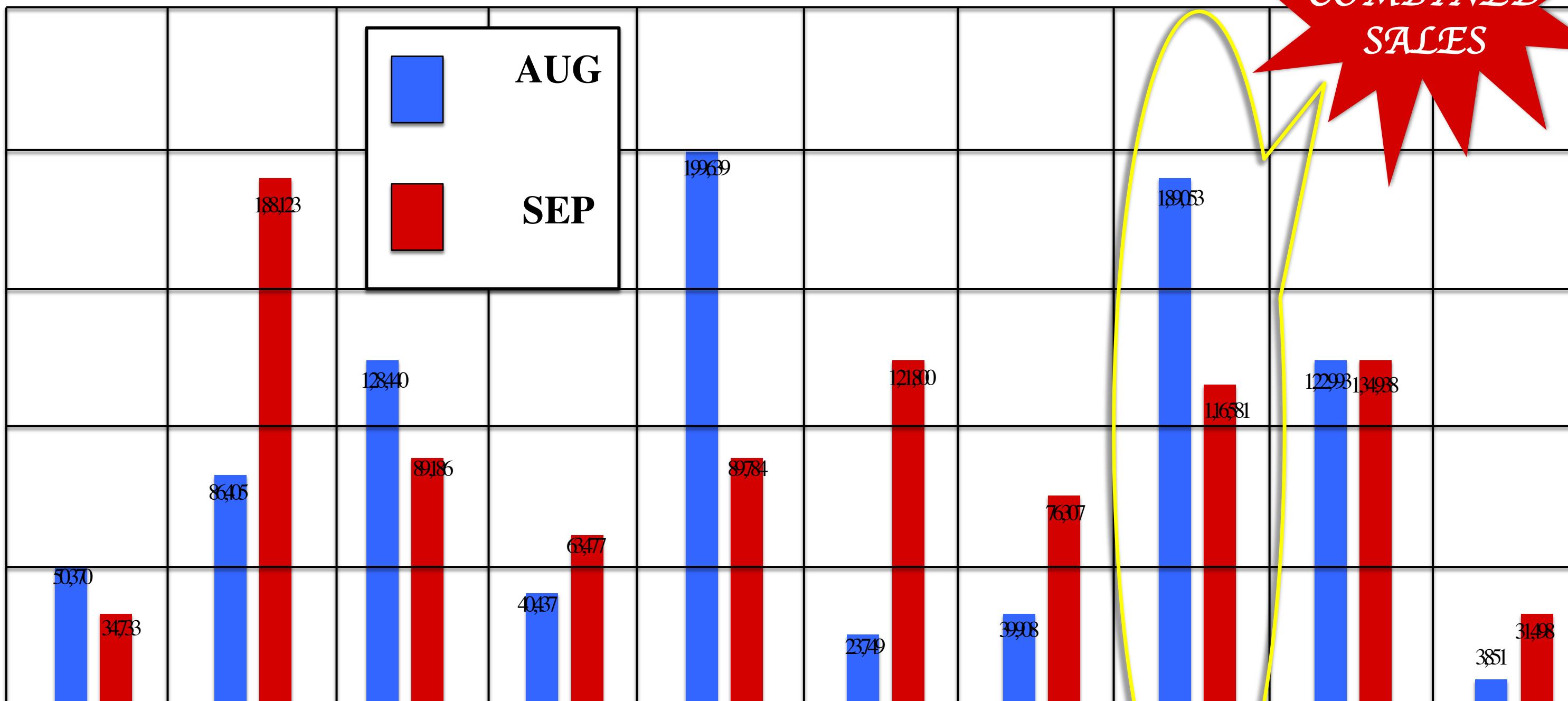
2,50,000

2,00,000

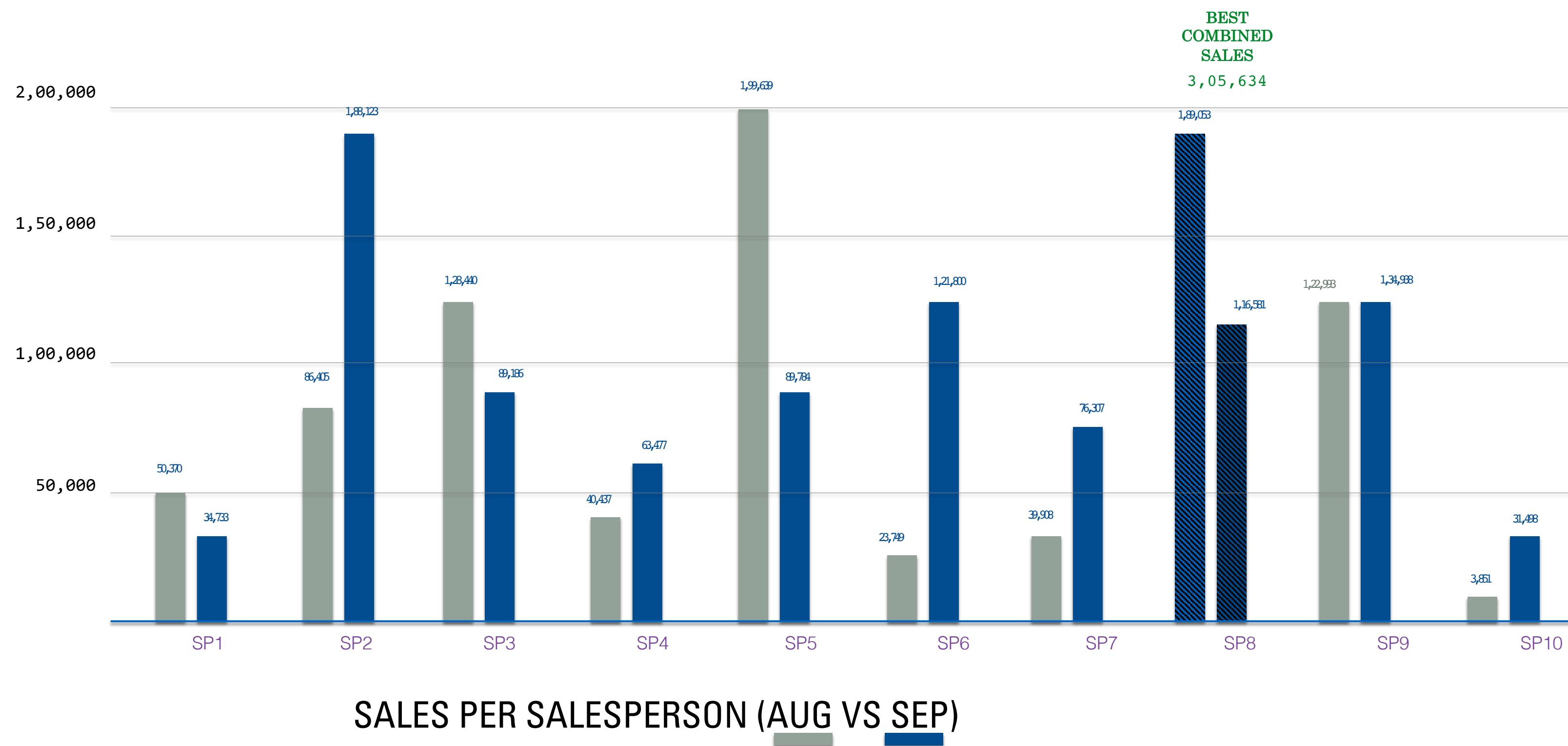
1,50,000

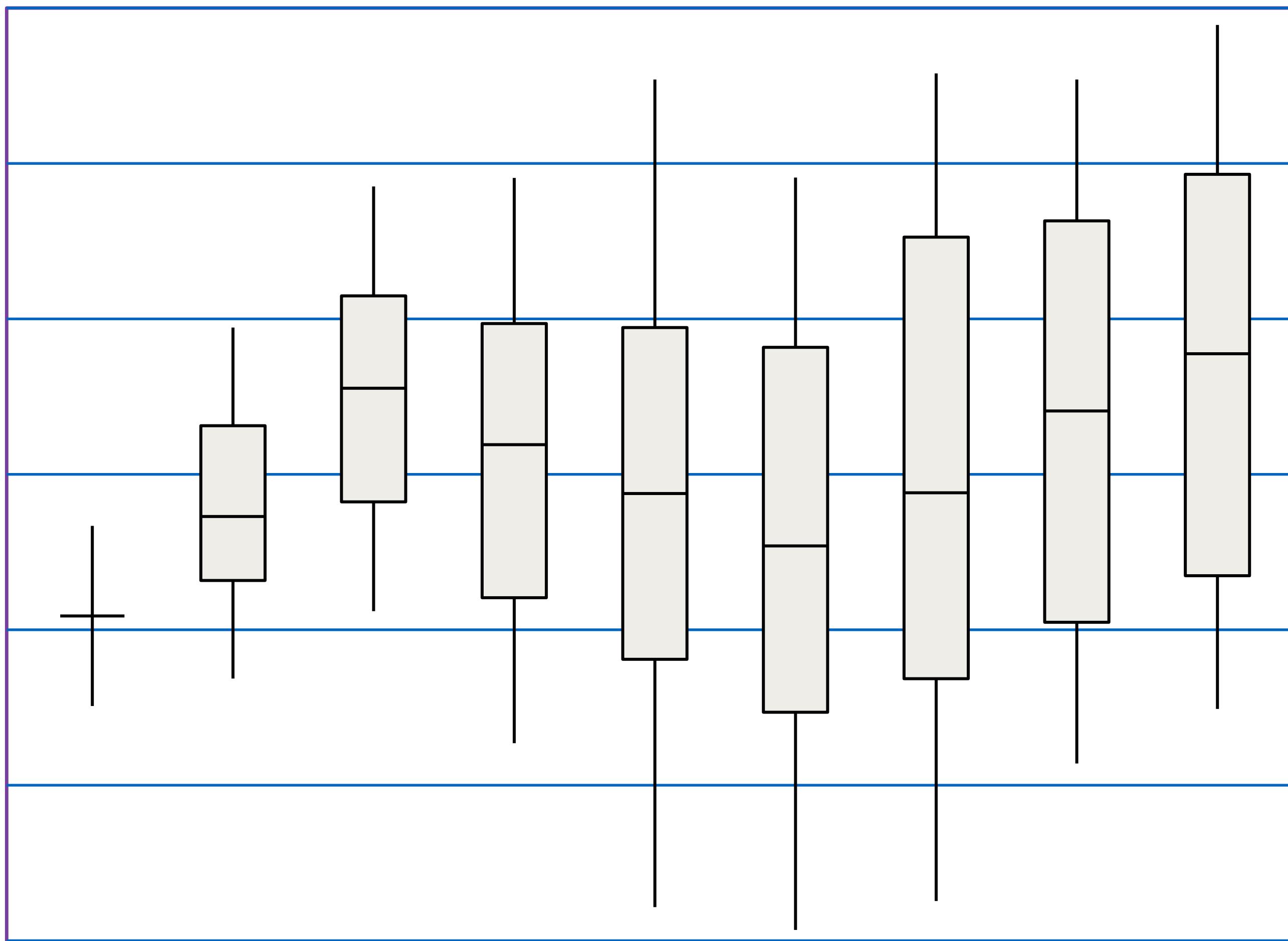
1,00,000

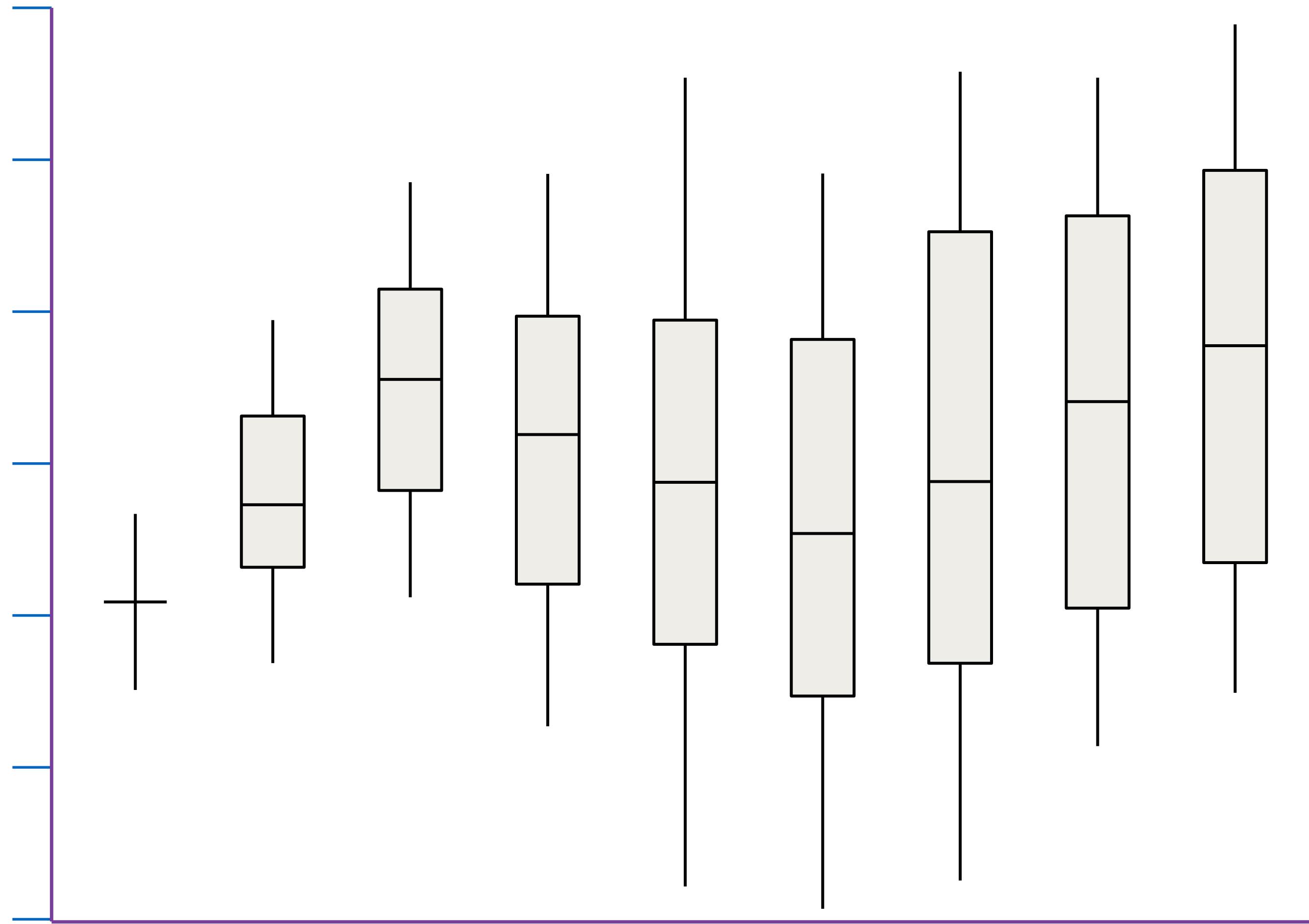
50,000

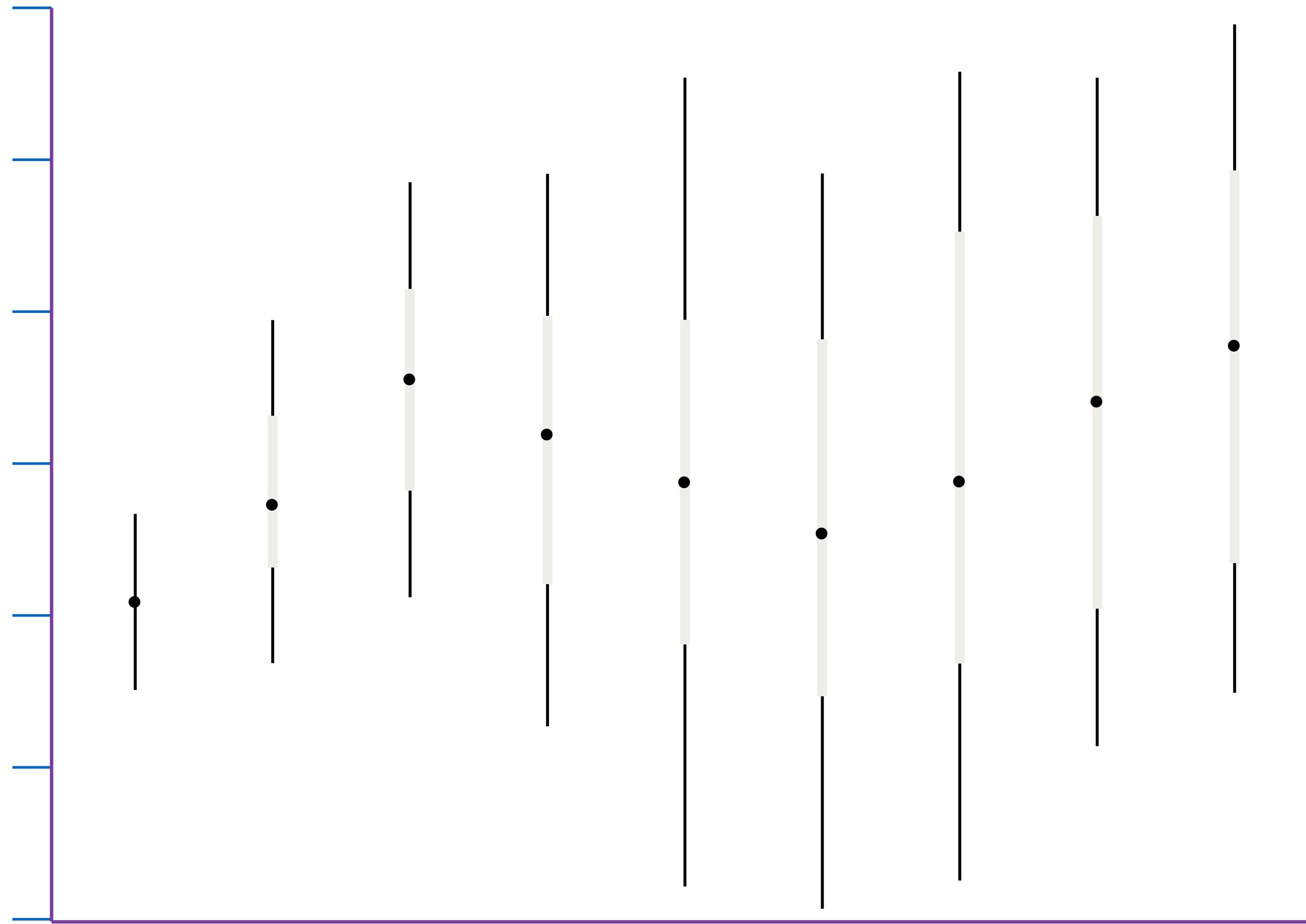


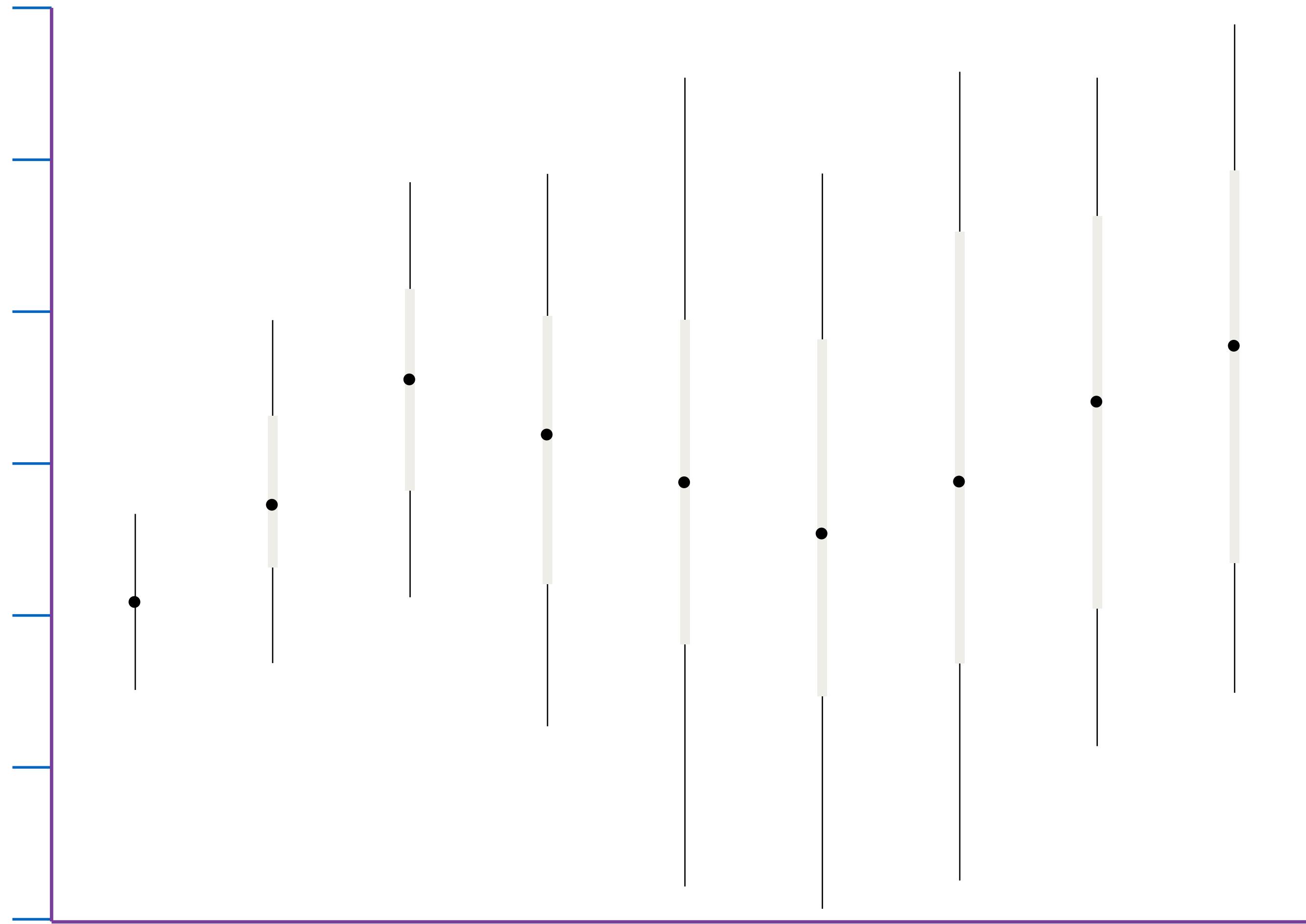
BEST
COMBINED
SALES



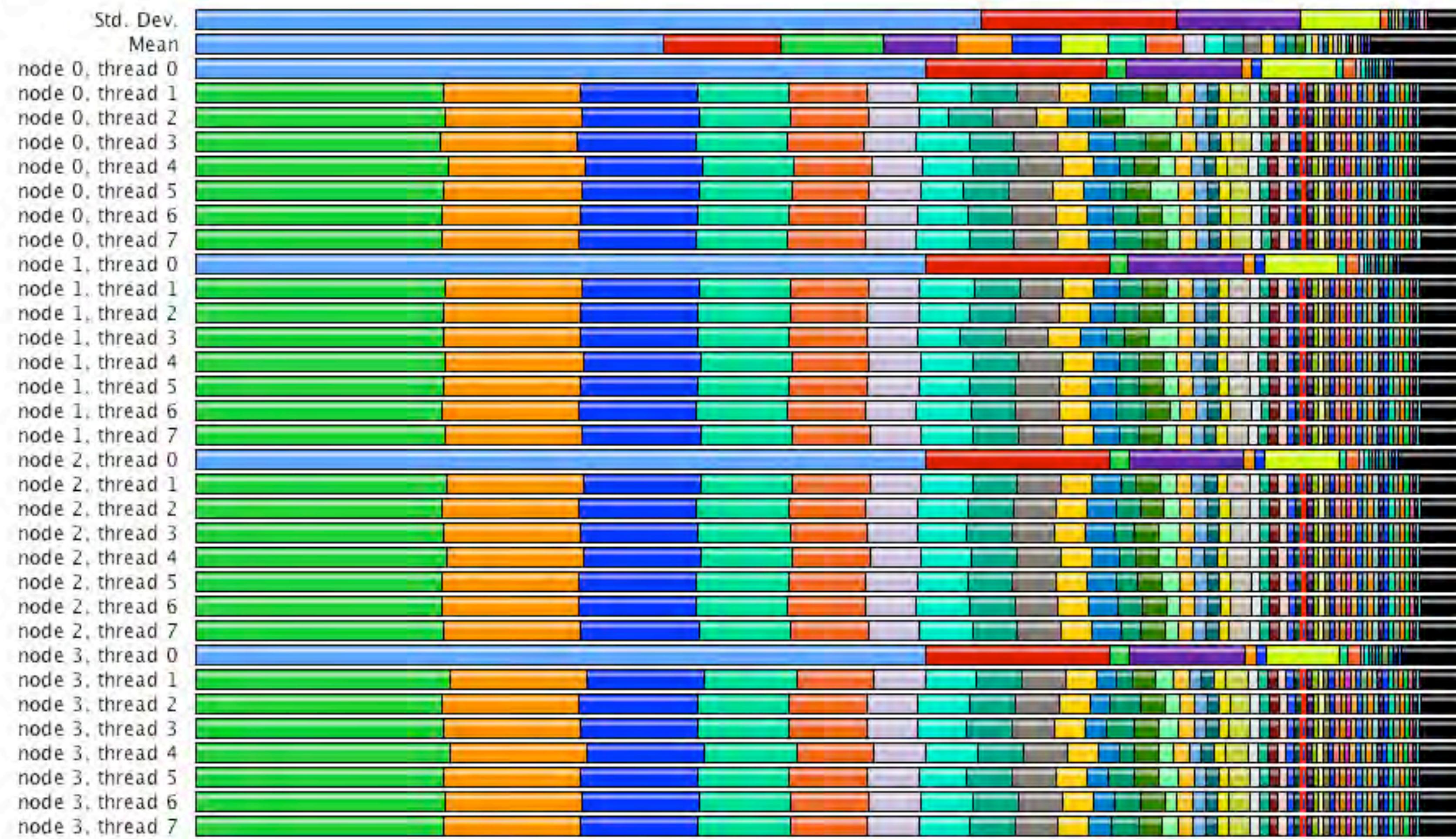




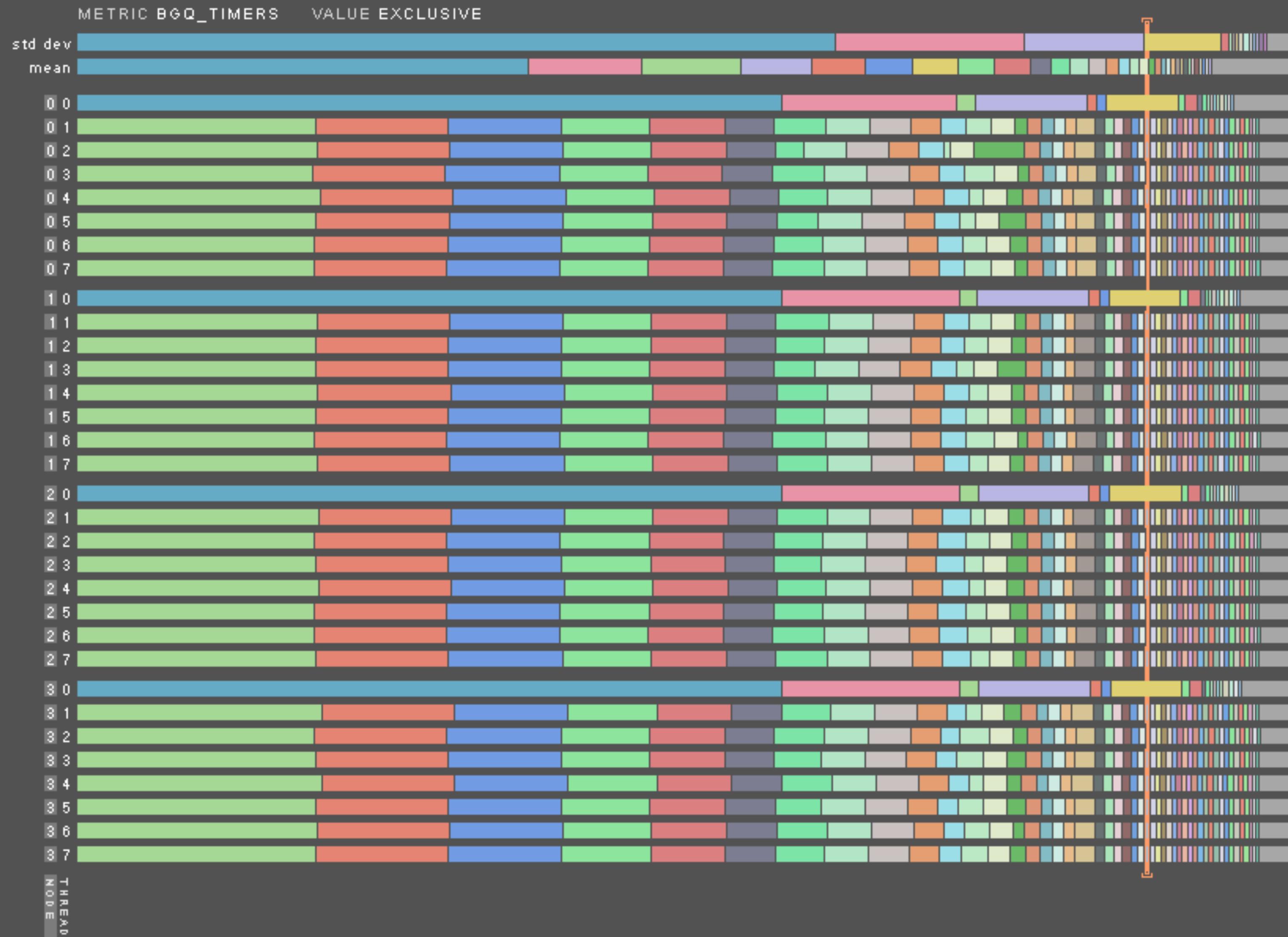




Metric: BGQ_TIMERS
Value: Exclusive

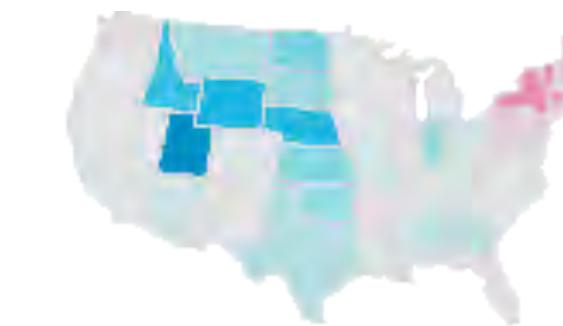
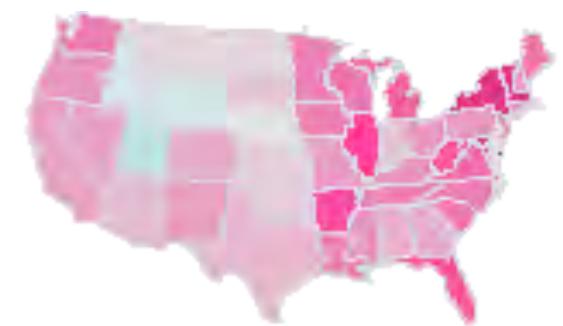
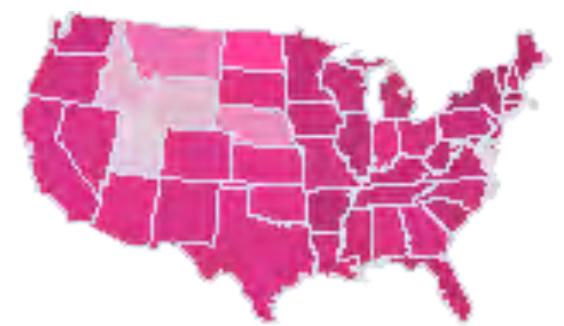
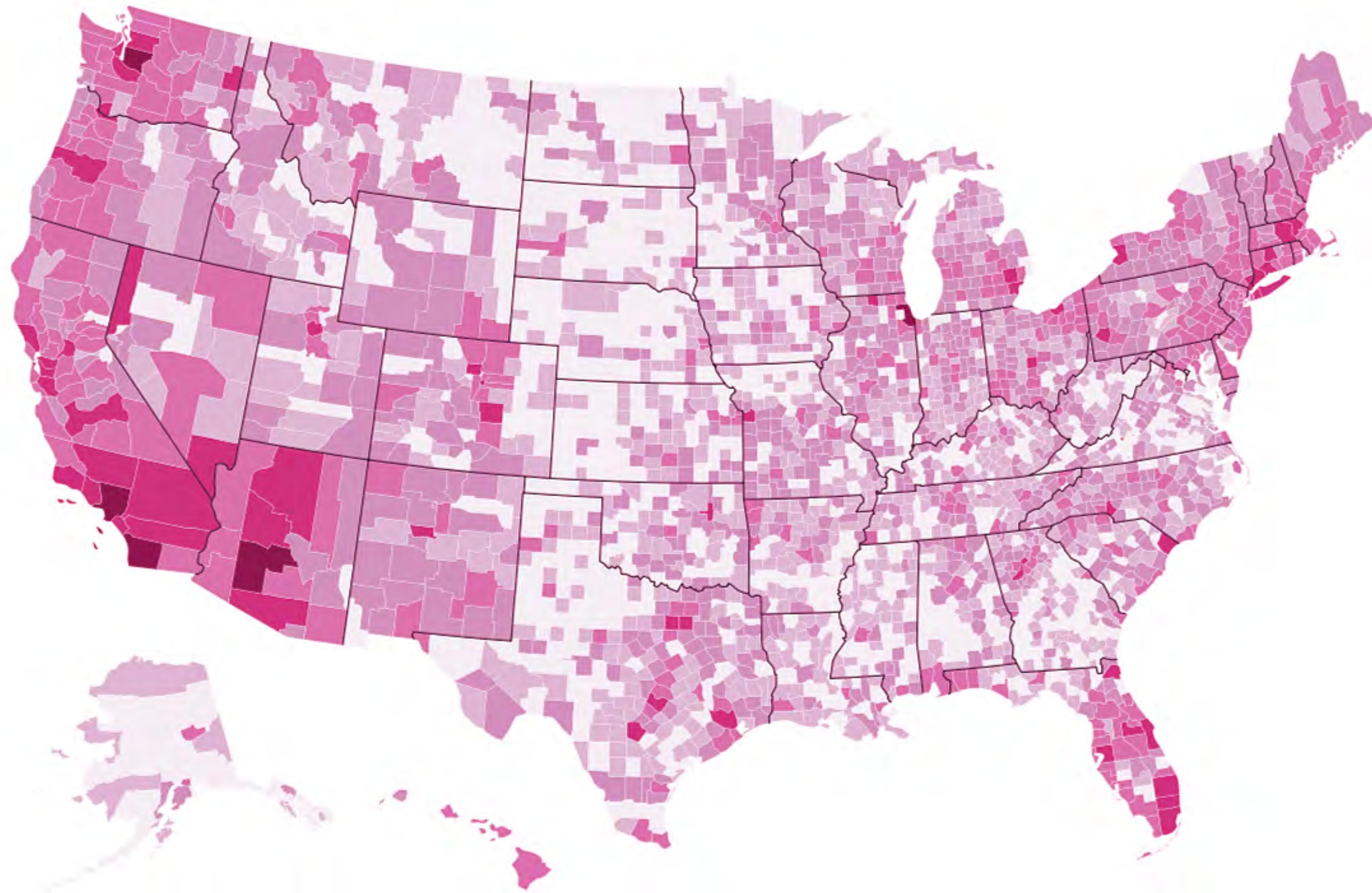




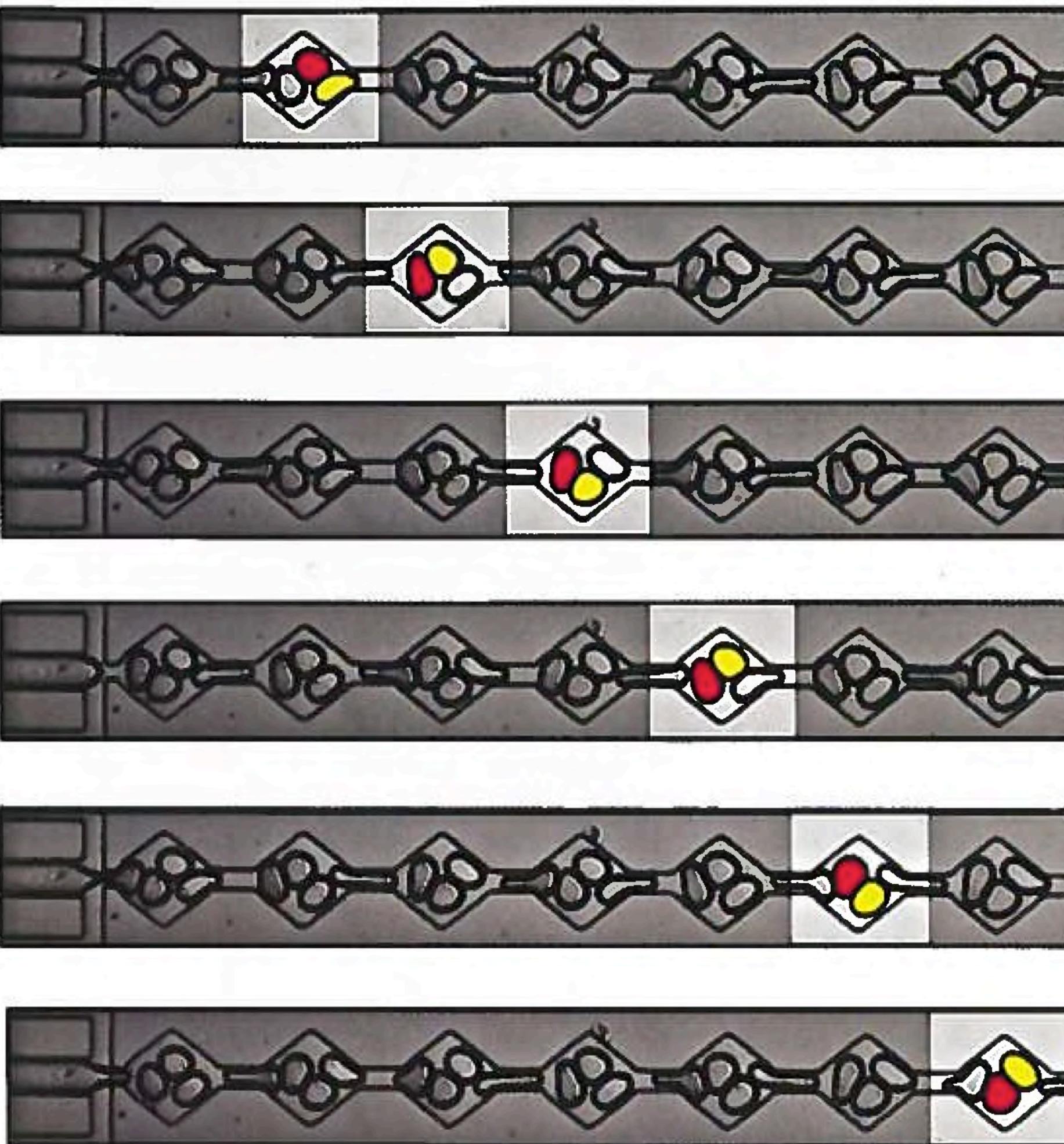


cool

HEATMAPS: SATURATION + VALUE DRAW ATTENTION



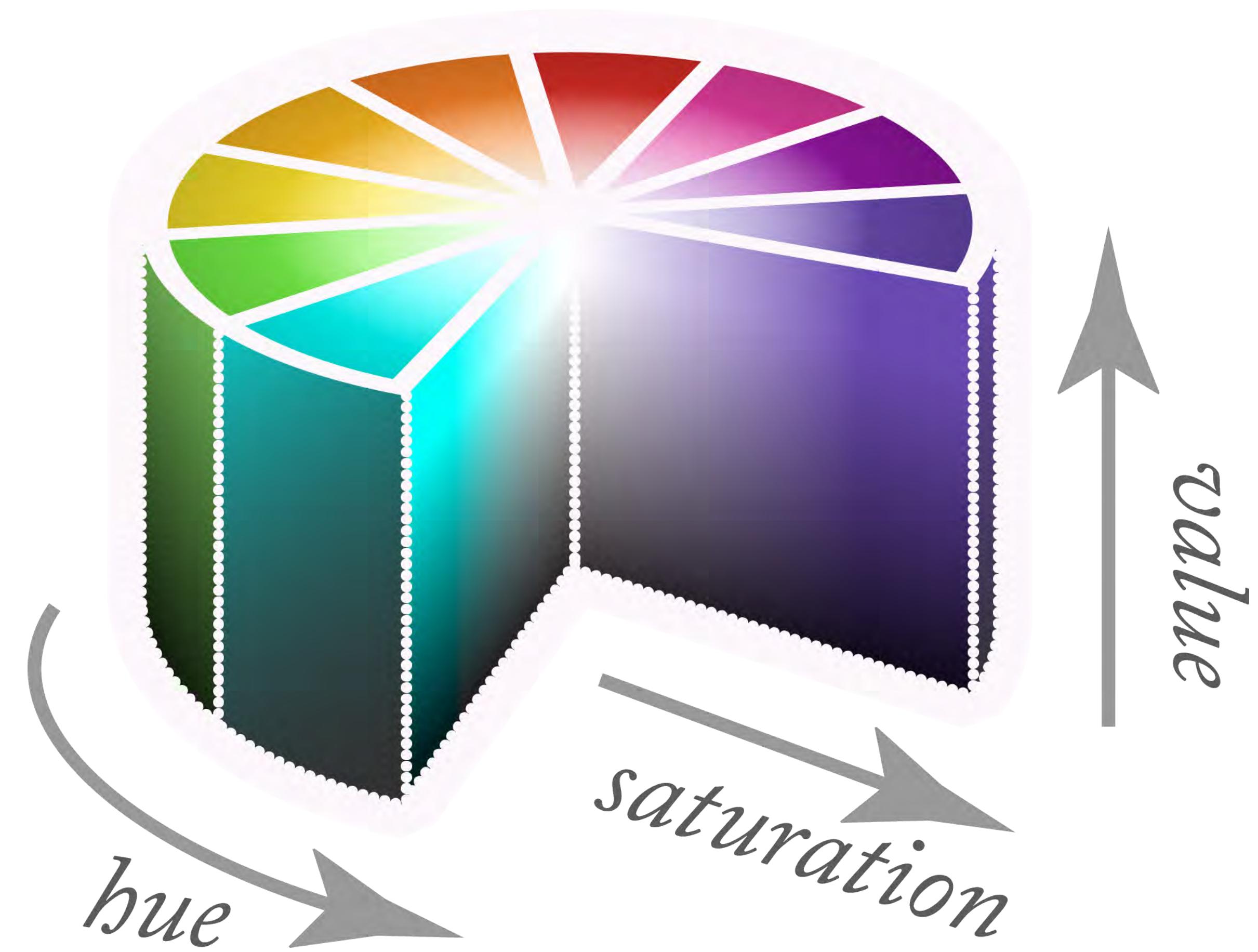
Hue + VALUE Draw ATTENTION

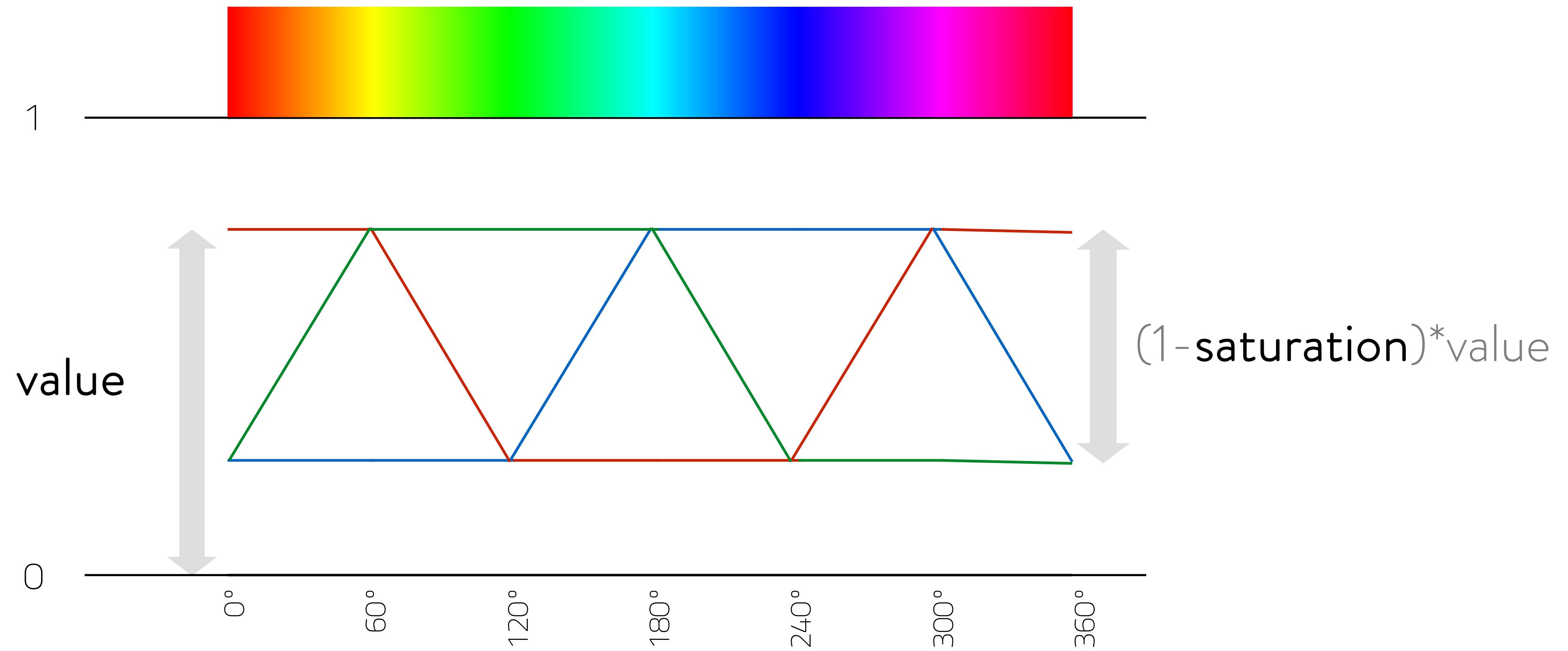


Bubbles moving in a microfluidic device.
Appl Phys Lett, 2004.
This figure shows a selection of "grab" shots from a video in which bubbles alternate between top and bottom positions as they flow through a channel. The addition of hand-coloring follows two selected bubbles.

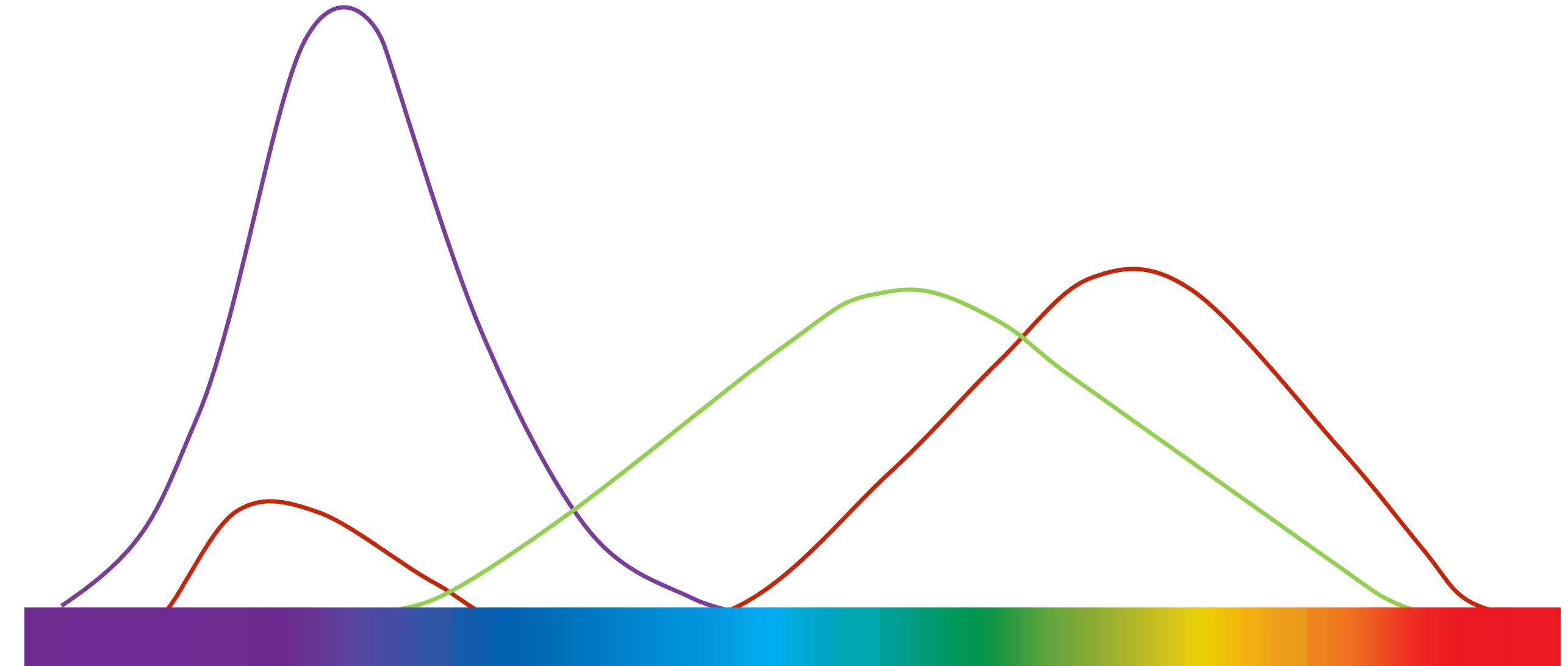
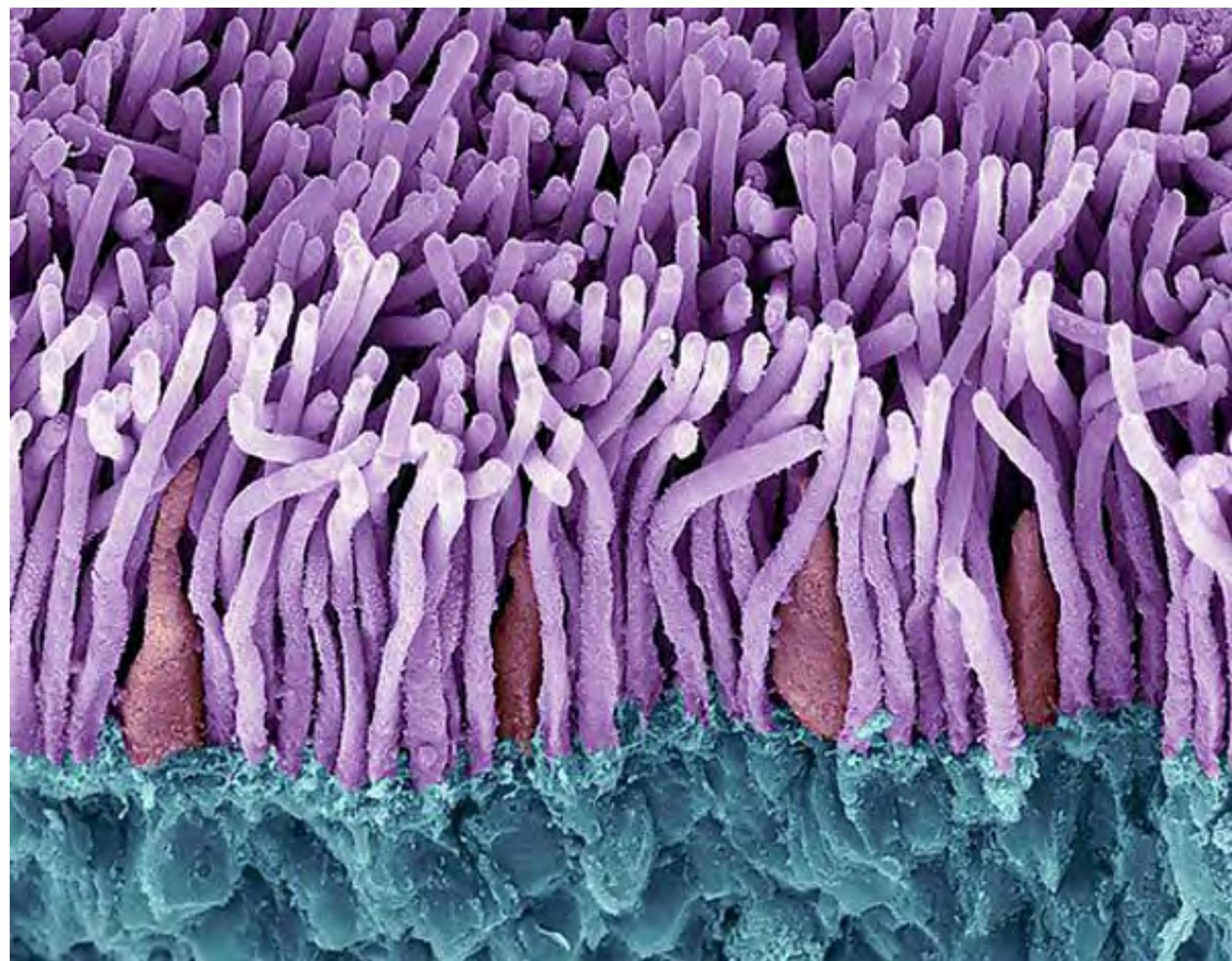
Source: dePace, Angela and Felice C. Frankel, Visual Strategies.









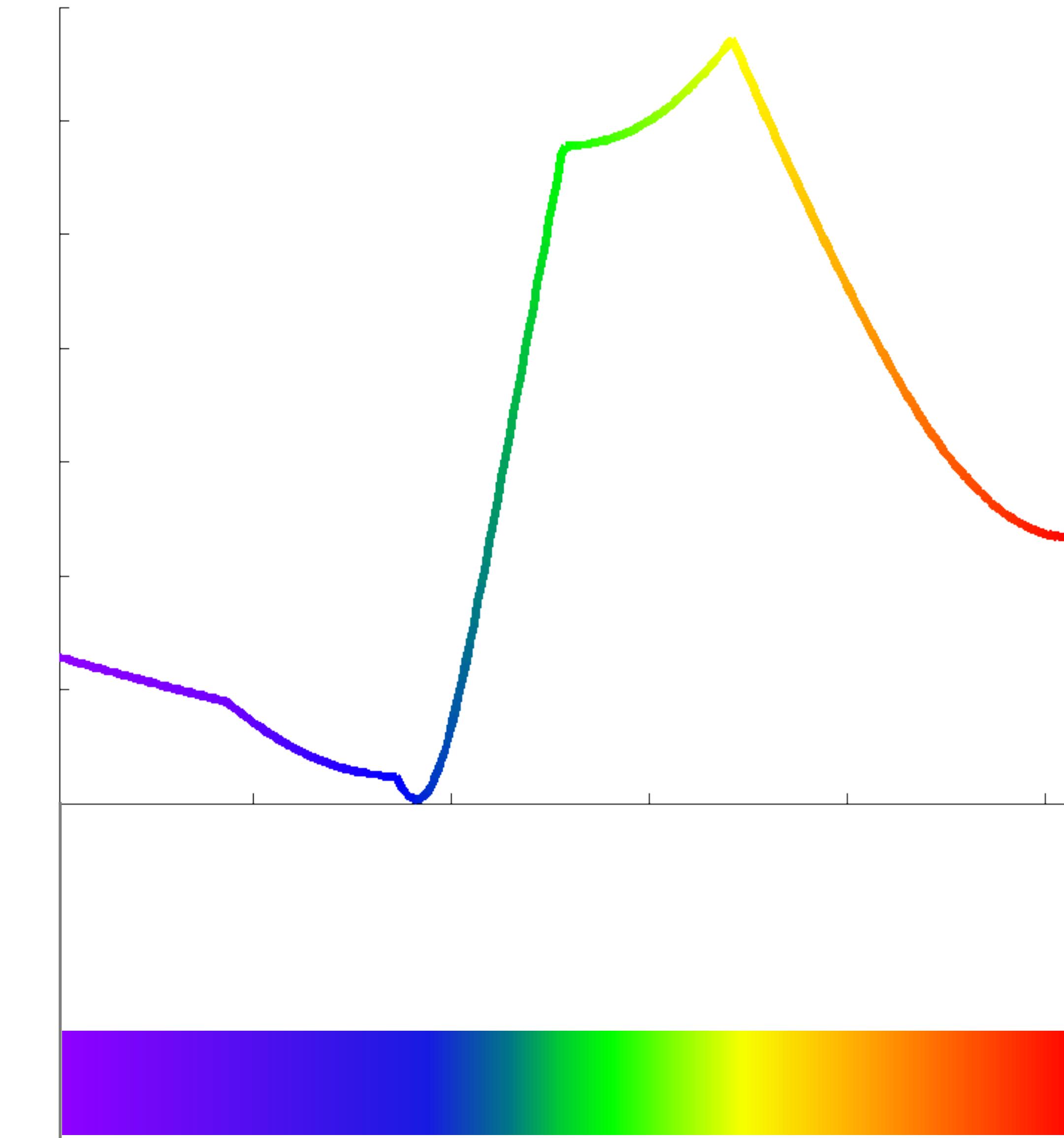


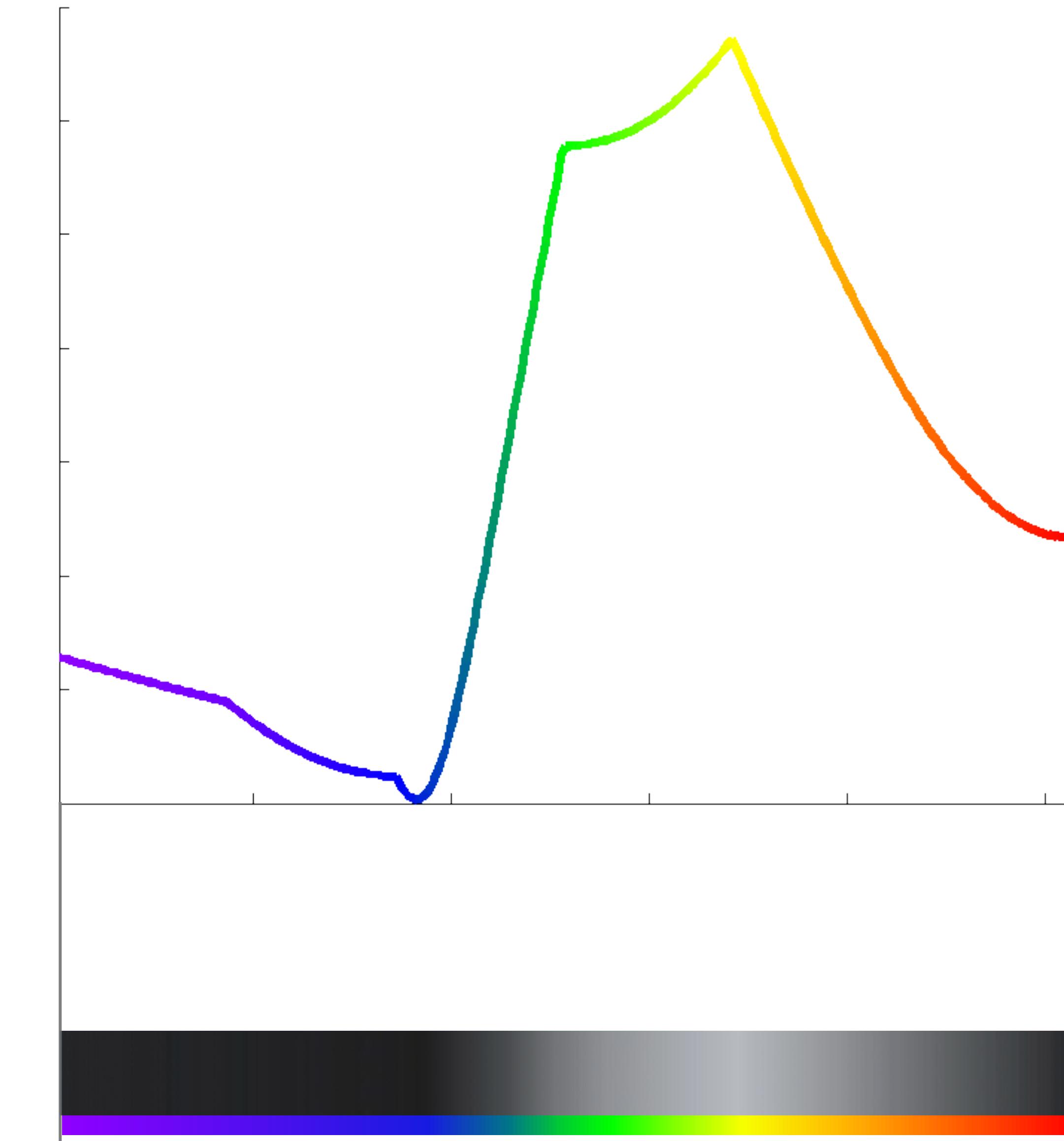
_rods
grayscale

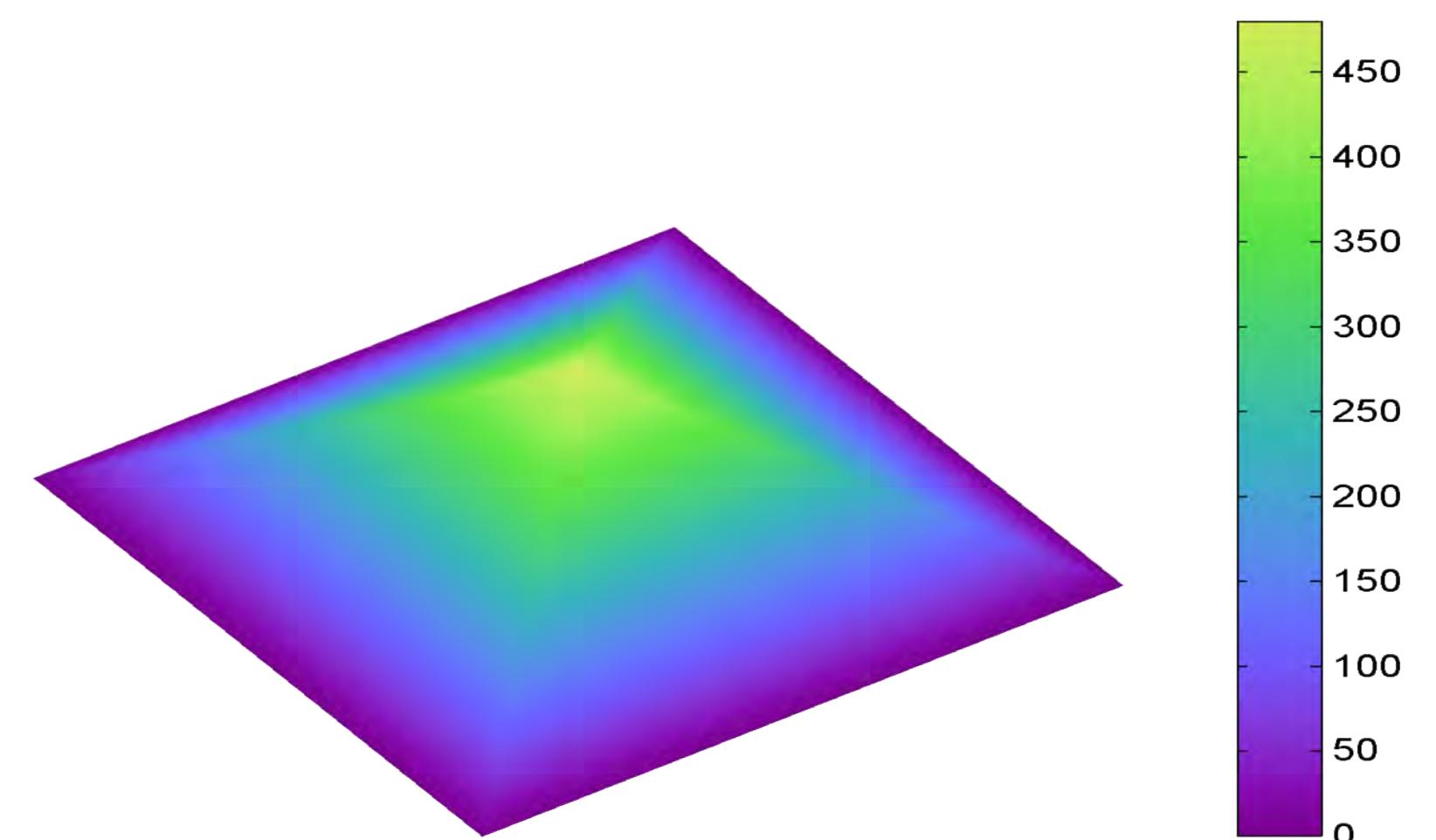
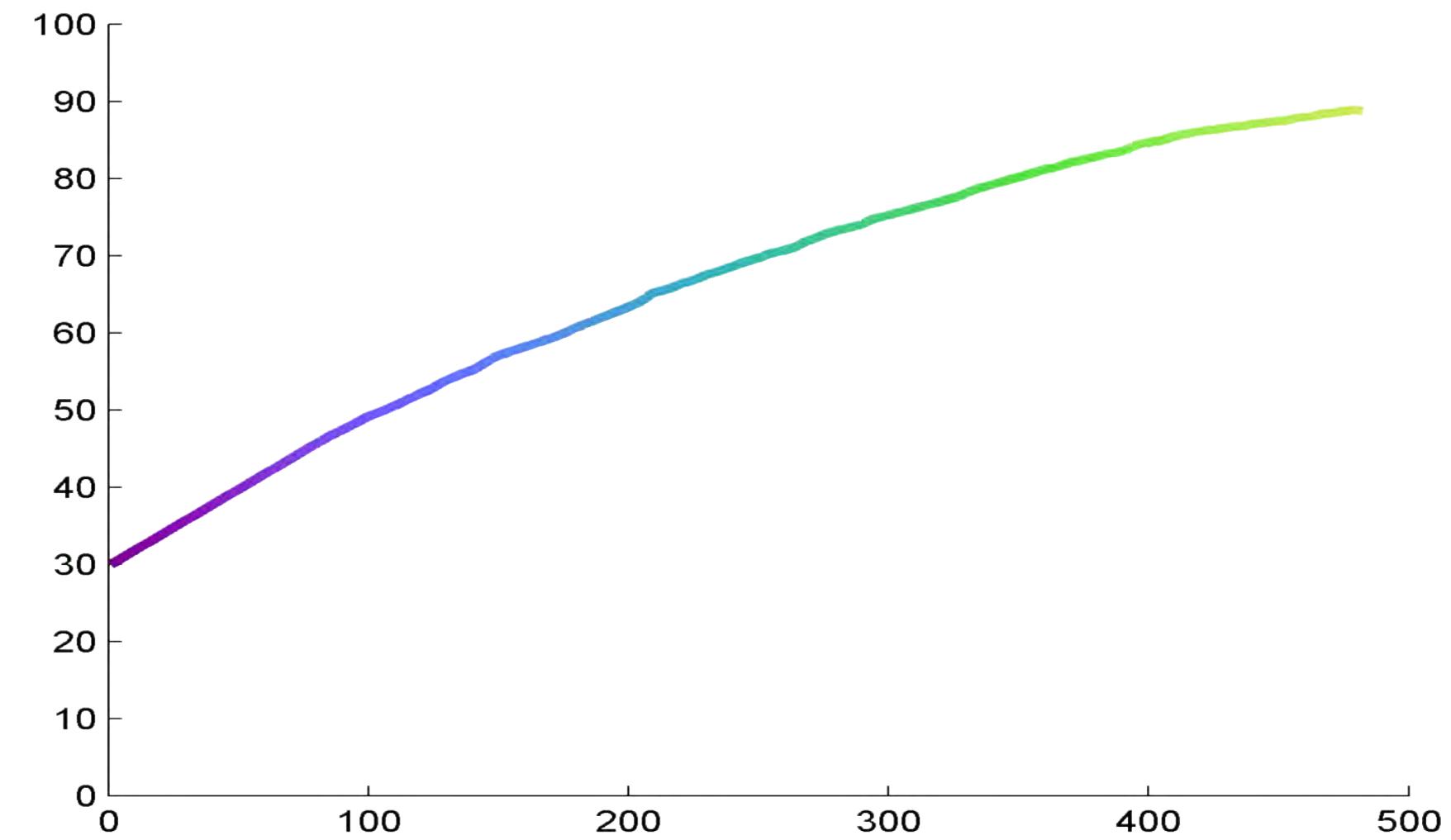
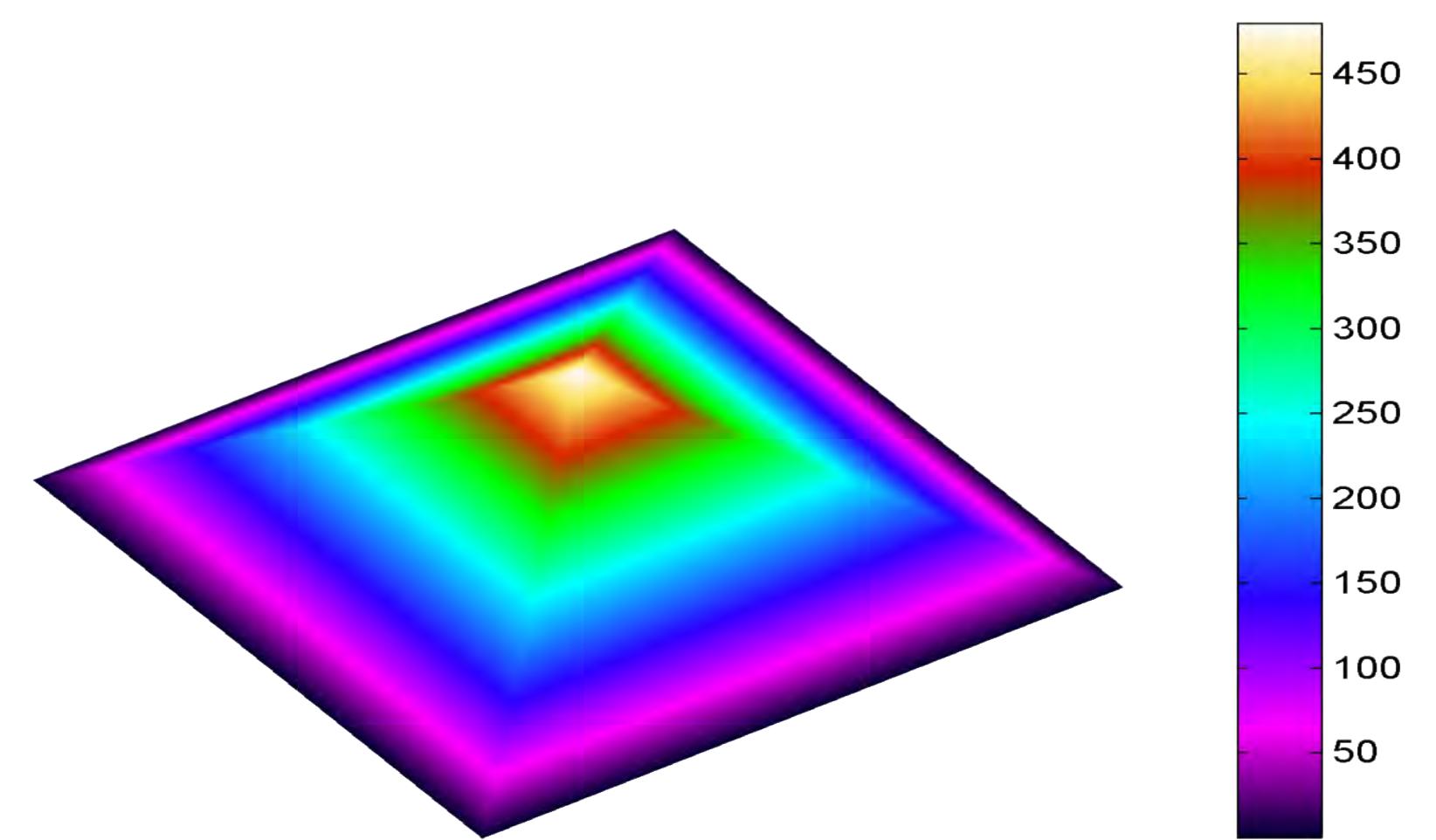
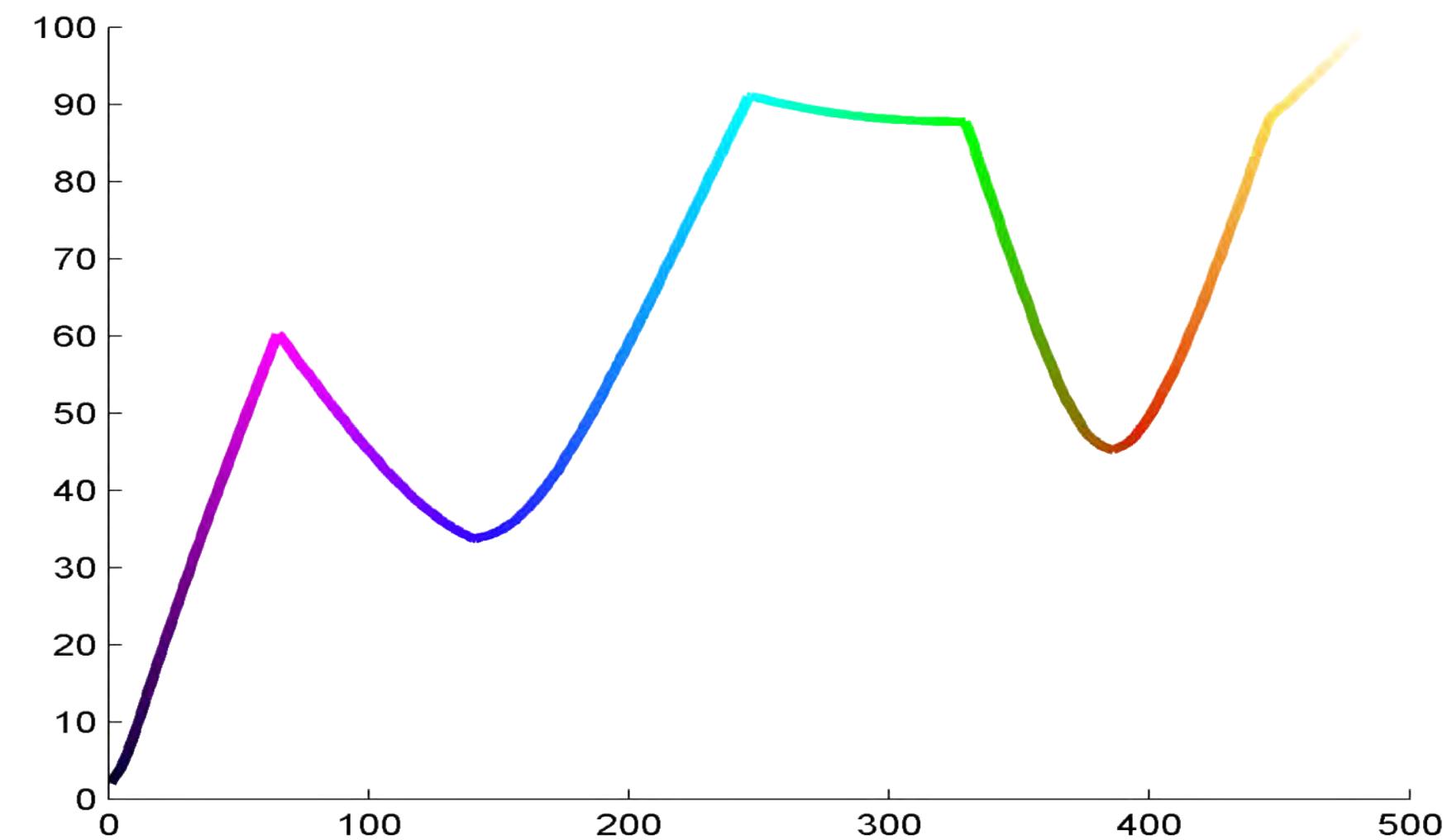
100 million
low light
less sharp

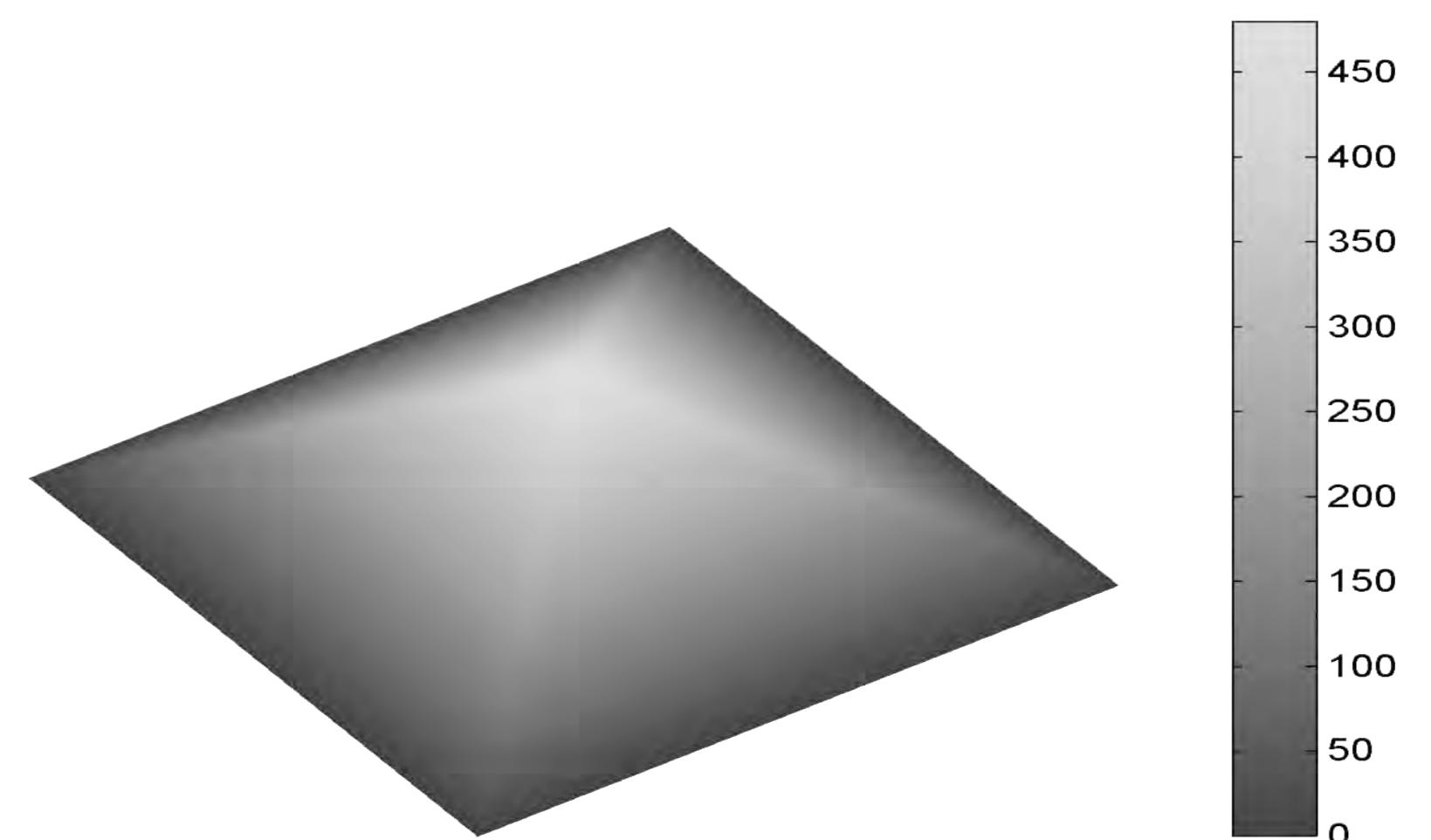
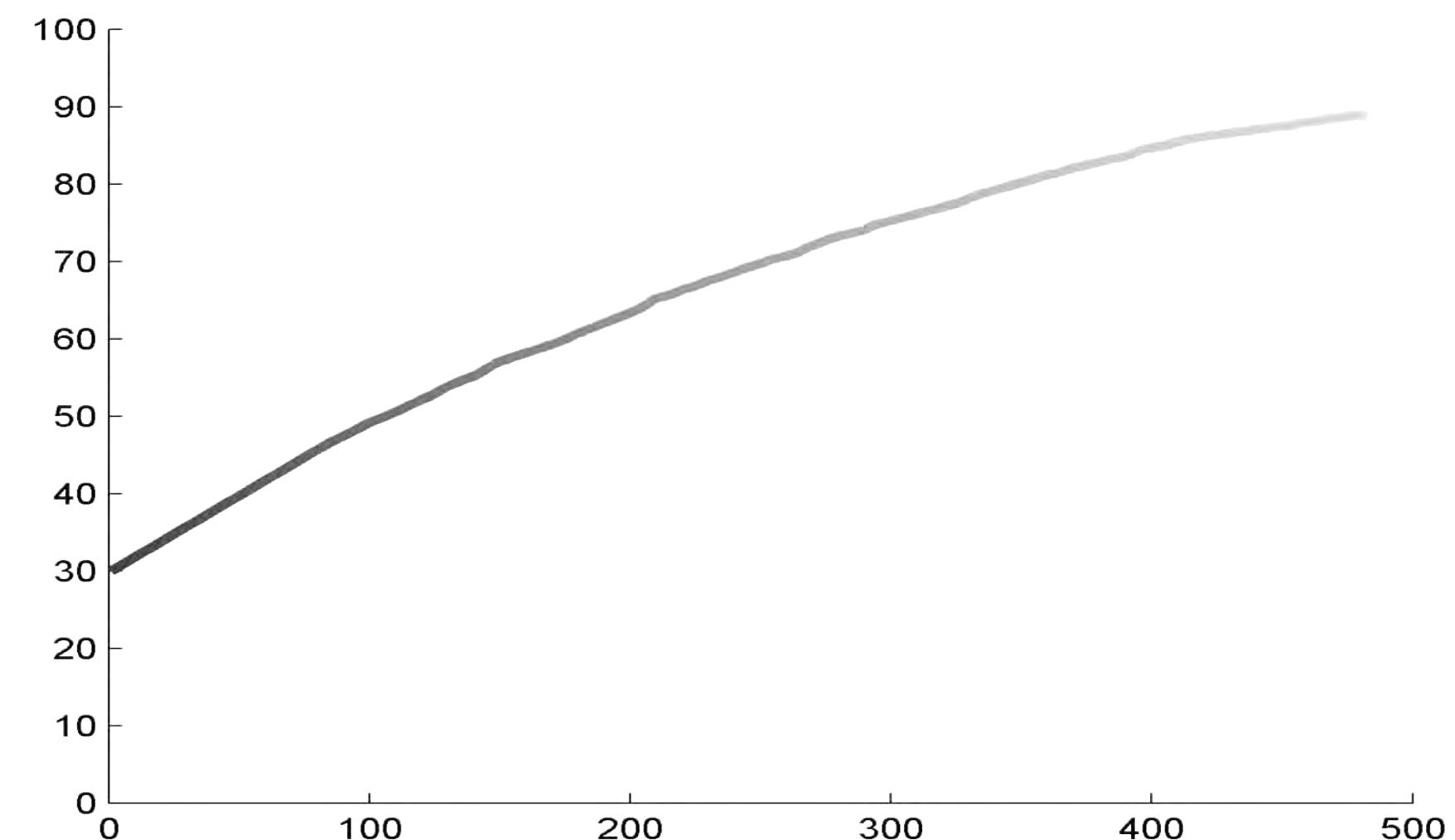
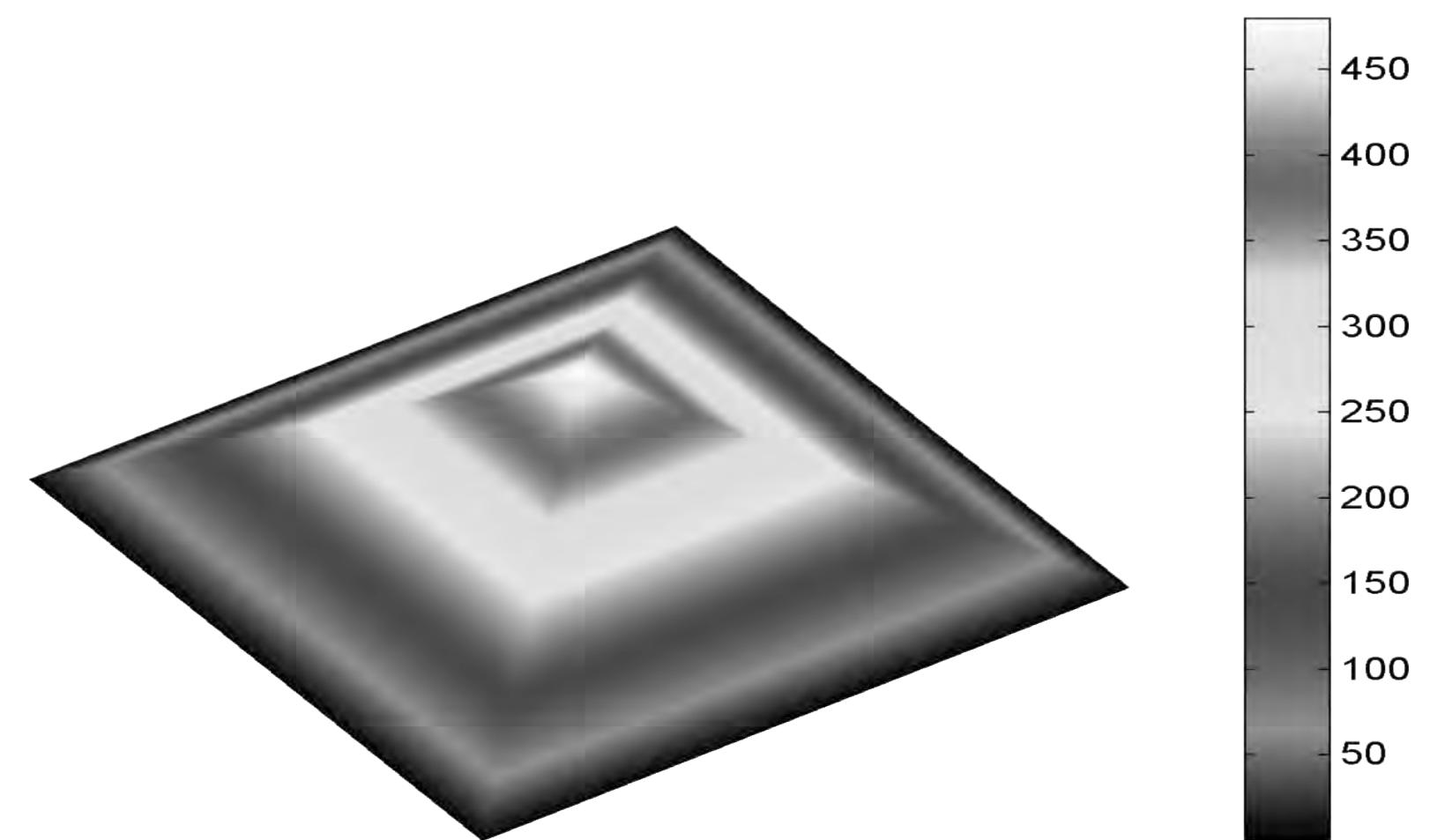
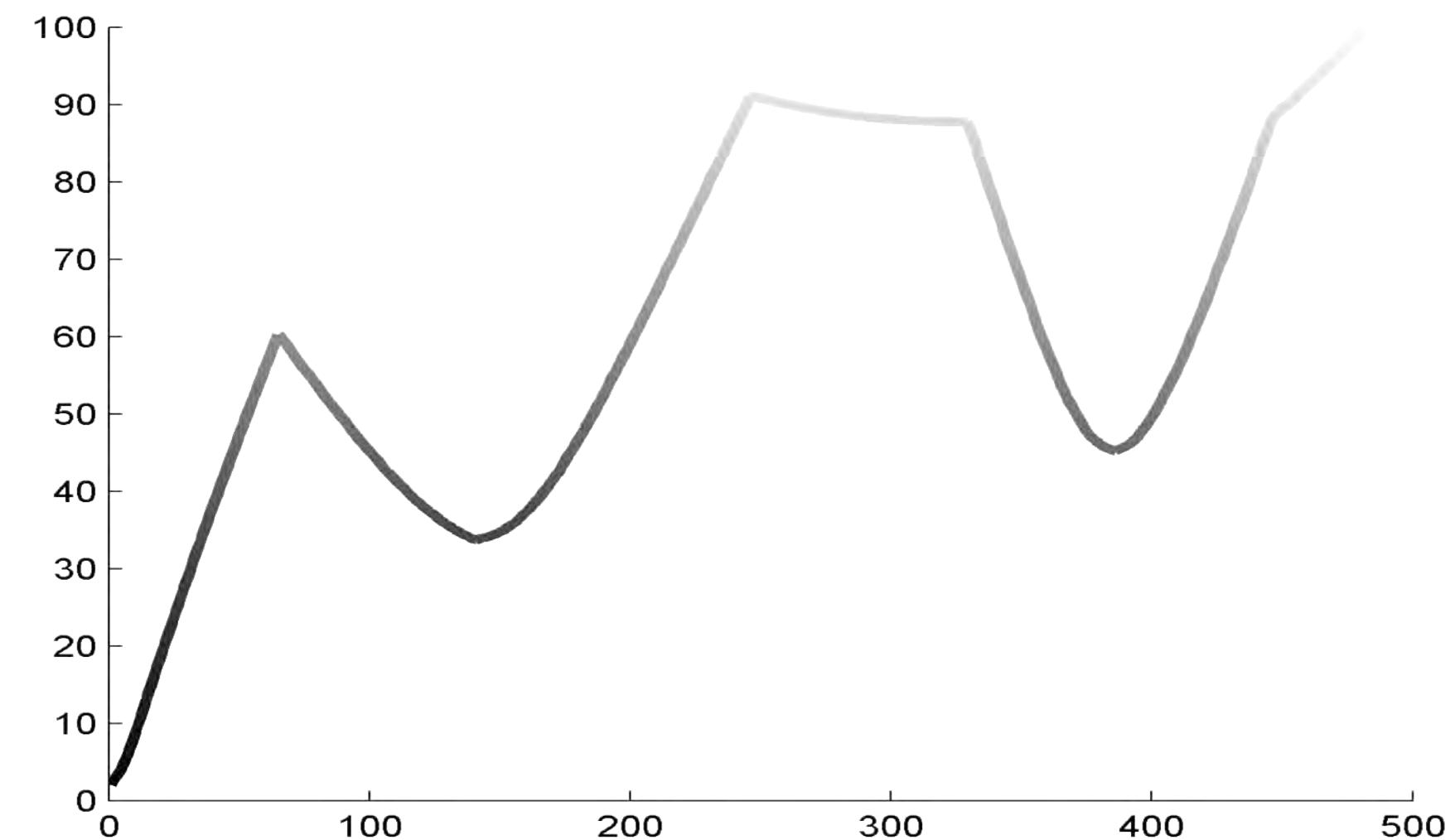
_cones
red | green | blue/violet

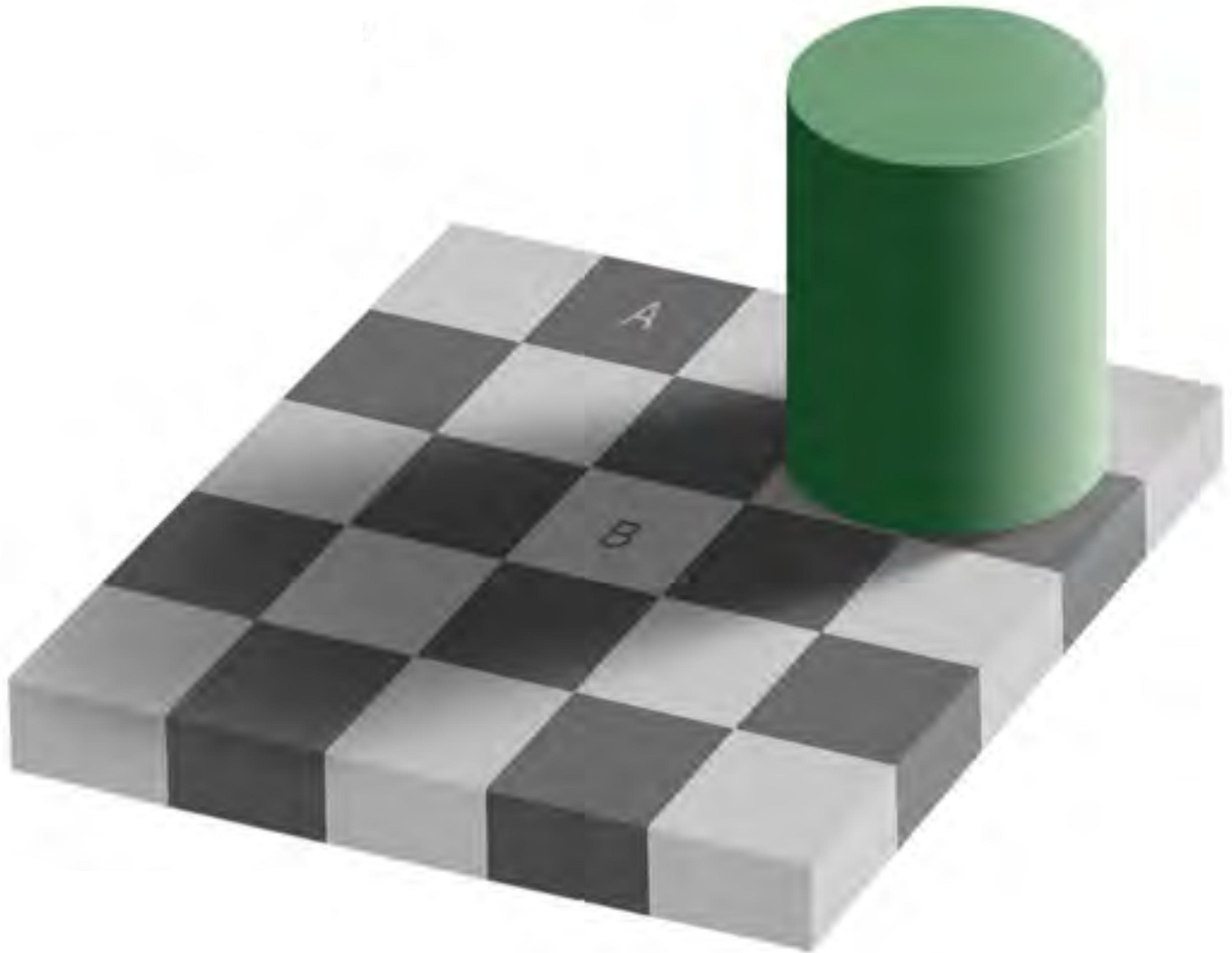
6 million
blue less sensitive
some fovea for extra detail

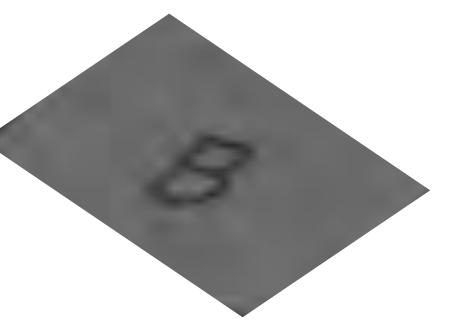
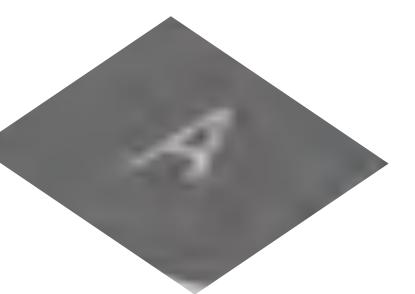


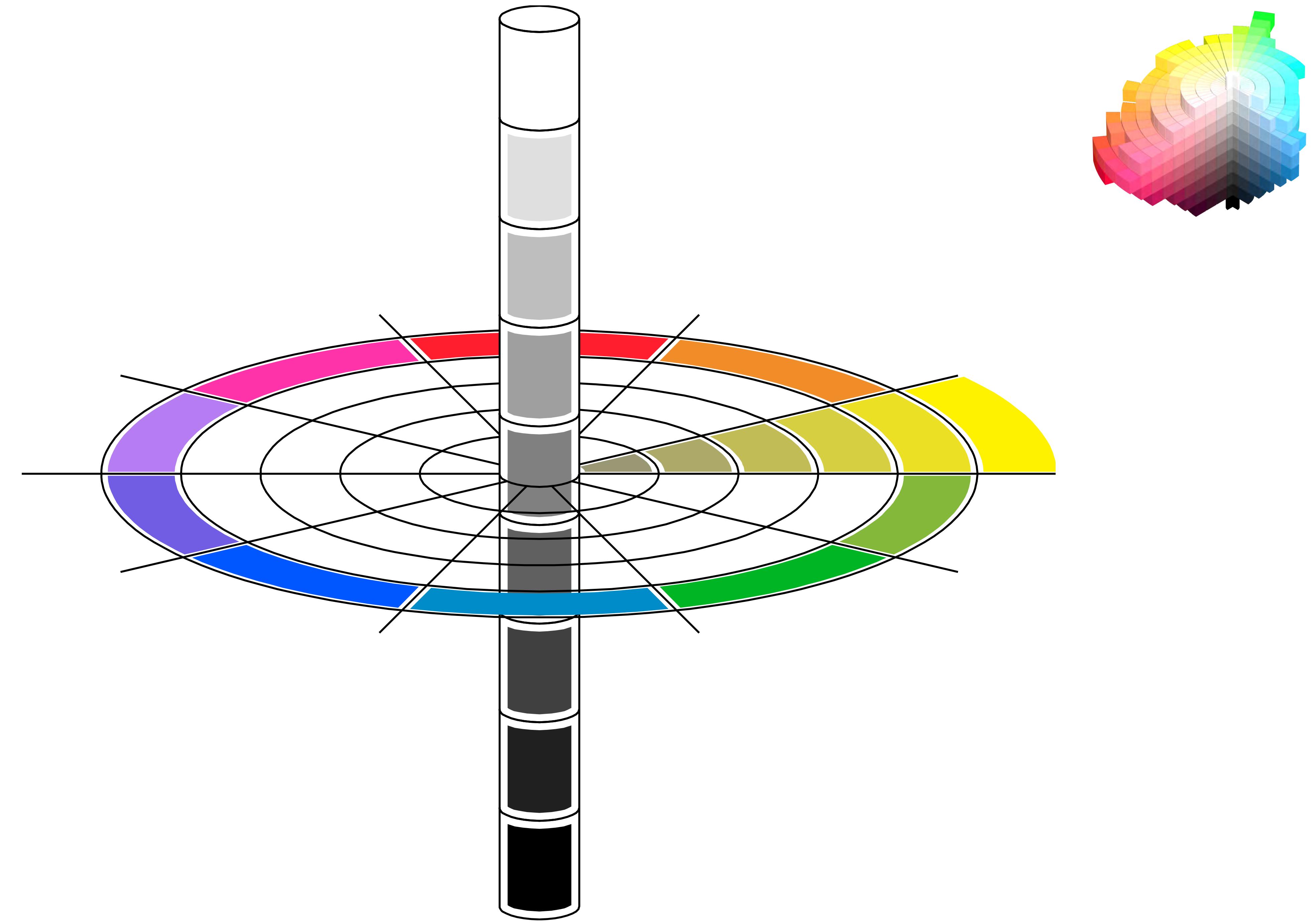


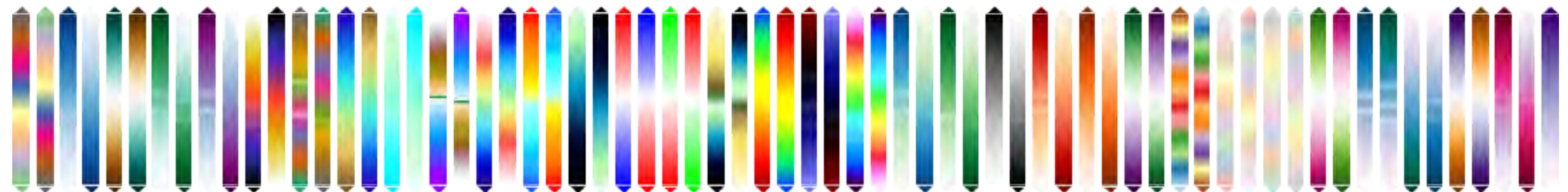
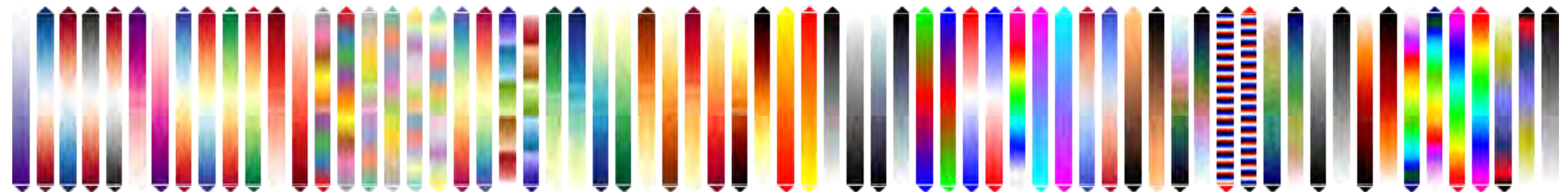
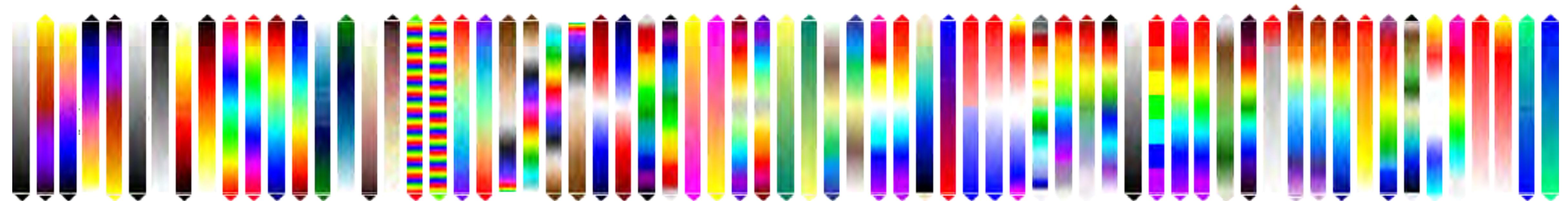


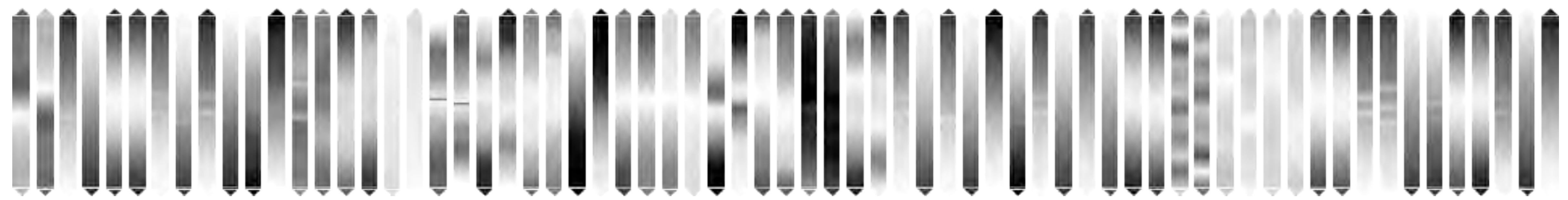
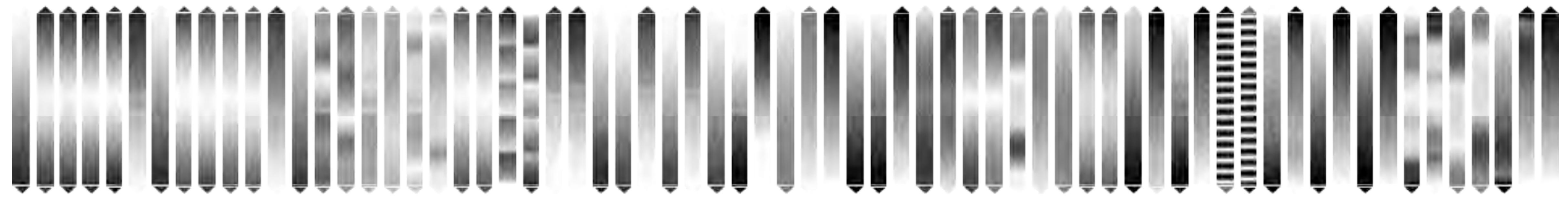
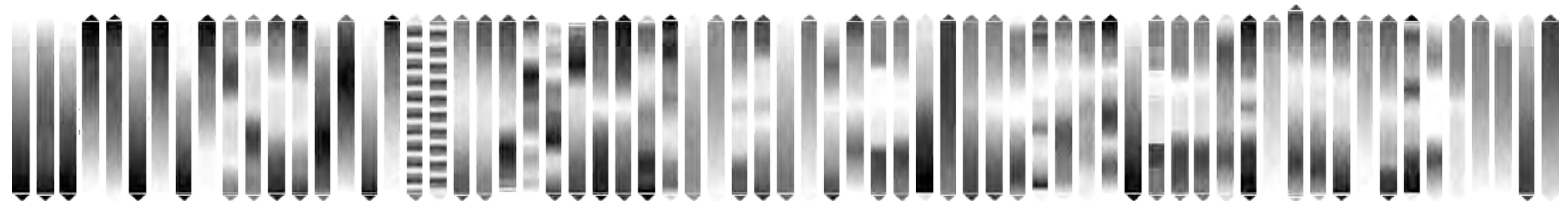








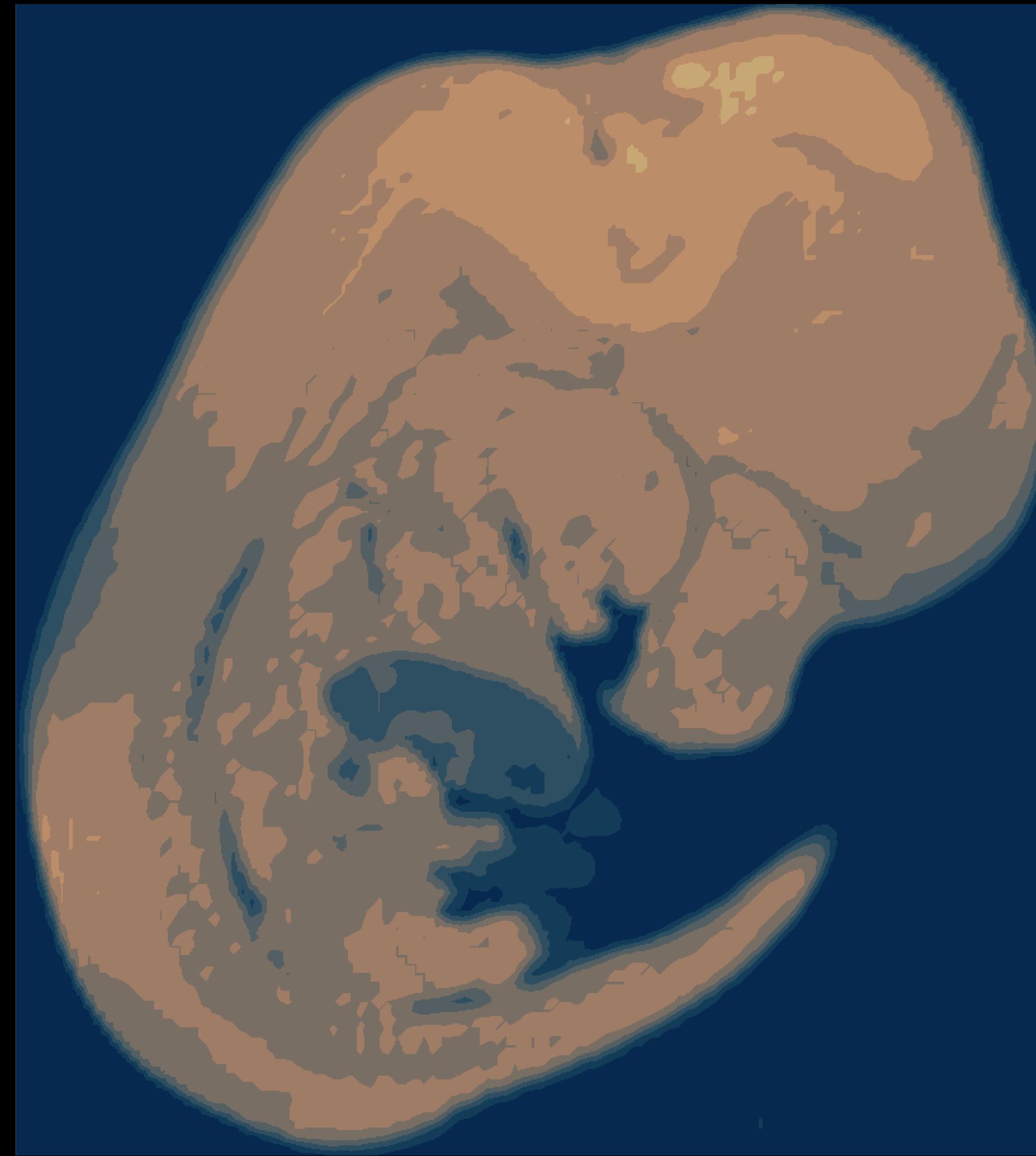


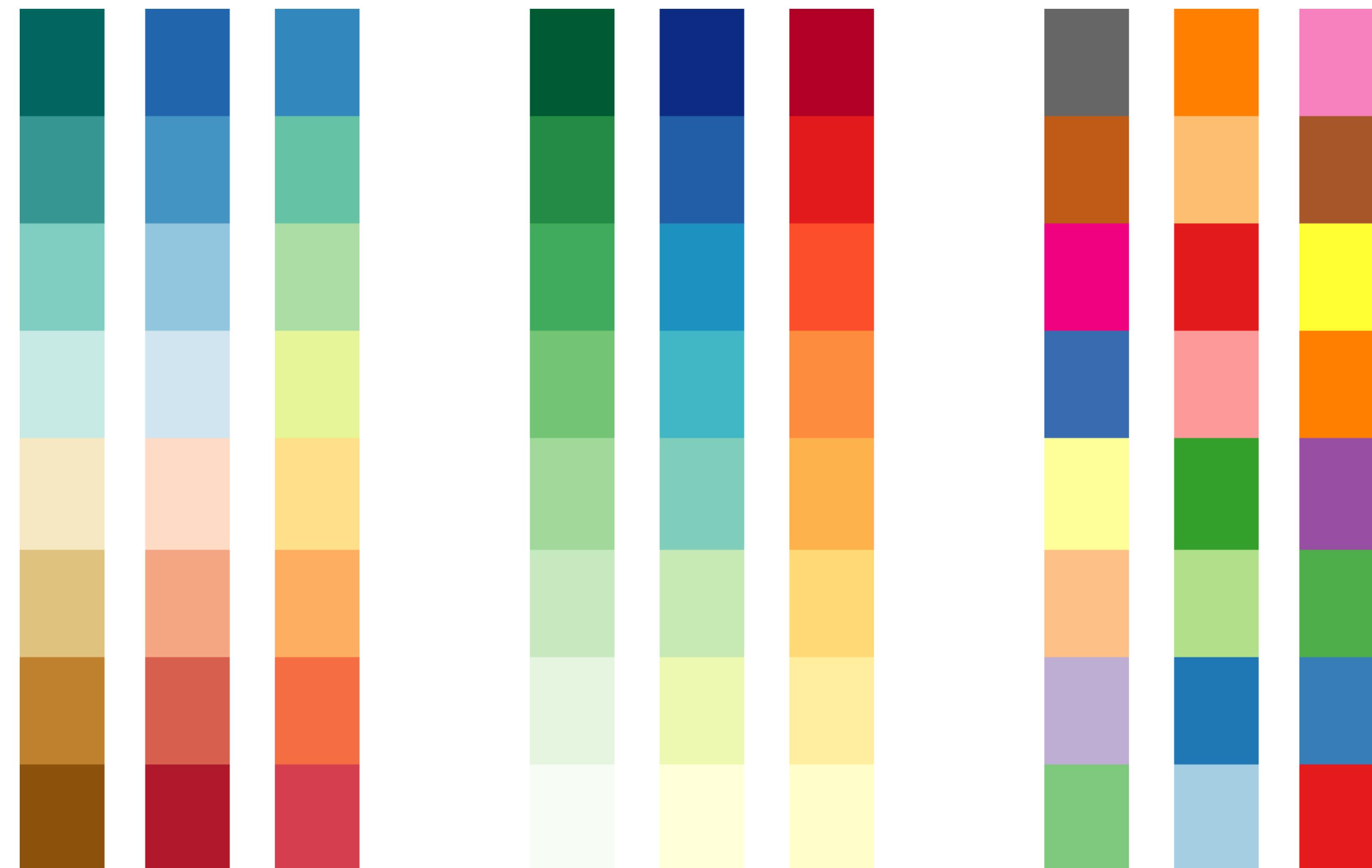


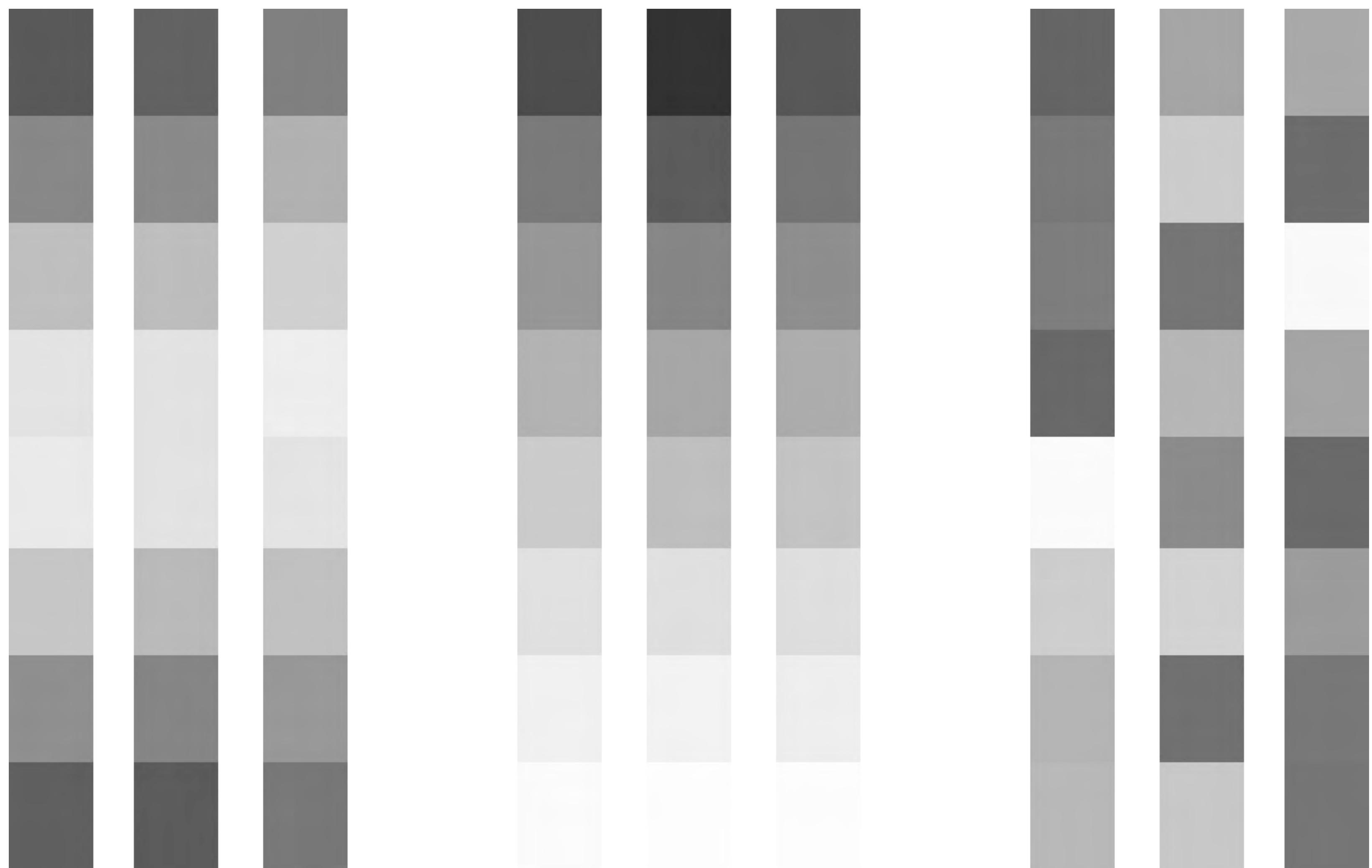
mm



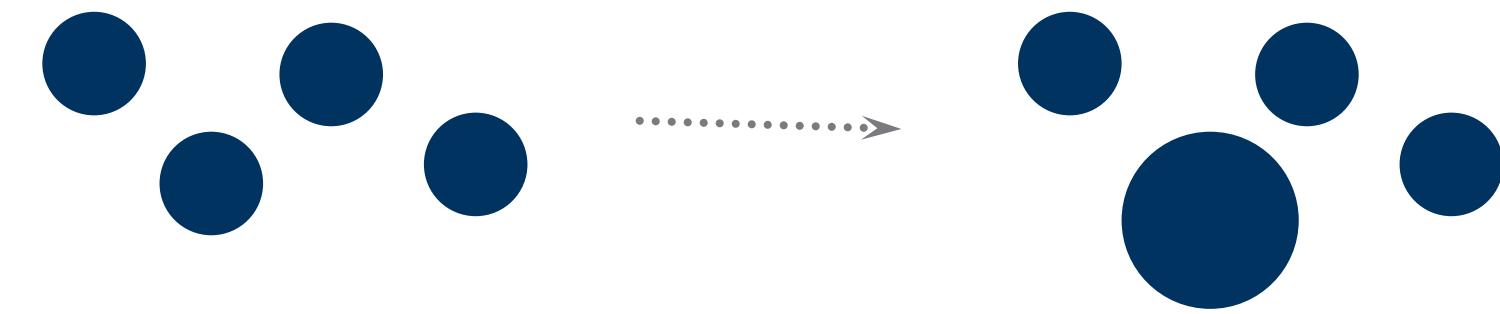
mm







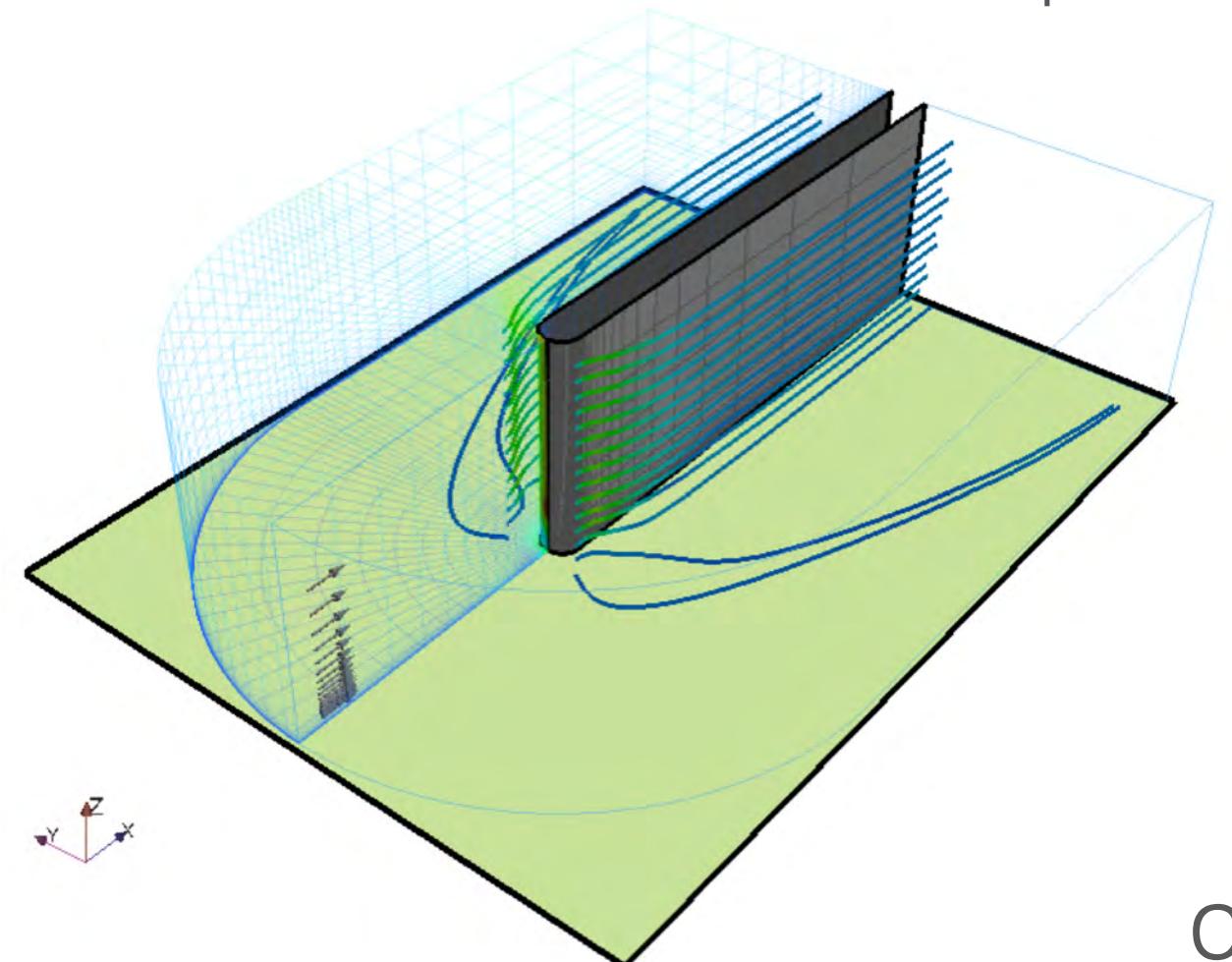
SCALE



SHAPE



position | orientation

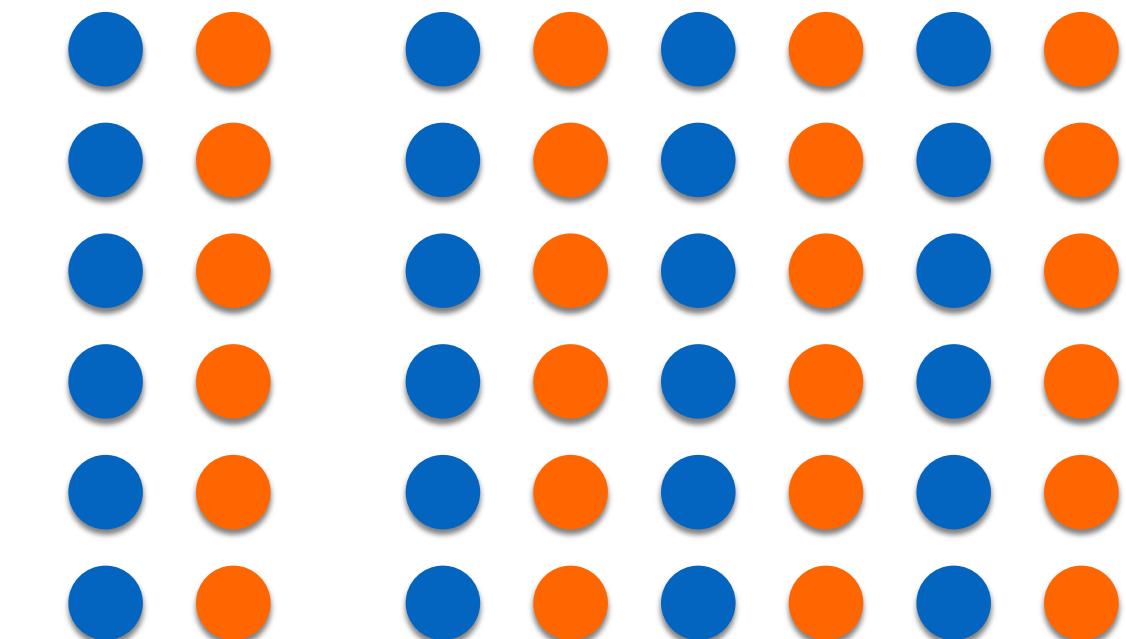


COLOR



luminosity | hue | saturation | texture

distinctive glyphs | bumps | points | whiskers



MOTION



vibration | rotation | deformation

DESIGN+VISUALIZATION STRATEGIES
ASTROINFORMATICS|2019

REFERENCES

Information Dashboard Design

—Displaying Data for At-a-Glance Monitoring

Stephen Few

Interactive Visualization—Insights into Inquiry

Bill Ferster

Visualizing Data

Ben Fry

The Ecological Approach to Visual Perception

James Gibson

Envisioning Information

Edward Tufte

The Visual Display of Quantitative Information

Edward Tufte

The Visual Miscellaneum

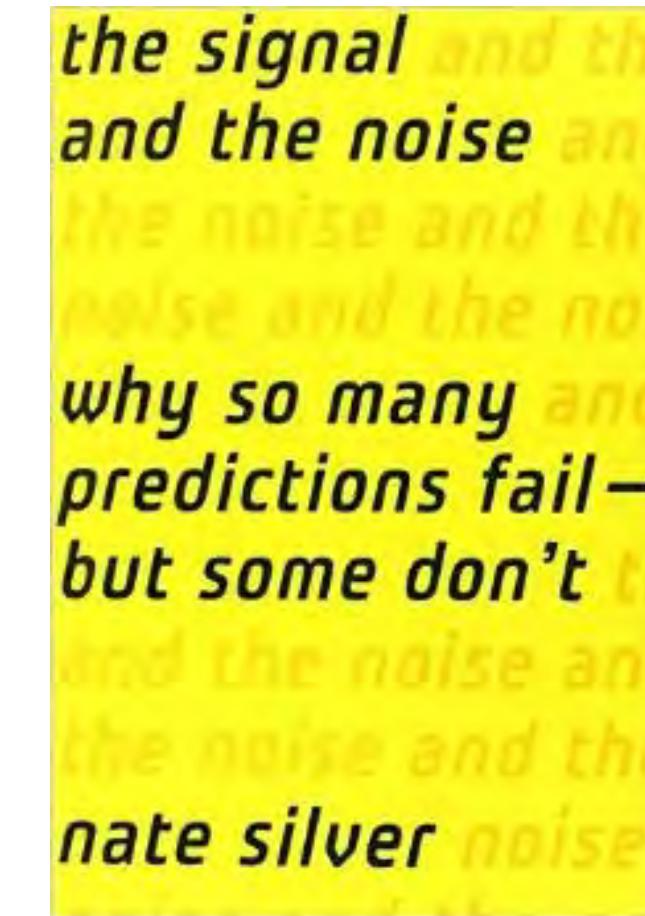
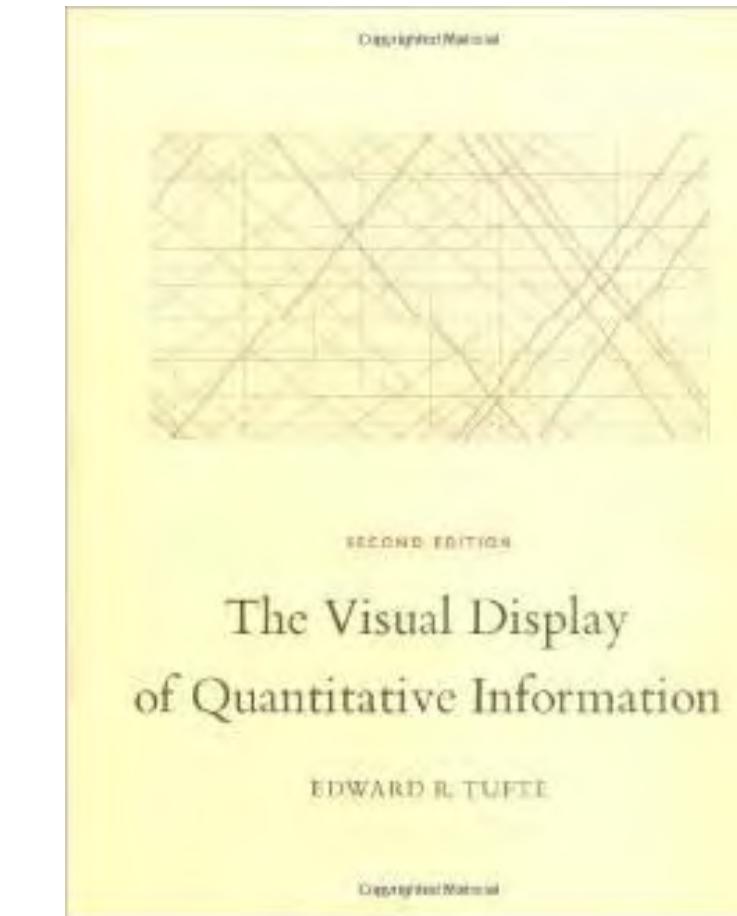
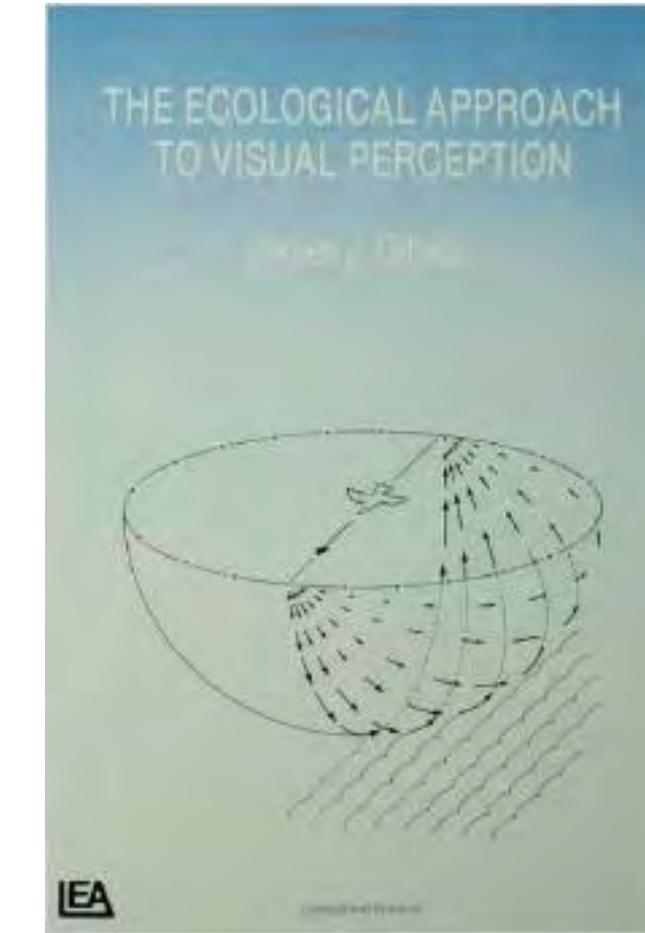
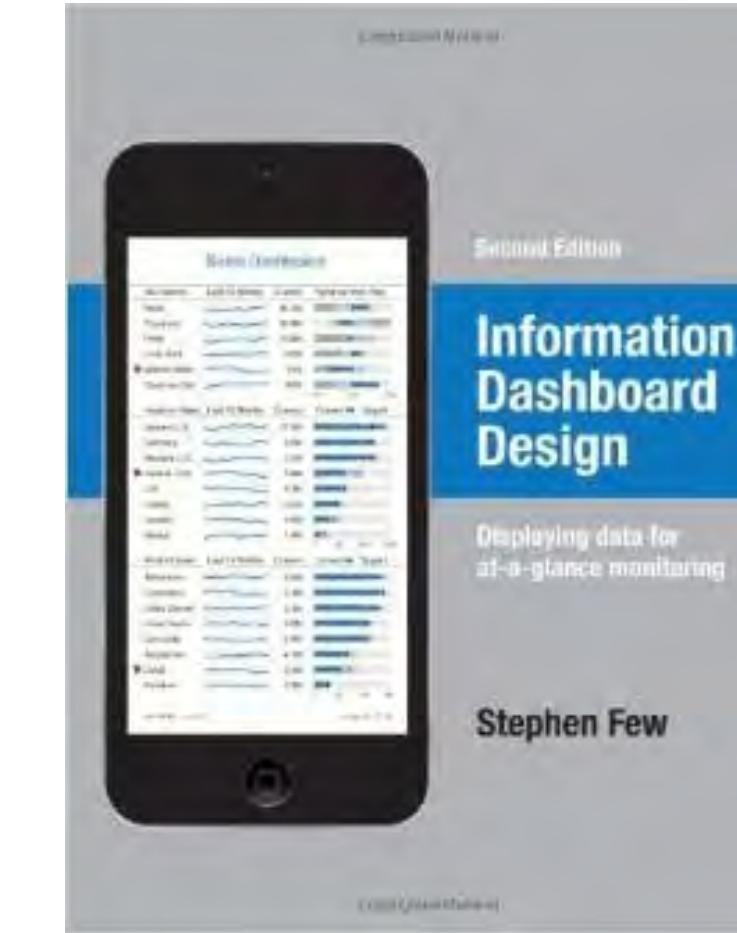
David McCandless

The Signal and the Noise

Nate Silver

“Design considerations for collaborative visual analytics”

Jeff Heer, Manesh Agrawala



DESIGN+VISUALIZATION STRATEGIES ASTROINFORMATICS|2019

artcenter | caltech

SANTIAGO LOMBEYDA