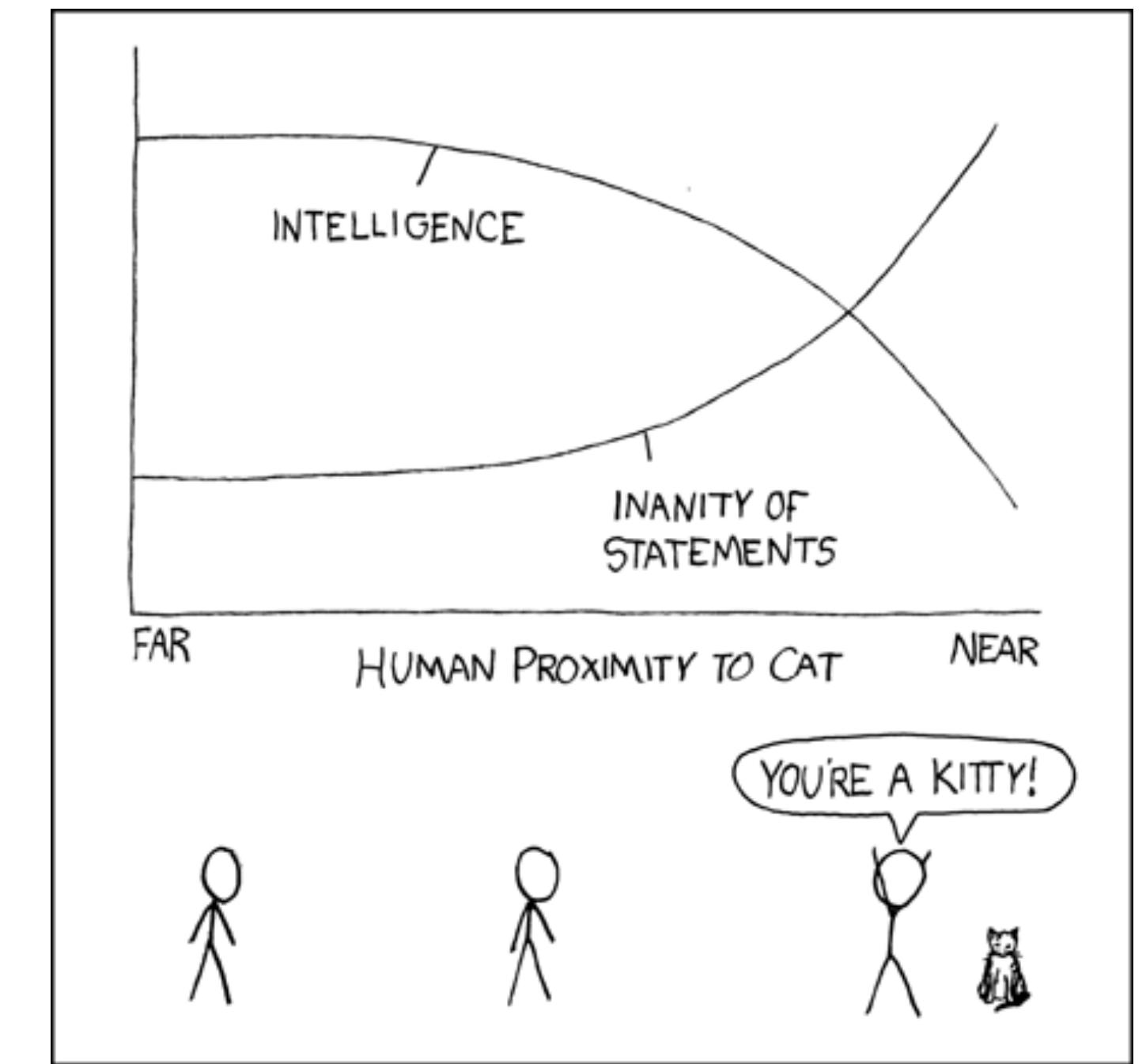


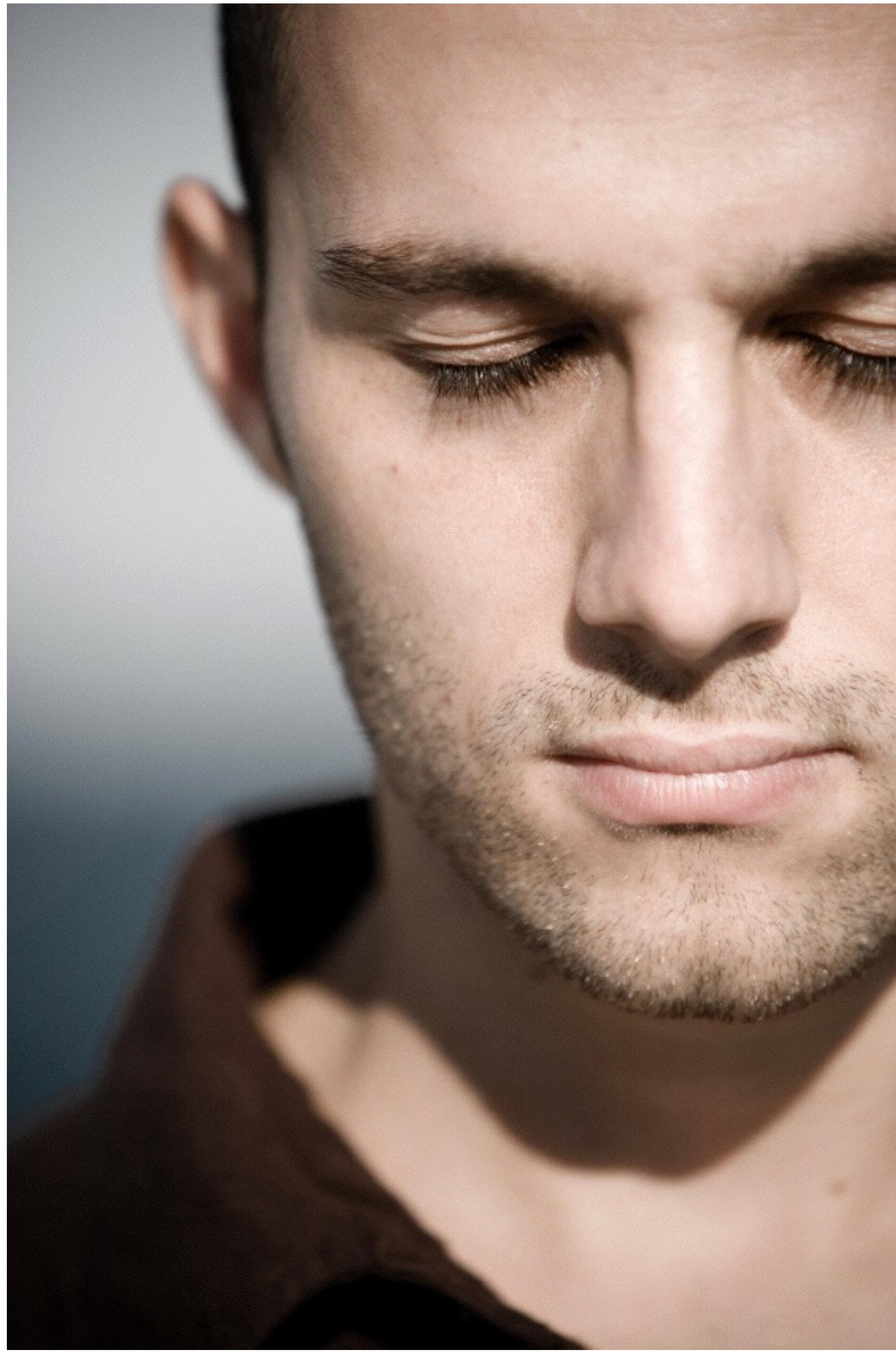
CS-5630 / CS-6630

Visualization

Alexander Lex
alex@sci.utah.edu



[xkcd]



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?

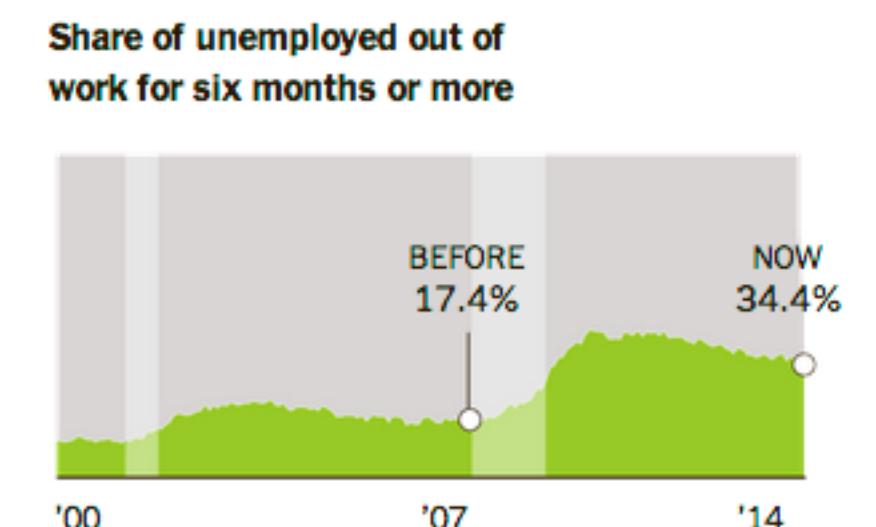
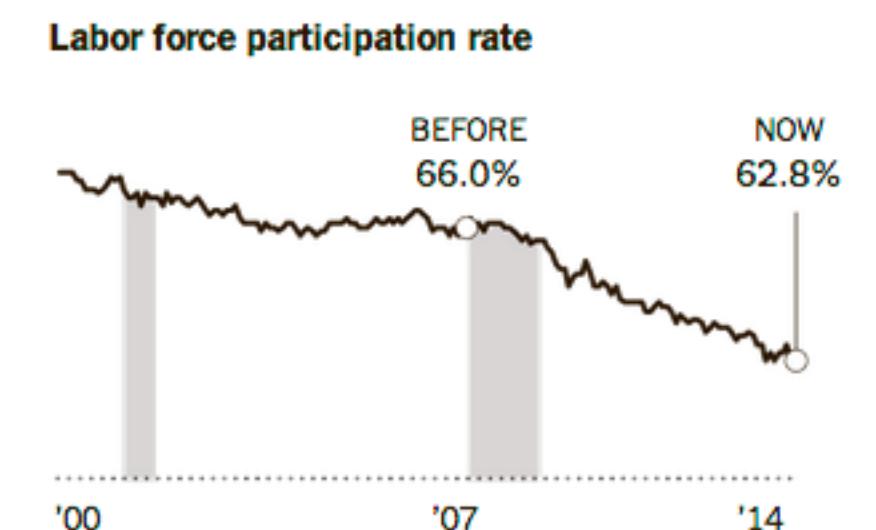
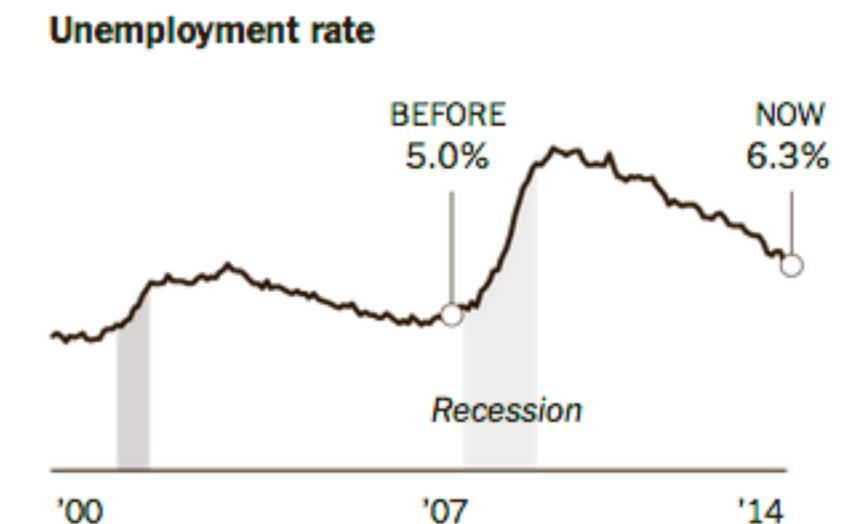
To inform humans: **Communication**

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

When questions are not well defined:
Exploration

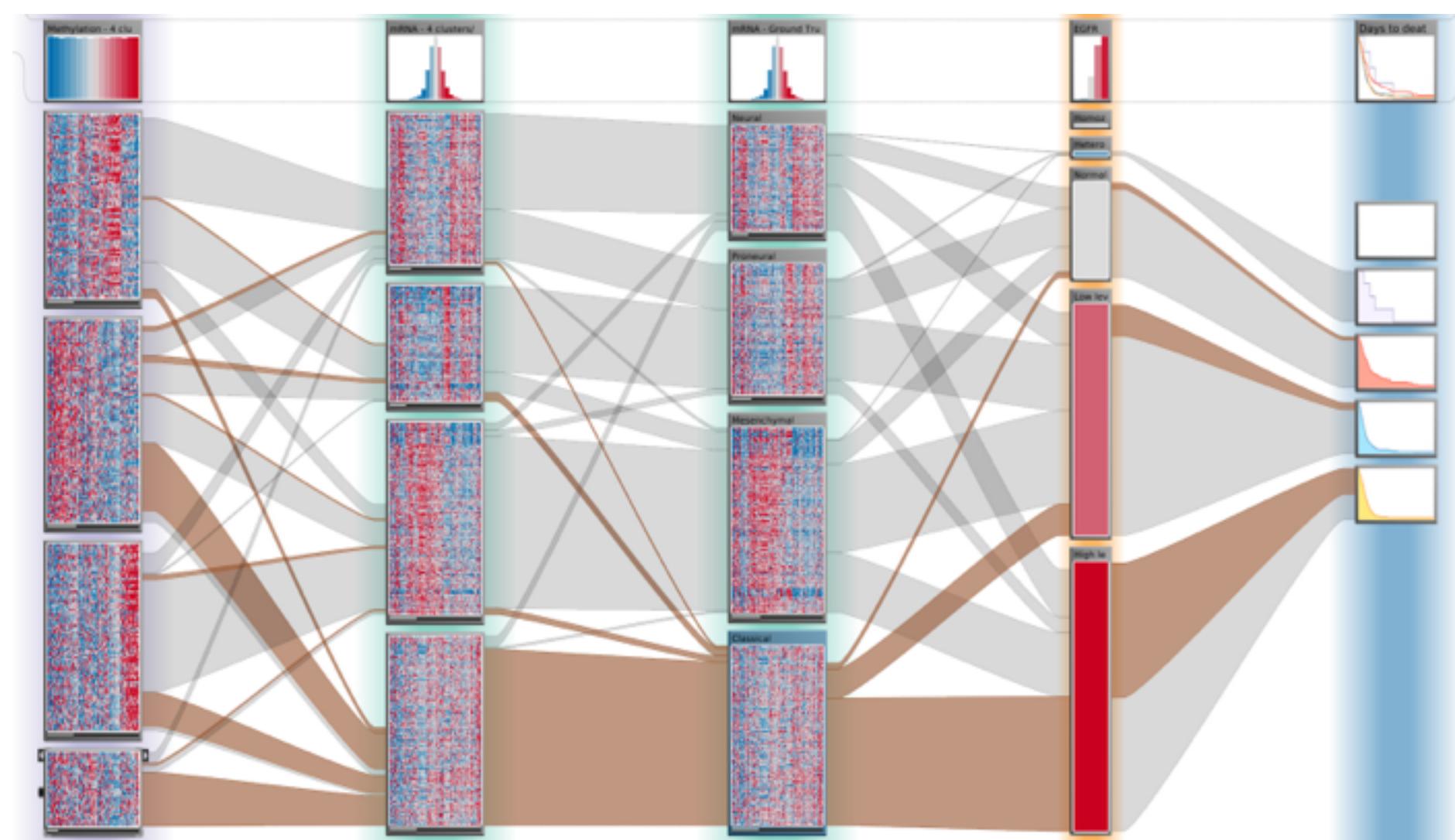
Which combination of genes causes cancer?

Which drug can help patient X?

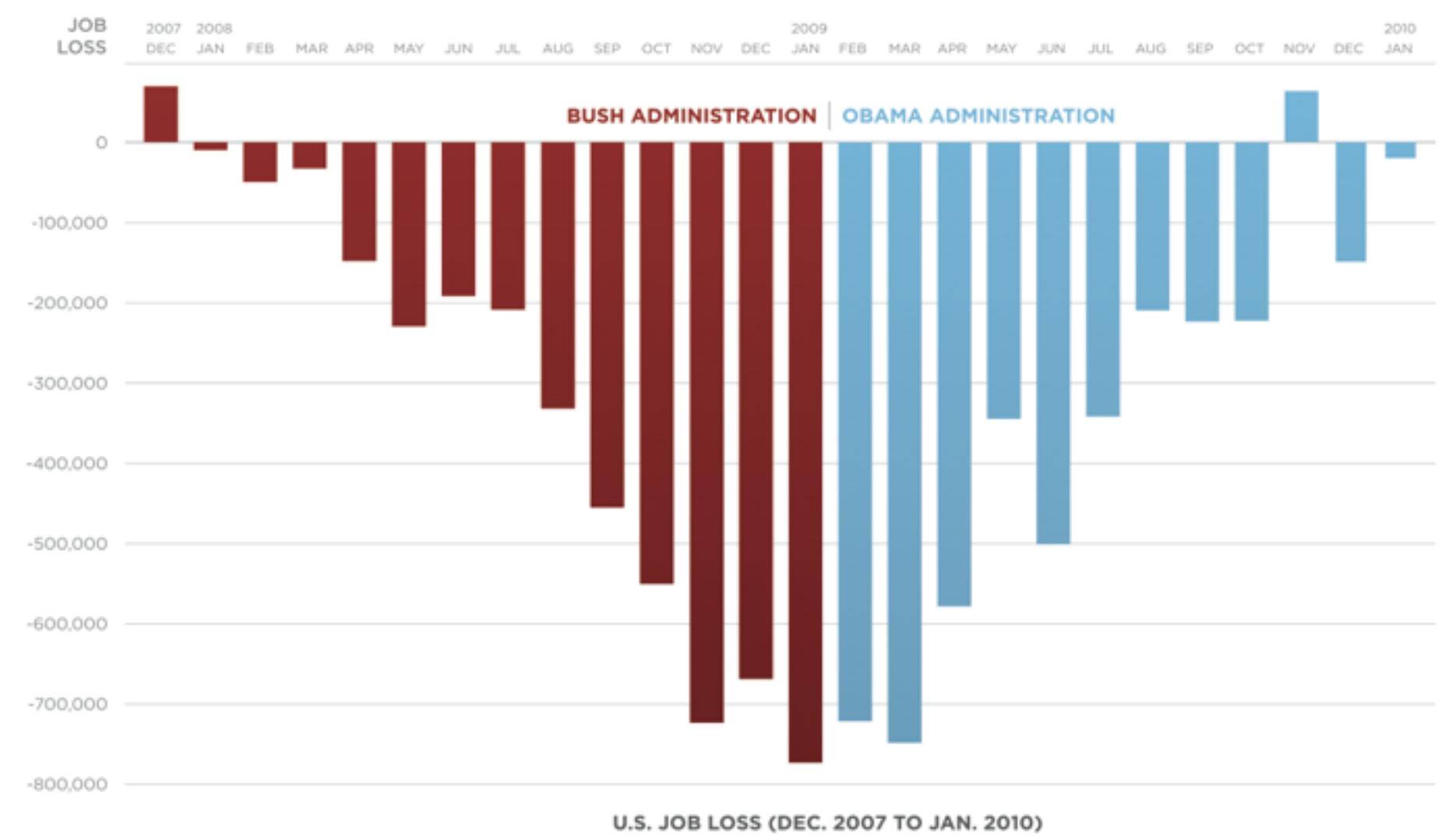


[New York Times]

Purpose of Visualization



Open Exploration



Confirmation

Communication

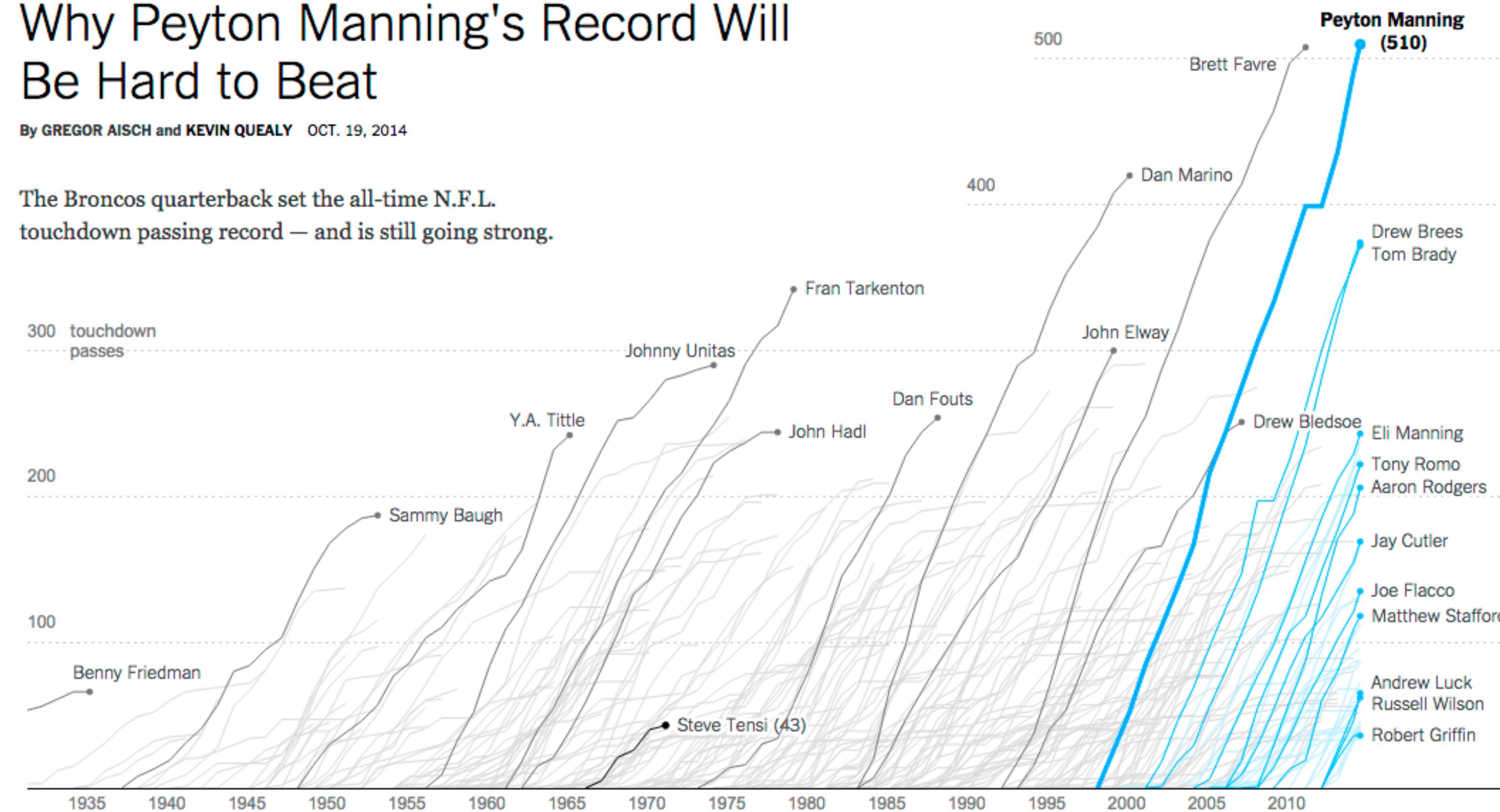


Example Communication

Why Peyton Manning's Record Will Be Hard to Beat

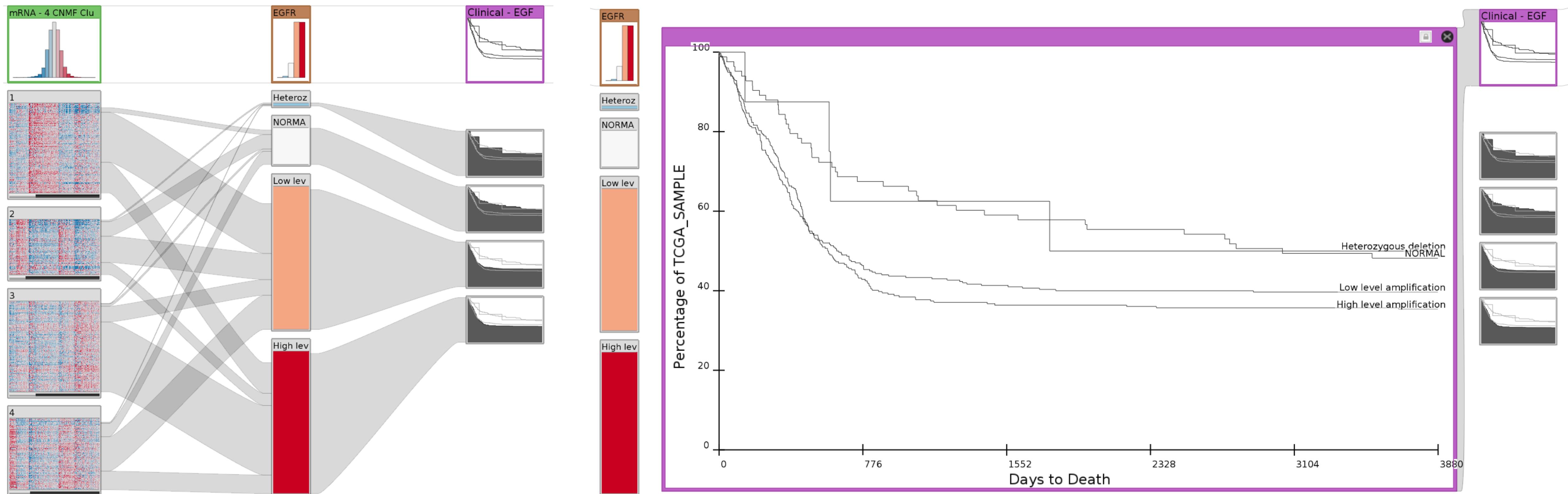
By GREGOR AISCH and KEVIN QUEALY OCT. 19, 2014

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



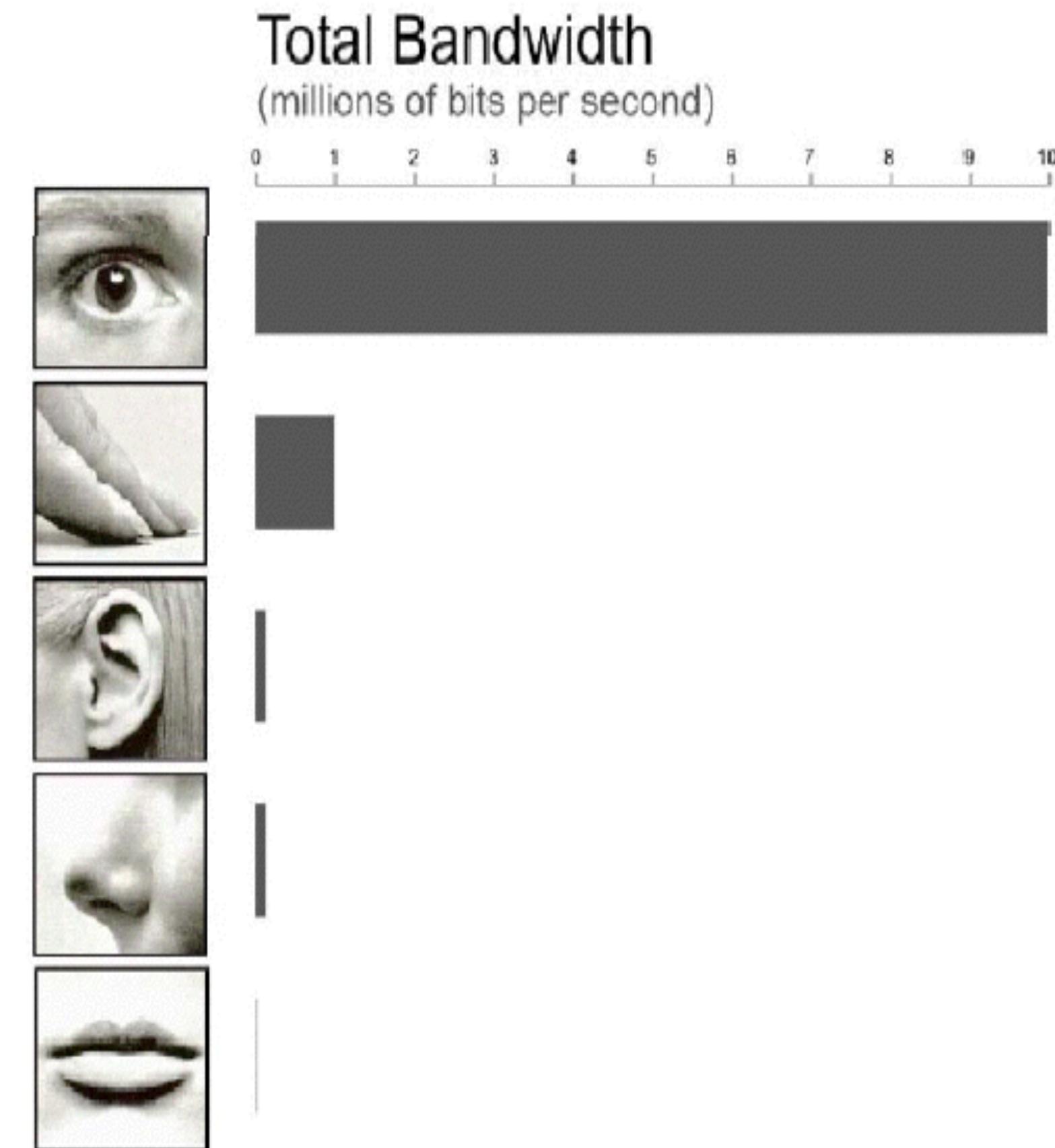
Why Graphics?

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]



the public schools were that down, the 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?

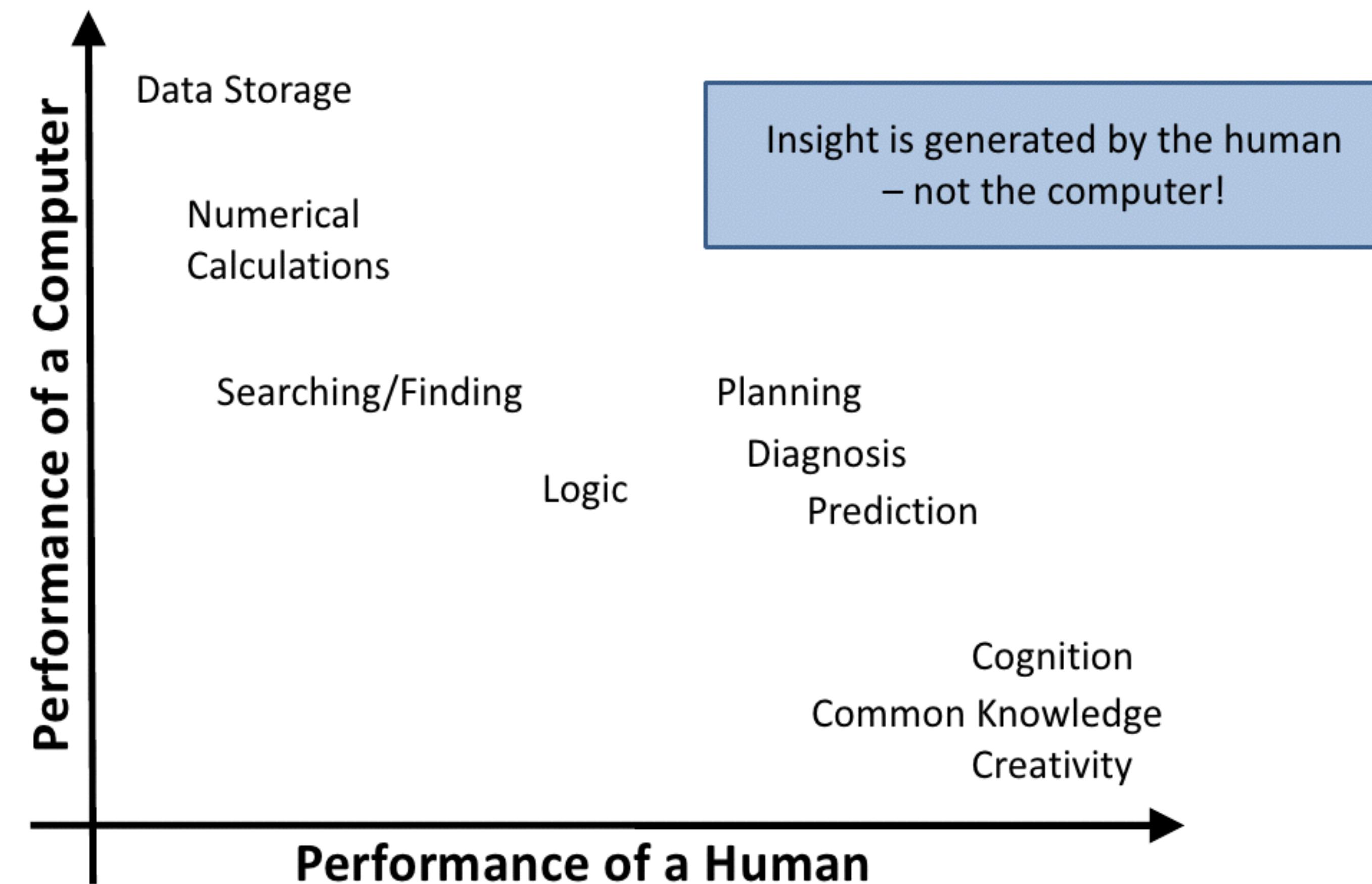
Decisions needed in minimal time

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

Manufacturing: is bottle broken?



The Ability Matrix

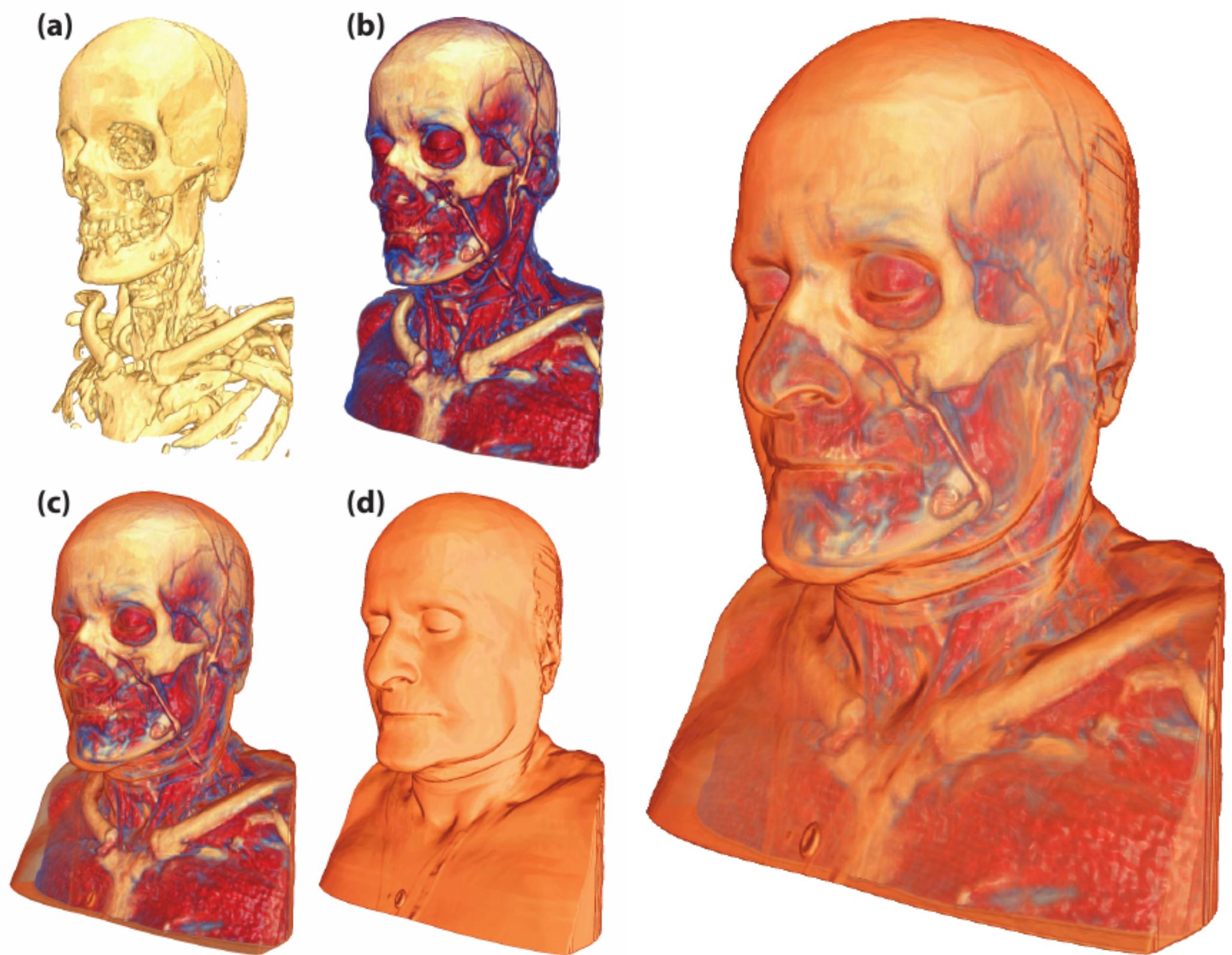


Why Use Computers?

Scale

Drawing by hand infeasible

How to draw an MRI scan?



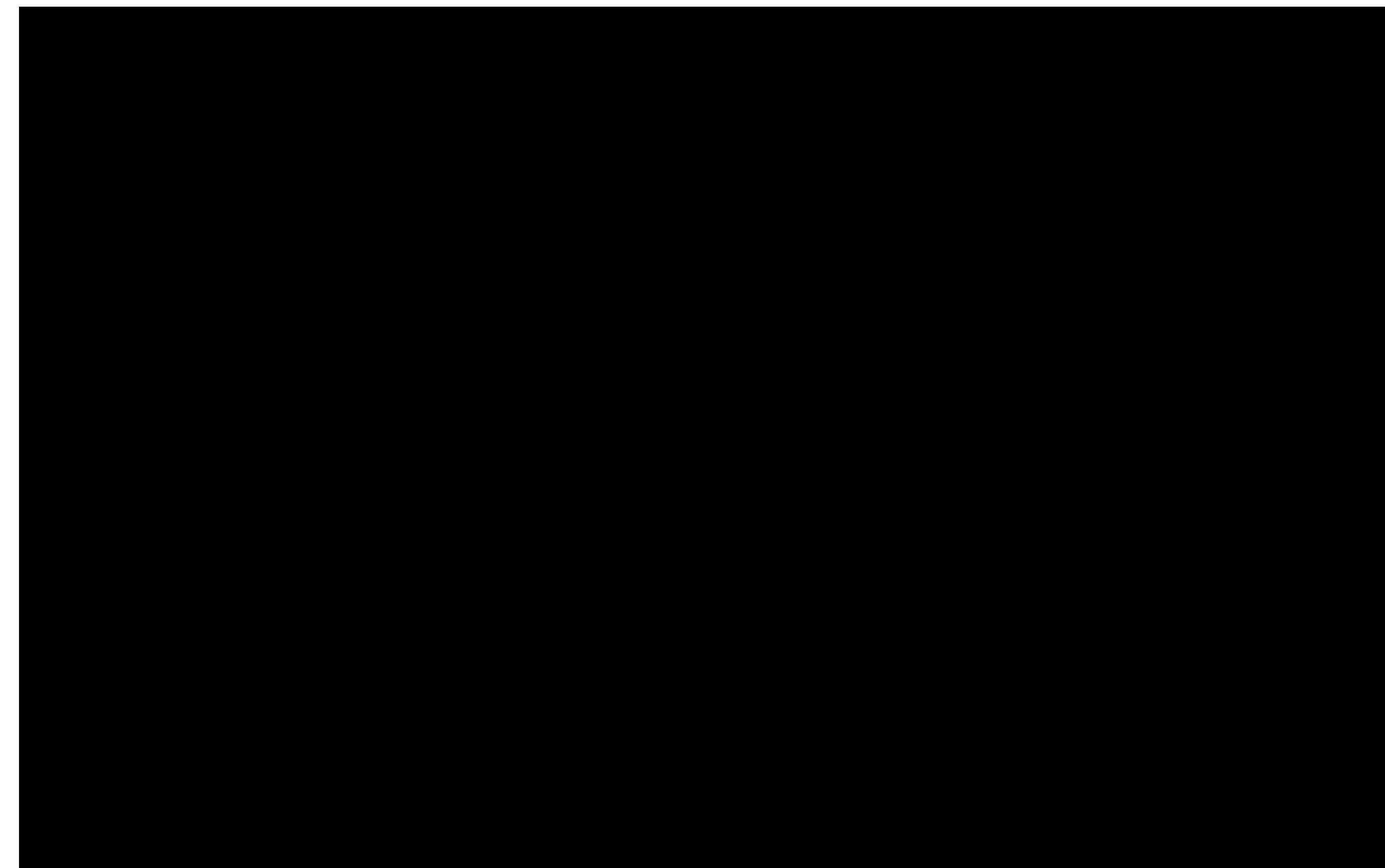
[Bruckner 2007]

Why Use Computers?

Scale

Interaction allows to “drill down” into data

Integration with algorithms



[Sunburst by John Stasko, Implementation in Caleydo by Christian Partl]

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	6.1	8	7.9
5	5.5						6.8

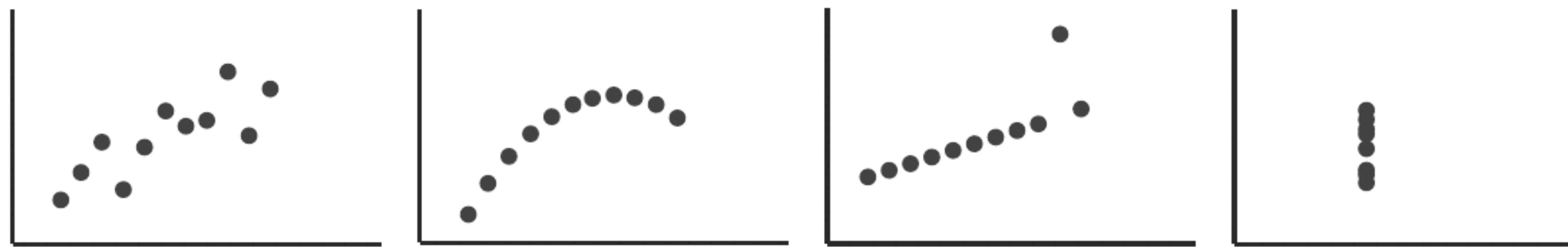
Mean x: 9 y: 7.50

Variance x: 11 y: 4.122

Correlation x - y: 0.816

Linear regression: $y = 3.00 + 0.500x$

Anscombe's Quartett



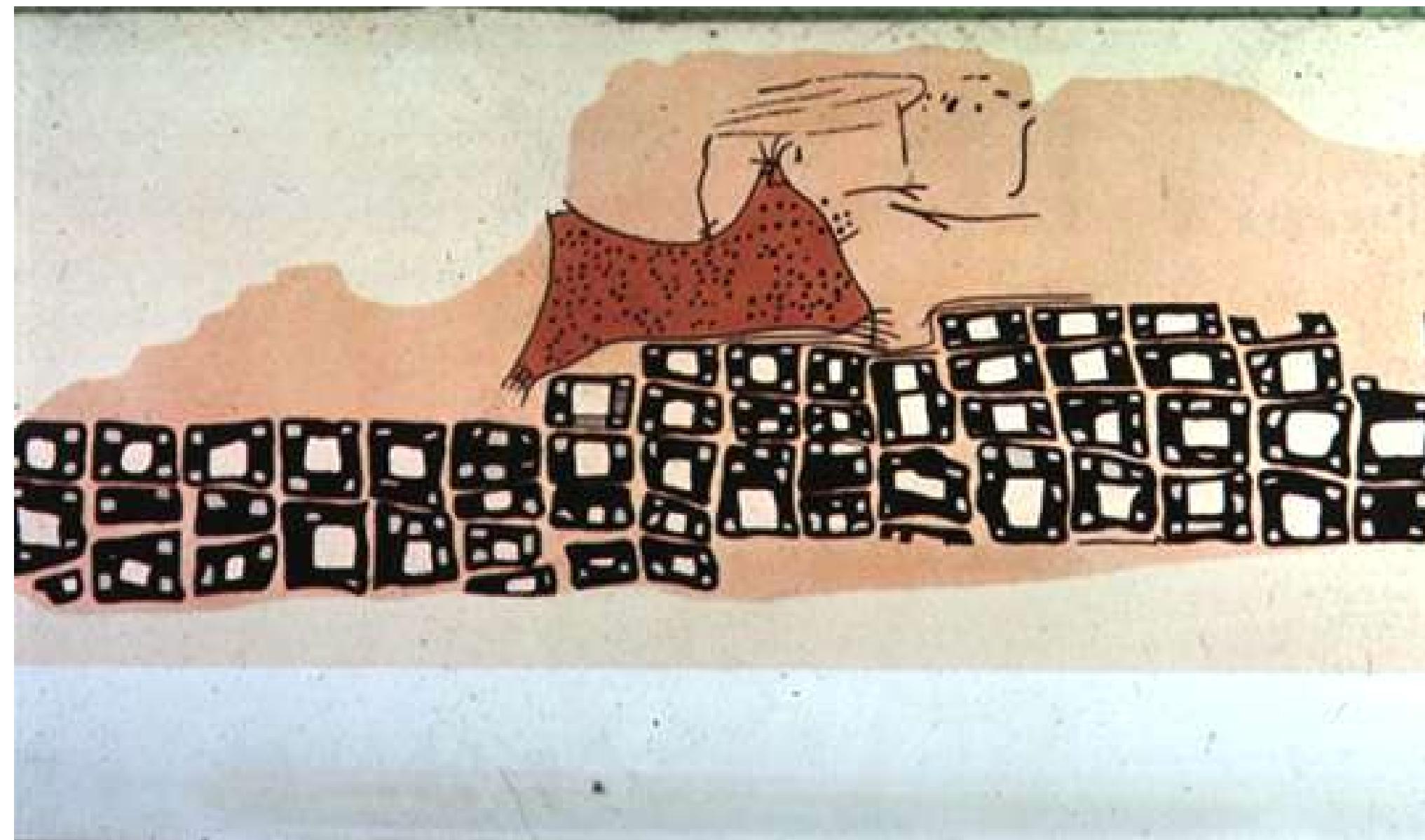
Mean x: 9 y: 7.50
Variance x: 11 y: 4.122
Correlation x - y: 0.816
Linear regression: $y = 3.00 + 0.500x$

Good Data Visualization

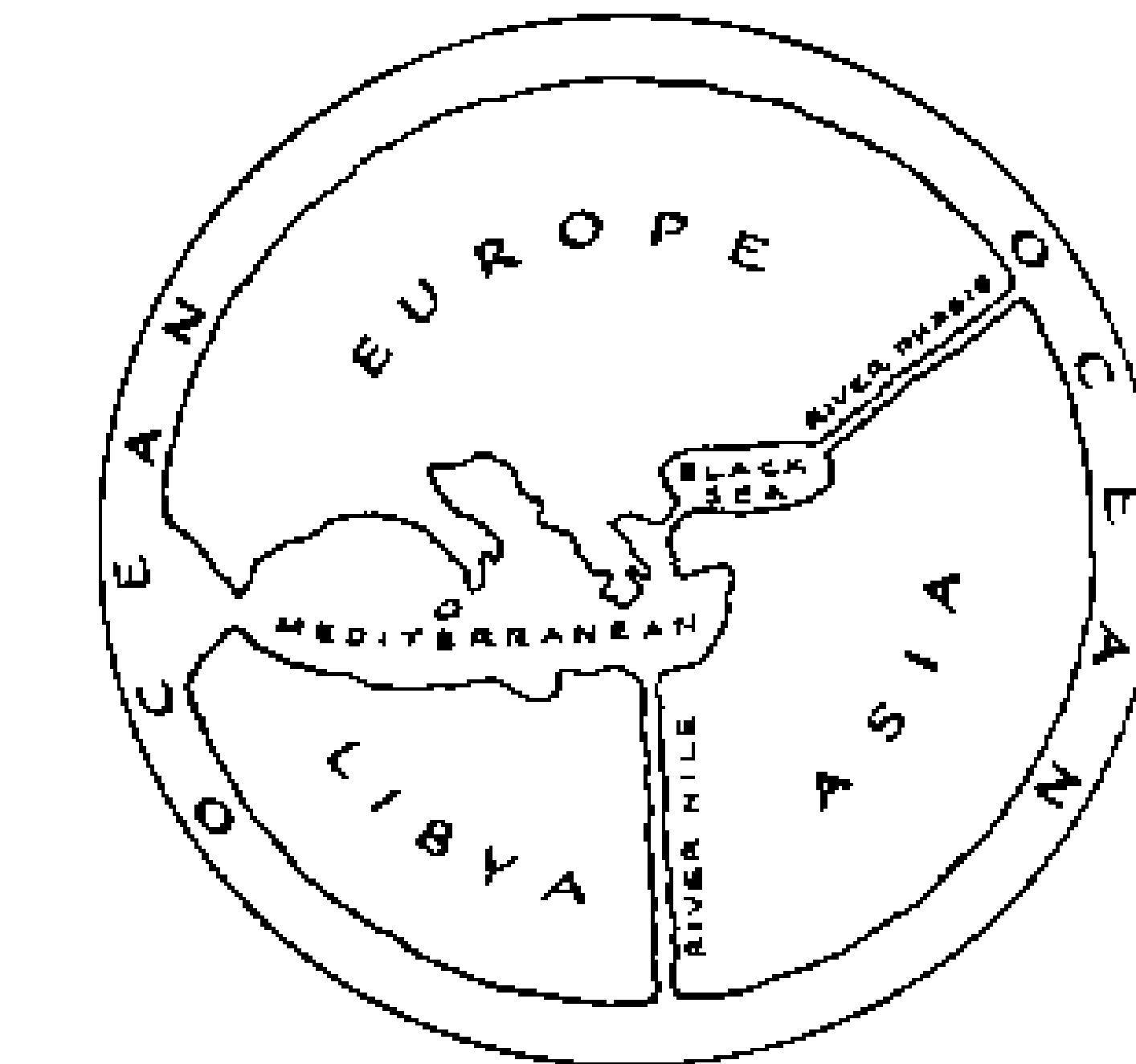
- ... makes data **accessible**
- ... combines strengths of
humans and computers
- ... enables **insight**
- ... **communicates**

How did we get here?

Record



Konya town map, Turkey, c. 6200 BC



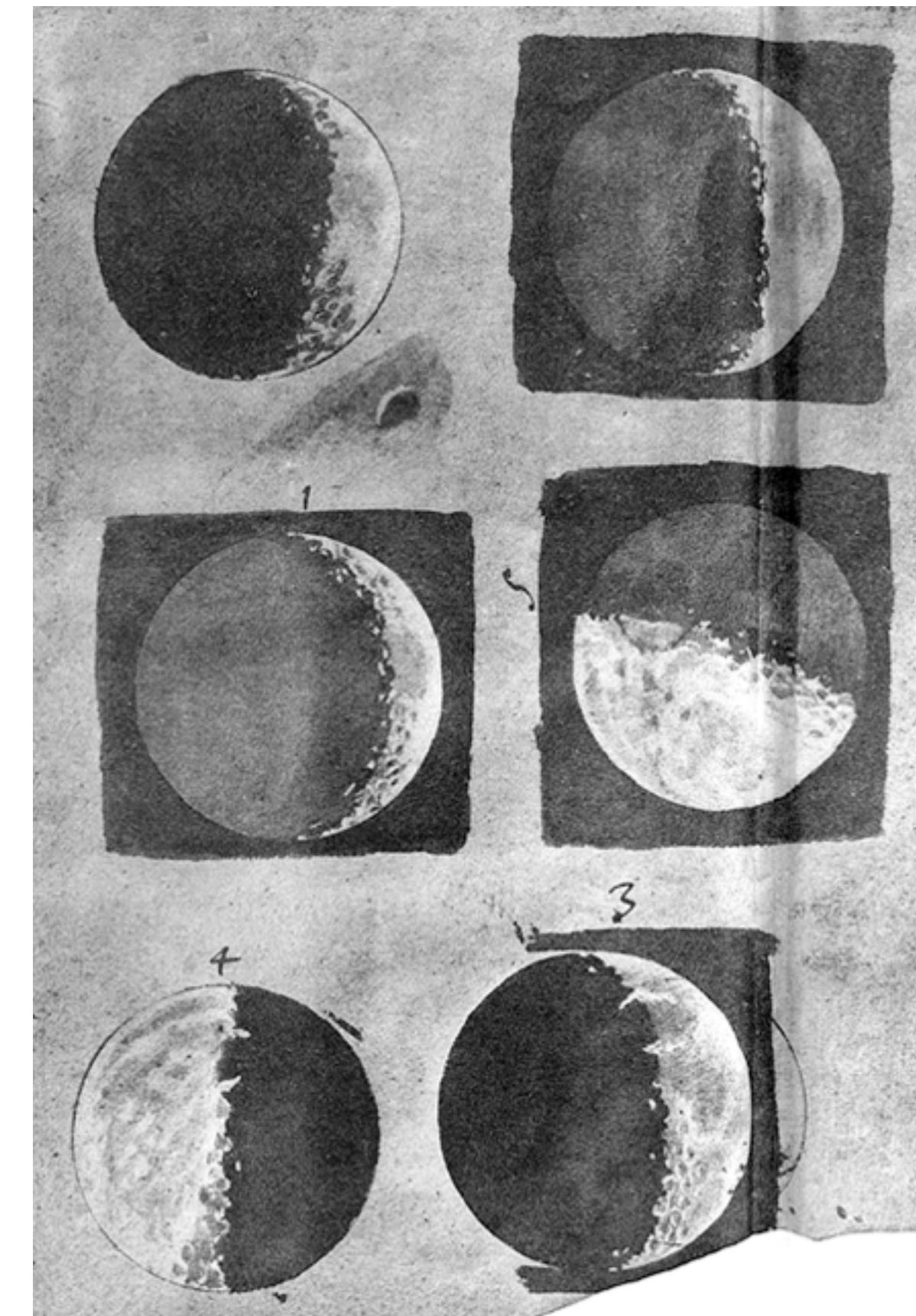
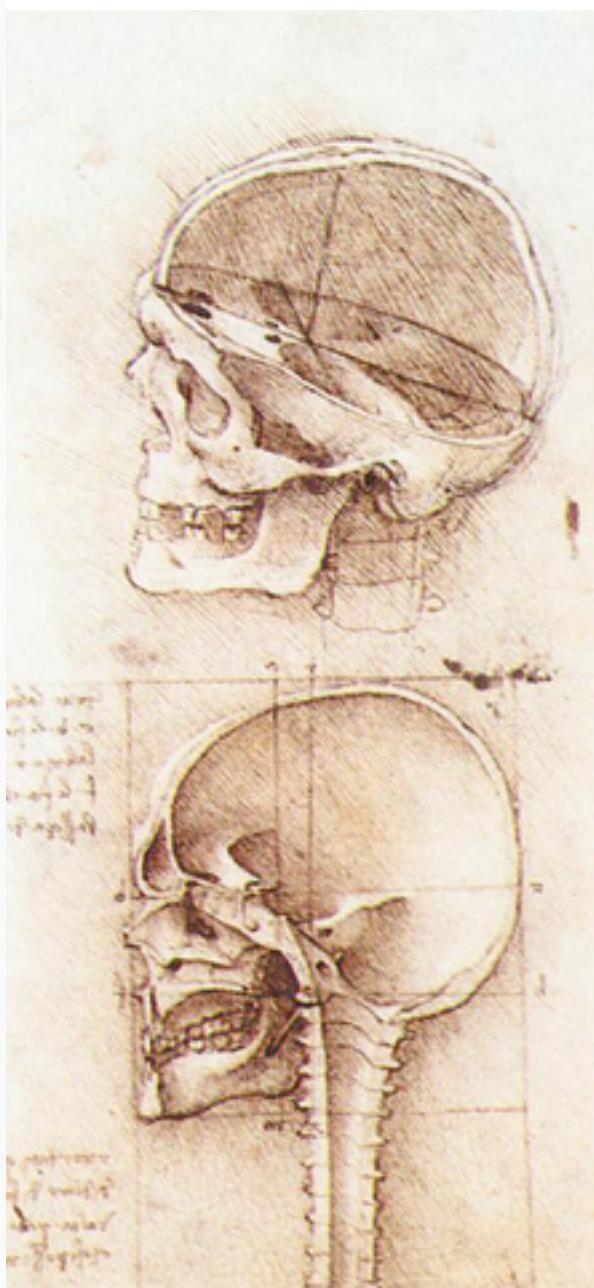
Anaximander's Map of the World

Anaximander of Miletus, c. 550 BC

Record



Leonardo Da Vinci, ca. 1500



Galileo Galilei, 1616

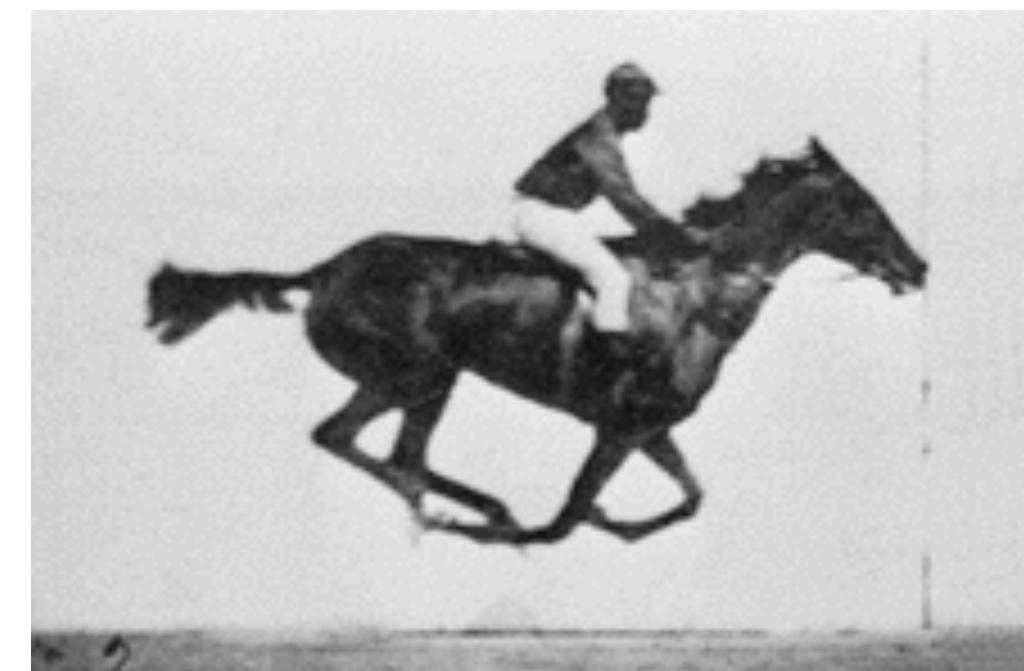
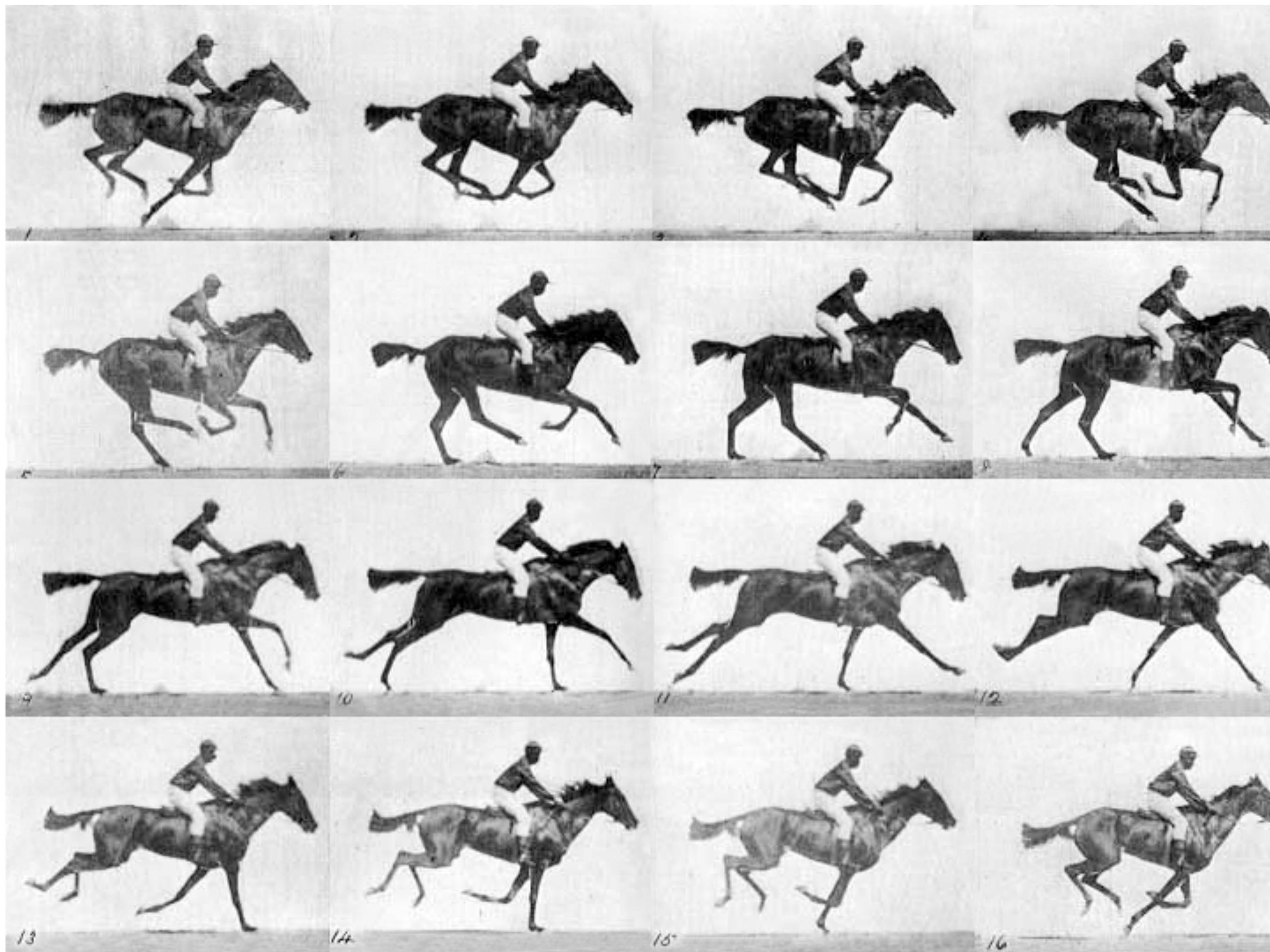
Donald Norman



William Curtis (1746-1799)

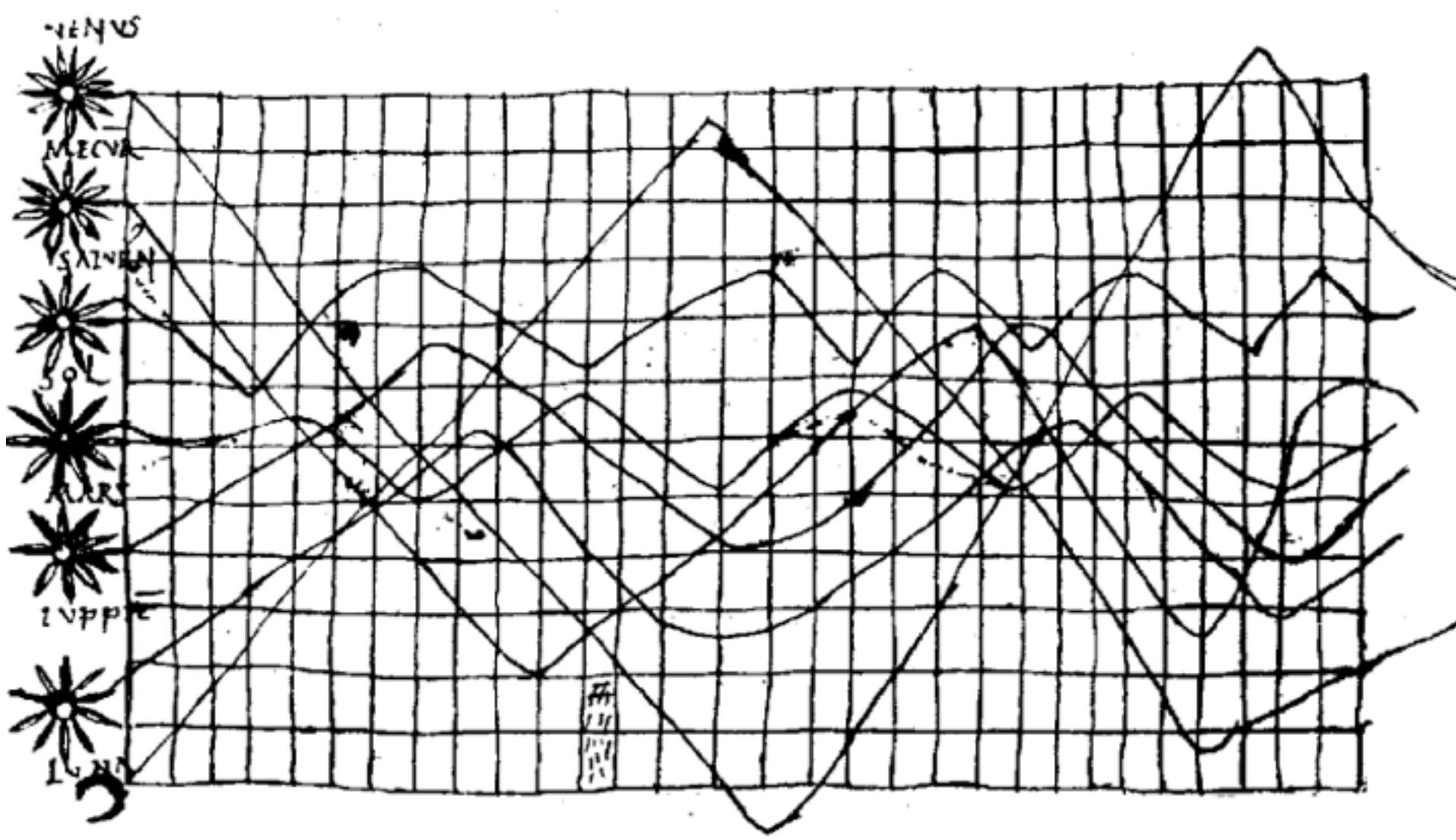
The History of Visual Communication
The Galileo Project, Rice University

Record

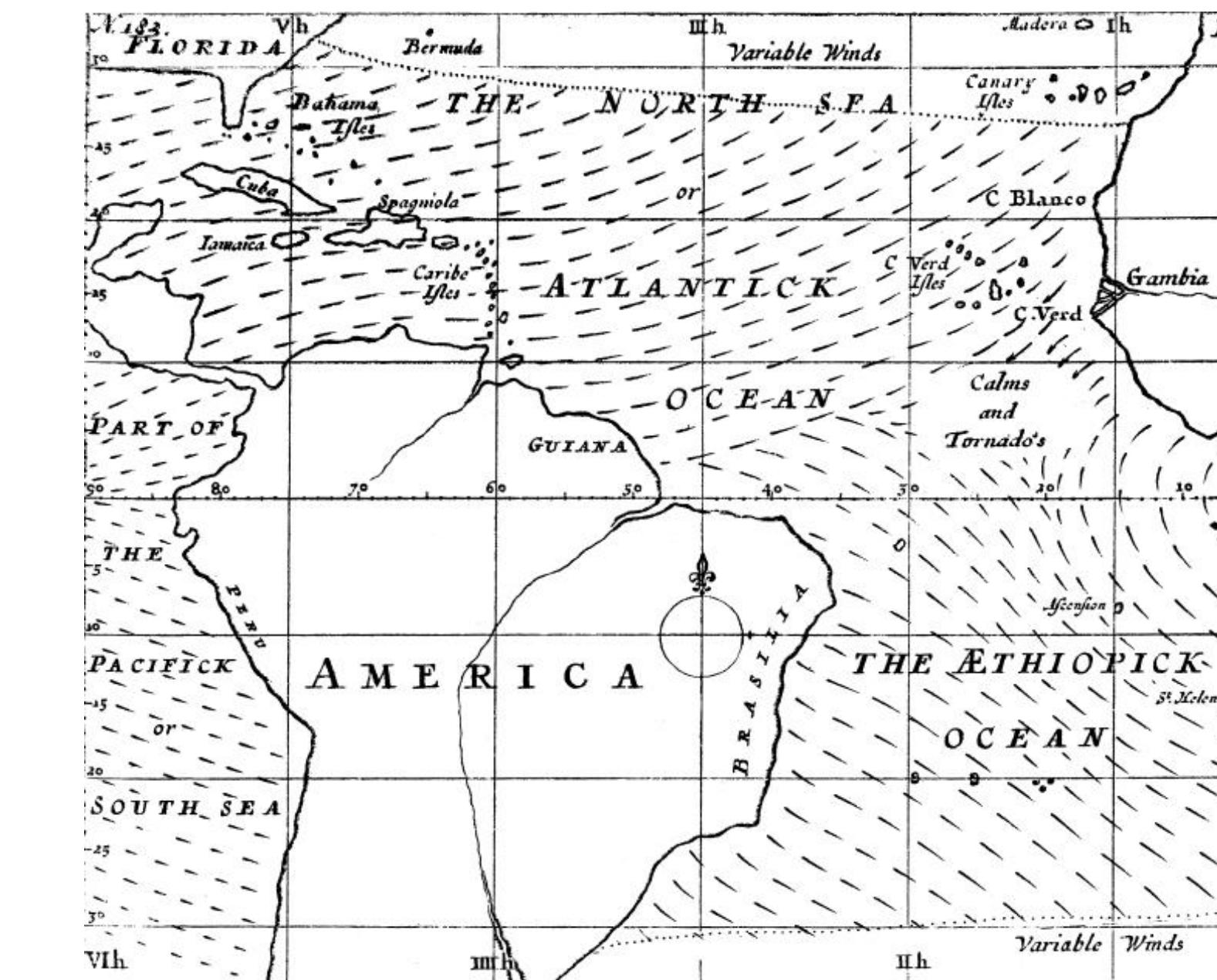


E. J. Muybridge, 1878

Analyze



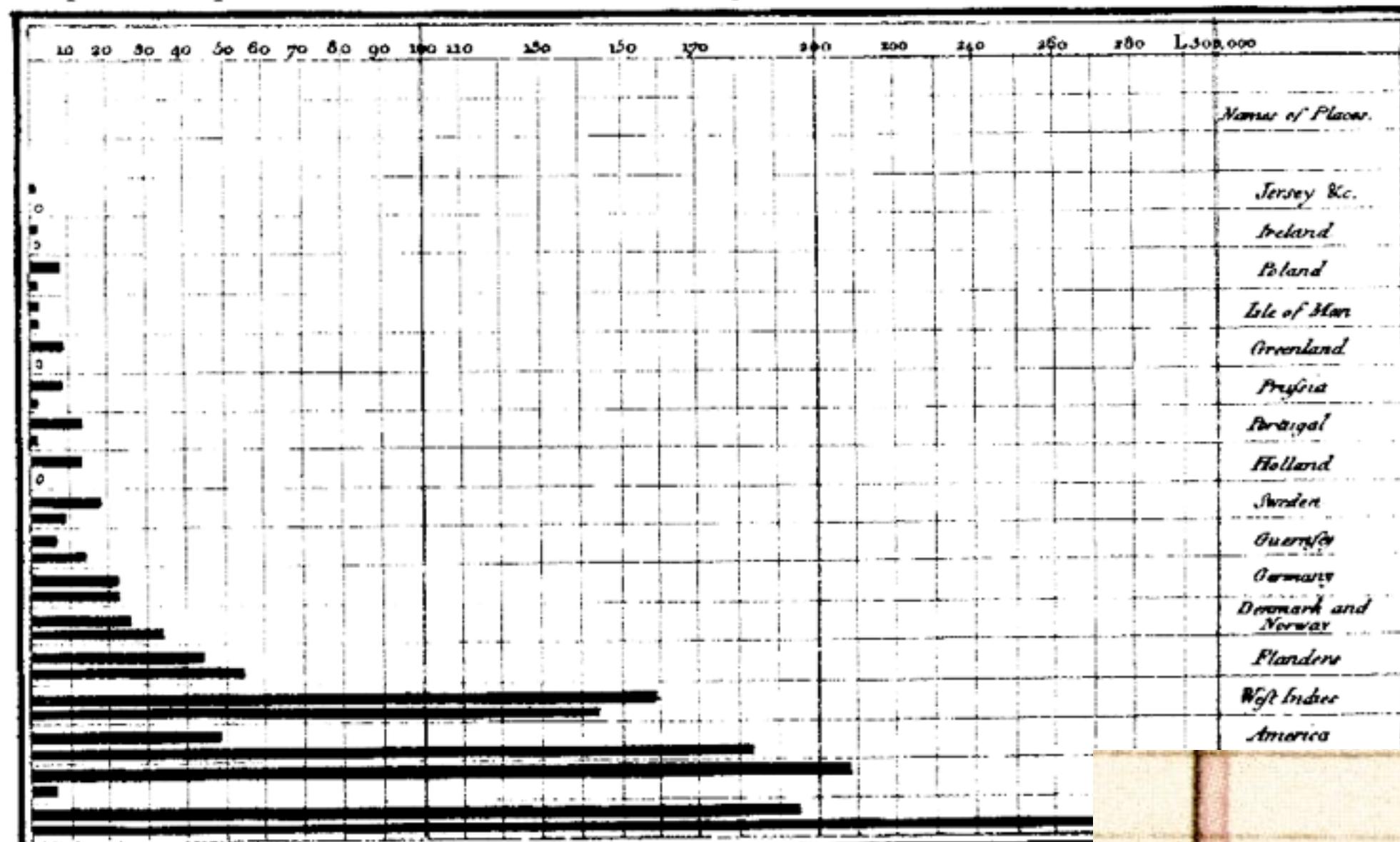
Planetary Movement Diagram, c. 950



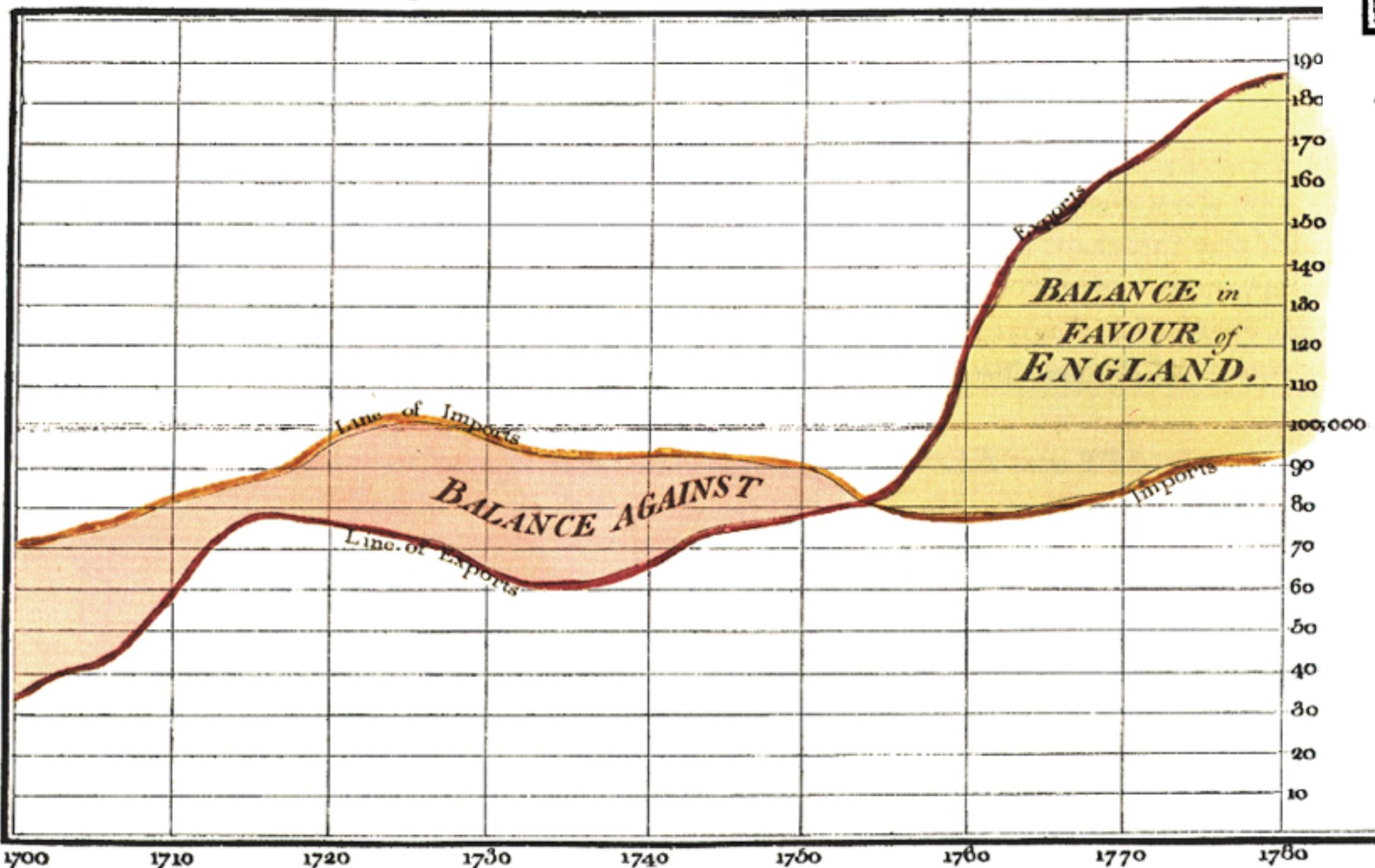
Halley's Wind Map, 1686

Analyze

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

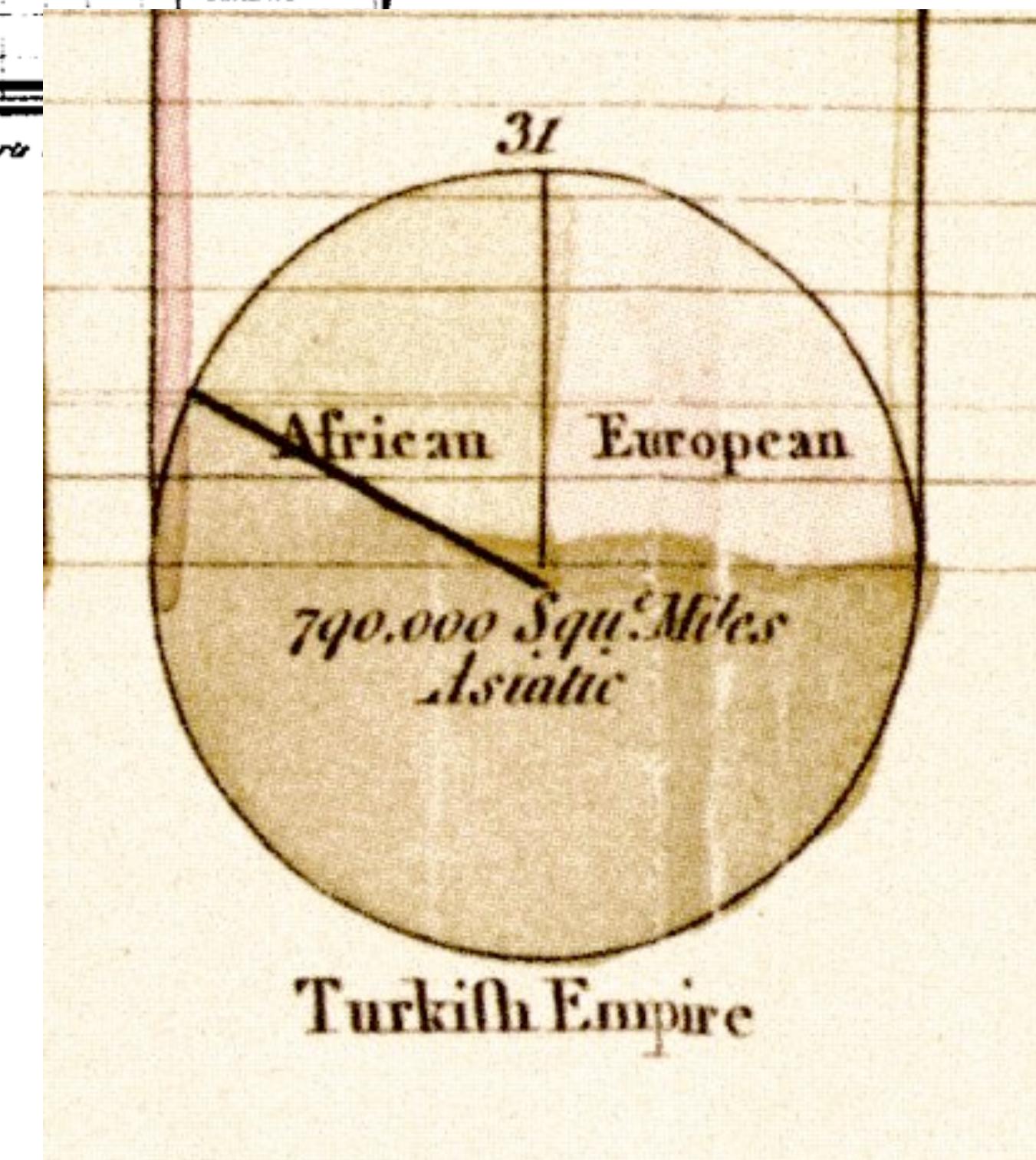


Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.



W. Playfair, 1786

The upright divisions are Ten Thousand Pounds each. The Black Lines are Exports
and the Orange Lines are Imports. See p. 50 for W^m Playfair's



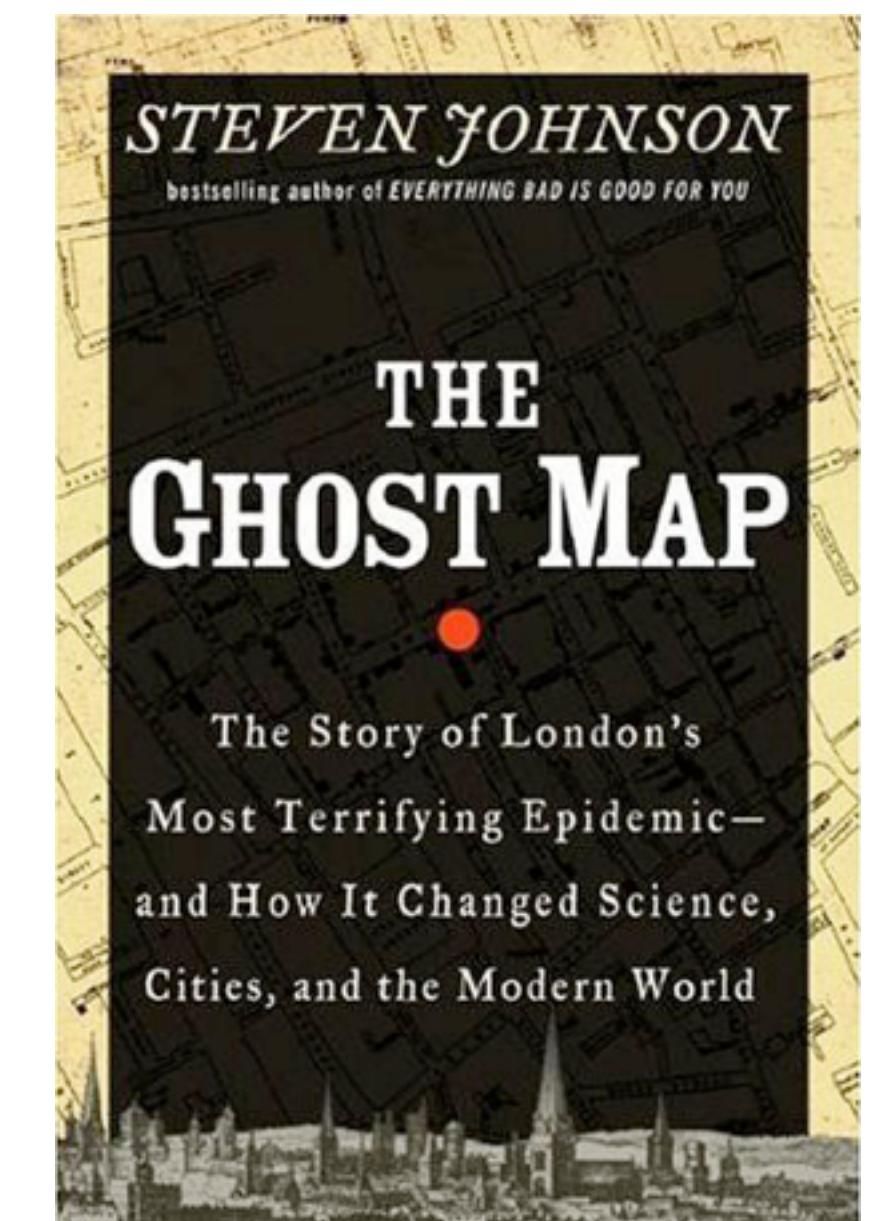
wikipedia.org

W. Playfair, 1801

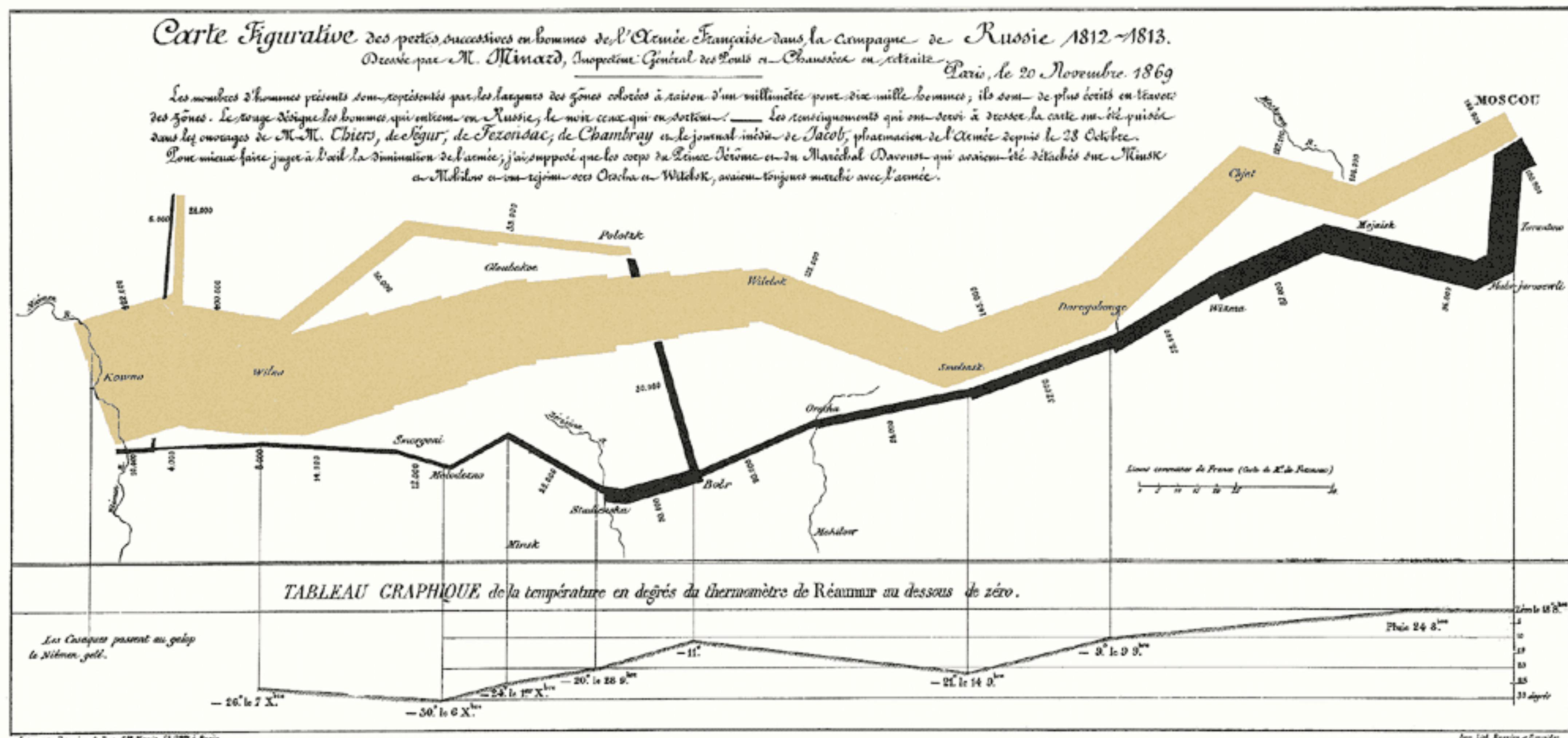
Find Patterns



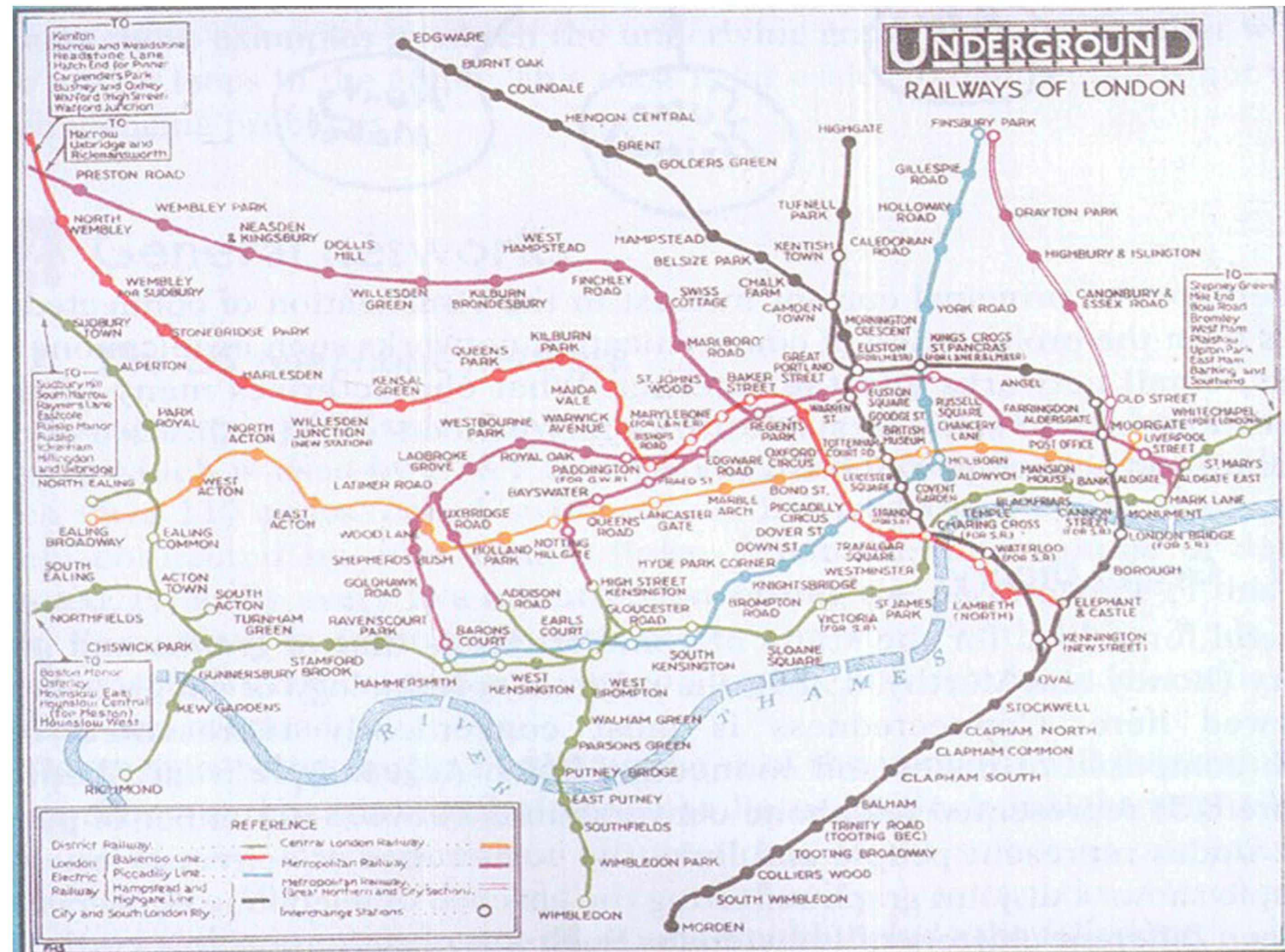
John Snow, 1854



Communicate

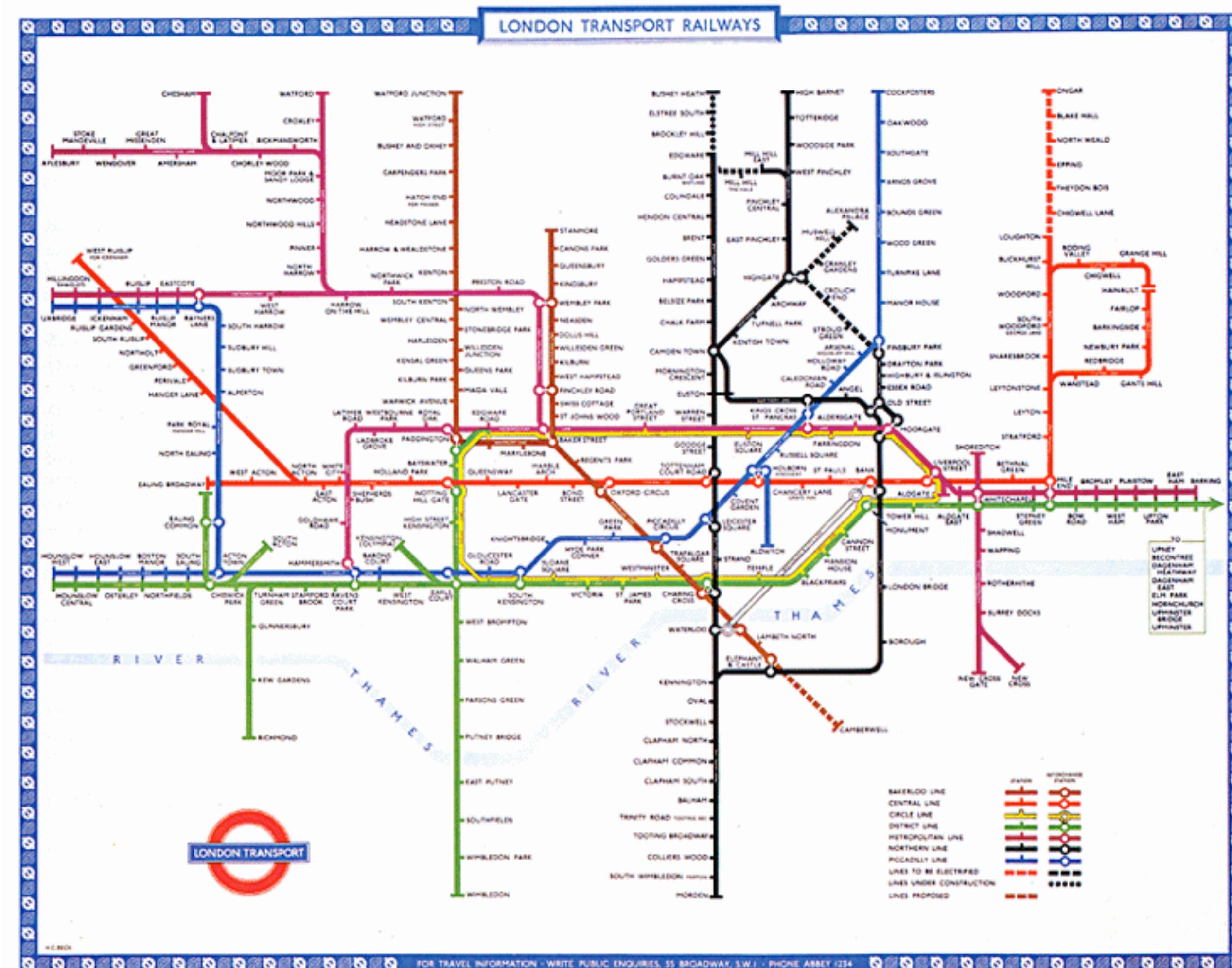


Communicate



London Subway Map, 1927

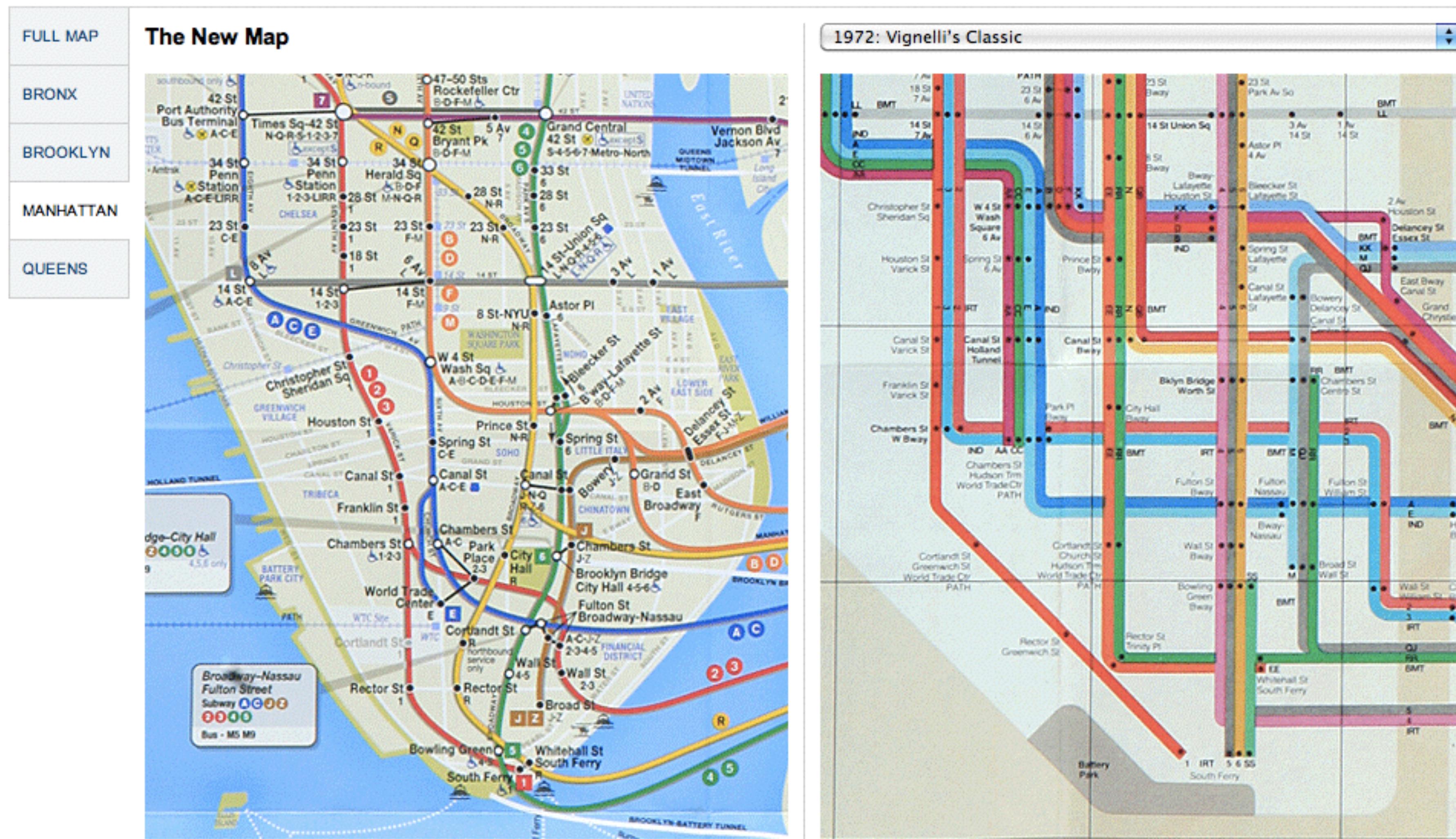
Communicate



Harry Beck, 1933

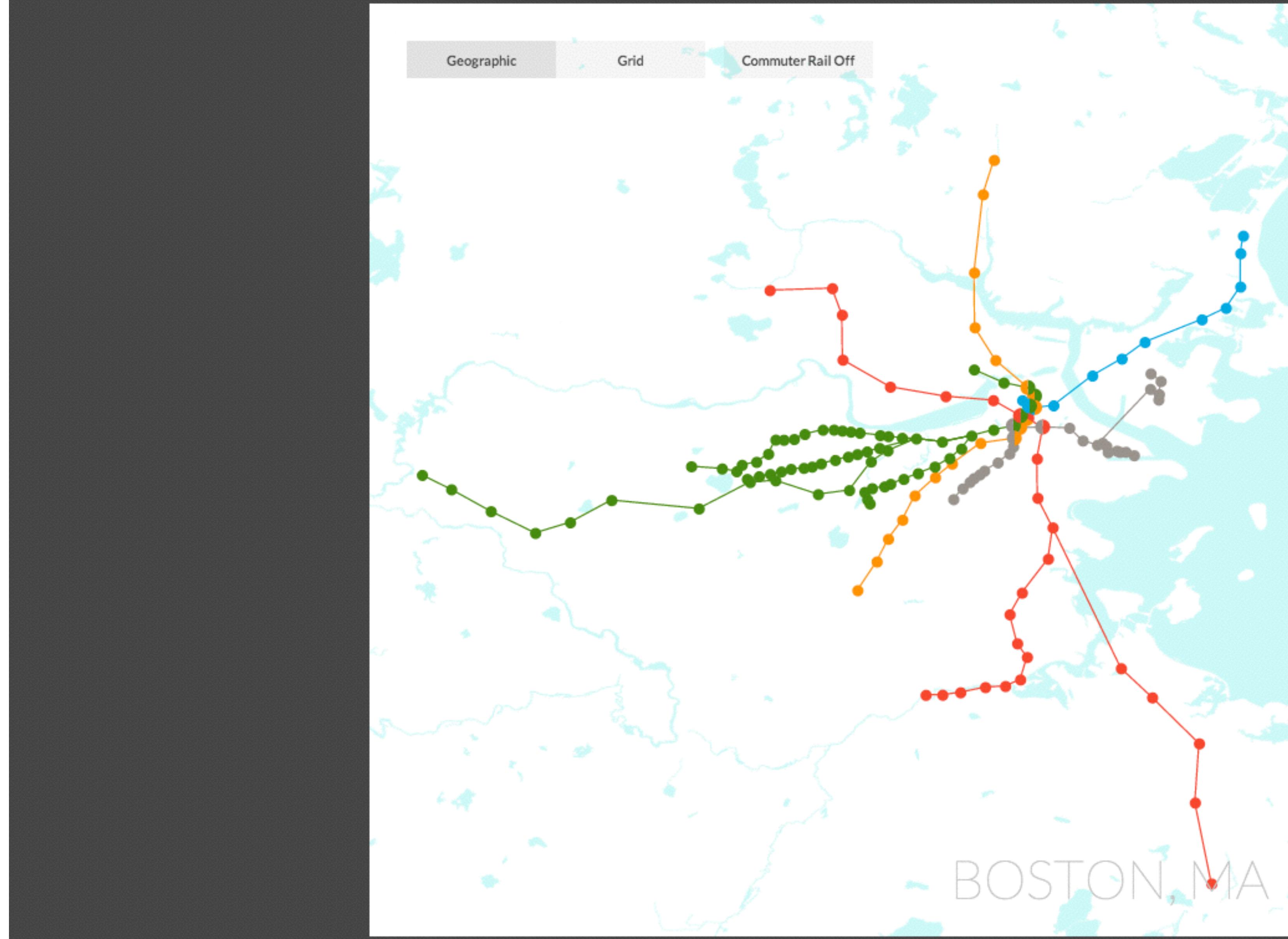
An Overhaul of an Underground Icon

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 »](#)

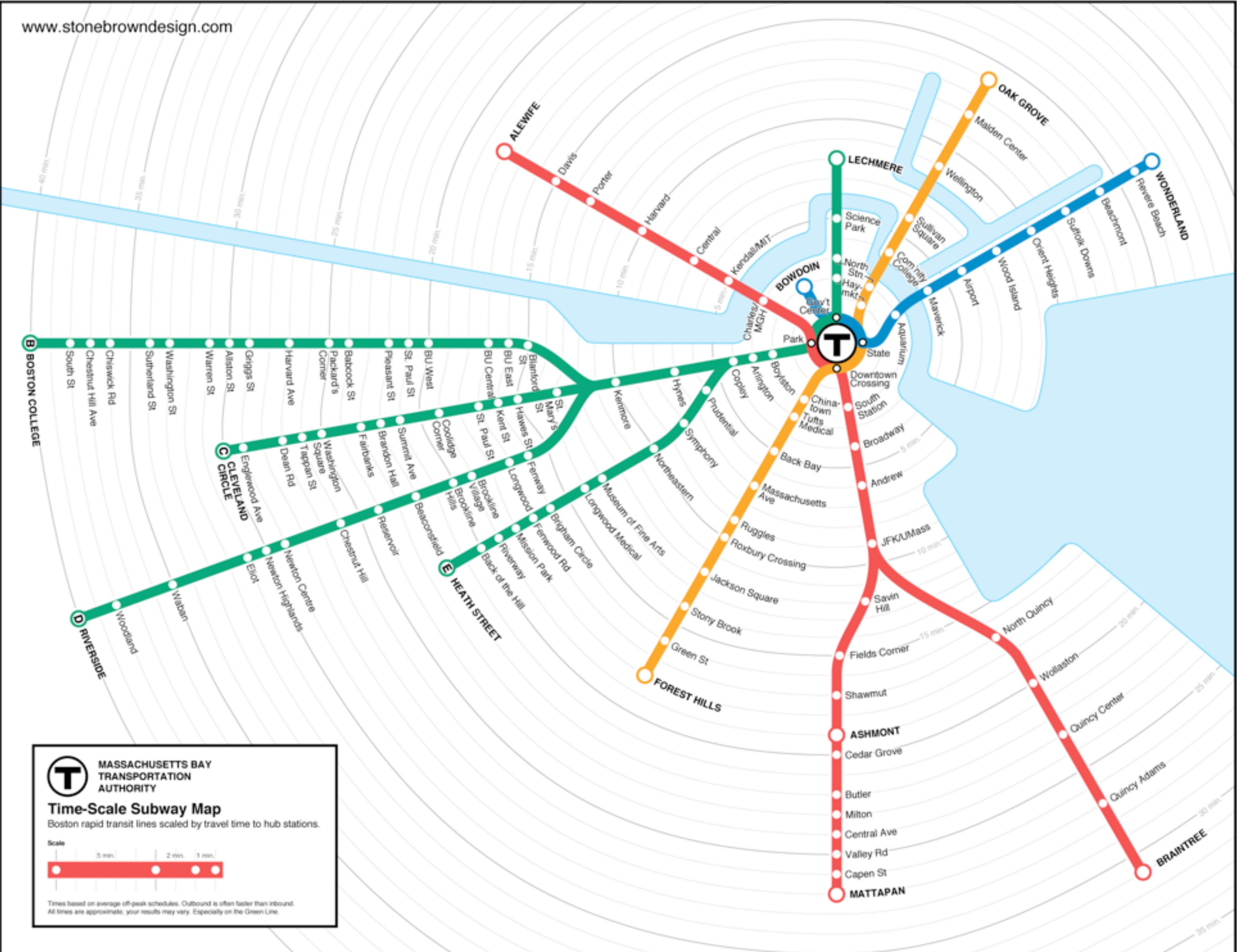


Geographic vs Topological Metro Map

FATHOM, 2013

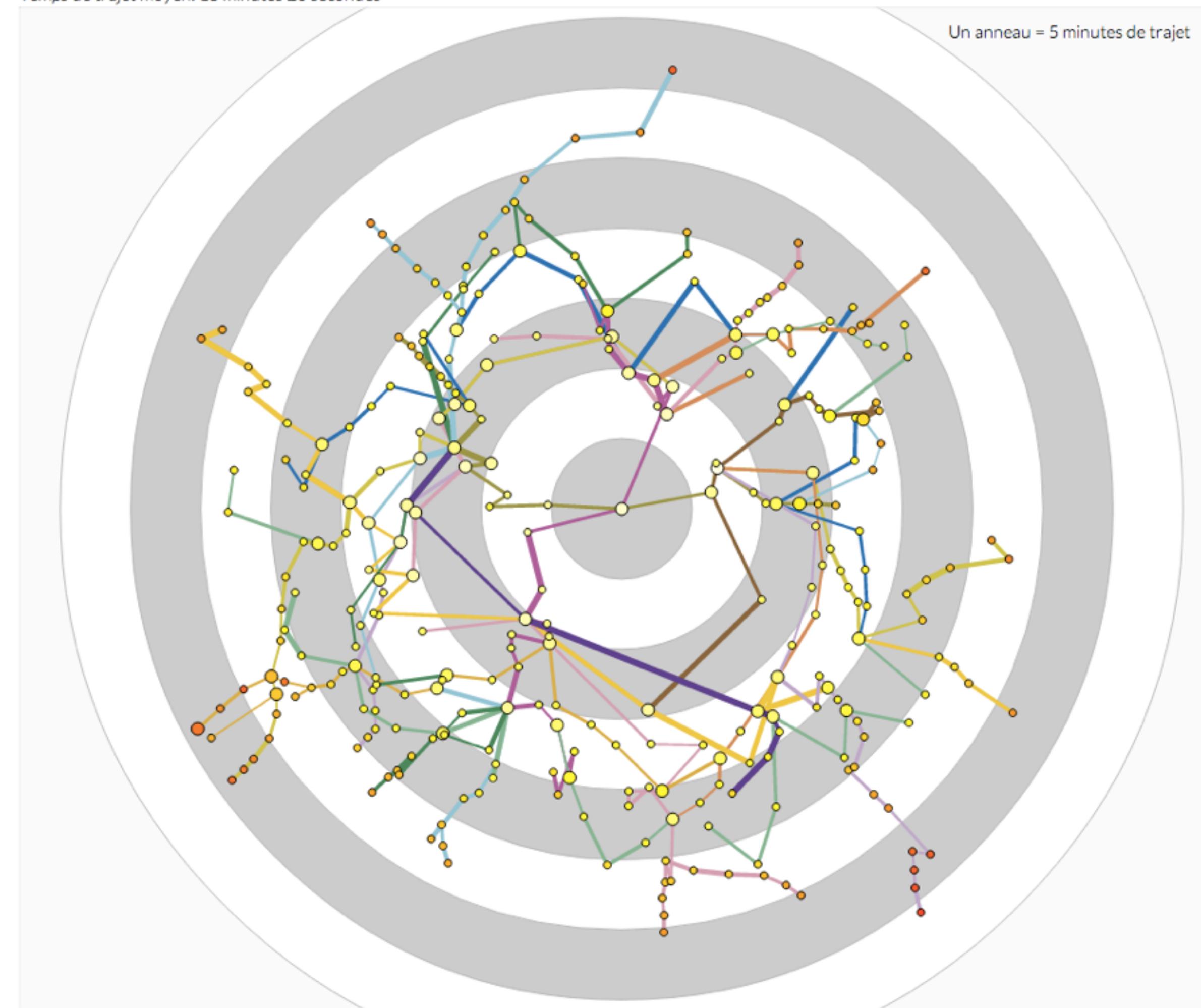


T. Fradet



Réaumur – Sébastopol

Temps de trajet moyen: 18 minutes 26 secondes



Un anneau = 5 minutes de trajet

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 ?

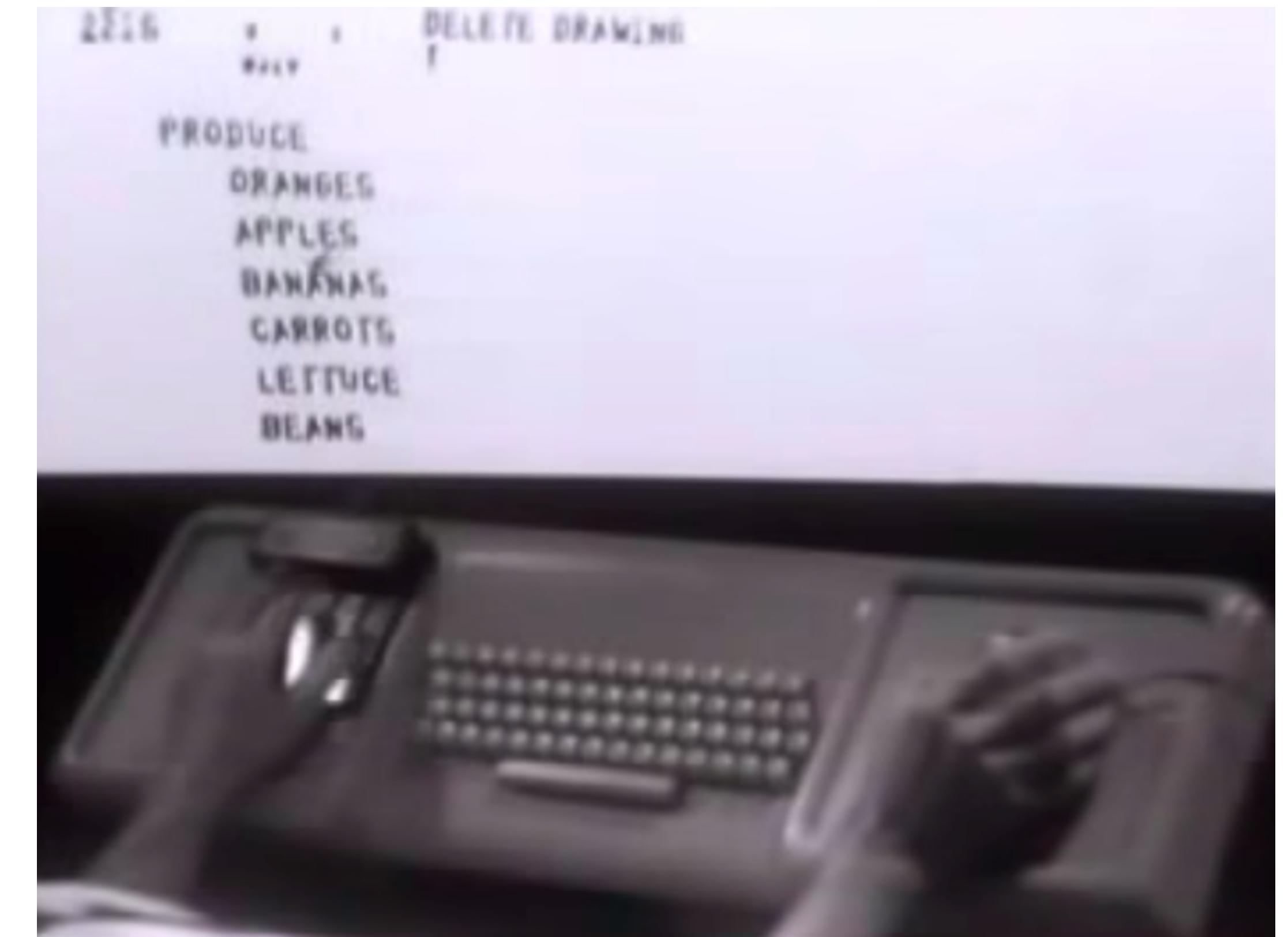
3	<div style="width: 100px; height: 10px;"></div>
4	<div style="width: 100px; height: 10px;"></div>

3	4	<div style="width: 100px; height: 10px;"></div>
---	---	---

Interact

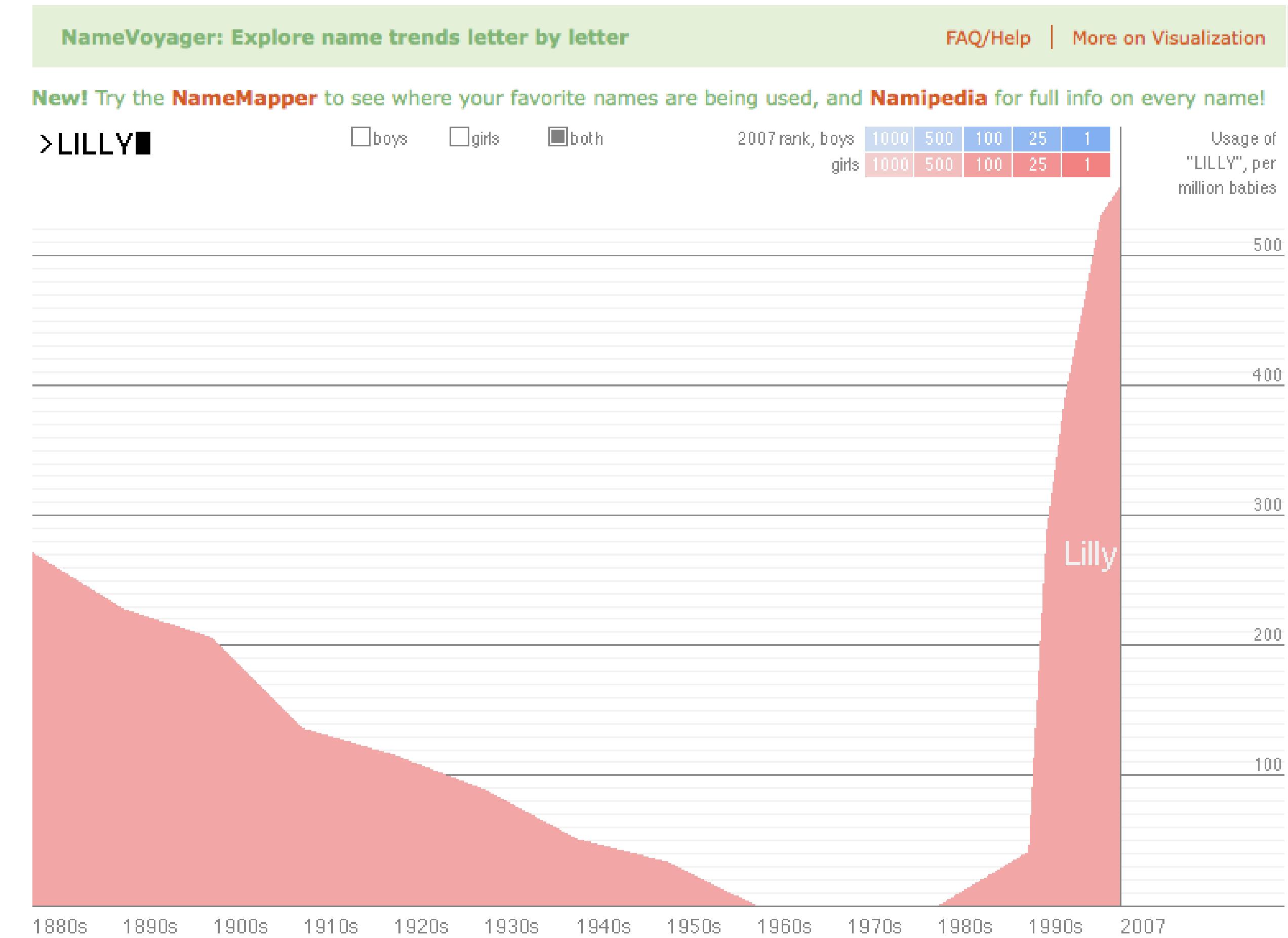


Ivan Sutherland, Sketchpad, 1963



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

A screenshot of a Google search results page. The search query "youtube cat videos" is entered in the search bar. Below the search bar, there are links for "Web", "Videos", "Shopping", "Images", "News", "More", and "Search tools". A red circle highlights the text "About 593,000,000 results (0.44 seconds)" which is displayed prominently. Below this, two video thumbnails are shown: one for "TOP 10 BEST CAT VIDEOS OF ALL TIME! - YouTube" and another for "The World's Most Funny Cat Videos 2013 - YouTube". Both thumbnails include the video duration (2:40 and 4:37 respectively) and the upload date (Sep 6, 2012 and Aug 15, 2013).



15 Exabytes in Punch Cards:
4.5 km over New England

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

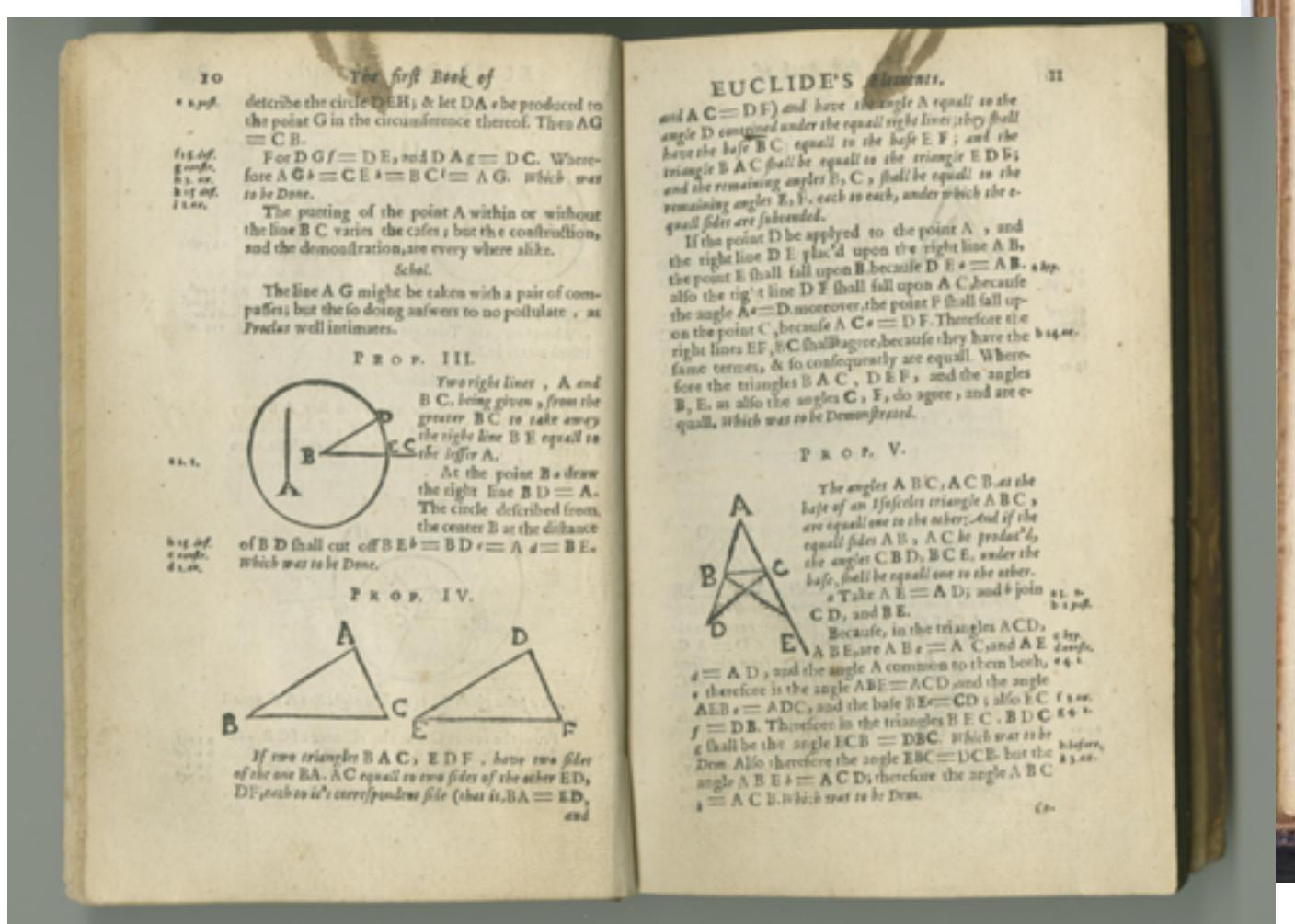


Daniel J. Simons and Daniel T. Levin, Failure to detect changes to people during a real world interaction, 1998

“It is things that make us smart”

Donald A. Norman





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?

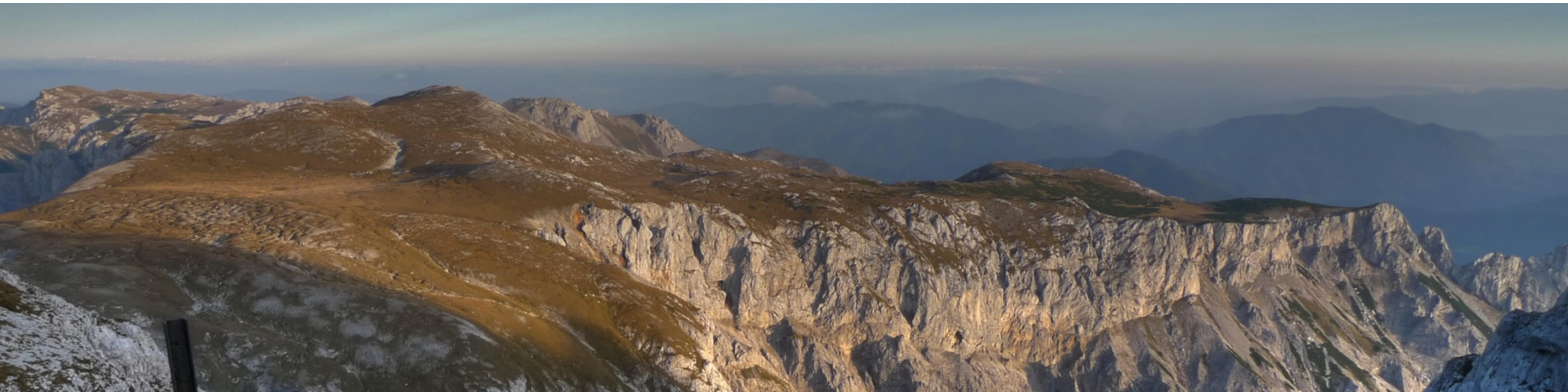
Alexander Lex

[@alexander_lex](https://twitter.com/alexander_lex)
<http://alexander-lex.net>

Assistant Professor, Computer Science

Before that: Lecturer, Postdoctoral Fellow, Harvard

PhD in Computer Science, Graz University of Technology



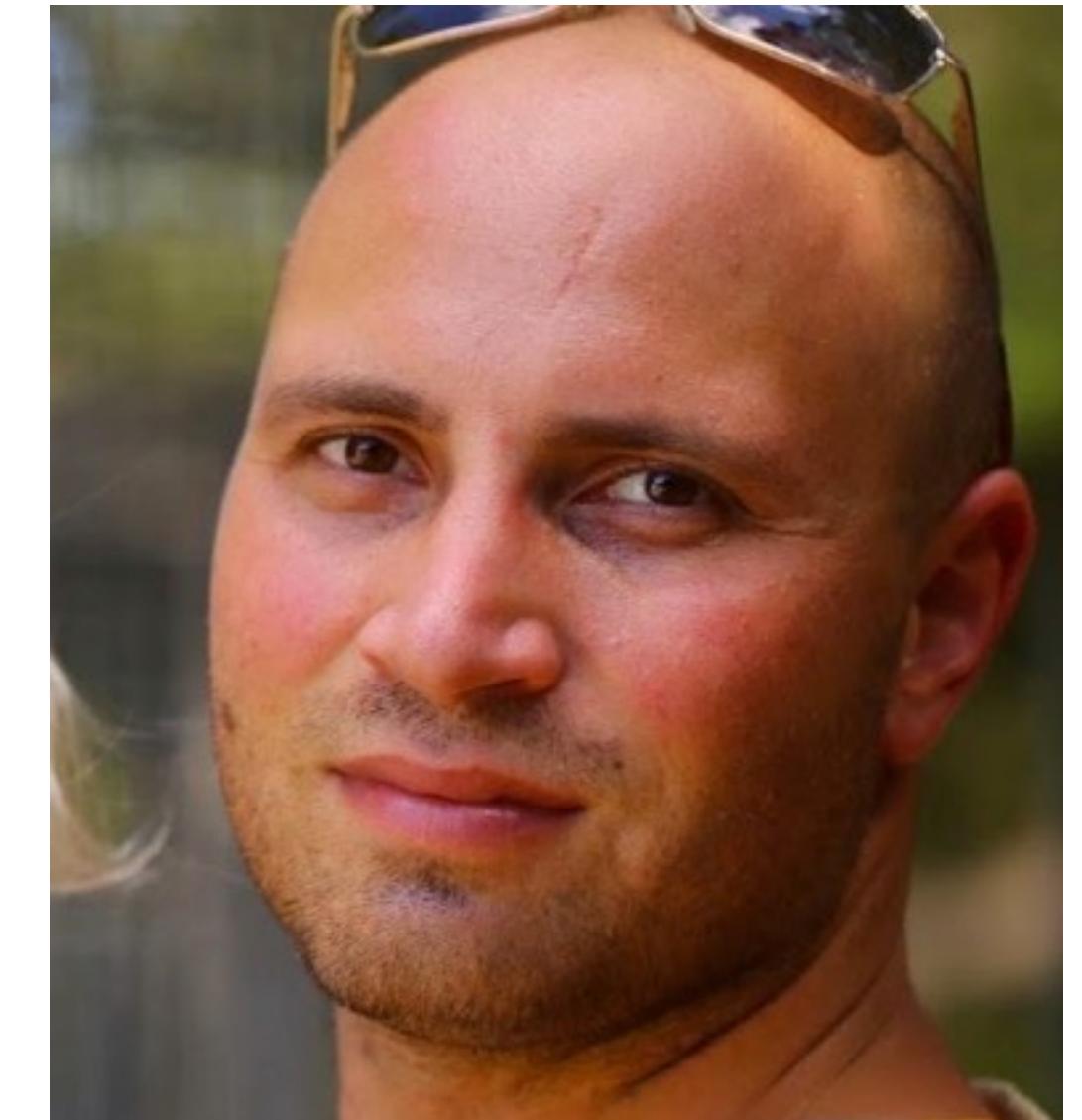
Aaron Knoll

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

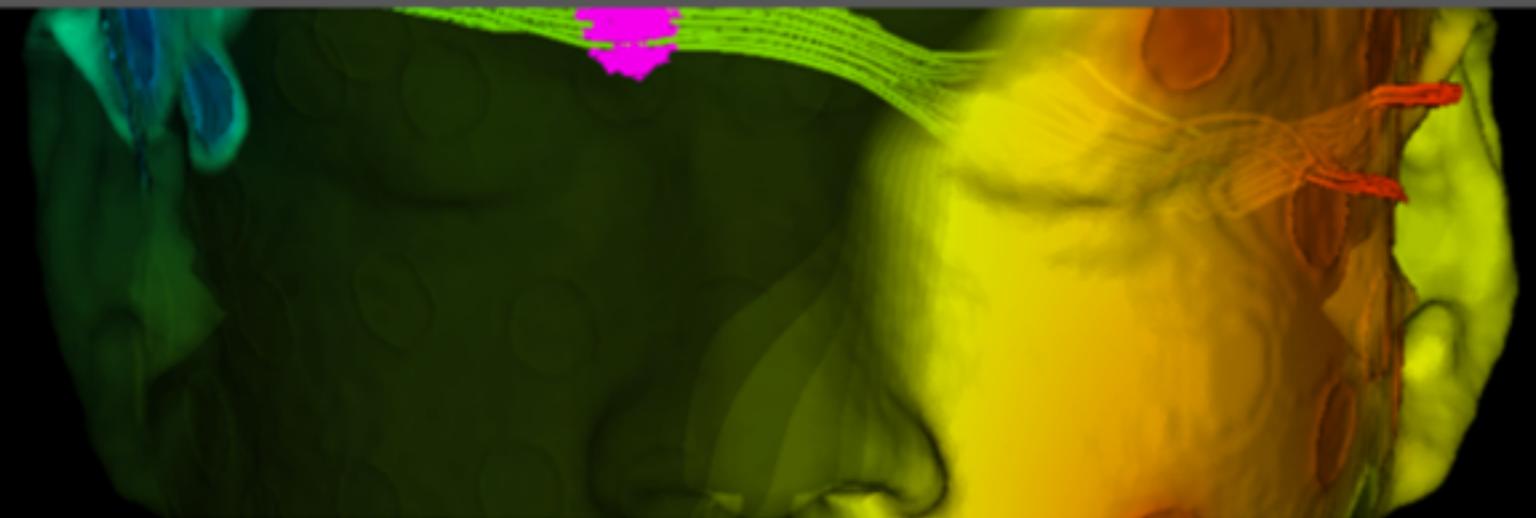
Information Visualization

Image Analysis



<http://sci.utah.edu>

The SCI Institute is an internationally recognized leader in visualization, scientific computing, and image analysis. Our overarching research objective is to create new scientific computing techniques, tools, and systems that enable solutions to problems affecting various aspects of human life.



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[Research News](#) | [Software News](#) | [Honors/Awards](#) | [Publications](#) | [All SCI News](#)

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

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

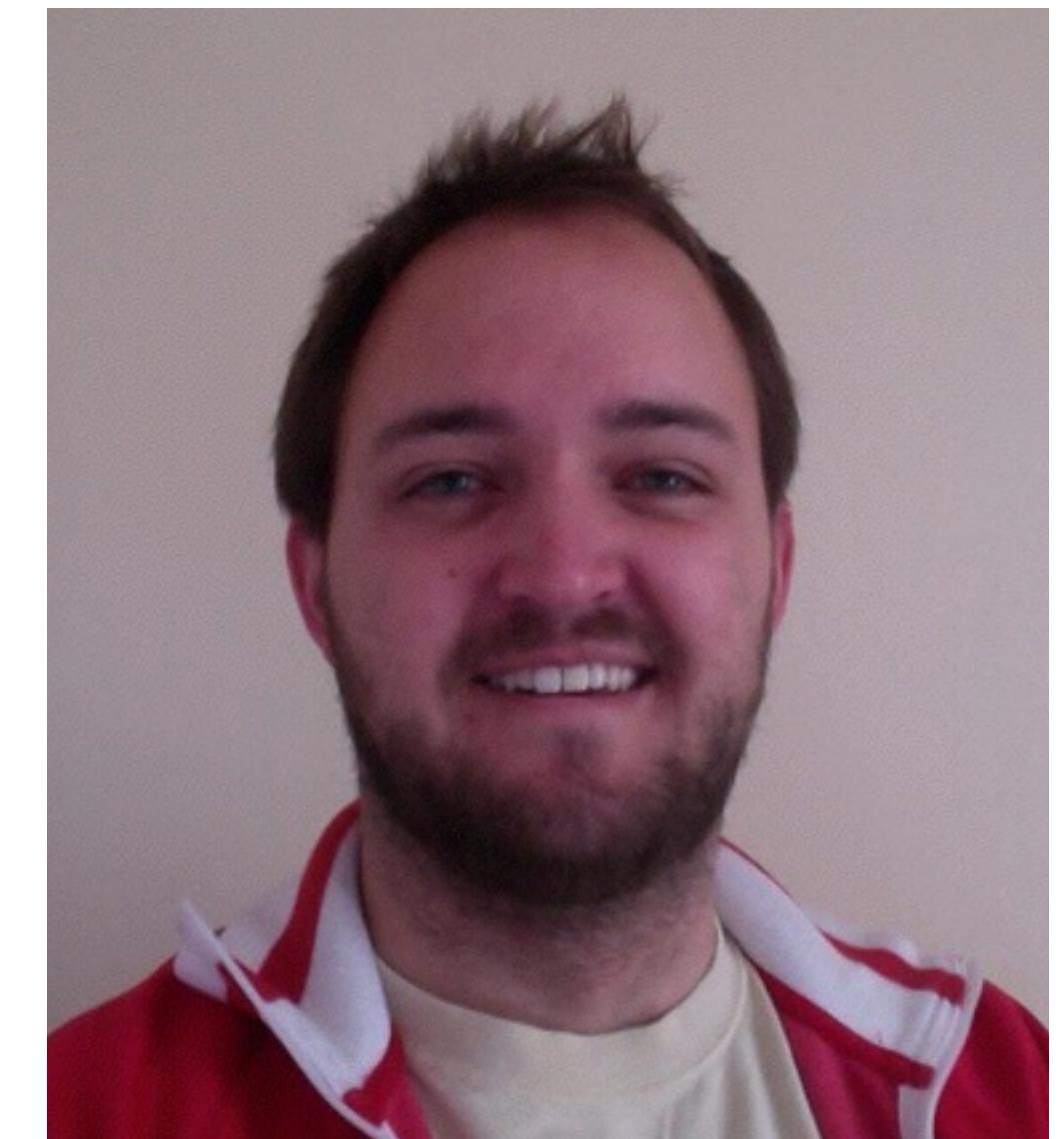
[RSS 2.0 FEED](#)

[View all SCI Events](#)

Upcoming SCI Events

Course Staff

Alex Bigelow
Teaching Assistant



Zinnia Mukherjee
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>

Visualization

CS-5630 / CS-6630

Home Syllabus Schedule Homework Project Resources Fame

The visualization page features three distinct data representations. On the left is an UpSet matrix showing the cardinality of intersections between various movie genres like Action, Comedy, Crime, Drama, and Romance. In the center is a Wind map of the United States, where the density and direction of lines represent political shifts across states. On the right is a treemap visualization of campaign contributions, with names like Obama, Romney, McCain, Bush, and Dole appearing as colored rectangles.

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 visualizations, and how to build them using the latest technologies such as HTML5, CSS3, Java, SVG, and D3.js.

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 the Piazza platform interface for the CS 171 class. The top navigation bar includes links for HW1, project, hw0, lectures, positions, New Post, Q & A, Resources, Statistics, and Manage Class. The main content area displays various posts and discussions:

- Search for Teammates:** 6 Open Teammate Searches (9/11/14)
- YESTERDAY:**
 - Instr: Research Intern -- Cognitive... (7:31PM)
To apply please email your CV and three references to Cody Dunne <cldurme@us.ibm.com> Job description: IBM
 - Instr: Homework 1 online (7:38PM)
Homework 1 can be found in the hw1 subfolder in this repository: <https://github.com/CS171/2015-cs171-homework>
- THIS WEEK:**
 - Instr: Classes cancelled tomorrow (Mon)
FAS and DCE have cancelled all classes tomorrow. Consequently we will meet for the first time on Thursday. We will update the schedule.
 - Instr: Homework 1 online (Mon)
See the hw0 subfolder in this repository: <https://github.com/CS171/2015-cs171-homework>
 - Project Teams (Sun)
I was reading the team project requirement for the class and wondering if we should post areas of interest to solicit help.
- WEEK 1/11 - 1/17:**
 - Instr: Green Corps Fellowships (1/13/15)
Early Winter Application Deadline: January 15th, 2015 Click here to learn more about Green Corps' paid environmental org
 - Instr: Visualization Job at the Worl... (1/13/15)
In case someone is interested: [OpenDRIDataVizDescription.pdf](#)
- WEEK 11/30 - 12/6:**
 - Instr: Introductions (12/1/14)
Hi everyone, welcome from the CS171 team! As part of Homework 0 we ask you to post your introduction as a follow-up to t
- WEEK 9/7 - 9/13:**
 - Private: Introduce Piazza to your stu... (9/11/14)
 - Private: Get familiar with Piazza (9/11/14)
 - Private: Tips & Tricks for a successf... (9/11/14)
- Welcome to Piazza!**

Piazza is a Q&A platform designed to get you great answers from classmates and instructors fast. We've put together thi

Followup Discussions: For lingering questions and comments

- Resolved: Pierre-Marie Meytang 2 days ago
Hi guys,
- Unresolved: Alexander Lex 2 days ago
Hi Pierre-Marie,
this wasn't an issue last year. If it becomes an issue we will find an appropriate solution.
- Alex 2 days ago
Thanks
- Matt Keane 2 days ago
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.
- Thanks Matt
- Alexander Lex 2 days ago
Hm, that's bad. That wasn't a problem at all last year. We'll e-mail them.
- Alexander Lex 1 day ago
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 Meytang 1 day ago
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 1 day ago
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 1 day ago
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.

Average Response Time: N/A Special Mentions: There are no special mentions at this time.

Course Components

Design Lecture

Design Studios

Lecture
Reading
Discussion

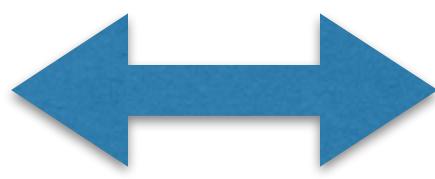
Sections

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

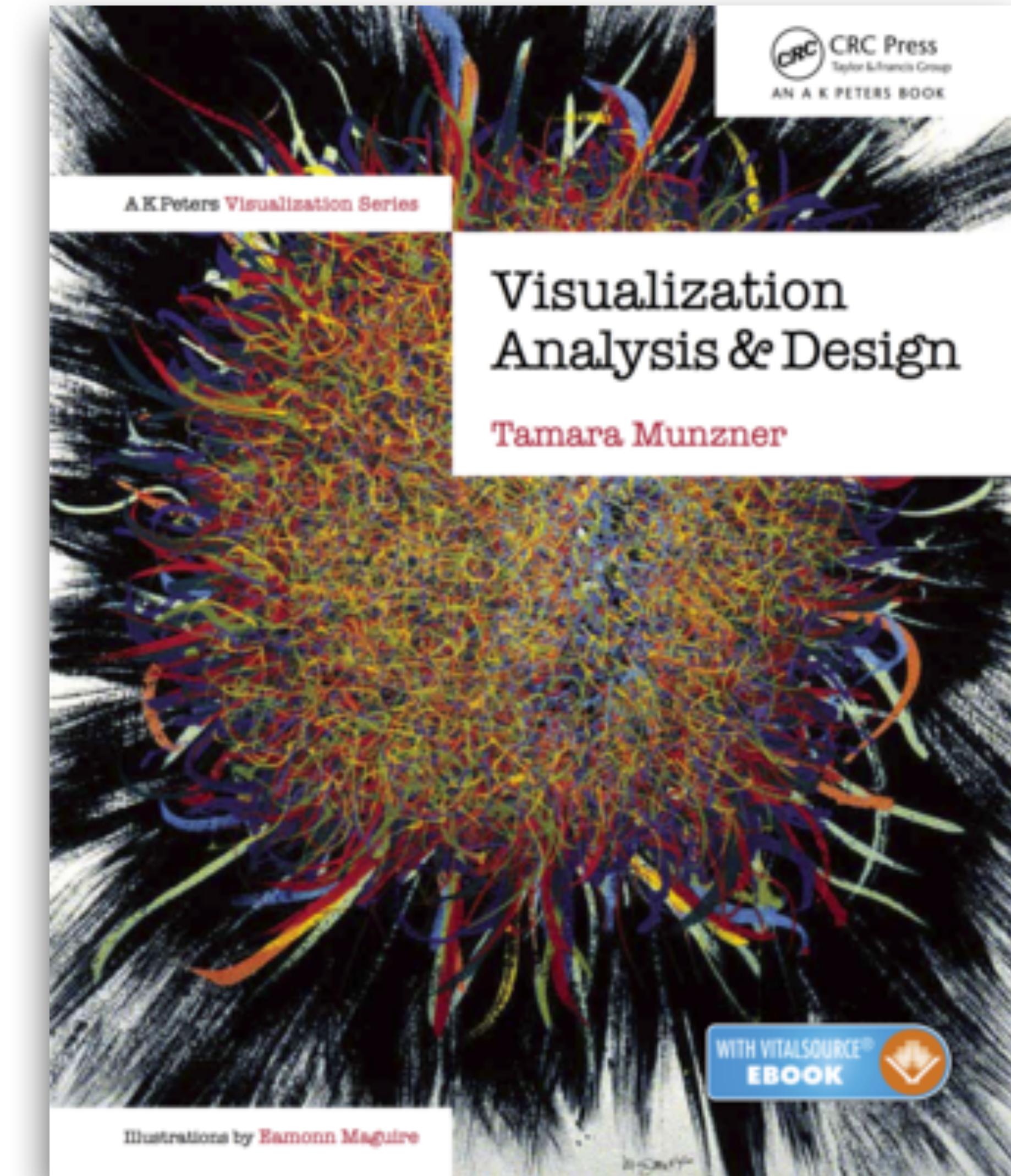
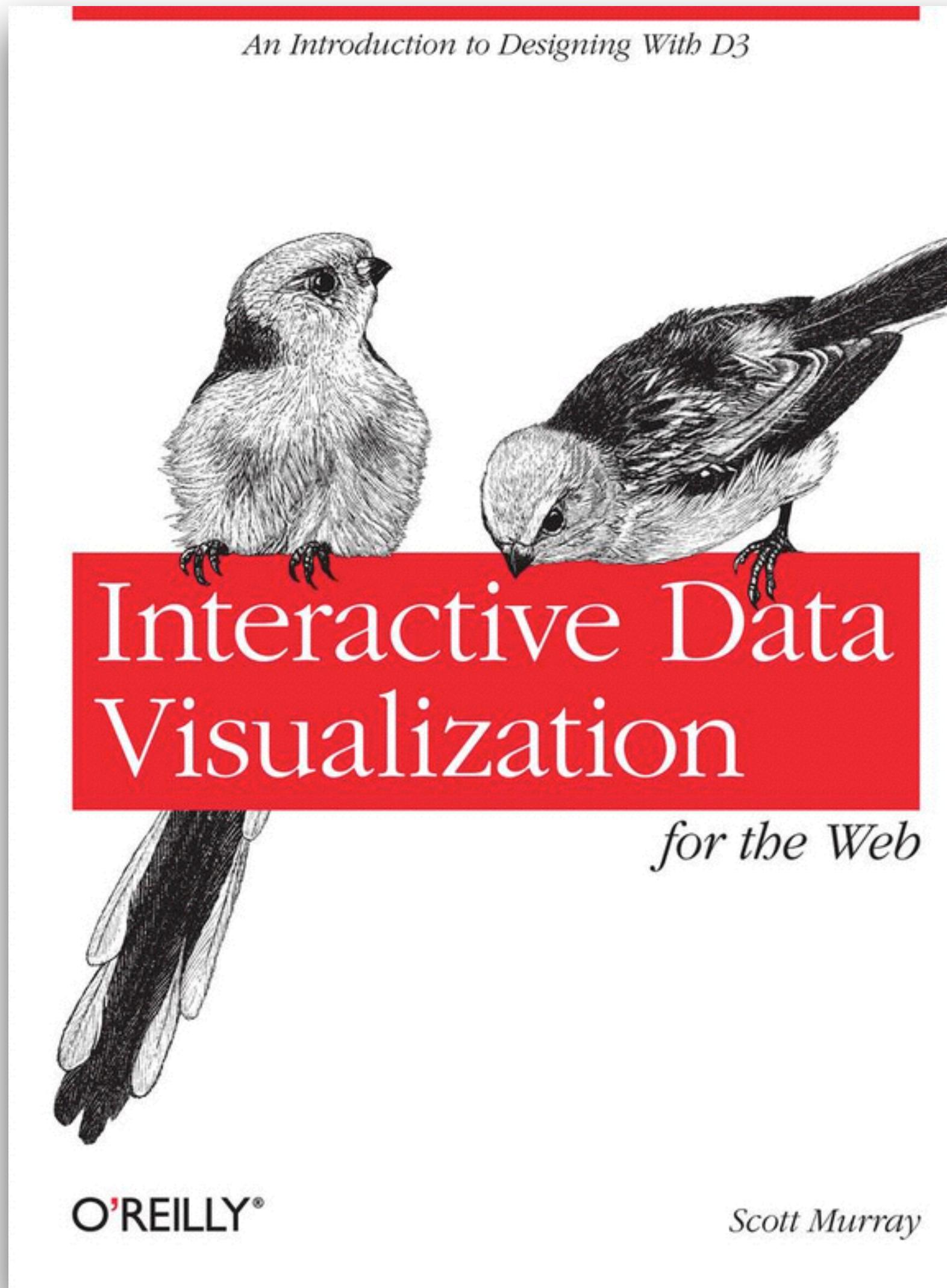
Introduction to git. HTML, CSS and the DOM. Selectors, etc.

[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

d3 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

HWO, 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!

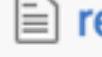
<https://github.com/dataviscourse/2015-dataviscourse-homework>

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

Update readme.md

 AnirudhNarasimhamurthy authored 4 days ago latest commit b6771174ee 

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 **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.

Sign up for GitHub now!

Problem 1 - Class Survey, Signups, and Introduction

Sign up for github

You'll be signing up for GitHub, so make sure you have a valid email address.