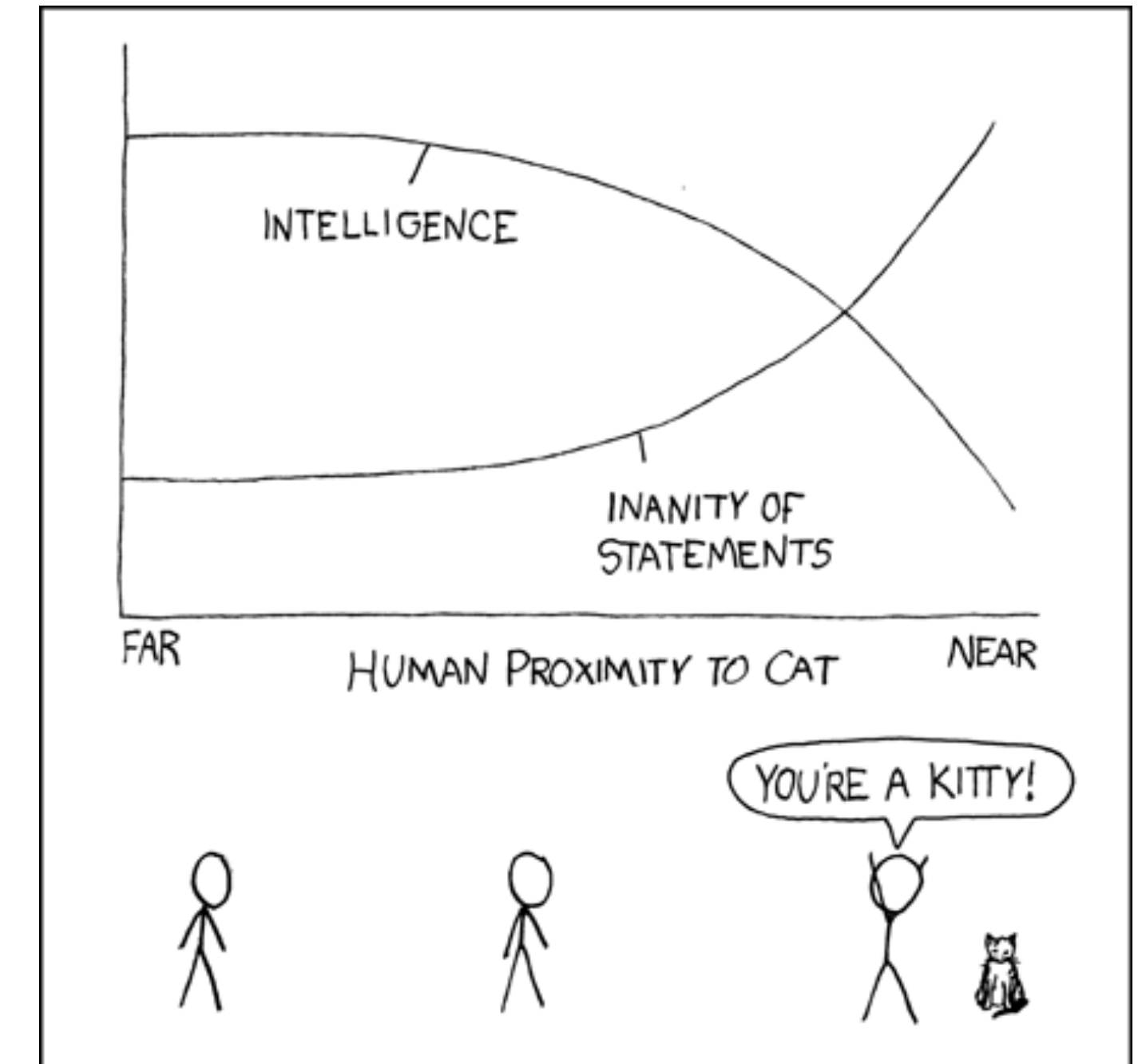


CS-5630 / CS-6630

Visualization

Alexander Lex
alex@sci.utah.edu





vi · su · al · i · za · tion

1. Formation of mental visual images
2. The act or process of interpreting in visual terms or of putting into visible form

Visualization Definition

Visualization is the process that **transforms** (abstract) **data** into **interactive graphical representations** for the purpose of **exploration, confirmation, or presentation.**

Why Visualize?

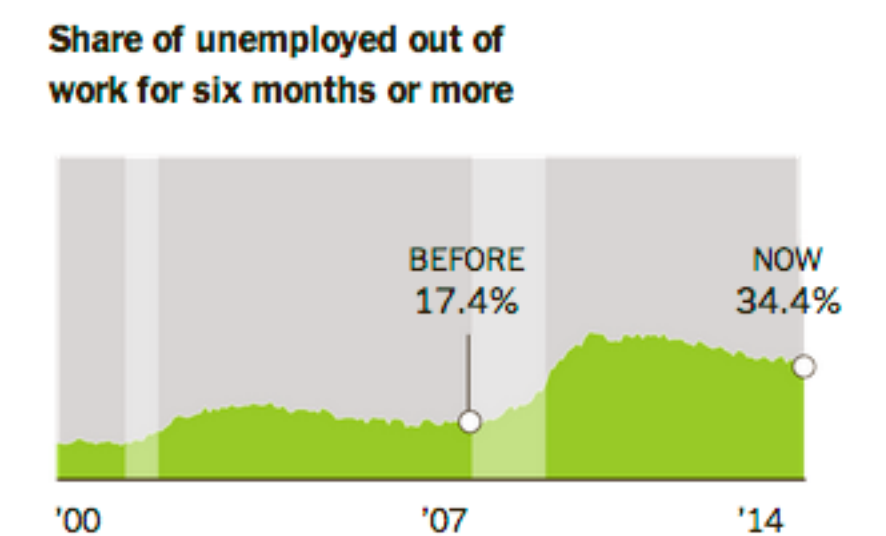
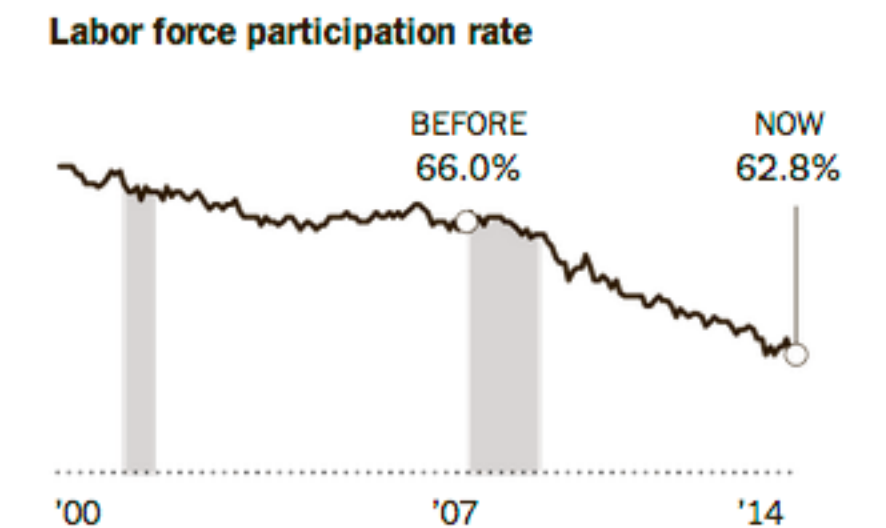
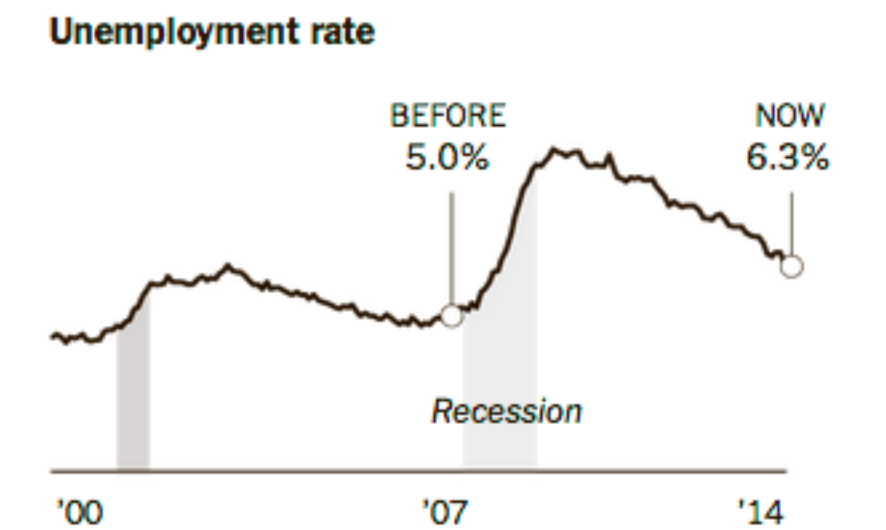
To inform humans: **Communication**

How did the unemployment and labor force develop over the last years?

When questions are not well defined: **Exploration**

Which combination of genes causes cancer?

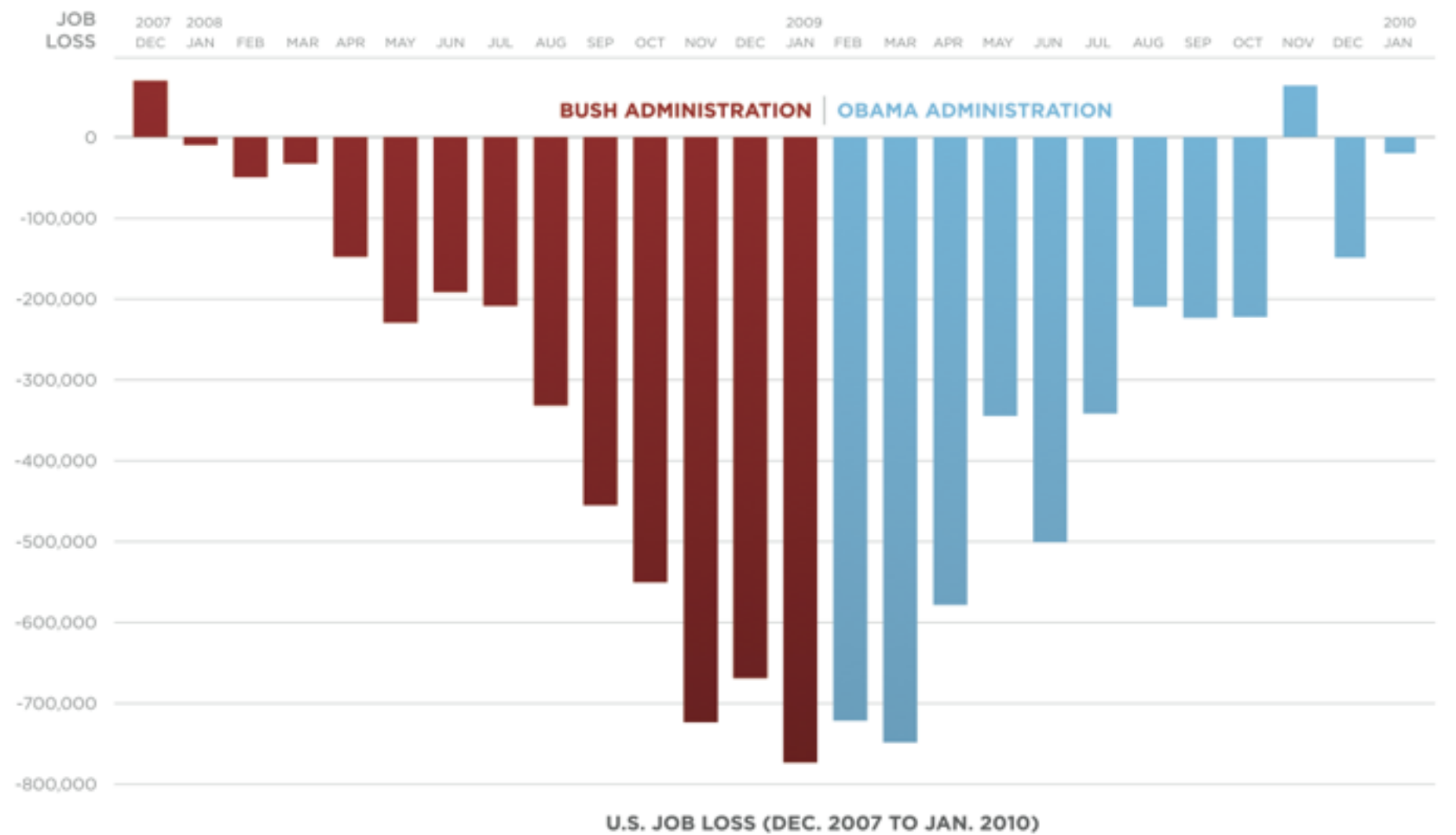
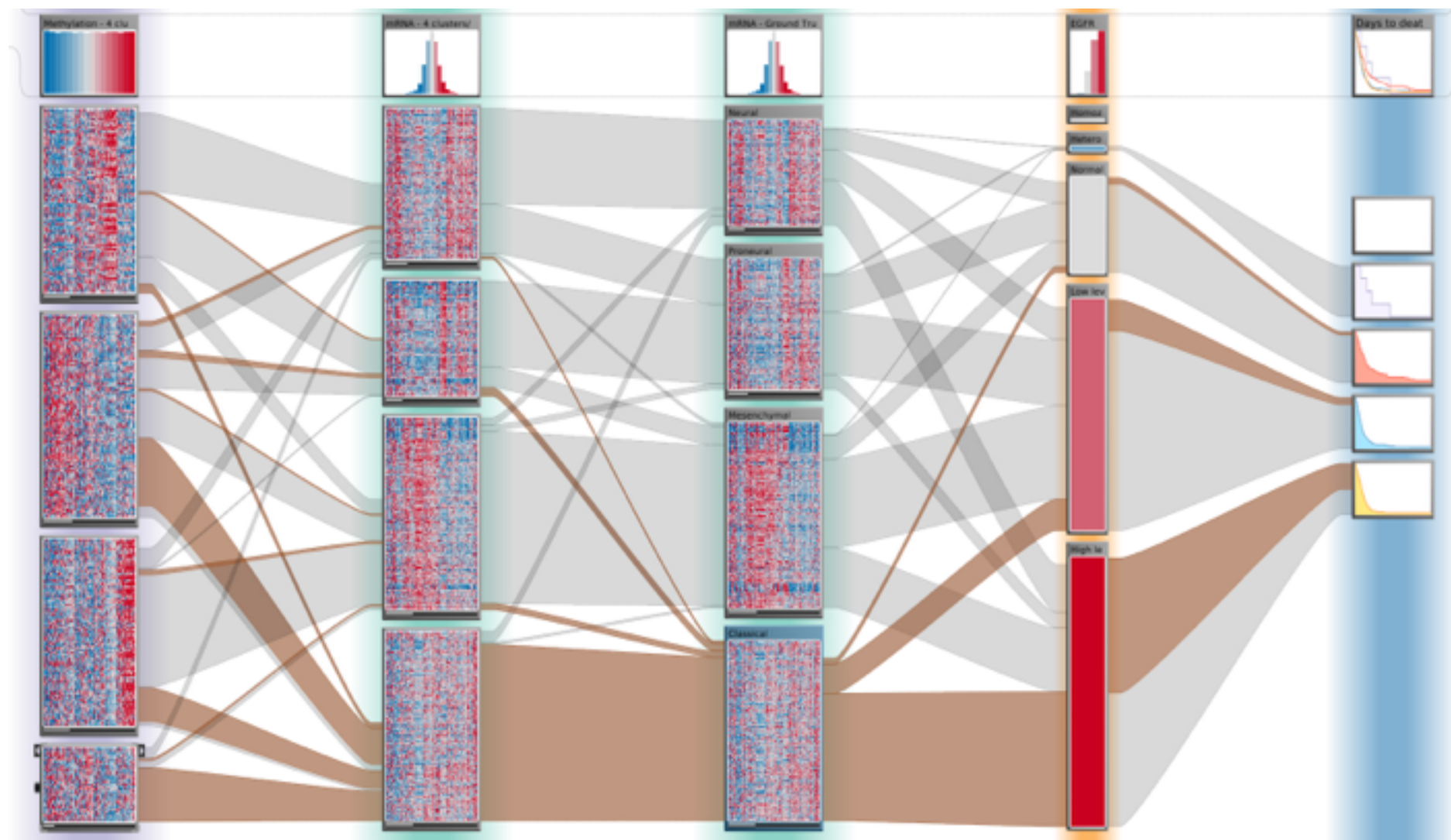
Which drug can help patient X?



[New York Times]

Purpose of Visualization

[Obama Administration]



Open Exploration

Confirmation

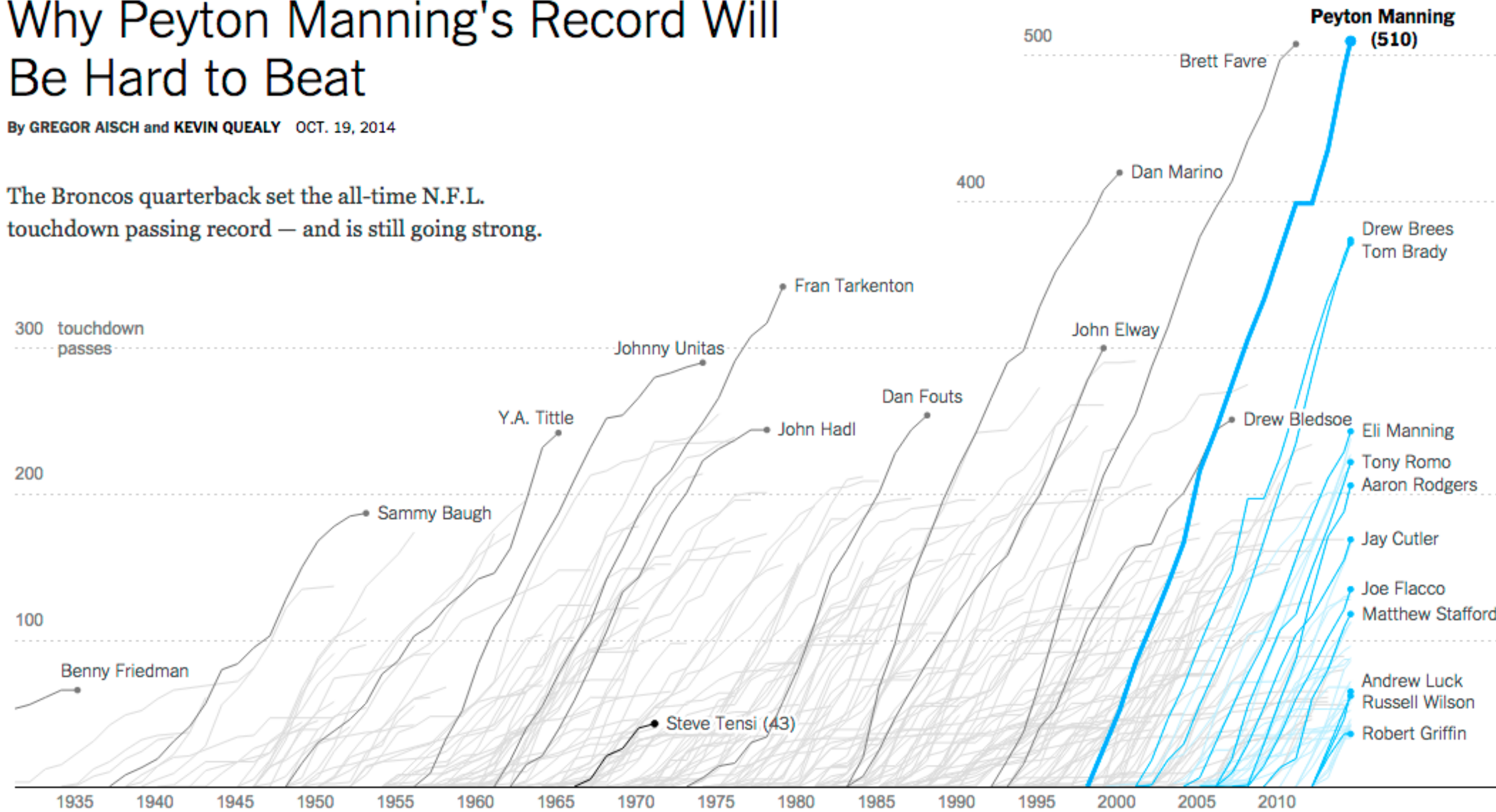
Communication

Example Communication

Why Peyton Manning's Record Will Be Hard to Beat

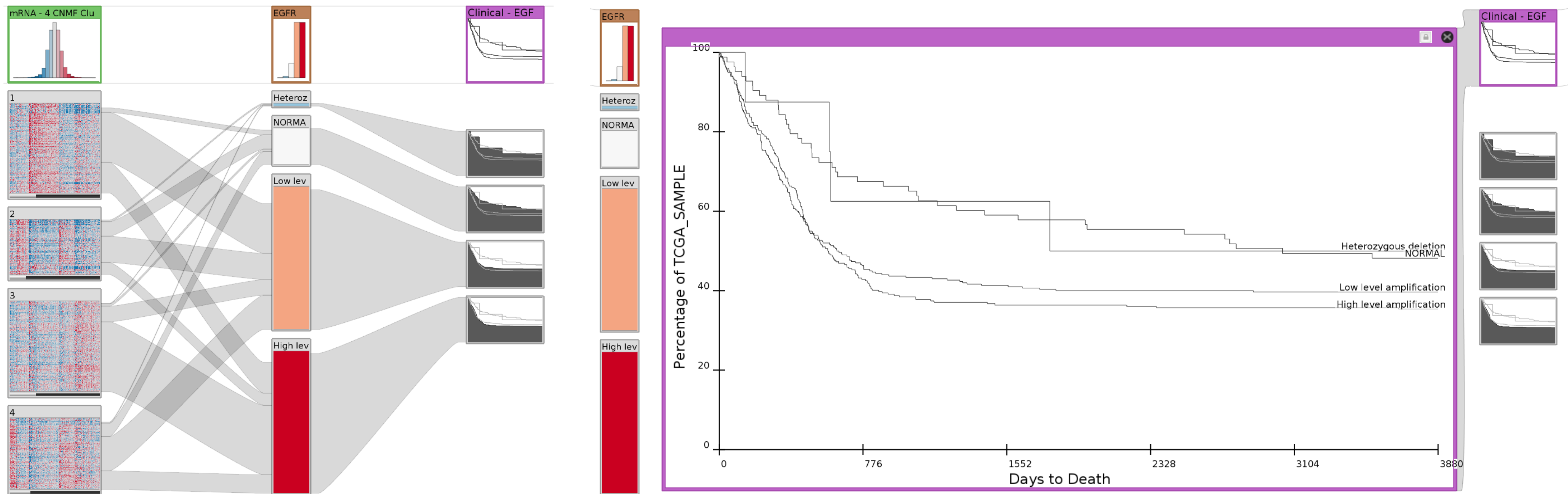
By GREGOR AISCH and KEVIN QUEALY OCT. 19, 2014

The Broncos quarterback set the all-time N.F.L. touchdown passing record — and is still going strong.



[New York Times]

Example Exploration: Cancer Subtypes



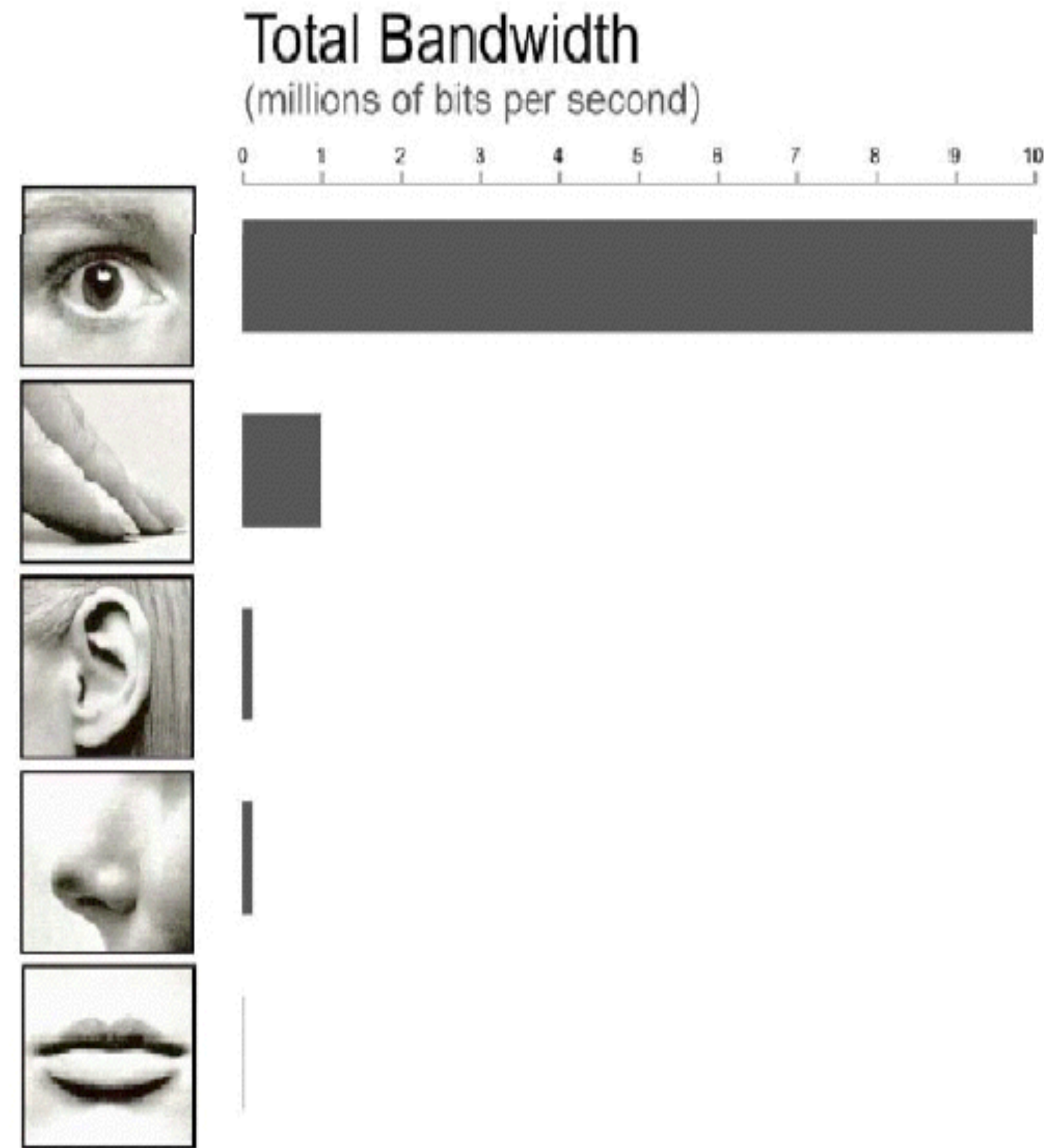
Why Graphics?

Figures are **richer**; provide more information with less clutter and in less space.

Figures provide the *gestalt* effect: they give an overview; **make structure more visible**.

Figures are **more accessible**, easier to understand, **faster to grasp**, more comprehensible, **more memorable**, more fun, and less formal.

list adapted from: [Stasko et al. 1998]



for city's main public hospital was a wreck, and the city's public-housing projects were shuttered.

Campanella then switched to an identically constructed map, only this time based on 2010 census data, and in bits and pieces on the screen there was a simple and arresting picture of what Katrina meant. In the neighborhoods that were once a dense black, many of the little squares had thinned and turned gray. The sharp lines that once separated the teapot from Central City were now blurry: the white areas of the city were pushing north, into the vacuum left by the exodus. The Bywater was graying, as it gentrified still further. "Before Katrina, an American Community Survey estimate of New Orleans Parish population was four hundred and fifty-five thousand, and about sixty-eight per cent black," Campanella said. "Now the latest estimate is three hundred and eighty-four thousand, and it's about

When not to visualize?

When to automate?

Well defined question on well-defined dataset

Which gene is most frequently mutated in this set of patients?

What is the current unemployment rate?

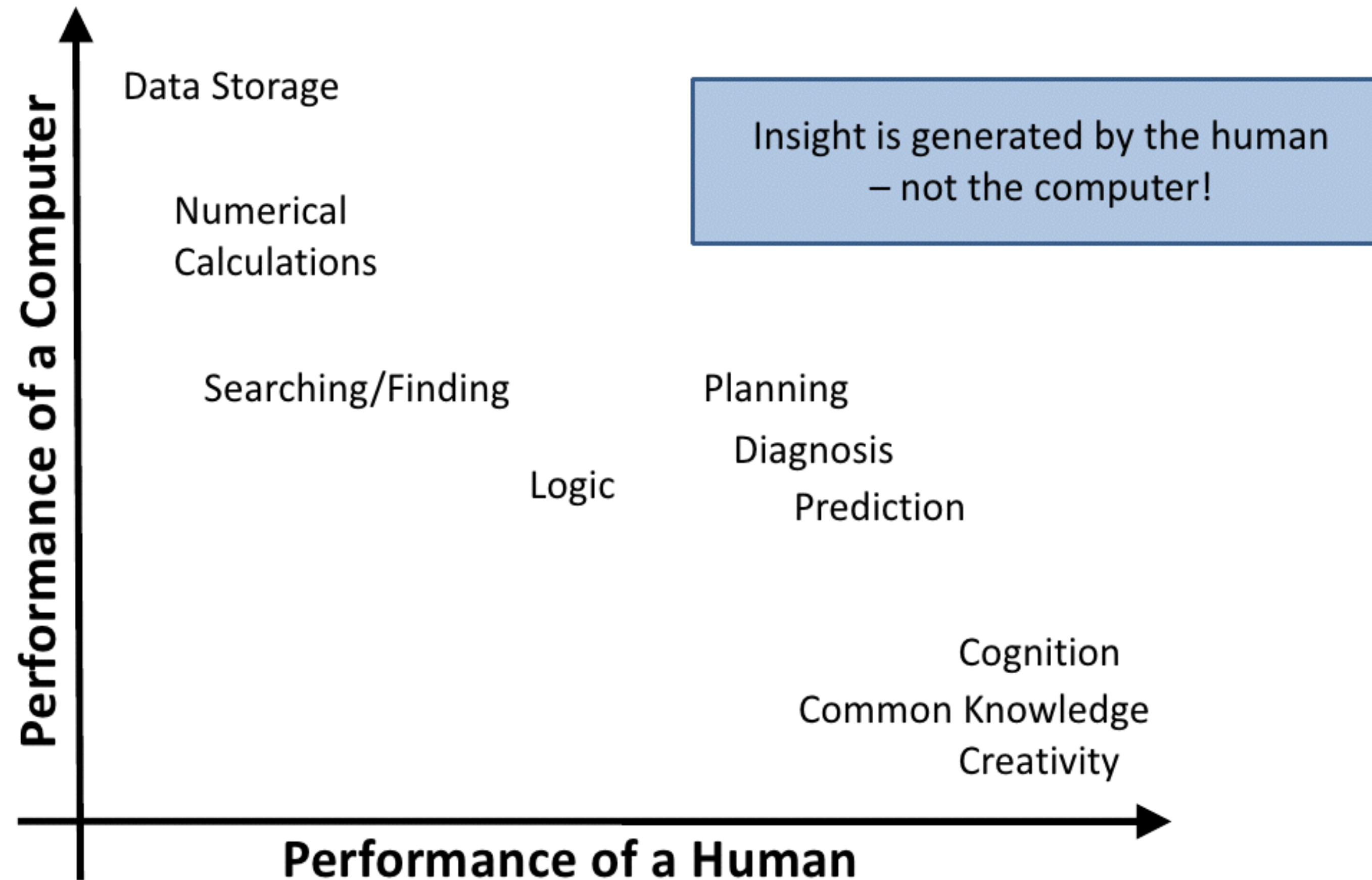
Decisions needed in minimal time

High frequency stock market trading: which stock to buy/sell?

Manufacturing: is bottle broken?



The Ability Matrix

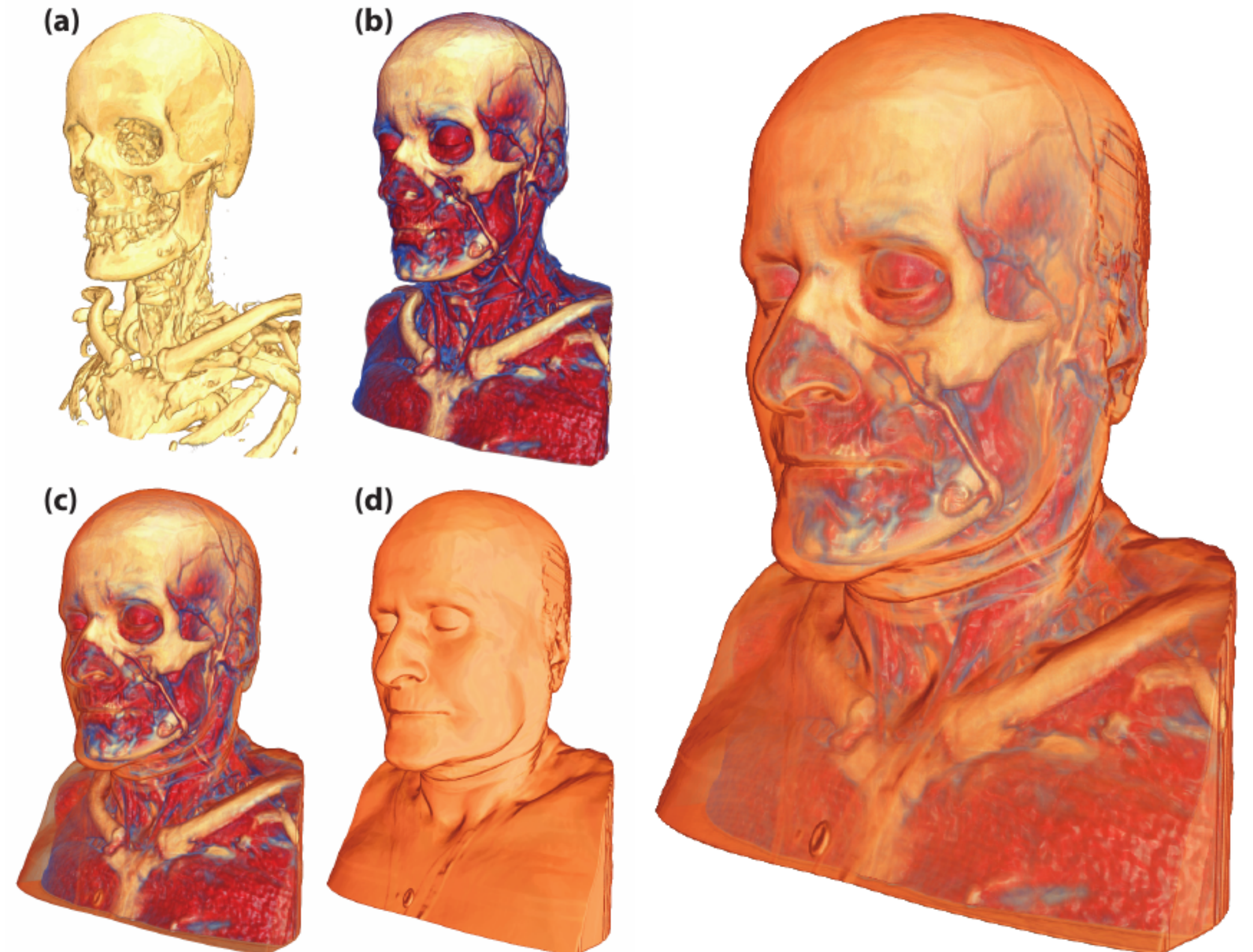


Why Use Computers?

Scale

Drawing by hand infeasible

How to draw an MRI scan?



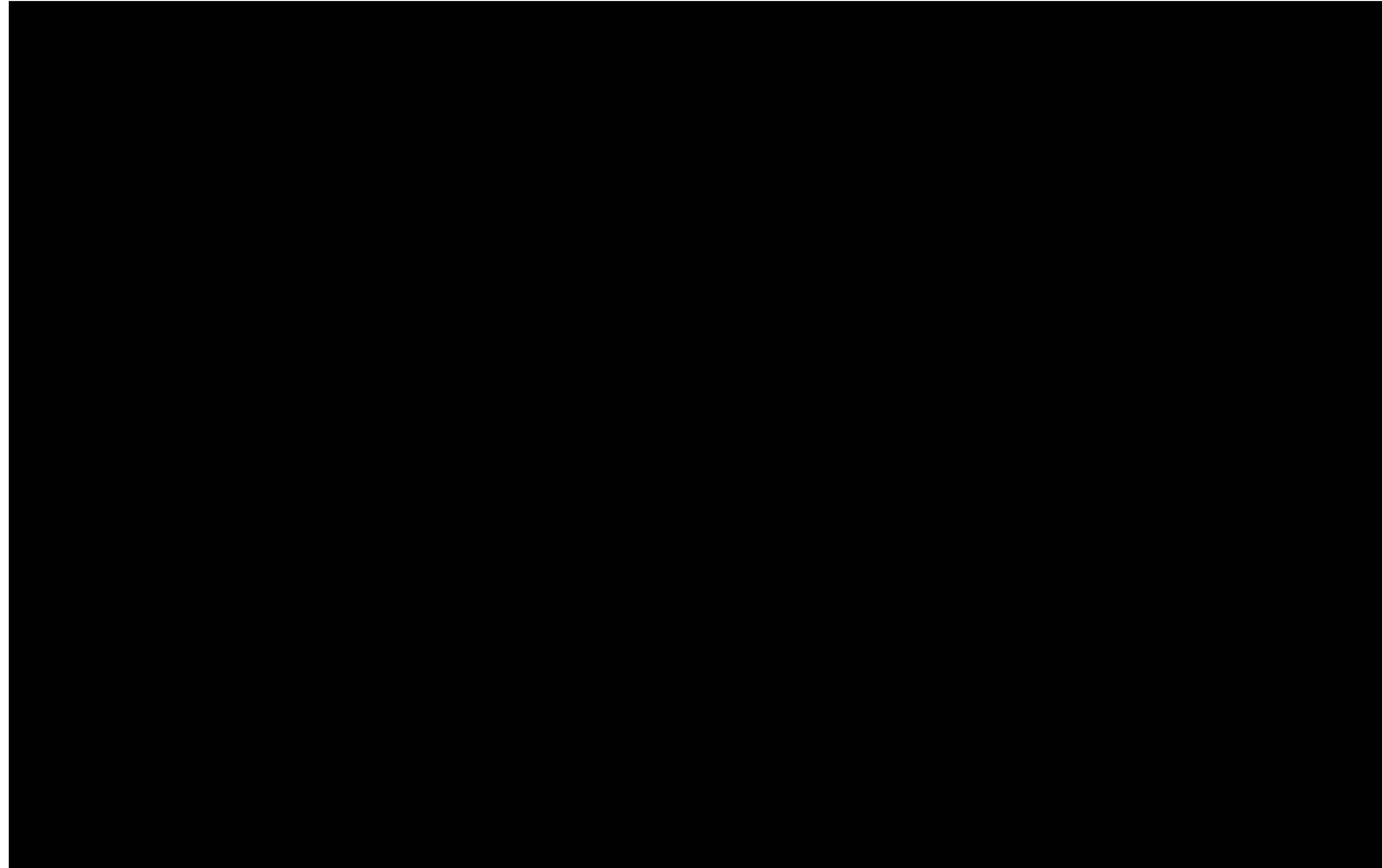
[Bruckner 2007]

Why Use Computers?

Scale

Interaction allows to “drill down” into data

Integration with algorithms



Why User Computers?

Efficiency

Re-use charts / methods for
different datasets

Quality

Precise data driven rendering

Storytelling

Use time

Tell Stories

[New York Times]

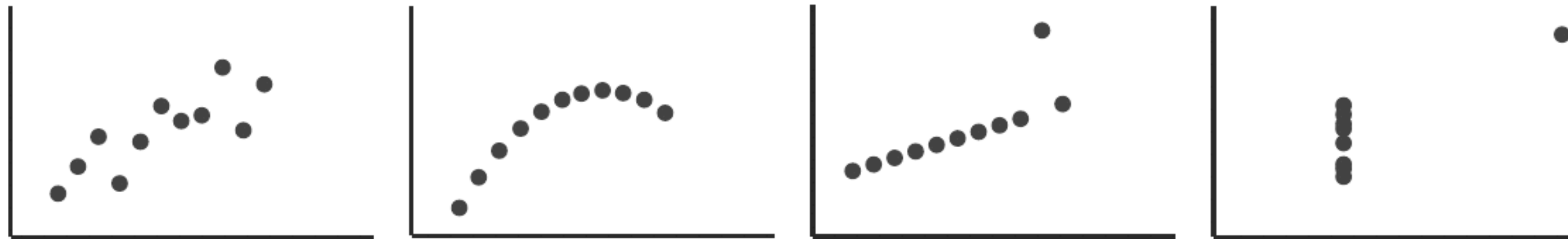


Why not just use Statistics?

I		II		III		IV	
x	y	x	y	x	y	x	y
10	8.0	10	9.1	10	7.4	8	6.5
8	6.9	8	8.1	8	6.7	8	5.7
13	7.5	13	8.7	13	12.	8	7.7
9	8.8	9	8.7	9	7.1	8	8.8
11	8.3	11	9.2	11	7.8	8	8.4
14	9.9	14	8.1	14	8.8	8	7.0
6	7.2	6	6.1	6	6.0	8	5.2
4	4.2	4	3.1	4	5.3	19	12.
12	10.	12	9.1	12	8.1	8	5.5
7	4.8	7	7.2	7	6.4	8	7.9
5	5.						6.8

Mean x: 9 y: 7.50
Variance x: 11 y: 4.122
Correlation x - y: 0.816
Linear regression: $y = 3.00 + 0.500x$

Anscombe's Quartett



Mean x: 9 y: 7.50

Variance x: 11 y: 4.122

Correlation x - y: 0.816

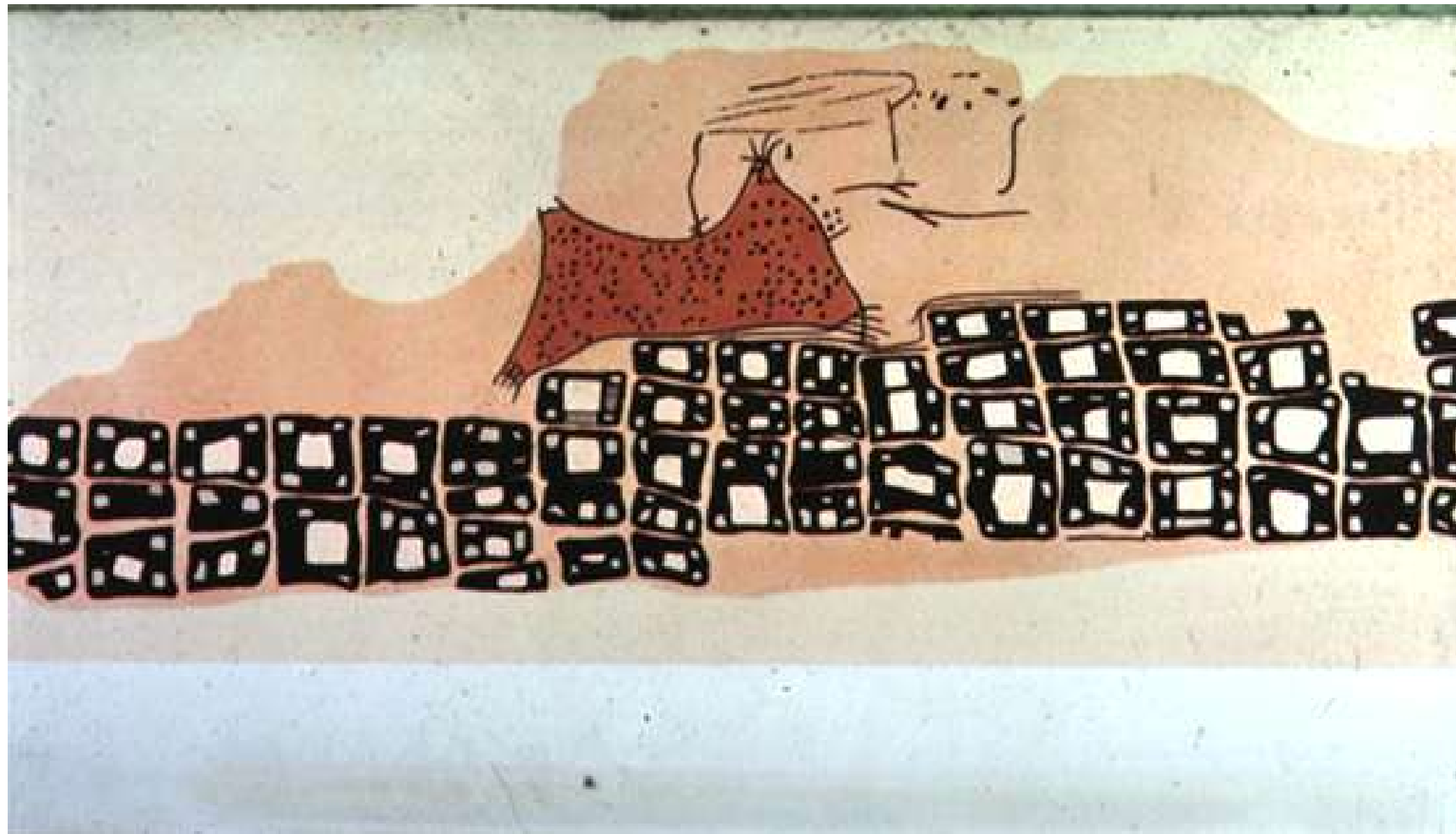
Linear regression: $y = 3.00 + 0.500x$

Good Data Visualization

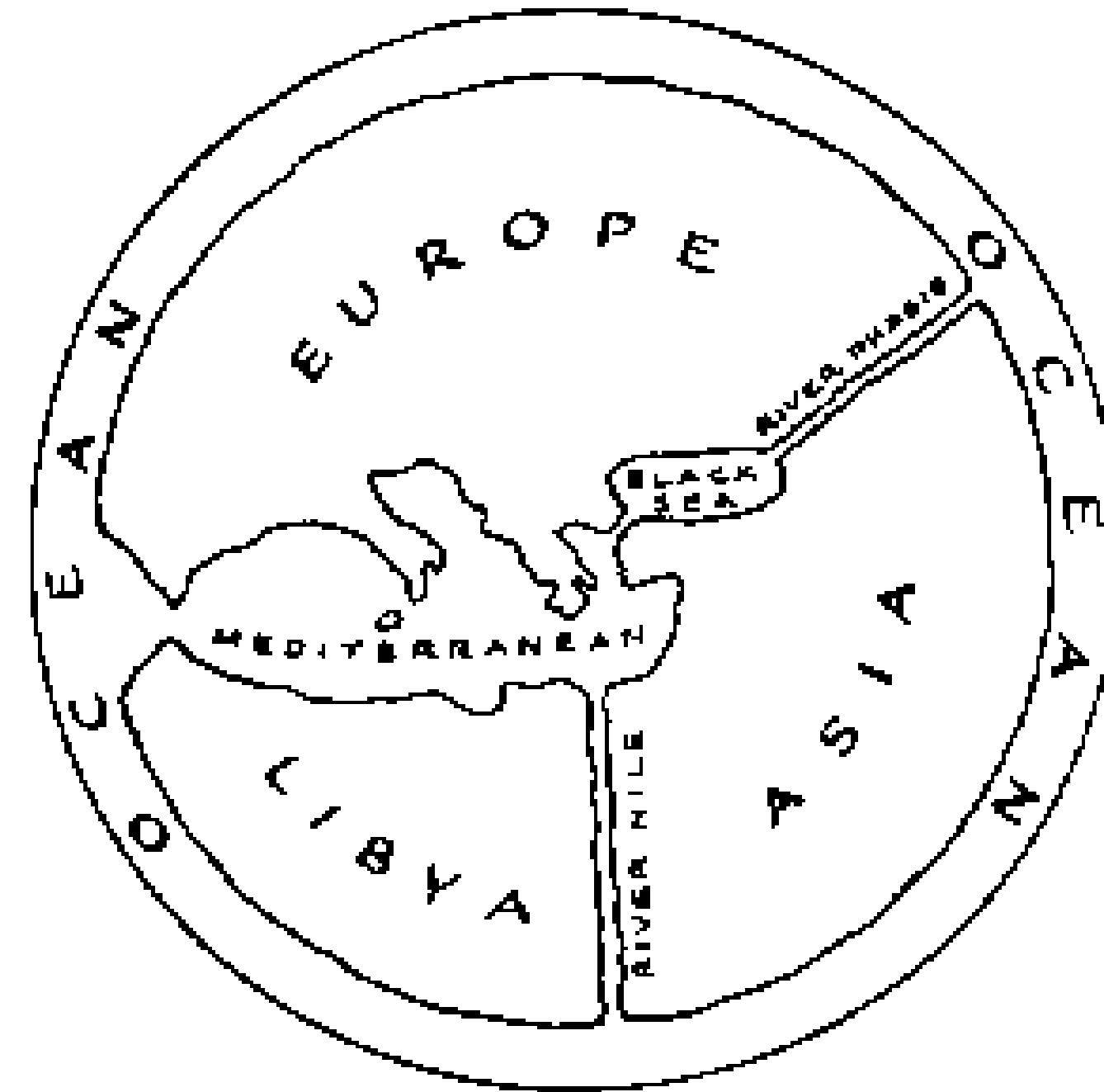
- ... makes data **accessible**
- ... combines strengths of
humans and computers
- ... enables **insight**
- ... **communicates**

How did we get here?

Record



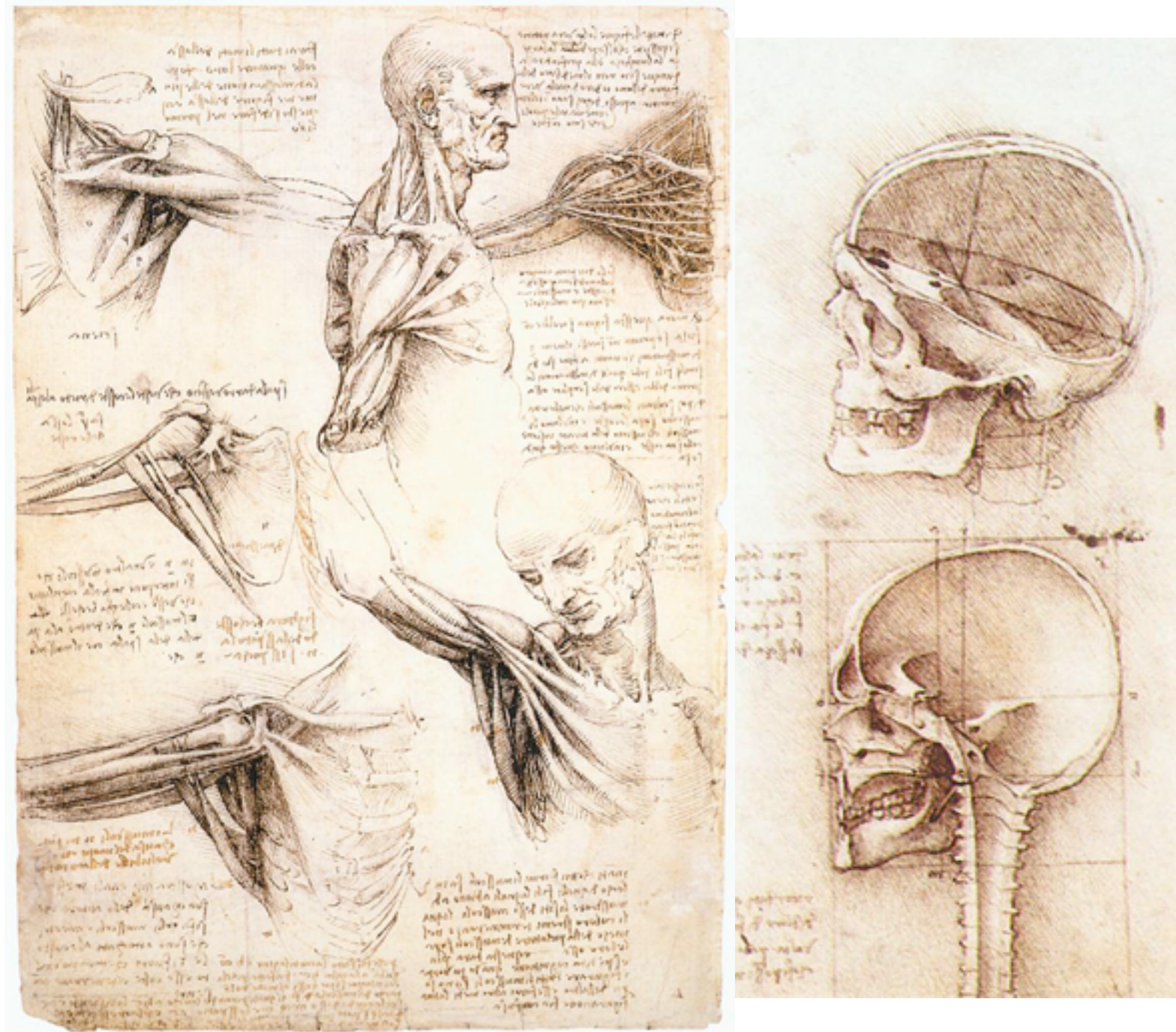
Konya town map, Turkey, c. 6200 BC



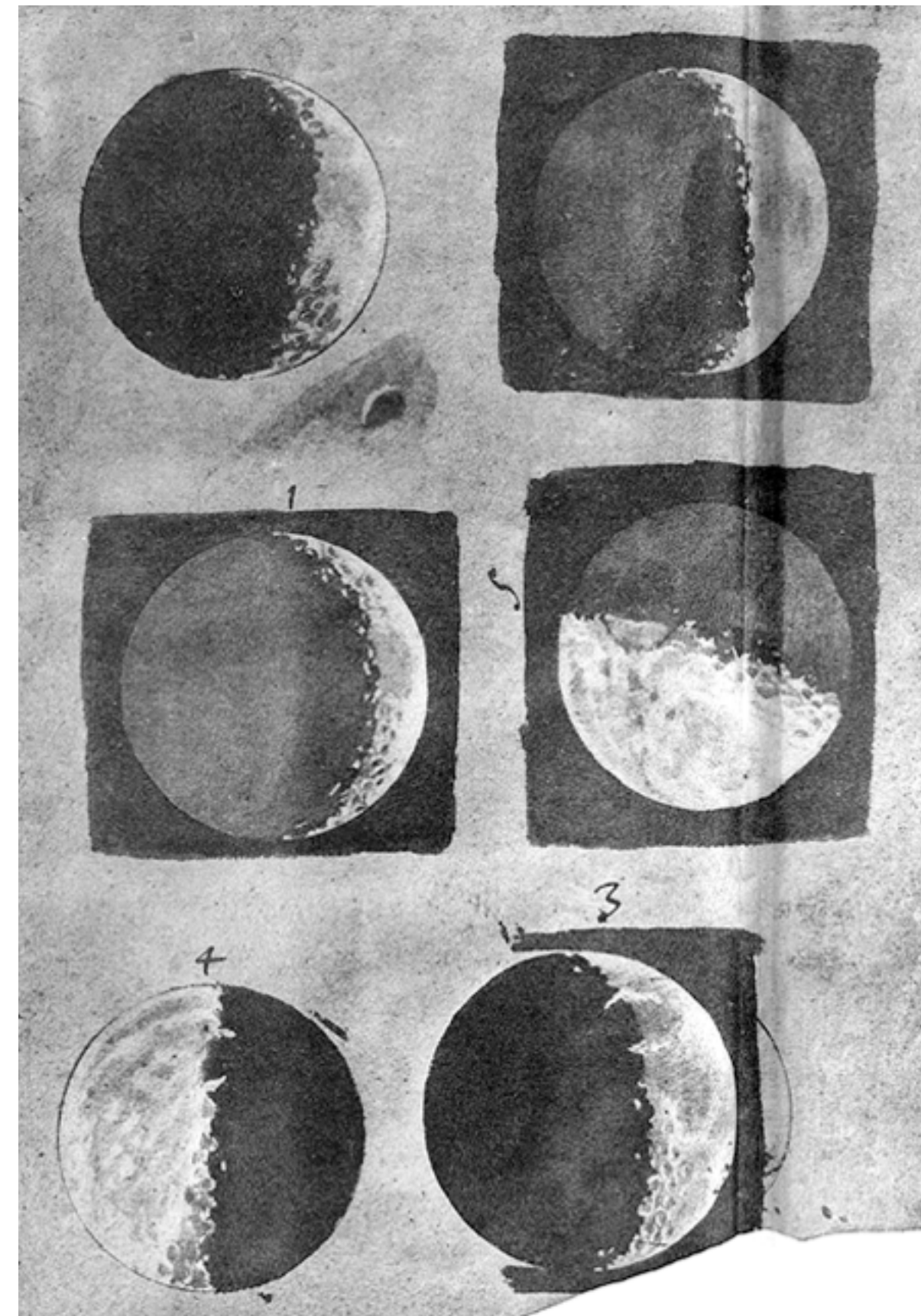
Anaximander's Map of the World

Anaximander of Miletus, c. 550 BC

Record



Leonardo Da Vinci, ca. 1500



Galileo Galilei, 1616

Donald Norman

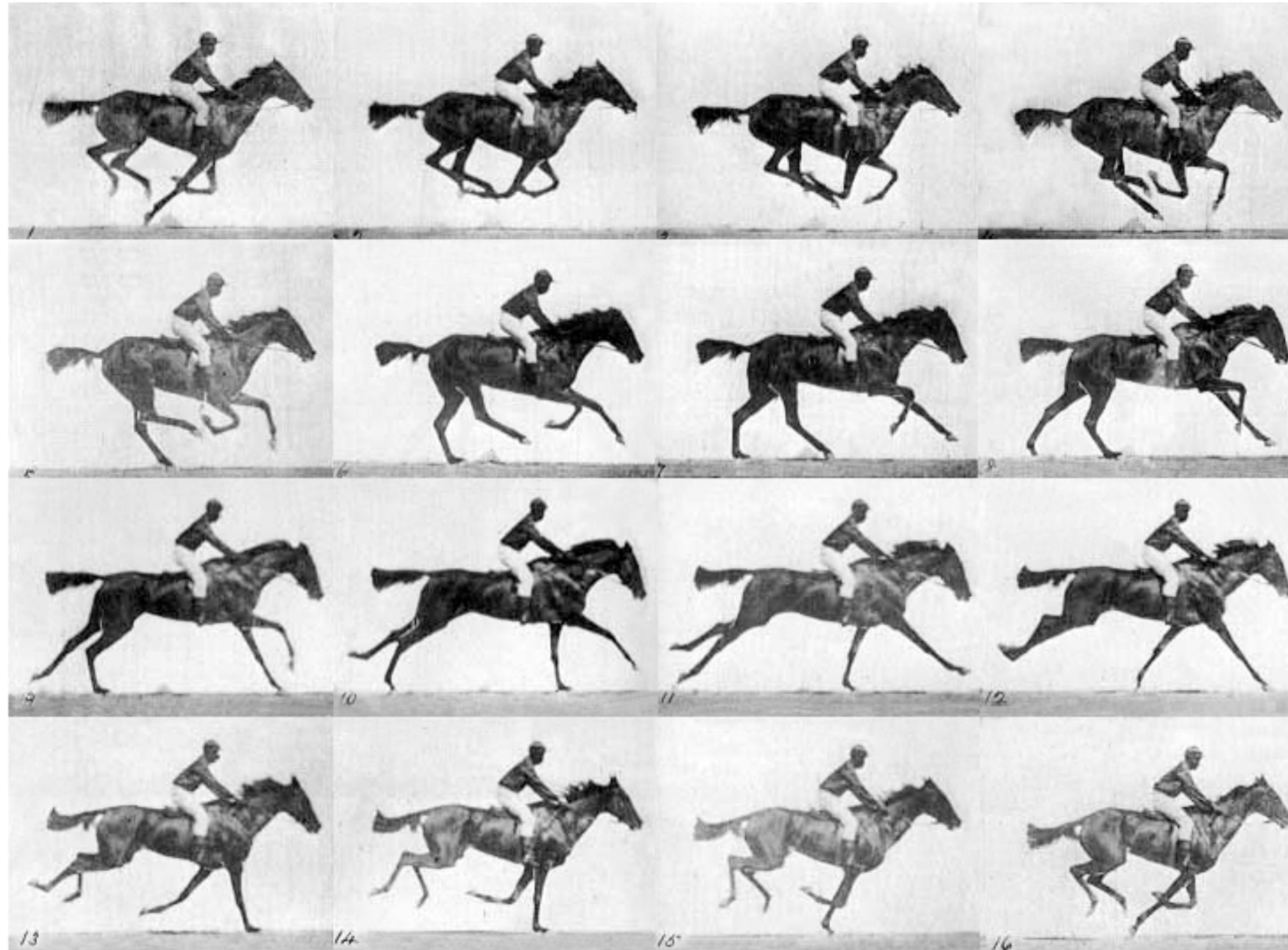


William Curtis (1746-1799)

The History of Visual Communication

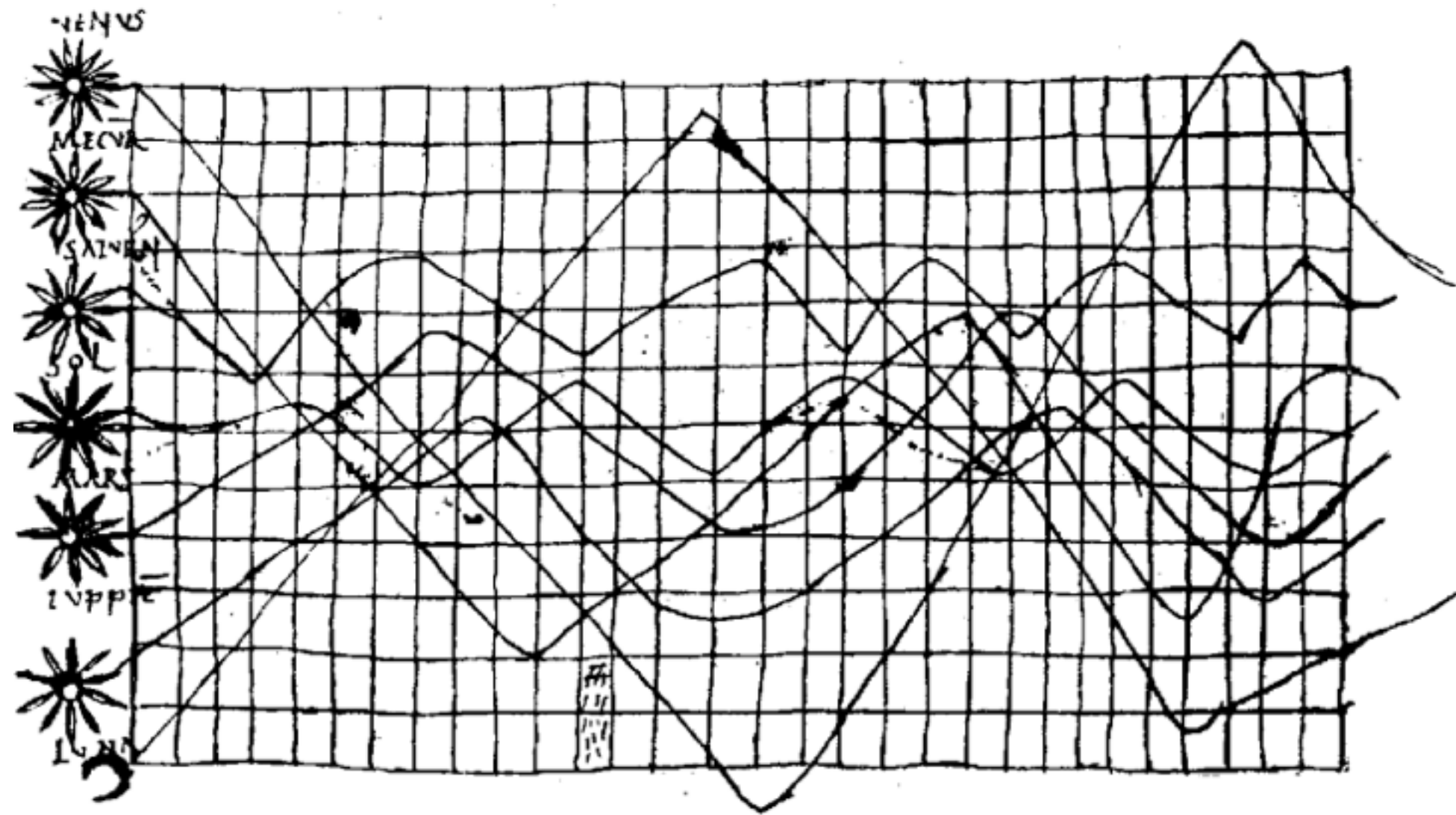
The Galileo Project, Rice University

Record

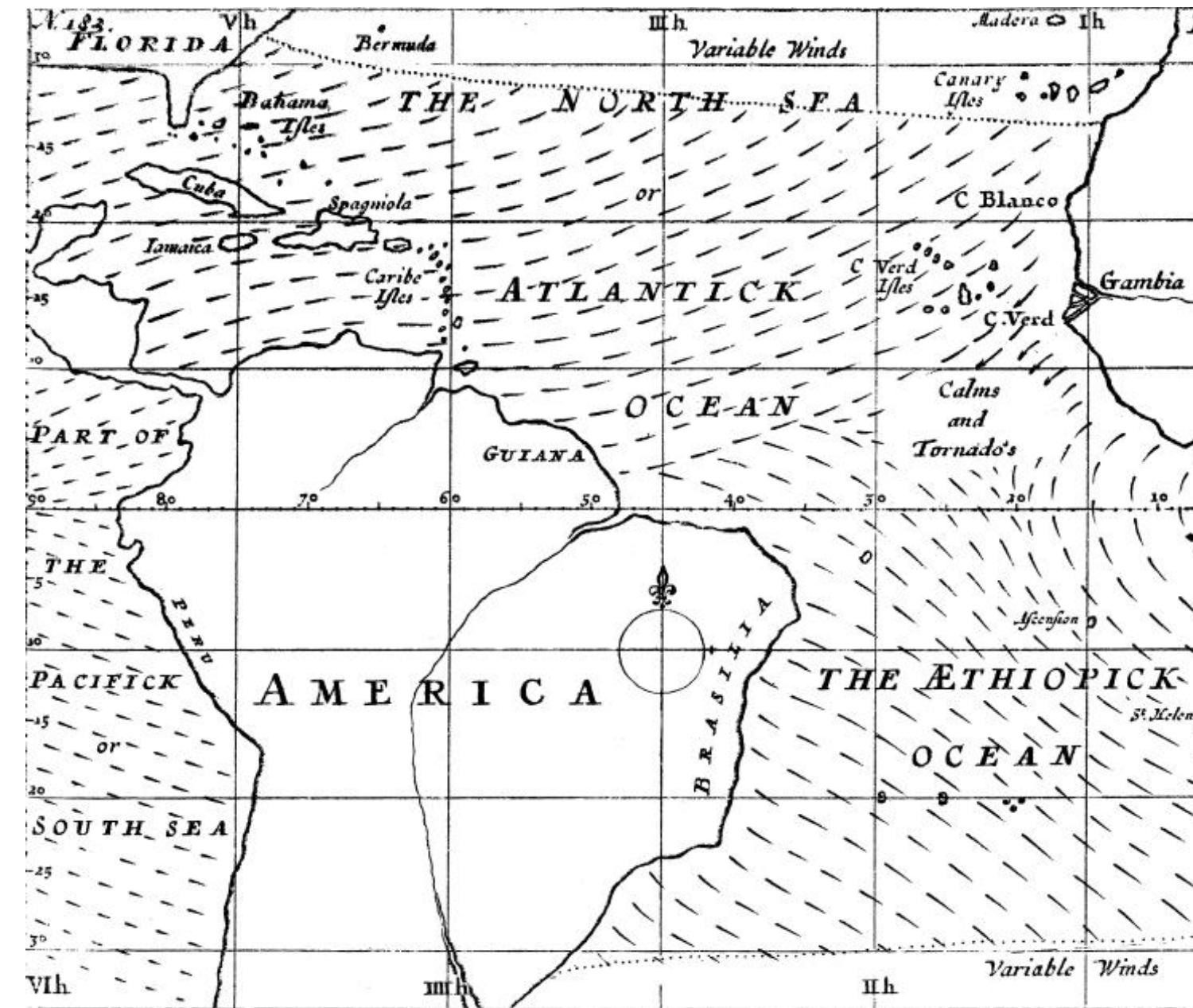


E. J. Muybridge, 1878

Analyze



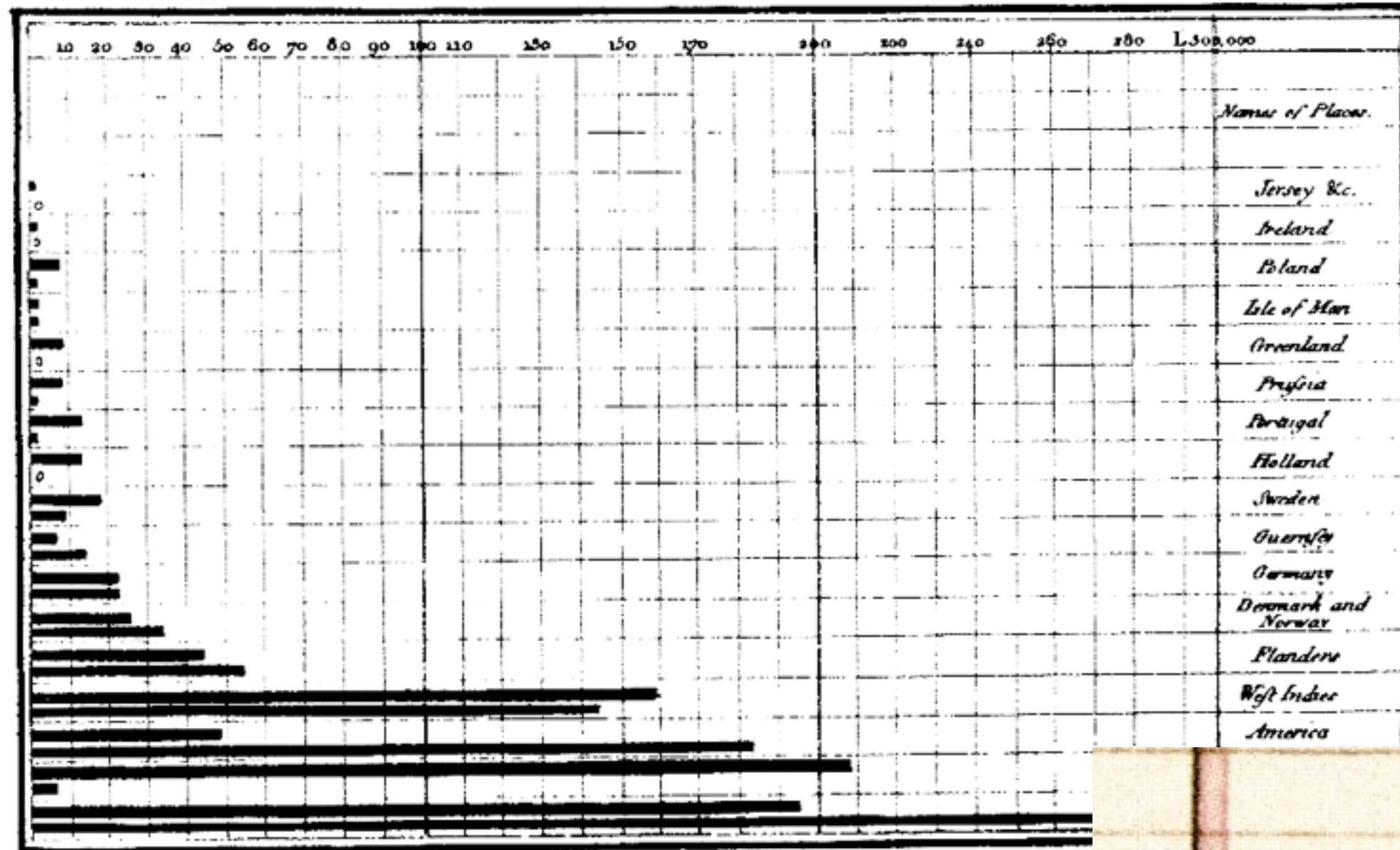
Planetary Movement Diagram, c. 950



Halley's Wind Map, 1686

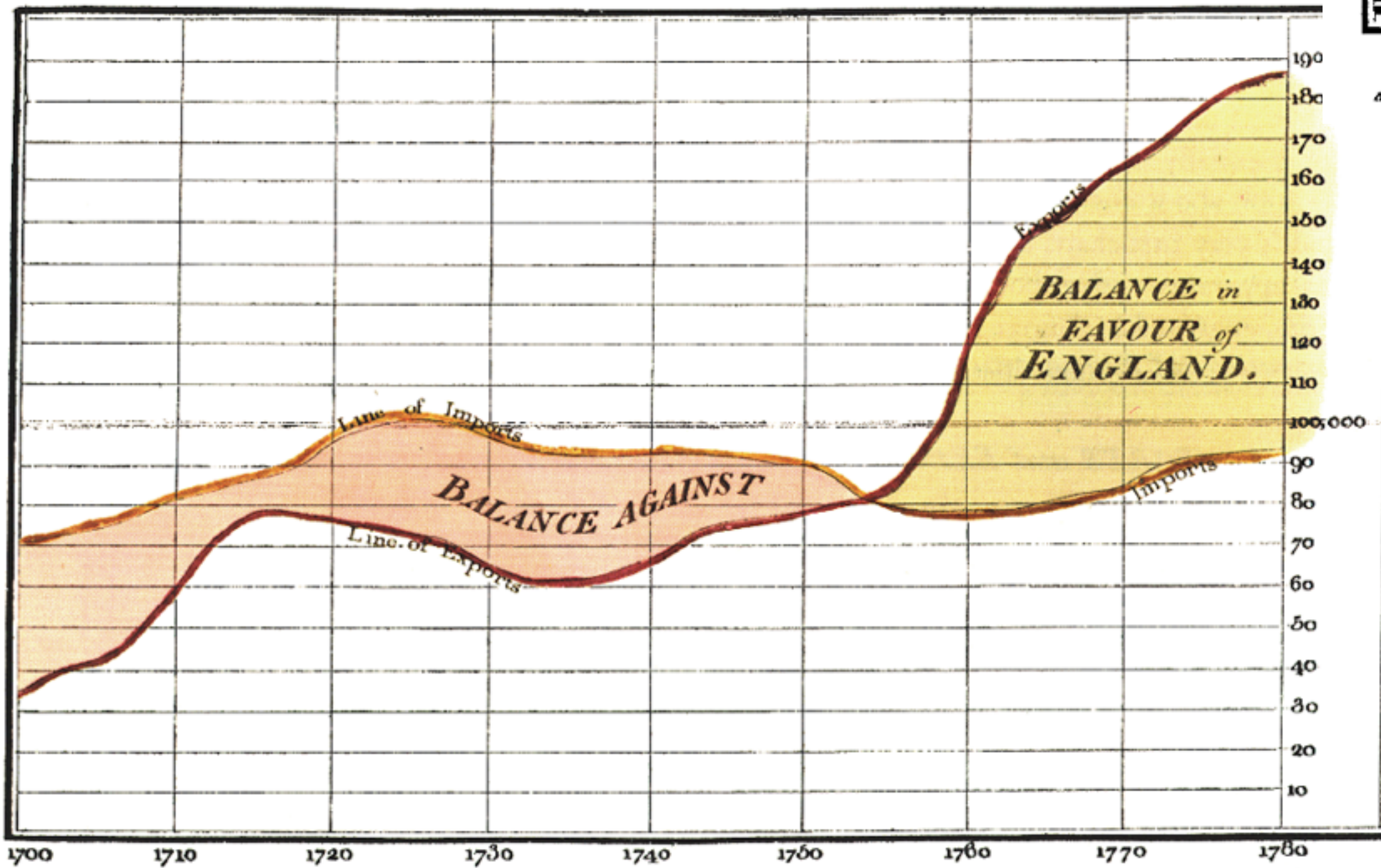
Analyze

Exports and Imports of SCOTLAND to and from different parts for one Year from Christmas 1780 to Christmas 1781.

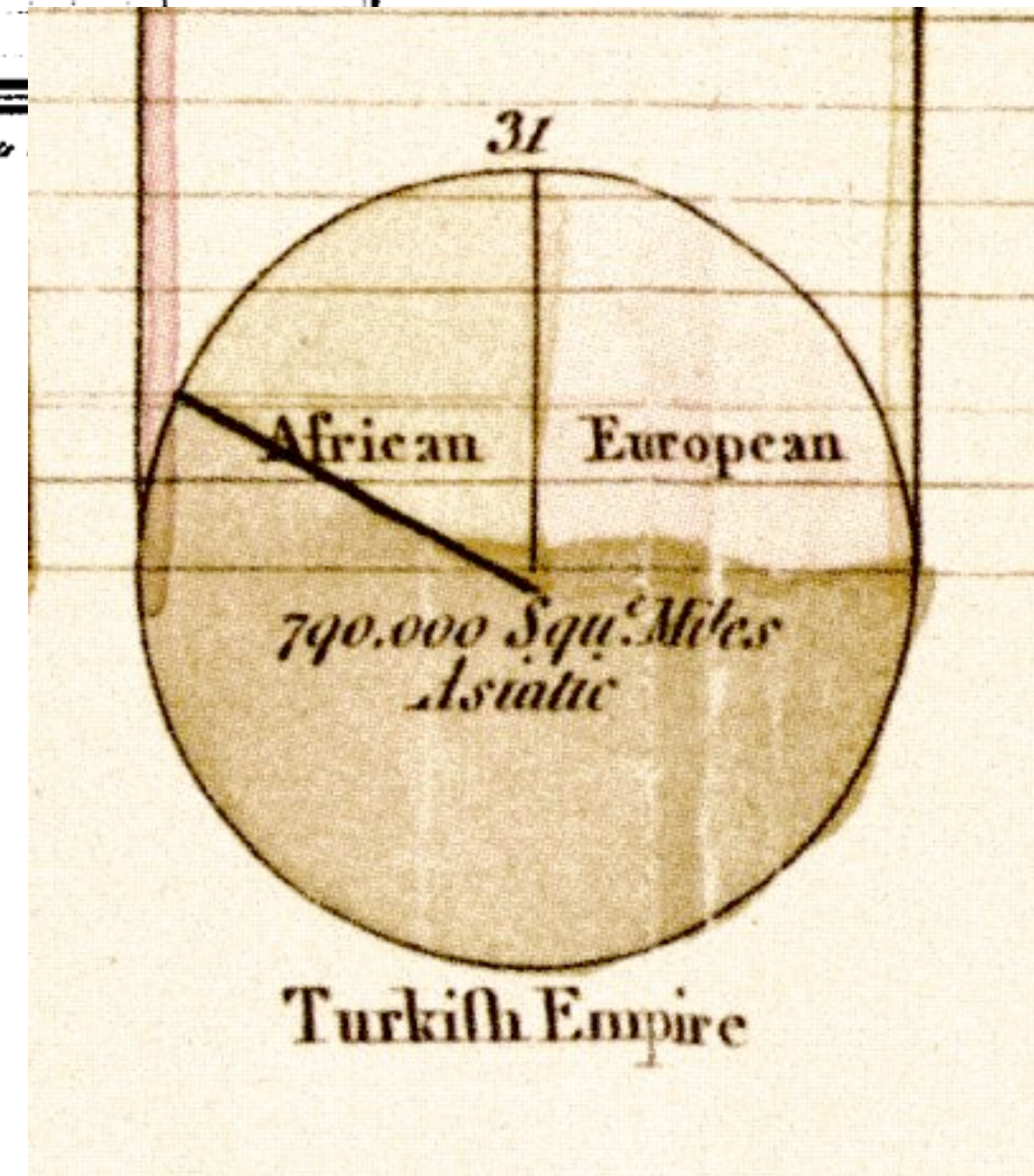


The upright divisions are Ten Thousand Pounds each. The Black Lines are Exports published in the Act done June 7th 1781 by W^m Playfair

Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.



W. Playfair, 1786

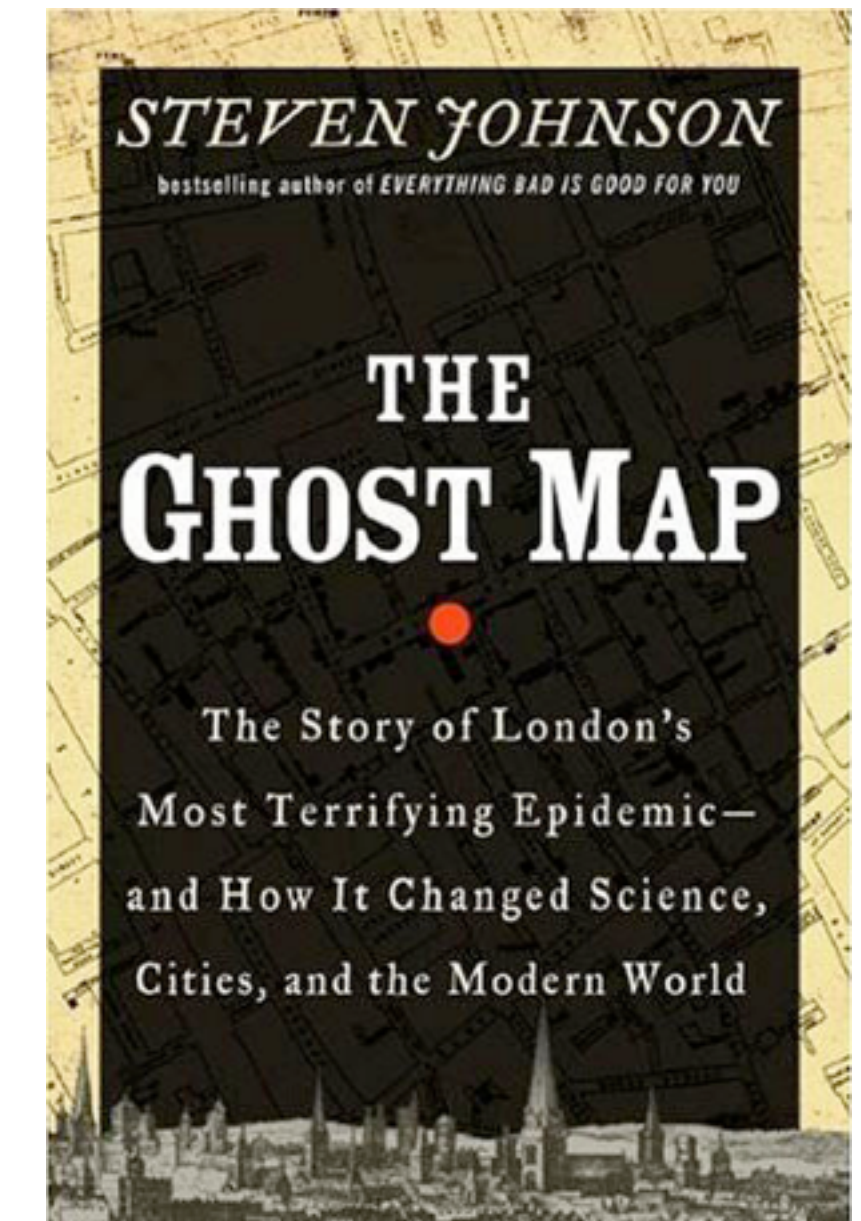


W. Playfair, 1801

Find Patterns

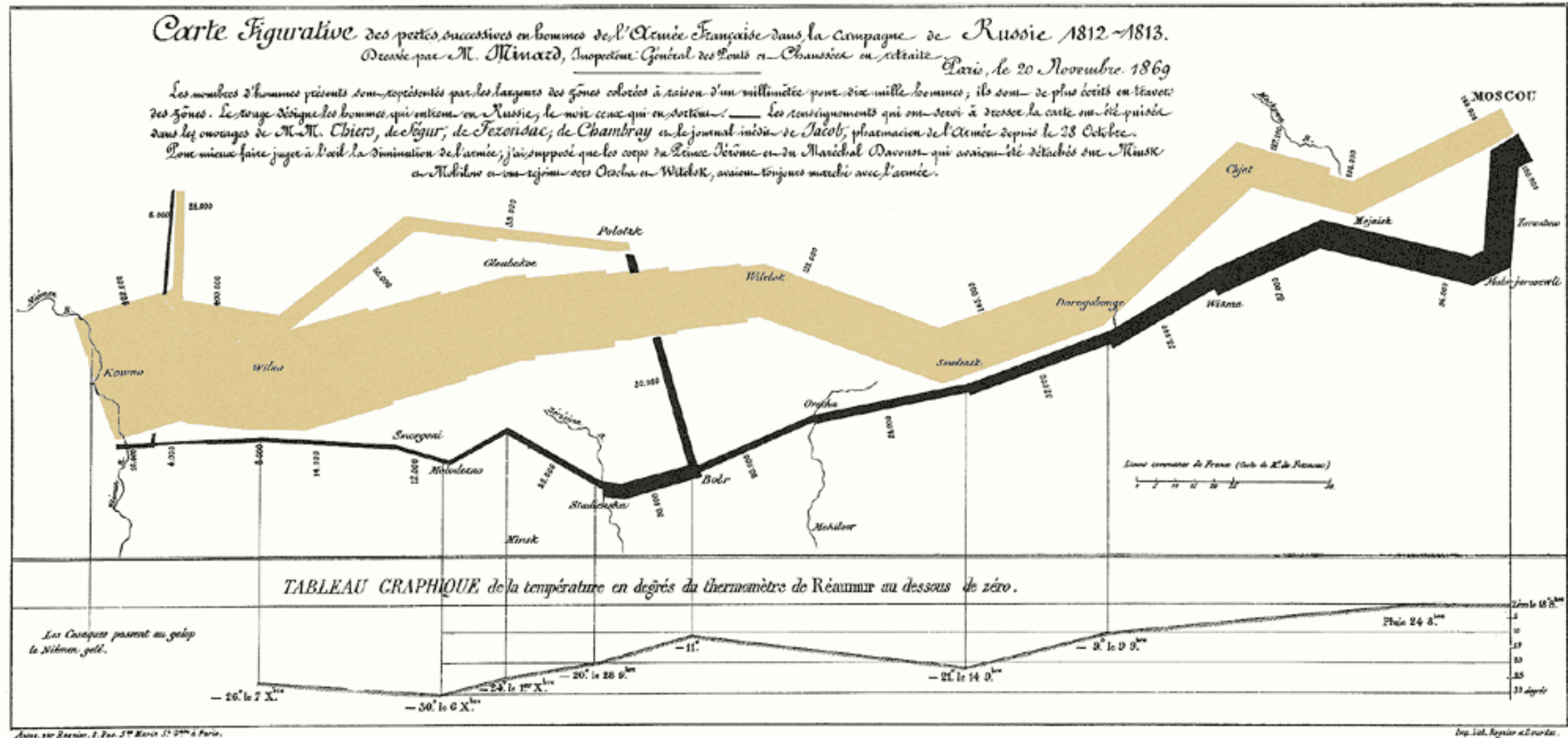


John Snow, 1854



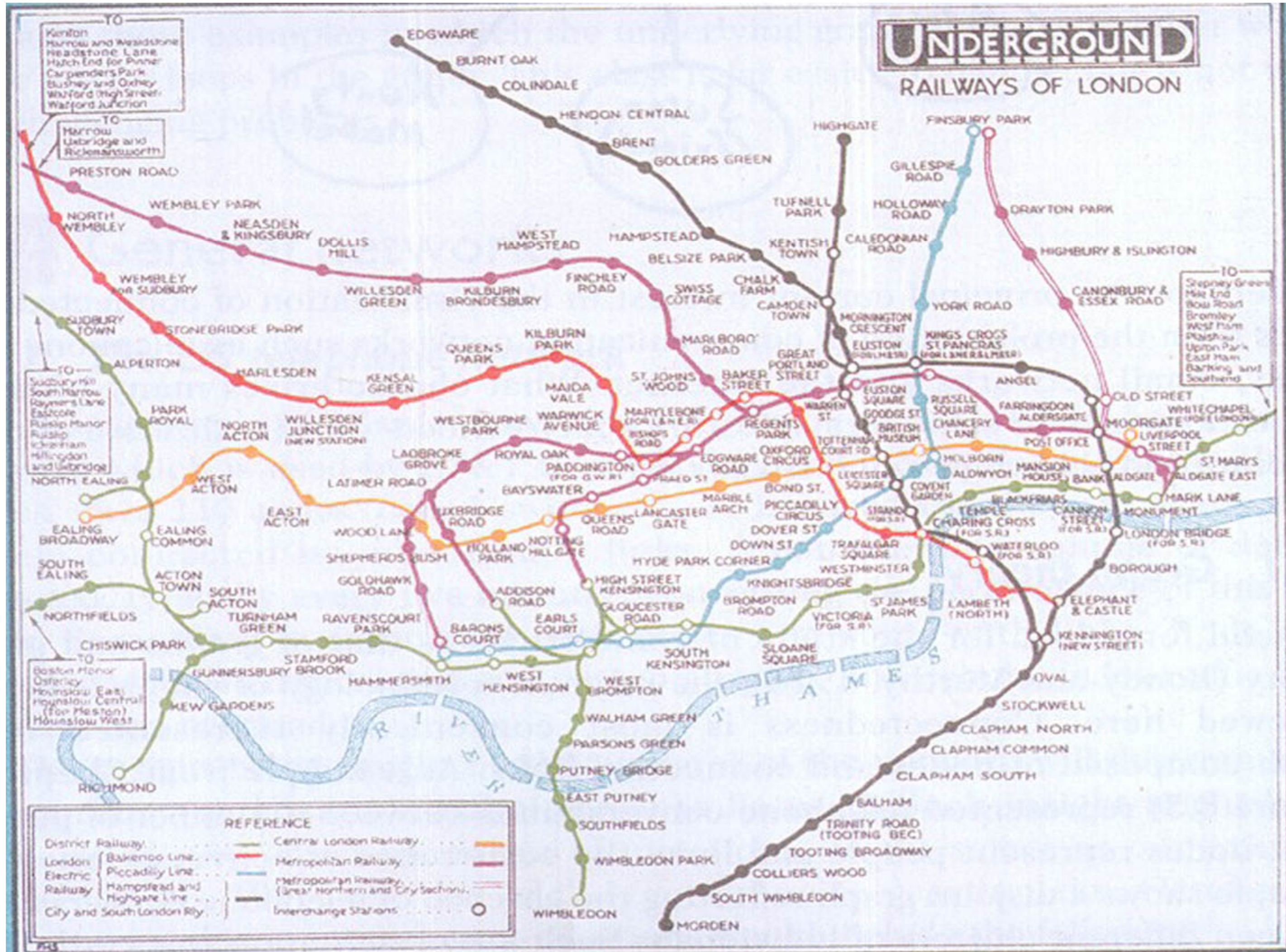
E. Tufte, Visual Explanations, 1997

Communicate



C.J. Minard, 1869

Communicate



London Subway Map, 1927


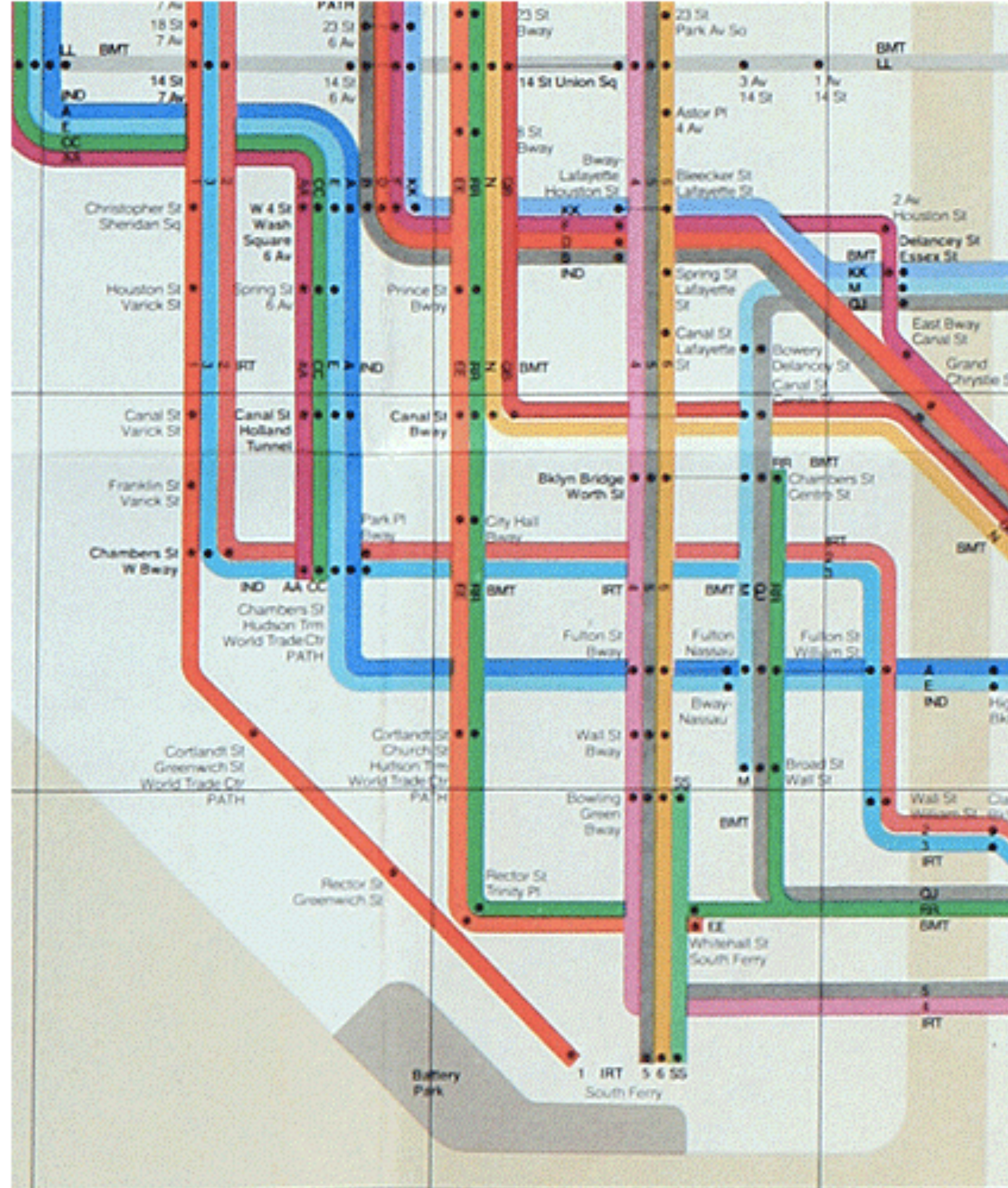
Communicate

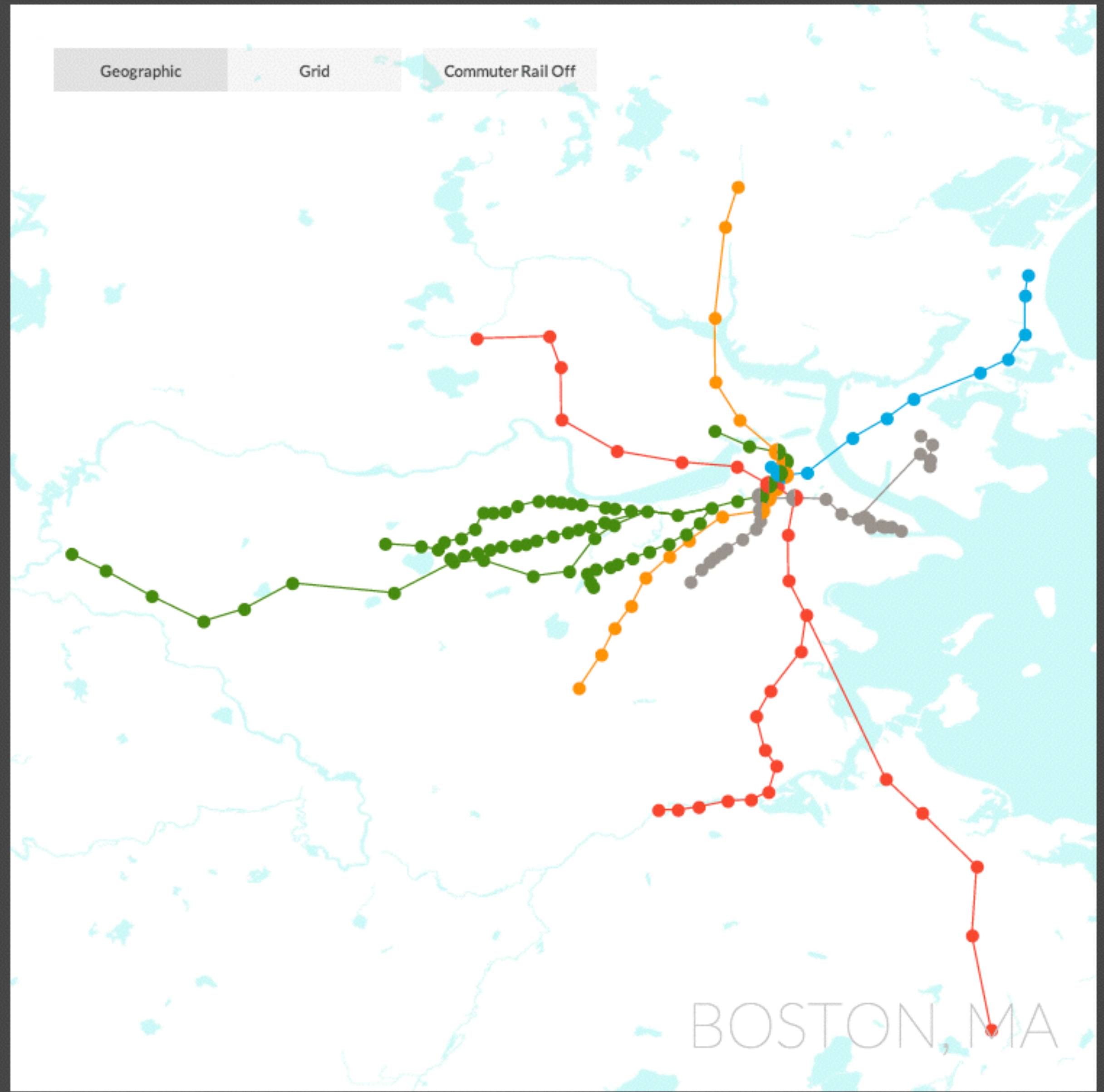


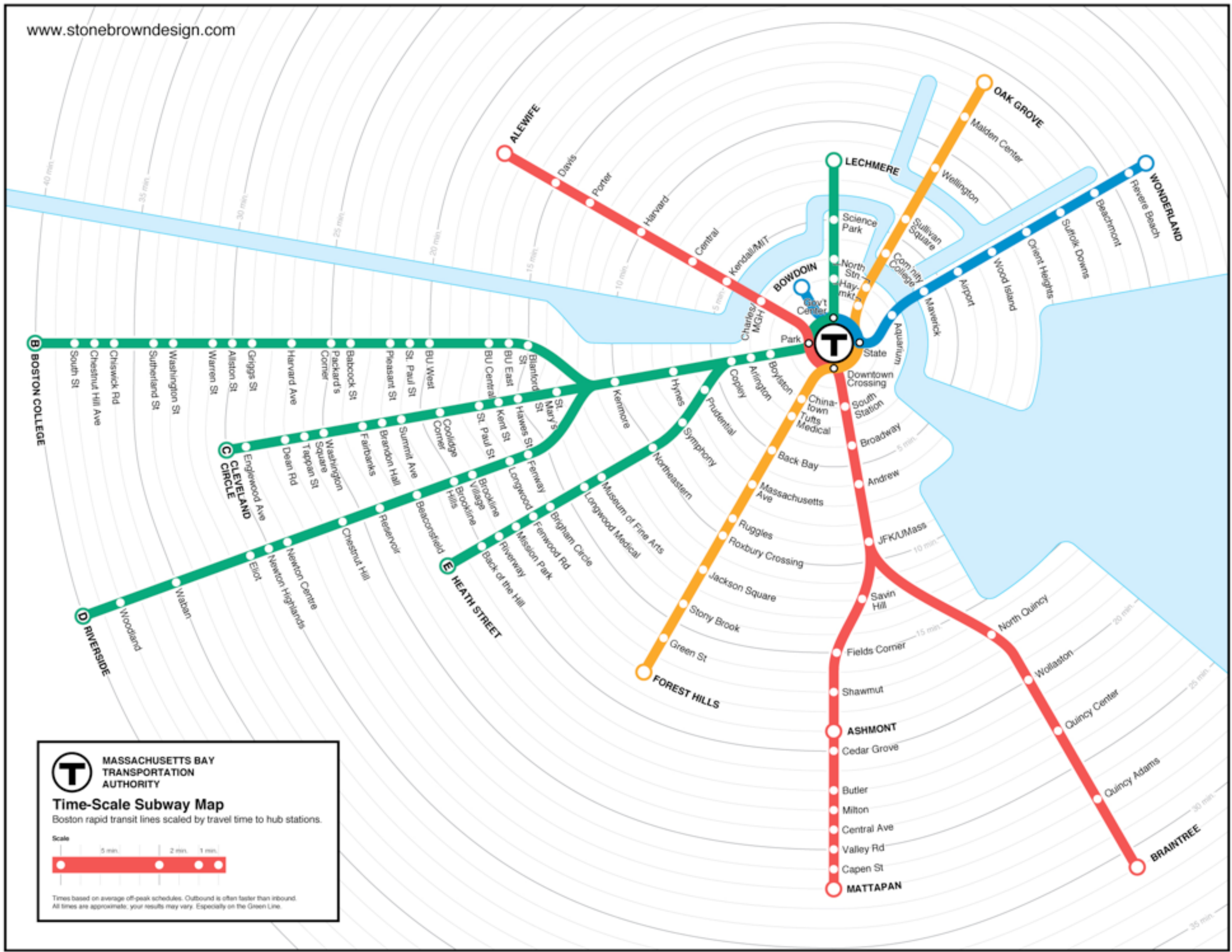
Harry Beck, 1933

An Overhaul of an Underground Icon

Next month, the Metropolitan Transportation Authority will unveil a resized, recolored and simplified edition of the well-known map, its first overhaul in more than a decade. [Related Article »](#)

FULL MAP	The New Map	1972: Vignelli's Classic
BRONX		
BROOKLYN		
MANHATTAN		
QUEENS		





T MASSACHUSETTS BAY
TRANSPORTATION
AUTHORITY

Time-Scale Subway Map
Boston rapid transit lines scaled by travel time to hub stations.

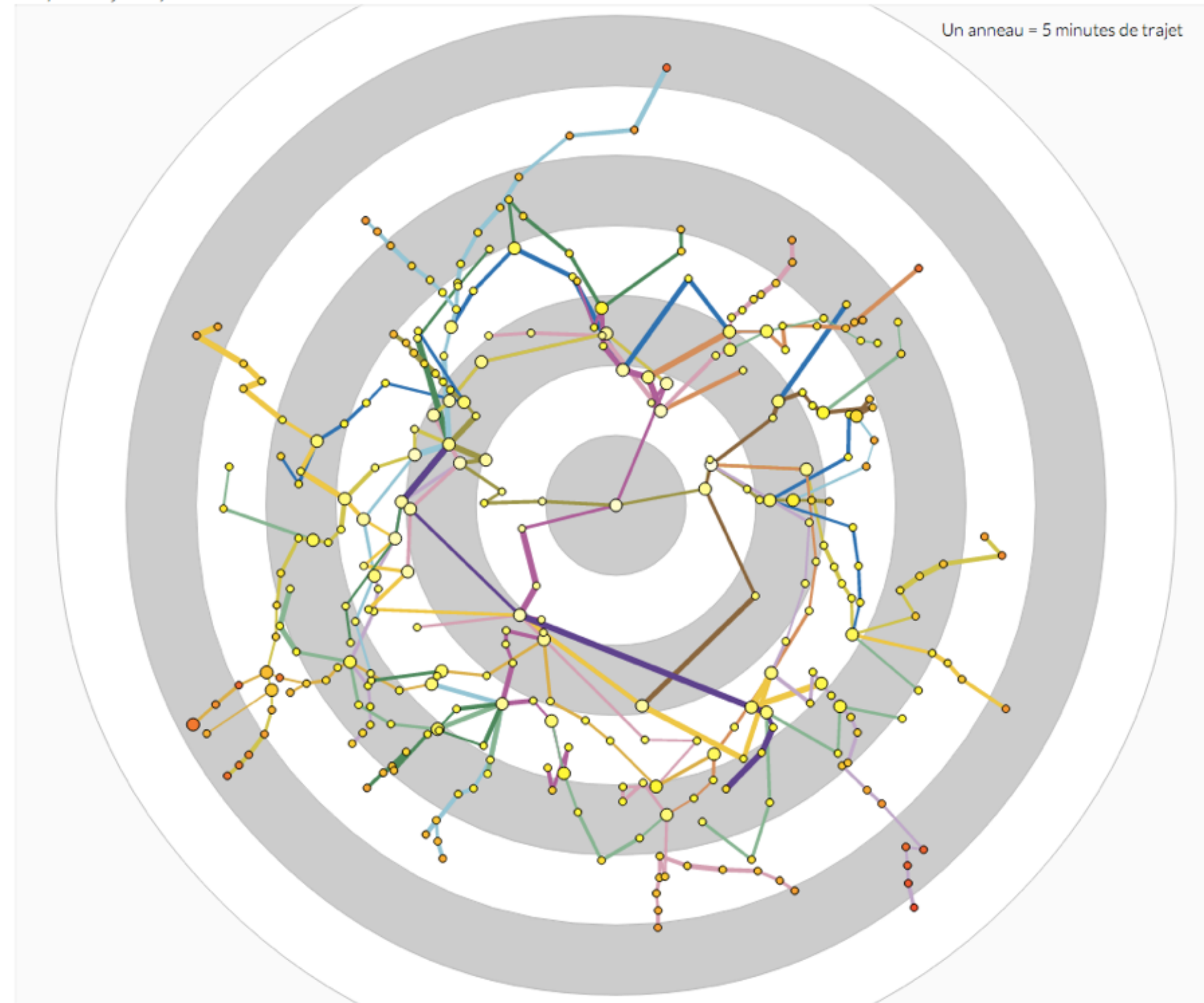
Scale

5 min. 2 min. 1 min.

Times based on average off-peak schedules. Outbound is often faster than inbound.
All times are approximate; your results may vary. Especially on the Green Line.

Réaumur — Sébastopol

Temps de trajet moyen: 18 minutes 26 secondes



Utiliser les positions exactes des stations

Améliorez le plan!

Vous connaissez bien la station Réaumur — Sébastopol ? Cliquez dans les zones grises pour améliorer les estimations.

Quelle distance entre la sortie et les quais ?



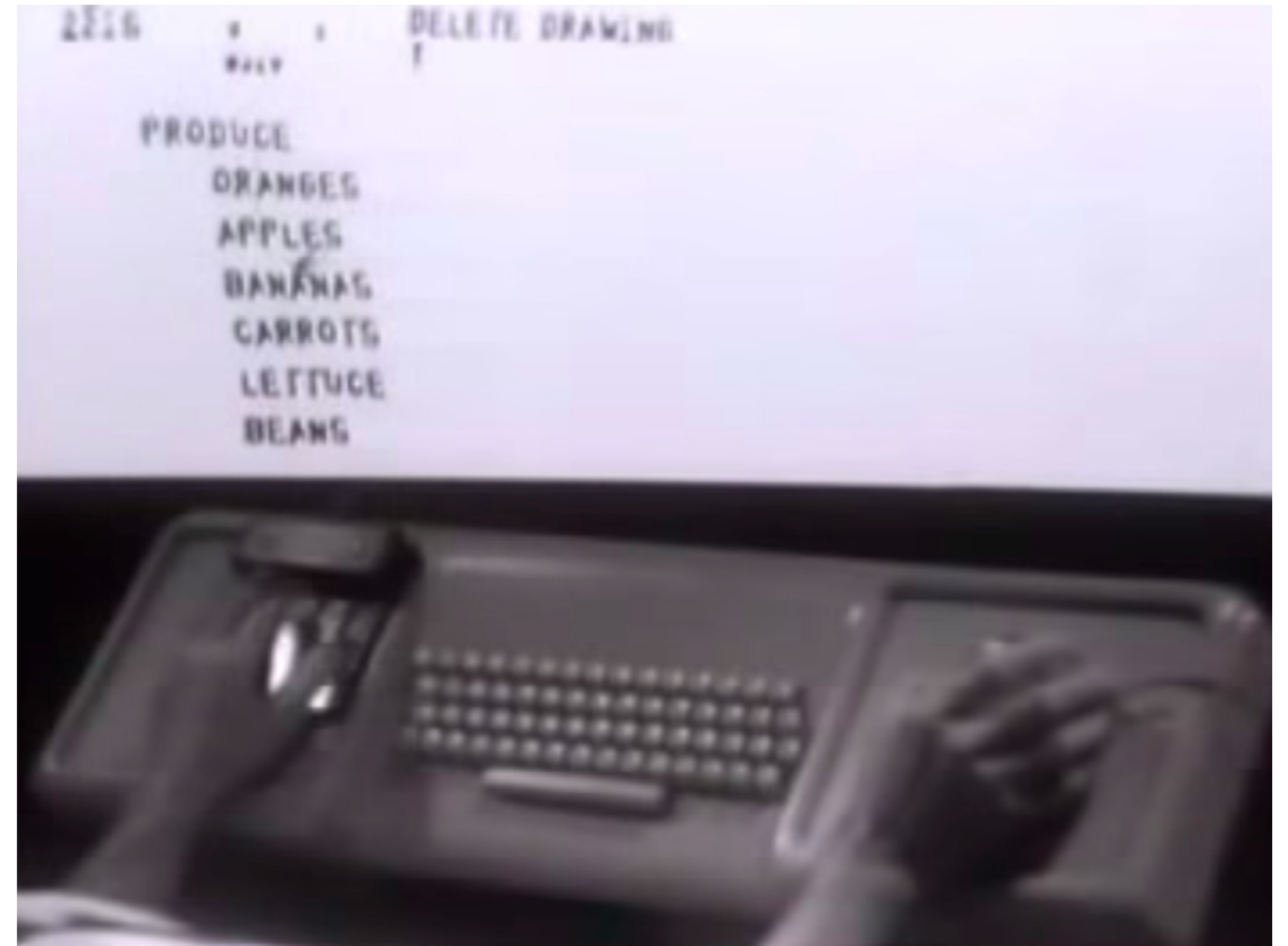
Quelle est la longueur des correspondances ?



Interact

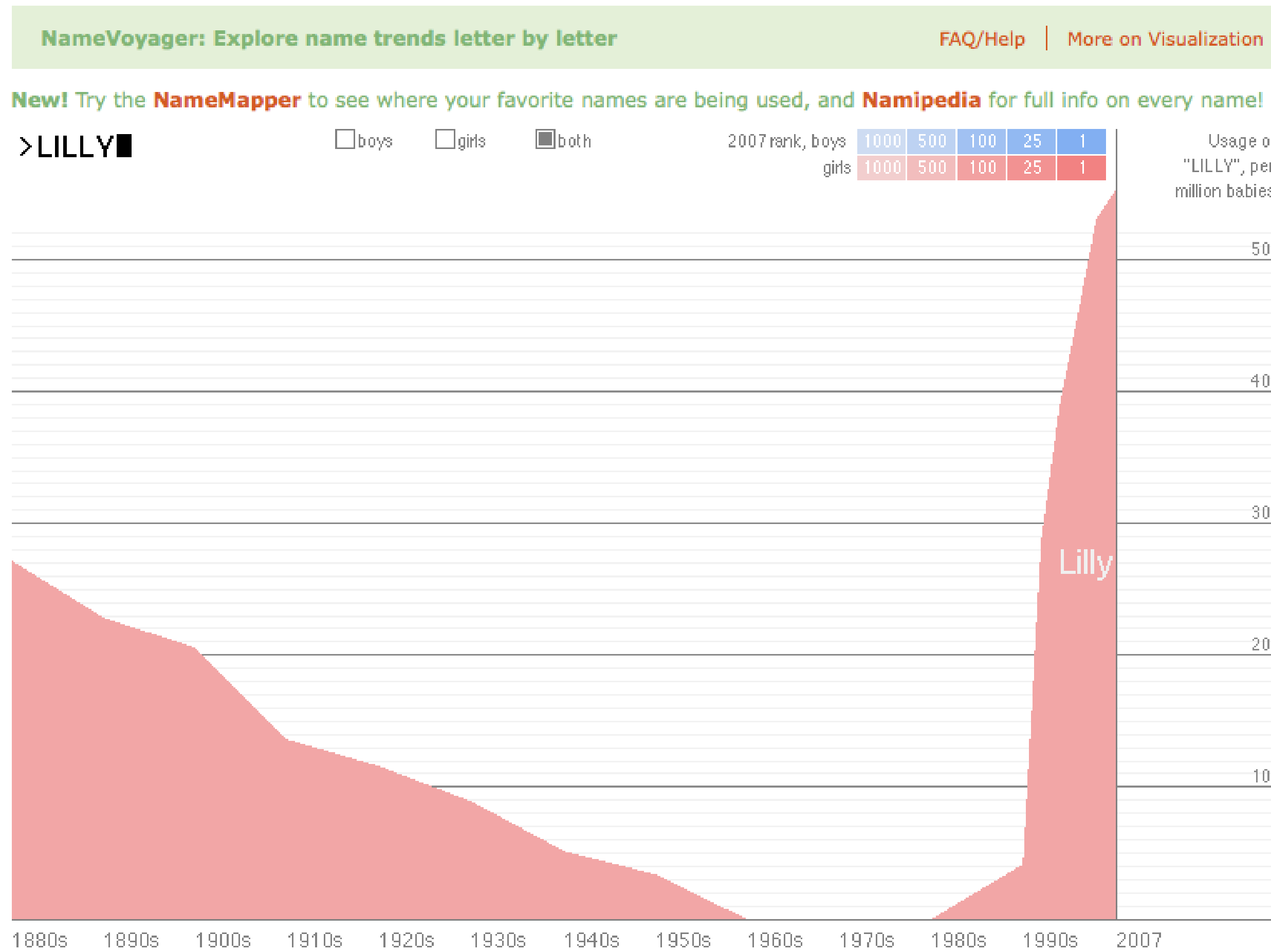


Ivan Sutherland, Sketchpad, 1963



Doug Engelbart, 1968

Analyze



M. Wattenberg, 2005

Communicate



Hans Rosling, TED 2006

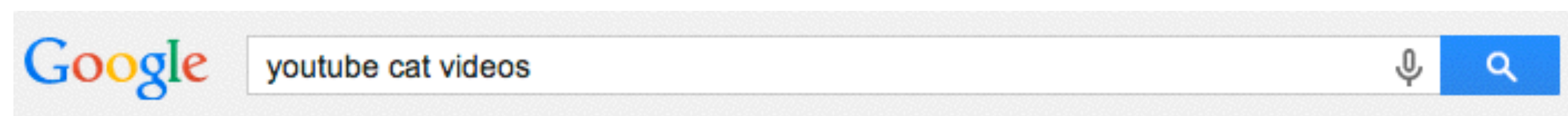
Big Data

2010: 1,200 exabytes, largely unstructured

Google stores ~10 exabytes (2013)

Hard disk industry ships ~8 exabytes/year

15 Exabytes in Punch Cards:
4.5 km over New England



Web Videos Shopping Images News More Search tools

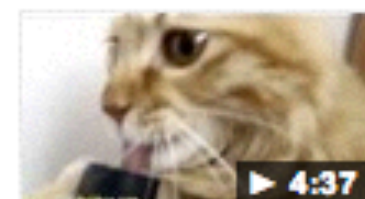
About 593,000,000 results (0.44 seconds)

[TOP 10 BEST CAT VIDEOS OF ALL TIME! - YouTube](#)



www.youtube.com/watch?v=... YouTube
Sep 6, 2012 - Uploaded by WatchTheDaily
We've scoured the internet and found the cutest and funniest cat videos of all time. Any we missed? Let us ...

[The World's Most Funny Cat Videos 2013 - YouTube](#)



www.youtube.com/watch?v=Ak... YouTube
Aug 15, 2013 - Uploaded by papiaanifails
FREE Cat Tree Construction Manual : <http://tinyurl.com/ovp252j>
Funniest Dog Videos <https://www.youtube.com> ...

In one second on the Internet there are...



“The ability to take data—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—that’s going to be a hugely important skill in the next decades, ... because now we really do have **essentially free and ubiquitous data.**”

Hal Varian, Google’s Chief Economist
The McKinsey Quarterly, Jan 2009

Limits of Cognition



Daniel J. Simons and Daniel T. Levin, Failure to detect changes to people during a real world interaction, 1998

“It is things that make us smart”

Donald A. Norman



15 a

E In terra pax hominibus bonae voluntatis. **Quidiam** re...

Domine deus rex caelestis deus pater omnipotens. **Virgine** re... **Sp** 7 al...

Domine deus agnus dei...

maie uirginis marie. **Dea** mundi. **Q**uoniam tollis peccata mundi...

30 The first Book of

describe the circle AEH ; and let DA be produced to the point G in the circumference thereof. Then $AG = CB$.

For $DG = DE$, and $DA = DC$. Wherefore $AG = CE = BC = AG$. Which was to be done.

The pointing of the point A within or without the line BC varies the cases; but the construction, and the demonstration, are every where alike.

PROP. III.

Two right lines, A and B , being given, from the greater B cut away the right line BE equal to the lesser A .

At the point B draw the right line $BD = A$. The circle described from the center B in the distance of BD shall cut off $BE = BD = A = BE$. Which was to be done.

PROP. IV.

If two triangles BAC , EDF , have two sides of the one BA , AC equal to two sides of the other ED , DF ; and the included angles BAC , EDF equal; then the third sides BC , EF shall be equal; and the other angles shall be equal, each to each.

EUCLIDE'S ELEMENTS.

PROP. V.

The angles ABC , ACB at the base of an isosceles triangle ABC , are equal one to the other; and if the equal sides AB , AC be produced, the angles CBD , BCE , under the base, shall be equal one to the other.

Take A in AD , and B join CD , and BE .

Because, in the triangles ACD , A is common, $AC = AC$, and $AD = AD$, and the angle A common to them both; therefore the angle $ADC = ACD$, and the angle $AEB = ABE$; and the base $BE = CE$; also $BC = BC$. Therefore in the triangles BCE , BCD the angle $ECB = DCB$, which was to be done. Also therefore the angle $EBC = DCB$; but the angle $BCE = ACD$; therefore the angle $ABC = ACB$. Which was to be done.

233

Incipit festiuitas sanctorum per dñi ceterum. **I**n isto sancti saturnini martyris. **Oratio.**

Eus qui non deat saturnini martyris cui concedis natalicio pfructu: non tribue meritis adiuuari. **P**ro domini nostri. **L. i.**

Rome natale faueti saturnini martyris et senio: et sicut uiaconi sub maximo. Et quo primo iter alios seruas dei caritati sunt ad fodendam harenas ad faciendam thermas vicentianam. Quorum unum sicut sibi presertim: cum interrogasset idem maximianus quomodo uocaretur. respondit: Ego peccator: sicut seruus seruorum domini nostri iesu christi. Et in eius post alia diceret maximianus: aut sacrificia deo herculi aut carnis tuae cremato: respondit. Ego quidem semper hoc optaui: ueritate si meriti seruo coonati desiderata accepta.

Maximus igitur laudato. **L. cetero secunda** perfectio missas est in custodia decem t...

Visualization

“Visualization is really about external cognition, that is, how resources outside the mind can be used to boost the cognitive capabilities of the mind.”



Stuart Card

Who is CS-5630 / CS-6630?

Alexander Lex

@alexander_lex
<http://alexander-lex.net>

Assistant Professor, Computer Science

Before that: Lecturer, Postdoctoral Fellow, Harvard

PhD in Computer Science, Graz University of Technology



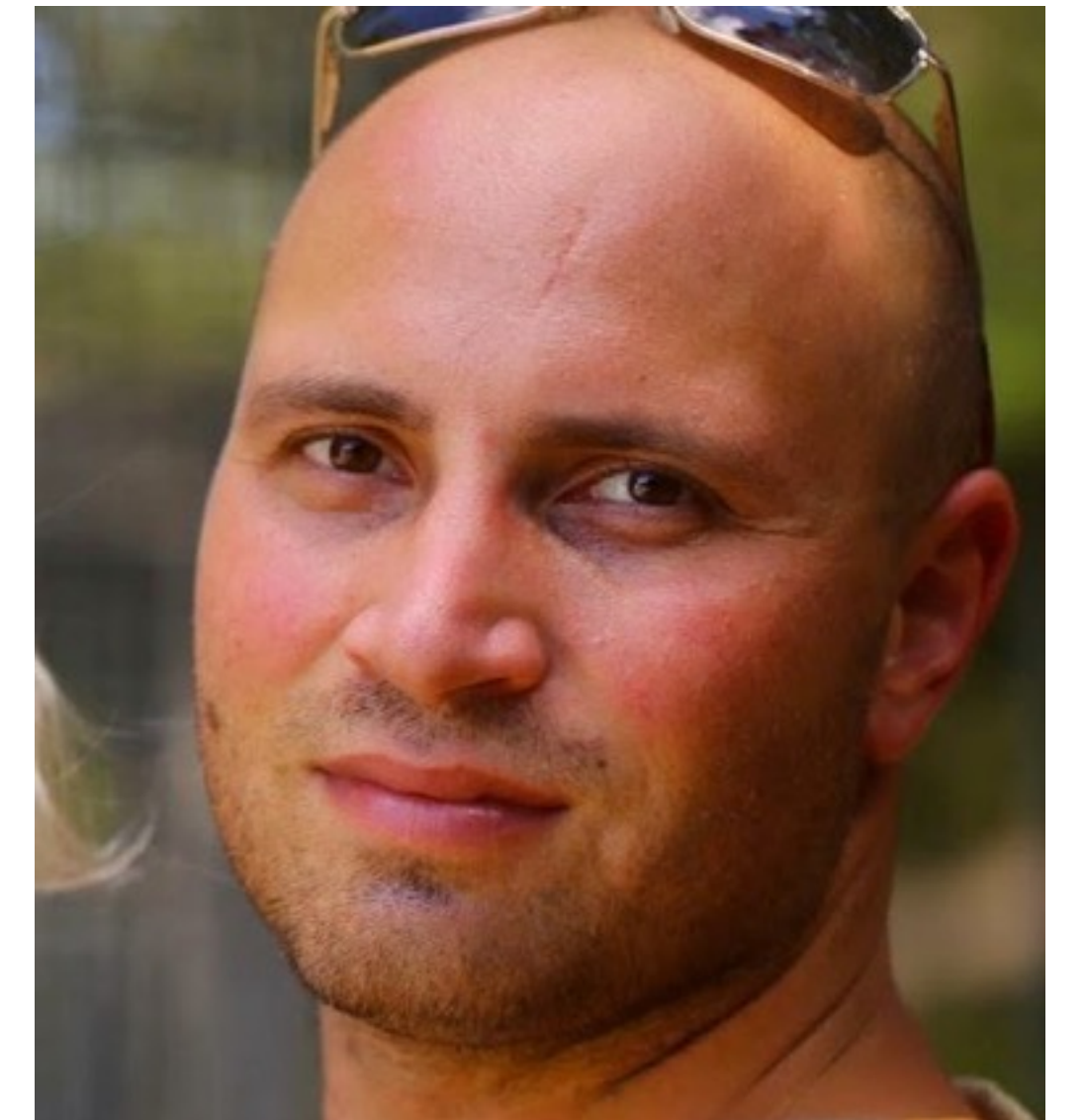
Aaron Knoll

Guest Lectures on Scientific Visualization

Research Scientist at SCI, SciVis Expert!

PhD from Univ. of Utah

PostDoc at University of Kaiserslautern in
Germany, and then at Argonne National
Laboratory



SCI Institute

Scientific Computing and Imaging Institute

Scientific Computing

Biomedical Computing

Scientific Visualization

Information Visualization

Image Analysis



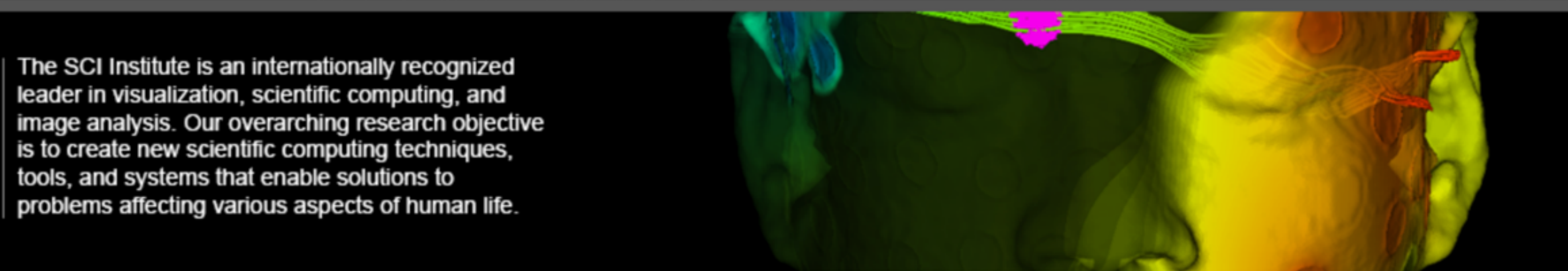
<http://sci.utah.edu>

[Login](#) [Admin](#)



University of Utah

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PREV **1** 2 3 4 NEXT



SCIRun 5.0 Released



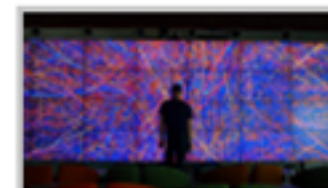
Seg3D 2.2.0 Now Available

Jul 01, 2015



SCI Institute welcomes two new Professors in Computer Science and Mathematics

Jun 25, 2015



Big Scientific Data Made Simple

Jun 23, 2015

SCI Events

Aug 2015						
S	M	T	W	T	F	S
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

[RSS 2.0](#) [FEED](#)

[View all SCI Events](#)

Upcoming SCI Events

Course Staff



Zinnia Mukherjee
Teaching Assistant

Alex Bigelow
Teaching Assistant



Anirudh Narasimhamurthy
Teaching Assistant

About You

Enrollment

Structure & Goals

Course Goals

Evaluate and critique visualization designs

Implement interactive data visualizations

Apply fundamental principles & techniques

Design visual data analysis solutions

Develop a substantial visualization project

No Device Policy

No Computers, Tablets, Phones in lecture hall

except when used for exercises

Switch off, mute, flight mode

Why?

It's better to take note by hand

Notifications are designed to grab your attention

Applies to Theory lectures, coding along in technical lectures encouraged

Information <http://dataviscourse.net>

The screenshot shows the header of the Visualization course website. On the left, the title "Visualization" is displayed in a large, bold, black font, with the course numbers "CS-5630 / CS-6630" below it. To the right is the logo for The University of Utah, featuring a red stylized 'U' followed by the text "THE UNIVERSITY OF UTAH". Below the header is a navigation menu with links for "Home", "Syllabus", "Schedule", "Homework", "Project", "Resources", and "Fame".

The main content area features three distinct visualizations:

- UpSet visualization:** A complex chart on the left showing the cardinality of various combinations of sets. It includes a grid of circles representing the presence or absence of elements in different sets, with corresponding horizontal bars showing the total count for each combination.
- Wind map:** A map of the United States in the center, where the density of lines represents wind patterns across the country.
- How states have shifted:** A Sankey diagram on the right showing the flow of states between different political affiliations (represented by blue and red lines) over time, with labels for various political figures like Obama, Romney, McCain, and Clinton.

Below the visualizations, a red caption reads: "UpSet visualizing intersecting sets | Wind map | How states have shifted".

The amount and complexity of information produced in science, engineering, business, and everyday human activity is increasing at staggering rates. The goal of this course is to expose you to visual representation methods and techniques that increase the understanding of complex data. Good visualizations not only present a visual interpretation of data, but do so by improving comprehension, communication, and decision making.

In this course you will learn about the fundamentals of perception, the theory of visualization, good design practices for

Communicate

Piazza

<http://piazza.com/utah/fall2015/cs5630cs6630>

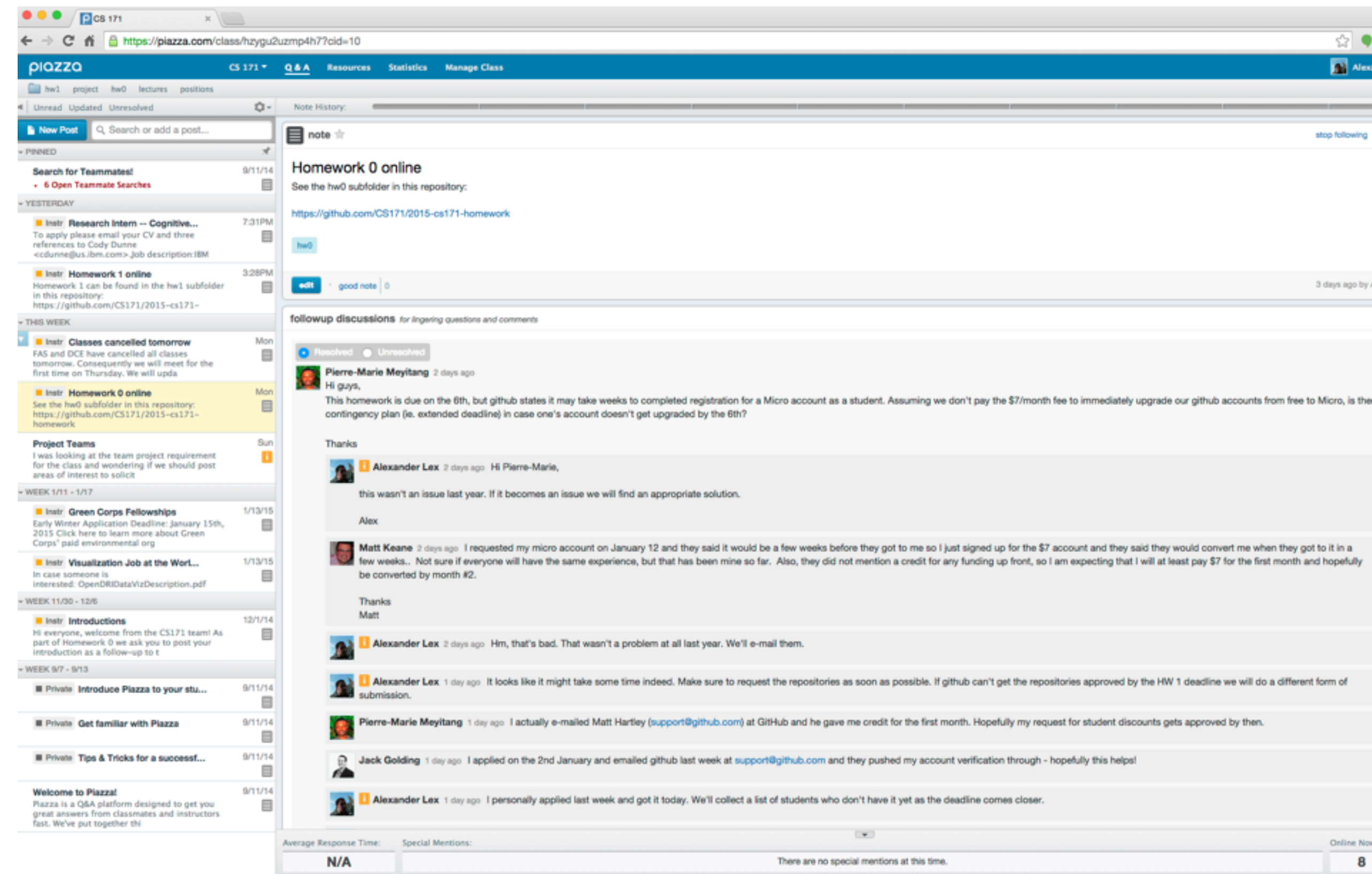
Office Hours

Alex: Thursday after class

TAs: starting next week

E-Mail

alex@sci.utah.edu



The screenshot shows a Piazza discussion for CS 171. The main post is titled "Homework 0 online" and includes a link to a GitHub repository: <https://github.com/CS171/2015-cs171-homework>. The post is pinned and has a "good note" badge. Below the main post, there are several replies and follow-up discussions. The replies include:

- Alexander Lex: "Hi Pierre-Marie, this wasn't an issue last year. If it becomes an issue we will find an appropriate solution."
- Matt Keane: "I requested my micro account on January 12 and they said it would be a few weeks before they got to me so I just signed up for the \$7 account and they said they would convert me when they got to it in a few weeks... Not sure if everyone will have the same experience, but that has been mine so far. Also, they did not mention a credit for any funding up front, so I am expecting that I will at least pay \$7 for the first month and hopefully be converted by month #2."
- Alexander Lex: "Hm, that's bad. That wasn't a problem at all last year. We'll e-mail them."
- Alexander Lex: "It looks like it might take some time indeed. Make sure to request the repositories as soon as possible. If github can't get the repositories approved by the HW 1 deadline we will do a different form of submission."
- Pierre-Marie Meyfang: "I actually e-mailed Matt Hartley (support@github.com) at GitHub and he gave me credit for the first month. Hopefully my request for student discounts gets approved by then."
- Jack Golding: "I applied on the 2nd January and emailed github last week at support@github.com and they pushed my account verification through - hopefully this helps!"
- Alexander Lex: "I personally applied last week and got it today. We'll collect a list of students who don't have it yet as the deadline comes closer."

The bottom of the screenshot shows the "Average Response Time" as "N/A" and "Special Mentions" as "There are no special mentions at this time."

Course Components

Theory

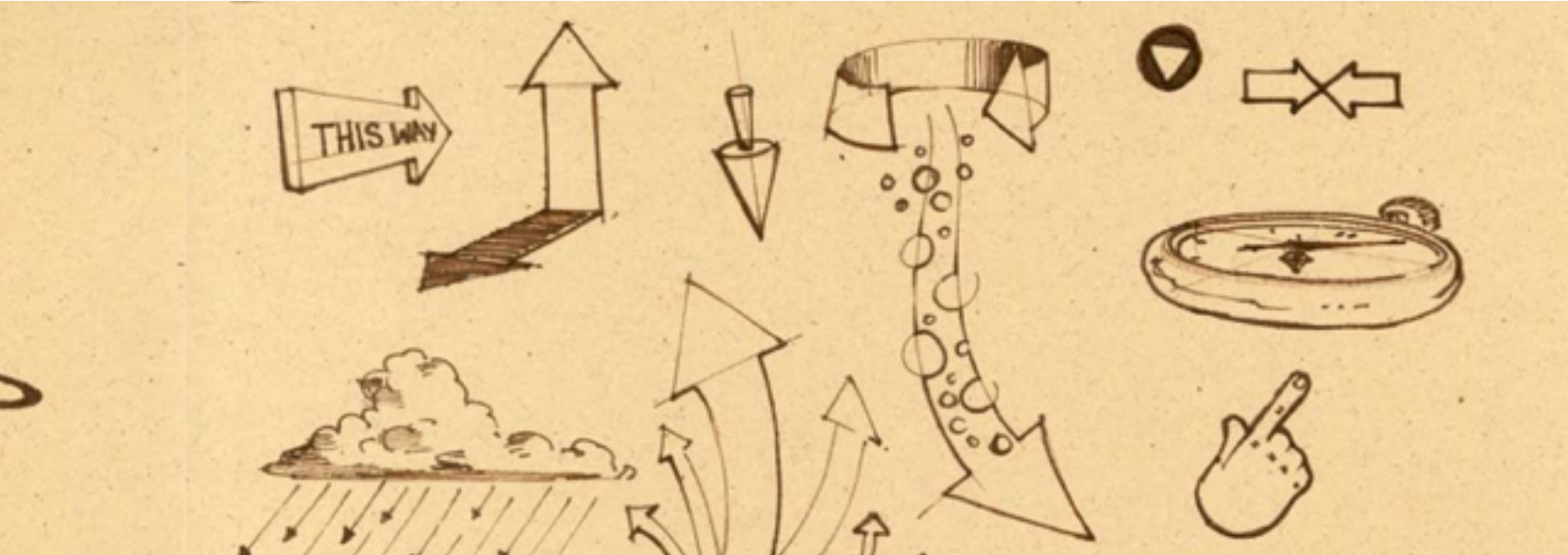
Lecture
Reading
Discussion

Design Lecture
Design Studios

Sections
D3 reading
Self-study
Office hours

Design Skills

Coding Skills



```
<!DOCTYPE html>
<meta charset="utf-8">
<style>

text {
  font: 10px sans-serif;
}

</style>
<body>
<script src="http://d3js.org/d3.v3.min.js"></script>
<script>
```


Two types of Lectures

Theory

Presentation with Videos etc.

Coding Skills

Short coding tutorials

Based on a published script on website

Strongly related to homework assignments

Schedule

Lectures: Tuesday and Thursday
9:10-10:30 am, L102 WEB

Online Students:
[YouTube Channel](#)

Office Hours:
See [Google Calendar](#)
Alex: Thursday after class
WEB 3887
Please limit to organizational/personal
issues and understanding of material (no
debugging in OH)

TAs: To be announced
Technical questions and help with
homework.

Visualization

CS-5630 / CS-6630



[Home](#) [Syllabus](#) [Schedule](#) [Homework](#) [Project](#) [Resources](#) [Fame](#)

Schedule

Subject to change.

Week 1

Lecture 1: Introduction

Tuesday, Aug. 25

What is visualization? Why is it important? Who are we? Course overview.

Introduction to [Homework 0](#).

Recommended reading

- [A Tour through the Visualization Zoo](#). Jeffrey Heer, Michael Bostock, Vadim Ogievetsky. Communications of the ACM, 53(6), pp. 59-67, Jun 2010.
- [The Value of Visualization](#). Jarke van Wijk. Proceedings of the IEEE Visualization Conference, pp. 79-86, 2005.

Lecture 2: Version Control and HTML

Thursday, Aug. 27

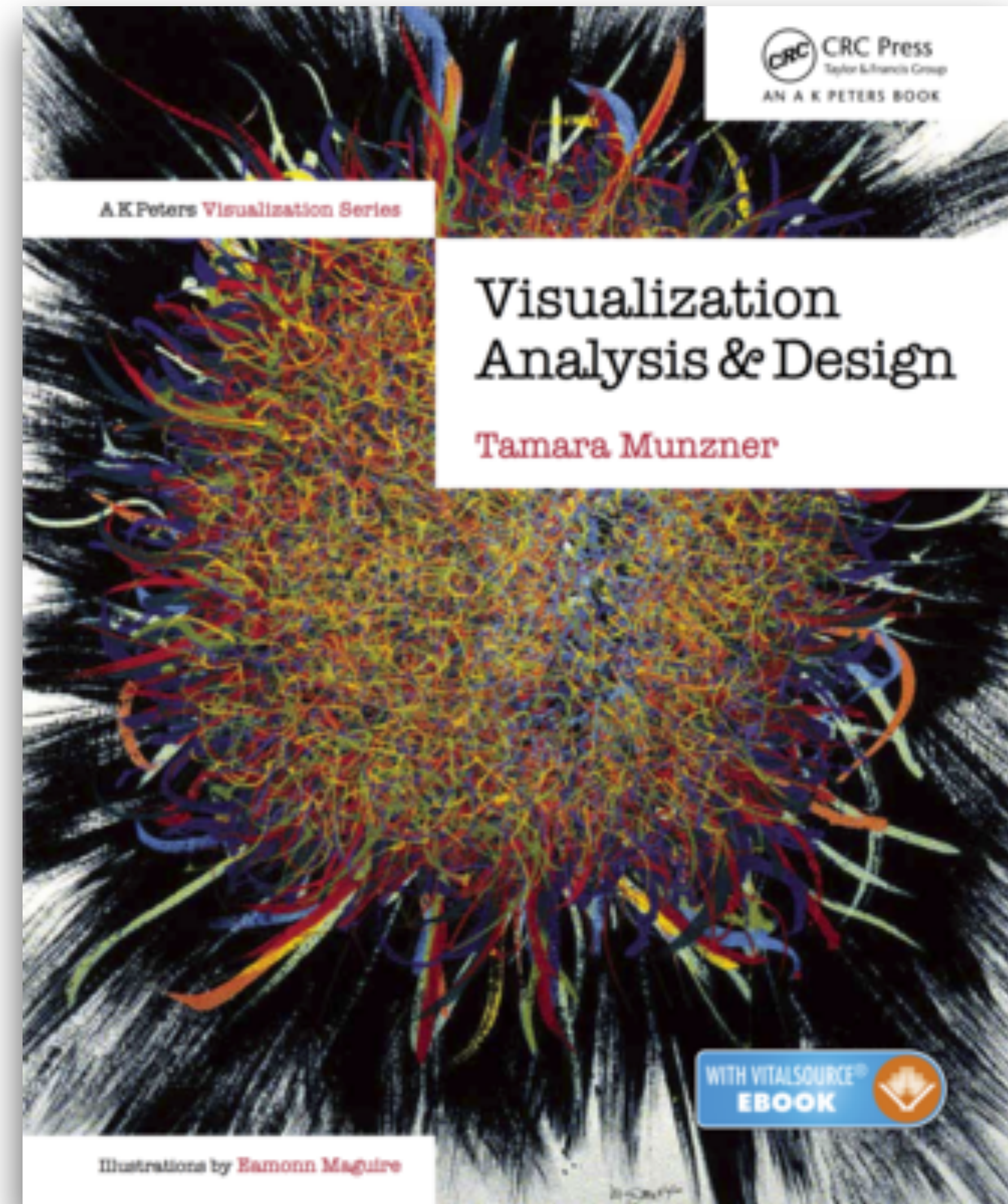
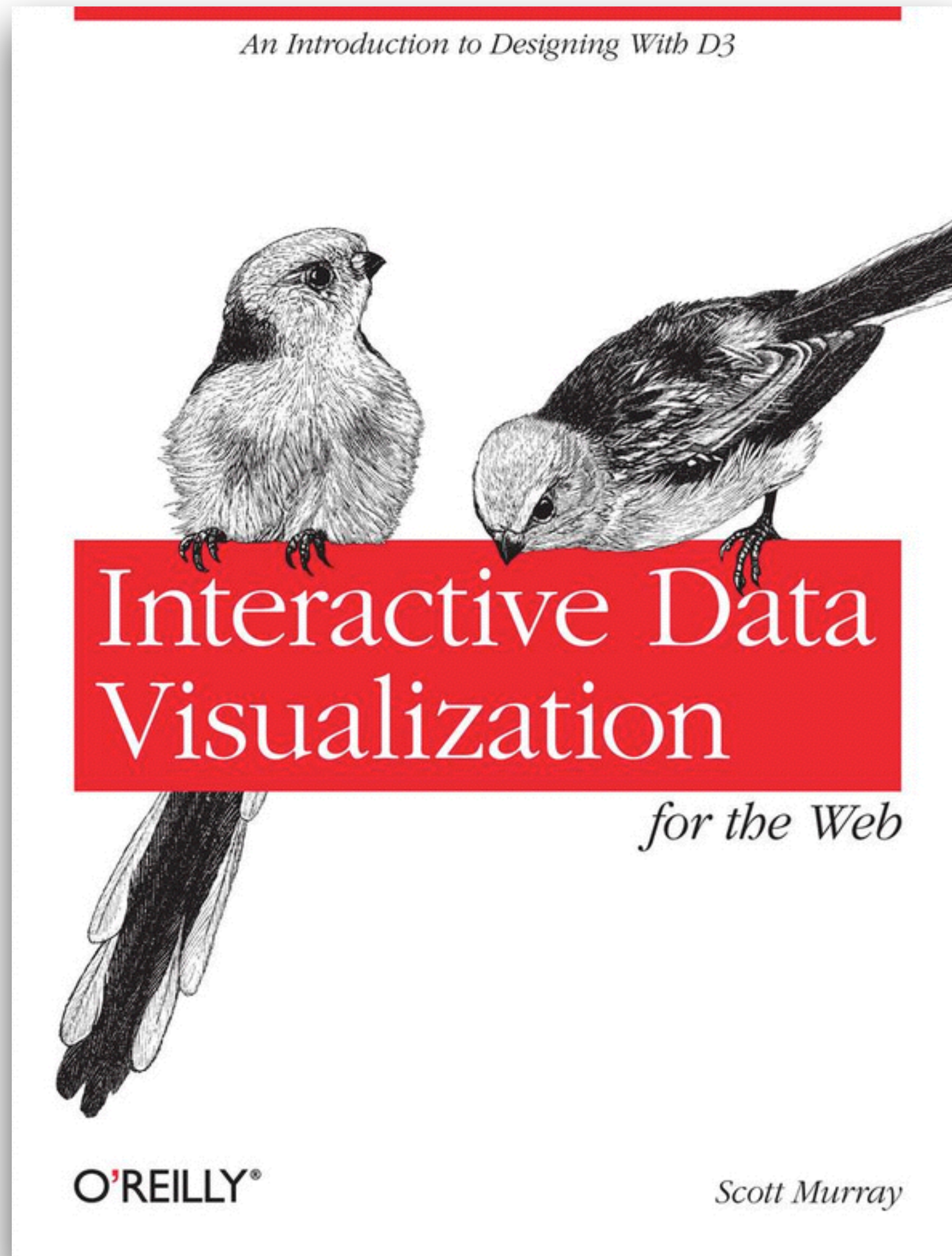
Introduction to git. HTML, CSS and the DOM. Selectors, etc.

[Go to interactive lecture content](#)

Recommended reading

- [Think like a git](#)
- [Understanding git conceptually](#)
- [Fun and insightful talk on git by Linus Torvalds](#)
- [A successful git branching model](#)
- [Complex CSS Selectors](#)

Required Books



Programming

HTML



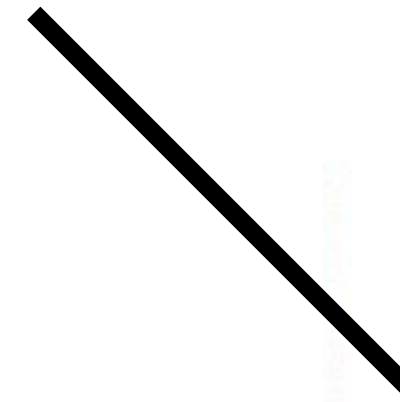
JS



Data-Driven Documents



Is this course for me ???



Prerequisites

Programming experience

C, C++, Java, Python, etc.

Willingness to learn new software & tools

This can be time consuming

You will need to build skills by yourself!

Engineering vs Computer Science

How are you graded?

6+1 Homework Assignments: 40%

Varying value, 2%-10%, depending on length/difficult

Start early! Will take long if you don't know JS/D3 yet

Due on Fridays, late days: -10% per day, up to two days.

Final Project: 40%

Teams, two milestones

Exams: 20%

Two exams, one on fundamentals, one on techniques

This Week

HW0, including course survey
Introduction to Git, HTML, CSS

Readings

D3 Book, Chapters 1-3

VDA Book, Chapter 1

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Next Week

HW1 due

More technological foundations

JavaScript, JSON, D3

Office hours start!

<https://github.com/dataviscourse/2015-dataviscourse-homework>


Branch: **master** ▾ **2015-dataviscourse-homework** / **hw0** / + ☰ 🔄

Update readme.md

 **AnirudhNarasimhamurthy** authored 4 days ago latest commit b6771174ee 

..

 [readme.md](#) Update readme.md 4 days ago

 **readme.md**

CS-5630 / CS-6630 Homework 0

Due: Friday, August 28, 11:59 pm. Value: 2%

Welcome to CS-5630 / CS-6630 - Visualization. In this class, we will be using a variety of tools that will require some initial configuration. To ensure everything goes smoothly moving forward, we will setup the majority of those tools in this homework. This homework will not be graded **except** for Problem 2. In Problem 2 you set up git and github for this course, which is essential before starting with HW 1.

Problem 1 - Class Survey, Signups, and Introduction

Sign up for github

Sign up for GitHub now!