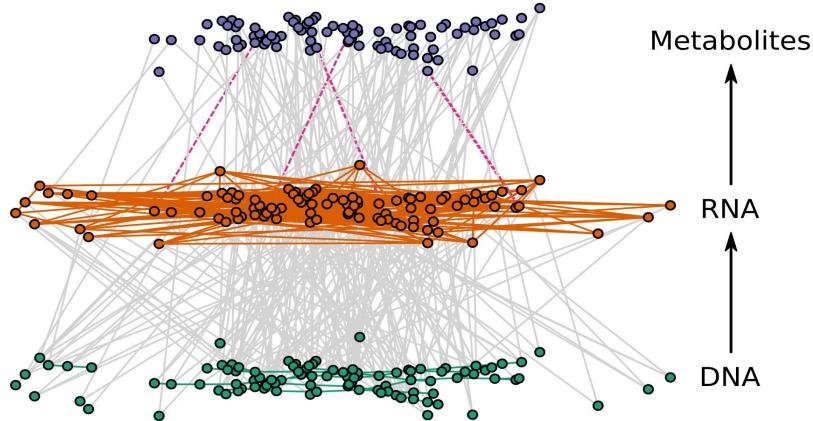


Lecture 0: Introduction to Applied Research in Health Data Science

CSCI6410/4148 & EPAH6410

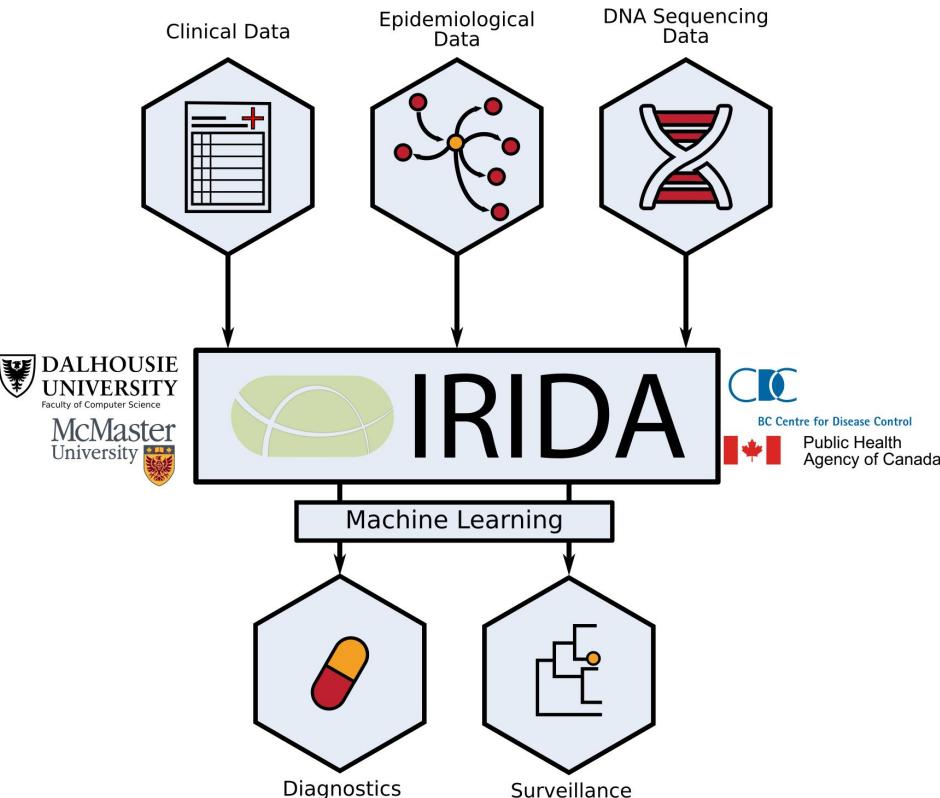
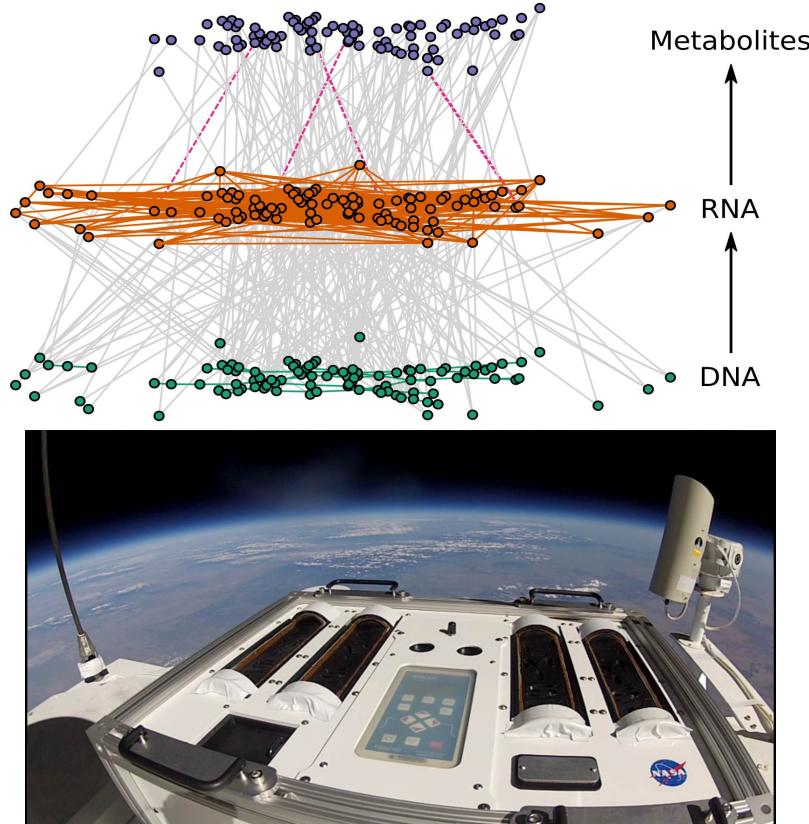
Finlay Maguire (finlay.maguire@dal.ca)

Why am I teaching this course?



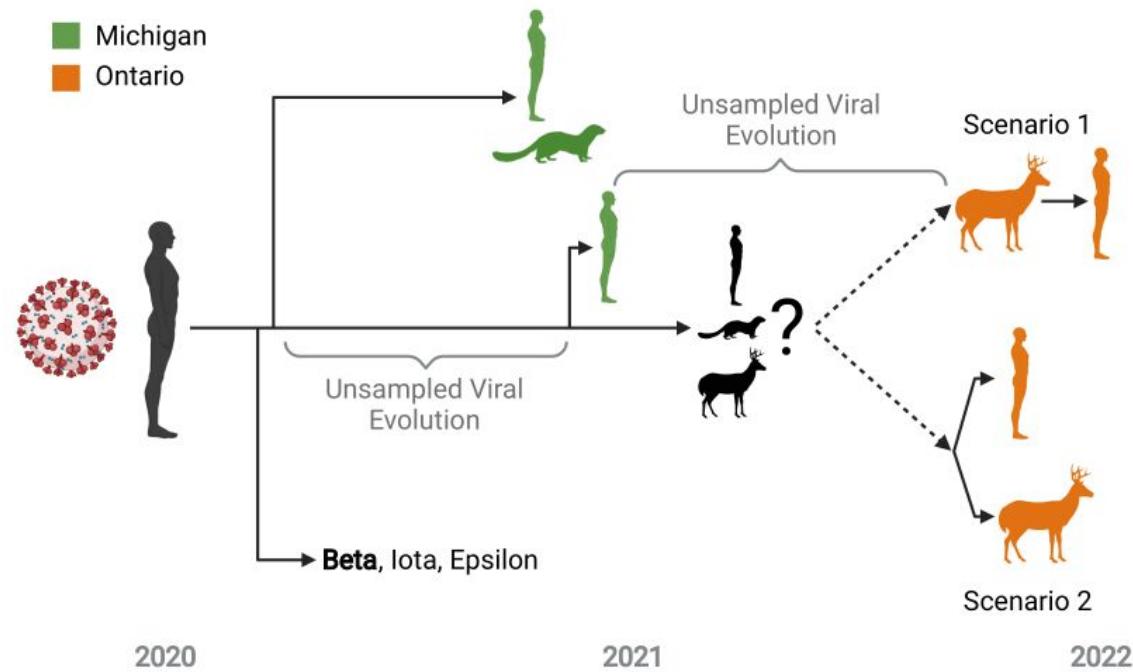
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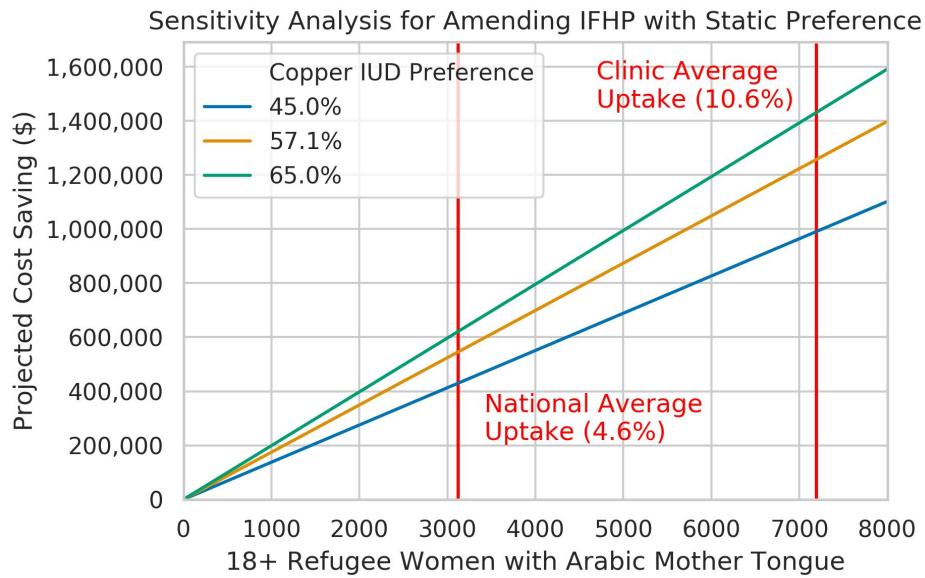
- **PhD (Bioinformatics):** using large noisy datasets to understand how microbial systems and mechanisms evolve.
- **Postdoc (Genomic Epidemiology):** using large noisy datasets to better diagnose, track and predict infectious diseases.

Why am I teaching this course?

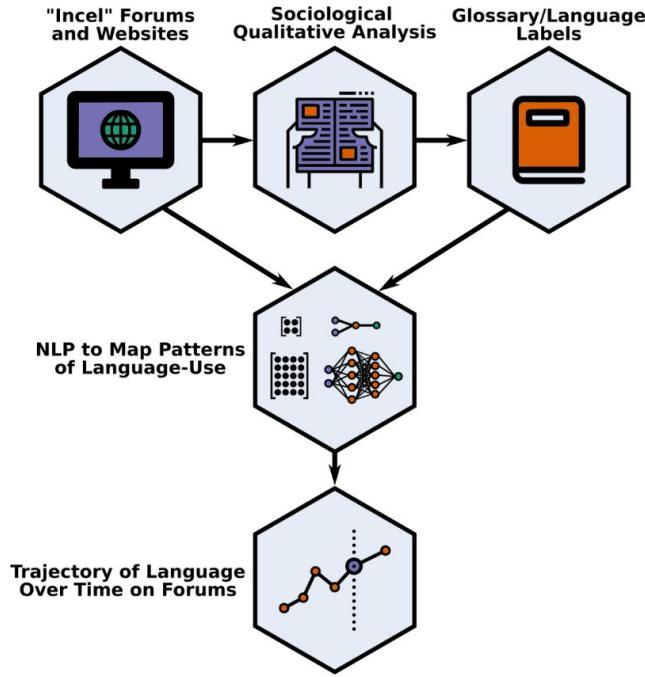


- **Research group:** using large noisy datasets:
 - Genomic epidemiology of infectious disease: **SARS-CoV-2, AMR**

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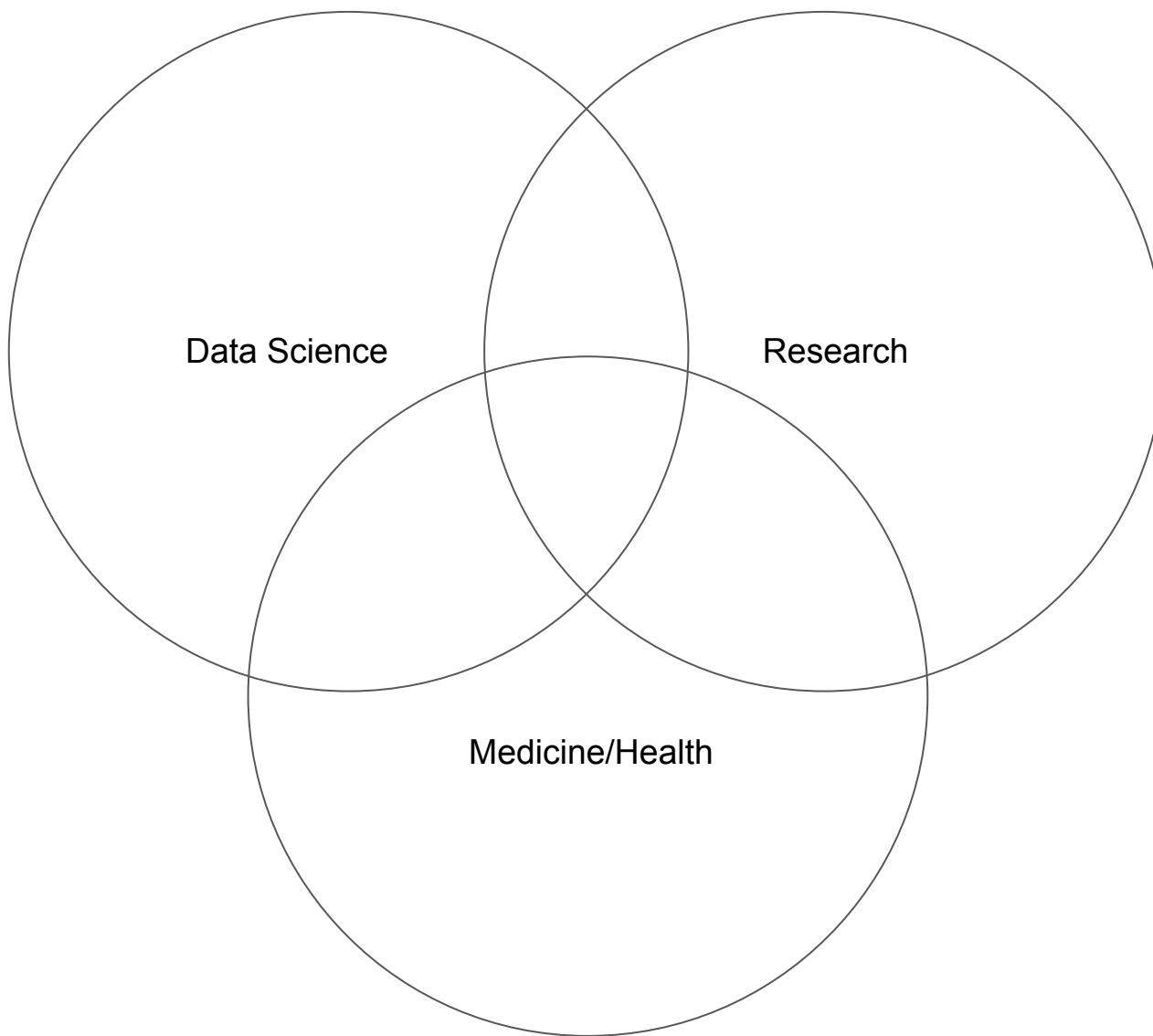
Modelling “Incel” Online Radicalisation via NLP



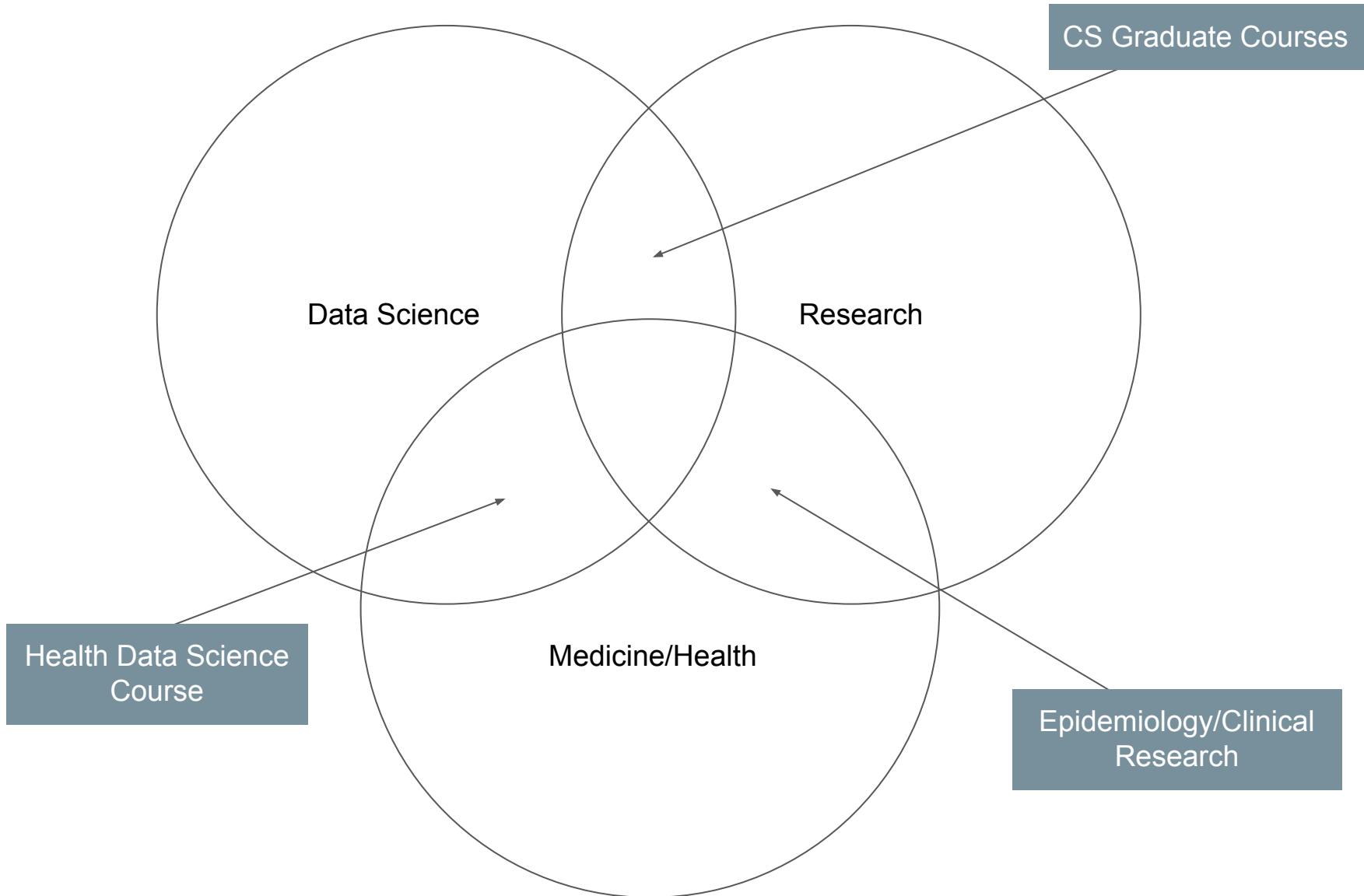
- **Research group:** using large noisy datasets:
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 - Collaborations on socially/health focused problems: **refugee health, incel radicalisation, health inequality**

Overview of course

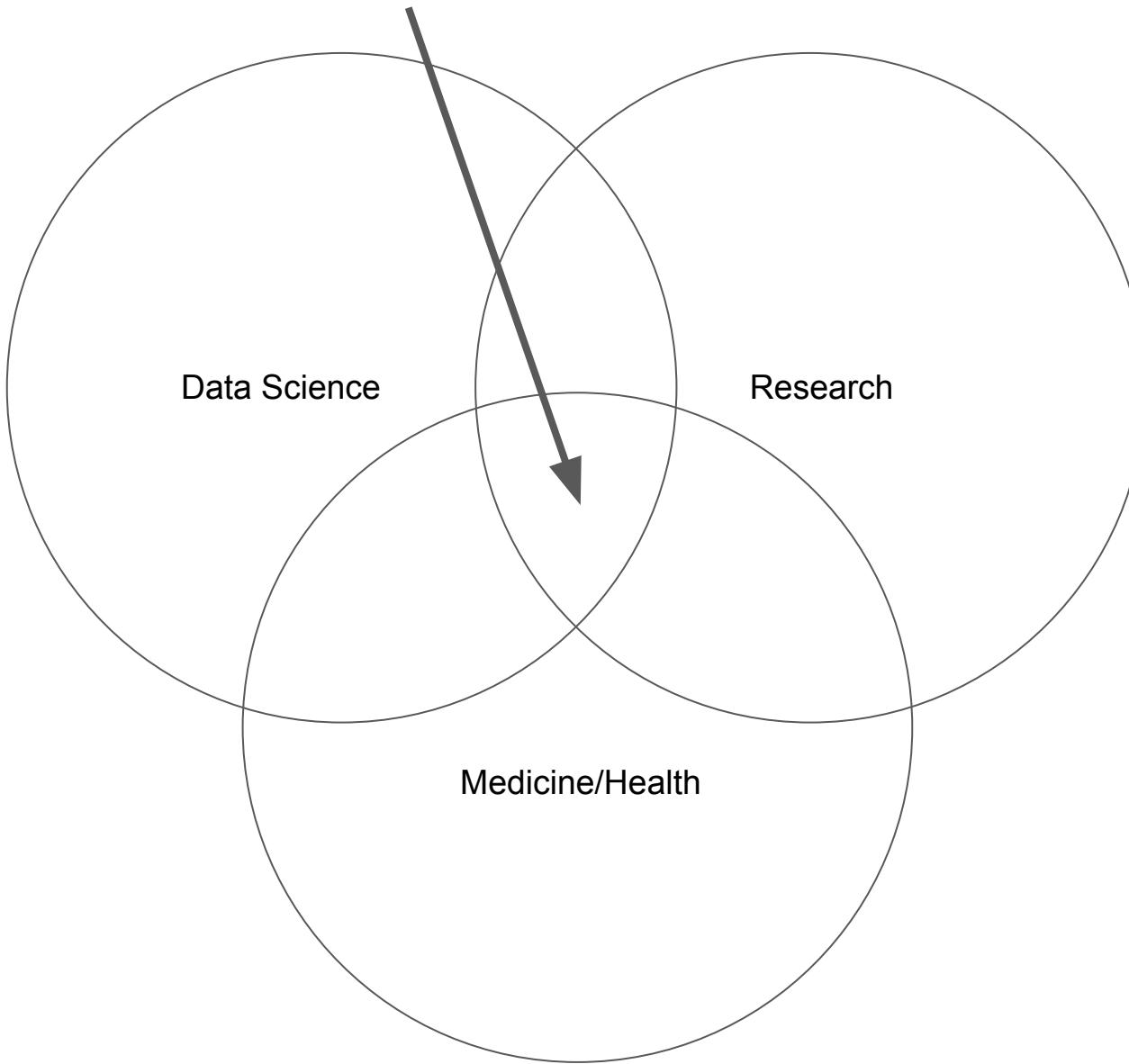
Applied Research in Health Data Science



Applied Research in Health Data Science



Applied Research in Health Data Science



Learning Outcomes

1. Understand the **4 principal sources and data types** of medical data:
 - a. longitudinal databases (tabular)
 - b. electronic medical records (structured, semi-structured, and unstructured text)
 - c. radiological imaging (image)
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5. Critically **appraise research literature** in health data science.
6. Combine these skills to develop high-quality collaborative health data science **research proposals**

What is not covered in this course

- **Breadth/depth** of each data science method: *each could be multiple graduate CS courses*

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- **Breadth/depth** of each data science method: *each could be multiple graduate CS courses*
- **Breadth/depth** of medical research: *again could be a whole PhD program*
- True **messiness** of real data: *provide tools but experience is invaluable*
- Some important forms of medical data (e.g., genomics): *see next year's **genomic medicine** course if interested.*

Course Structure

Overview of data types & analysis methods:

- **Lectures** (Monday/Wednesday)

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Assessment: Submission of Practical Exercise Due
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(CSCI4148: drop lowest scoring assignment)

```
dens <- density(data, n = npts)
dx <- dens$x
dy <- dens$y
if(add == TRUE)
  plot(0., 0, main = "", xlab = "", ylab = "")
  if(orientation == "horizontal")
    dx2 <- (dx - min(dx)) / max(dx)
    x[1.]
    dy2 <- (dx - min(dx)) / max(dy)
    y[1.]
    seqbelow <- rep(y[1.], length(dx))
    if(Fill == T)
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Research in health data science:

- **Journal Club** (Wednesday/Friday)

2 papers per week, rota for leading discussion of paper with rest of class.

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Paper presentation (10%)

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<https://www.coursera.org/learn/r-programming>

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Development of a research proposal:

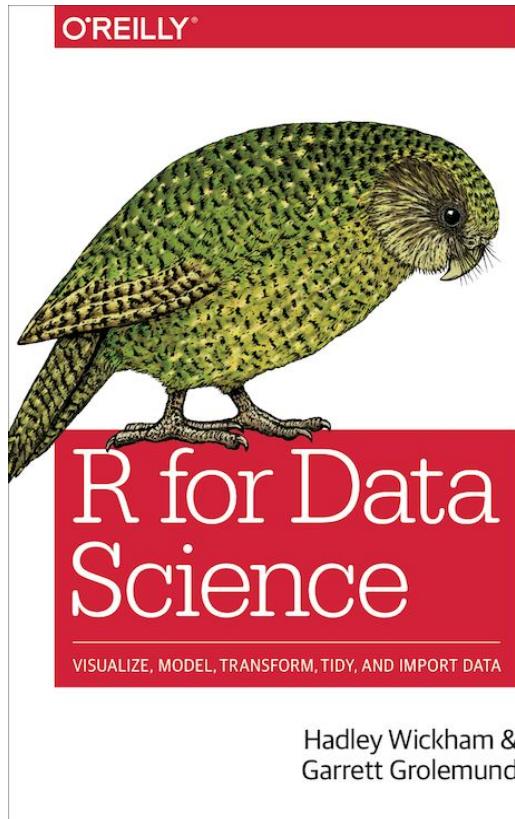
- **Class** (Wednesday/Friday)

Assessment:

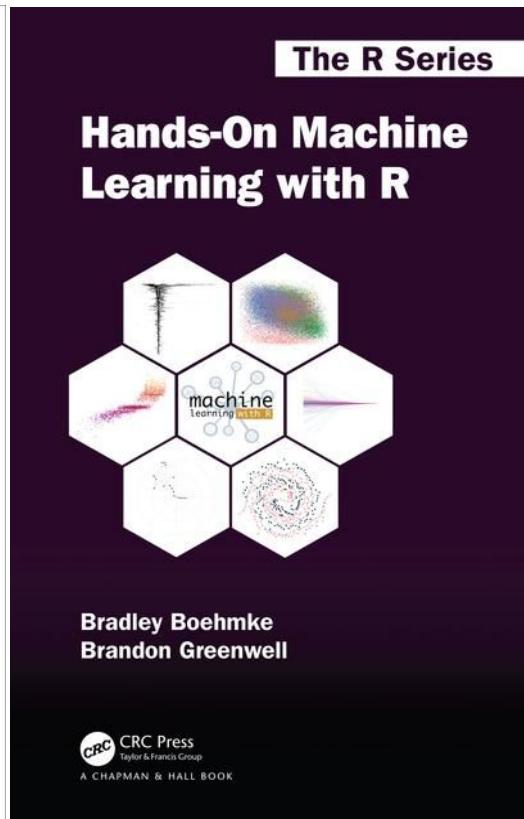
Presentation last full week of class (25%)

Submitted final day of class (15%)

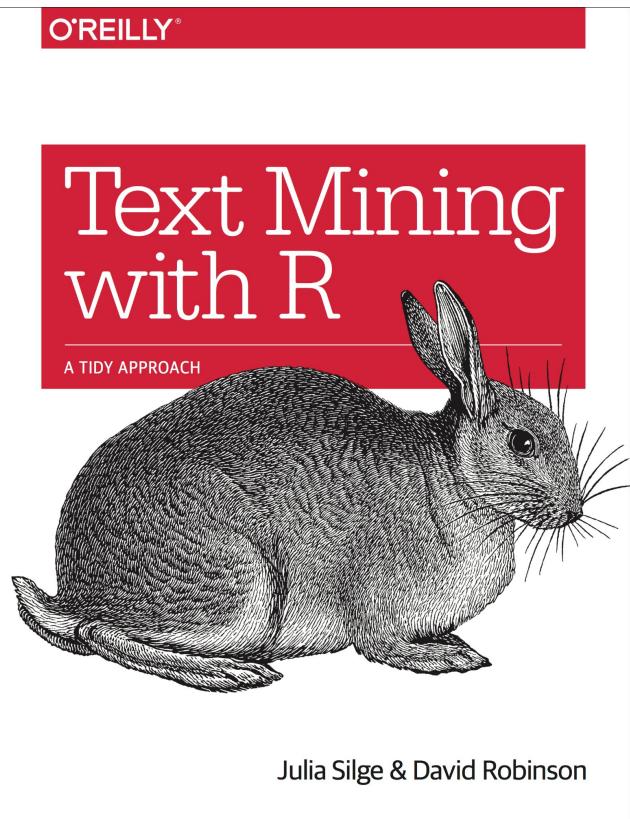
Course Materials



<https://r4ds.had.co.nz/>



<https://bradleyboehmke.github.io/HOML/>



<https://www.tidytextmining.com/>

Course Website



CSCI6410/CSCI4148/EPAH6410: Applied Research in Health Data Science / Summer 2023-2024

Updates

- New Lecture is up: Lecture 0 - Introduction to health data science [[slides](#)]

https://maguire-lab.github.io/health_data_science_research_2024/

Course Website

The header features the Dalhousie University logo, the course title "CSCI6410/CSCI4148/EPAH6410: Applied Research in Health Data Science", and the semester "Summer 2023-2024". Below the title is a navigation bar with links: HOME, SCHEDULE, LECTURES, PRACTICALS, PROPOSAL, and LITERATURE.

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CSCI4148 CSCI6410 EPAH6410 - Appl...



Finlay Maguire



Course Home Content Discussions Assessments ▾ My Tools ▾ Help ▾ Course Admin

CSCI4148 CSCI6410 EPAH6410 - Applied Res. Health Data
Sci - Sec: 01 - 2023/2024 Summer

Announcements ▾

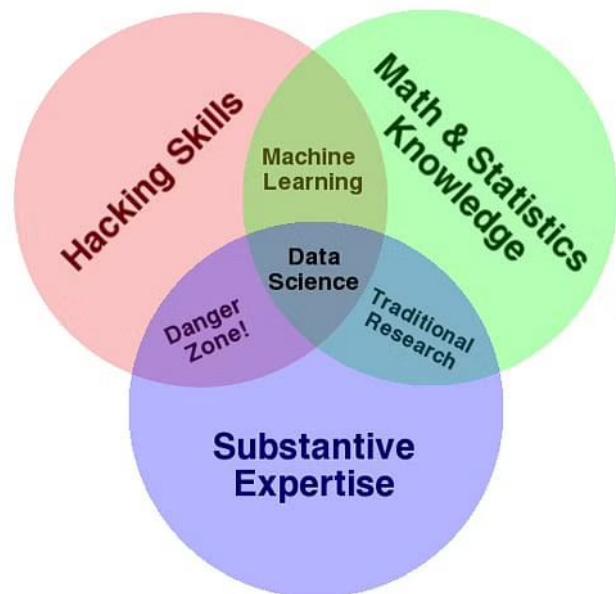
Updates ▾

Grades/Submissions:

<https://dal.brightspace.com/d2l/home/331766>

What is ~~health~~ data science?

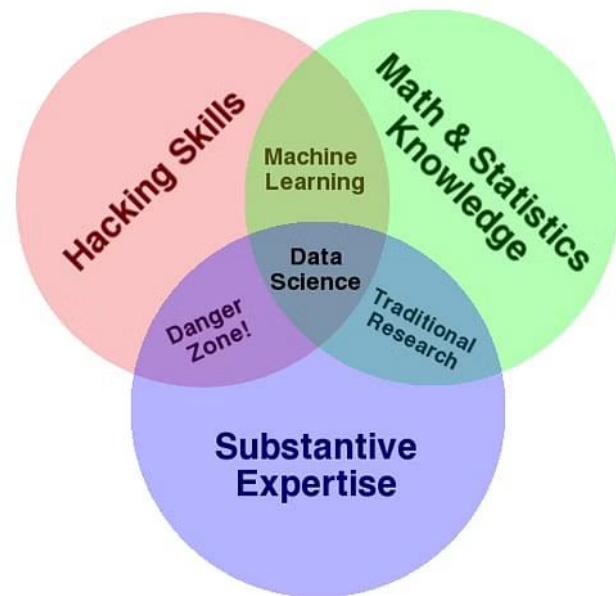
Data Science: *Using Data to Better Understand Things in the Real World*



<http://drewconway.com/zia/2013/3/26/the-data-science-venn-diagram>

Data Science: *Using Data to Better Understand Things in the Real World*

A range of partial and totally overlapping terms:

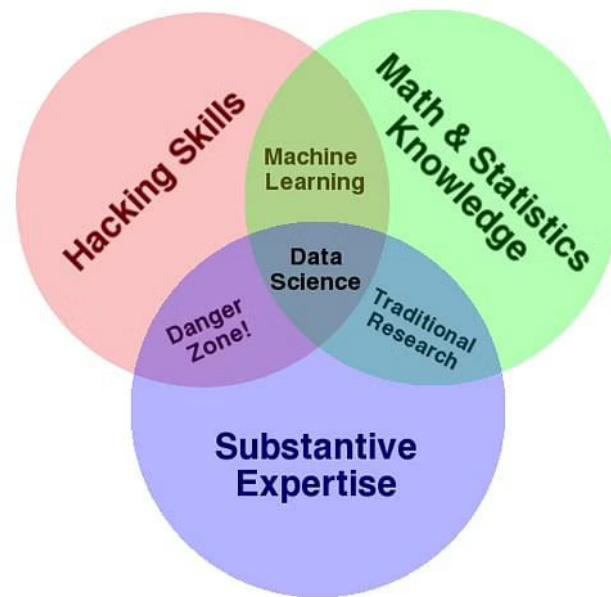


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Data Science: *Using Data to Better Understand Things in the Real World*

A range of partial and totally overlapping terms:

- Data Analytics
- Data Engineering
- Data Mining
- {Health,Bio,Medical}Informatics
- Database Analysis
- Business Intelligence
- Epidemiology
- Statistics
- Machine Learning
- Pattern Recognition
- Predictive Analytics
- Quantitative Researcher
- Scientist
- Analyst
- Algorithmic Modeling



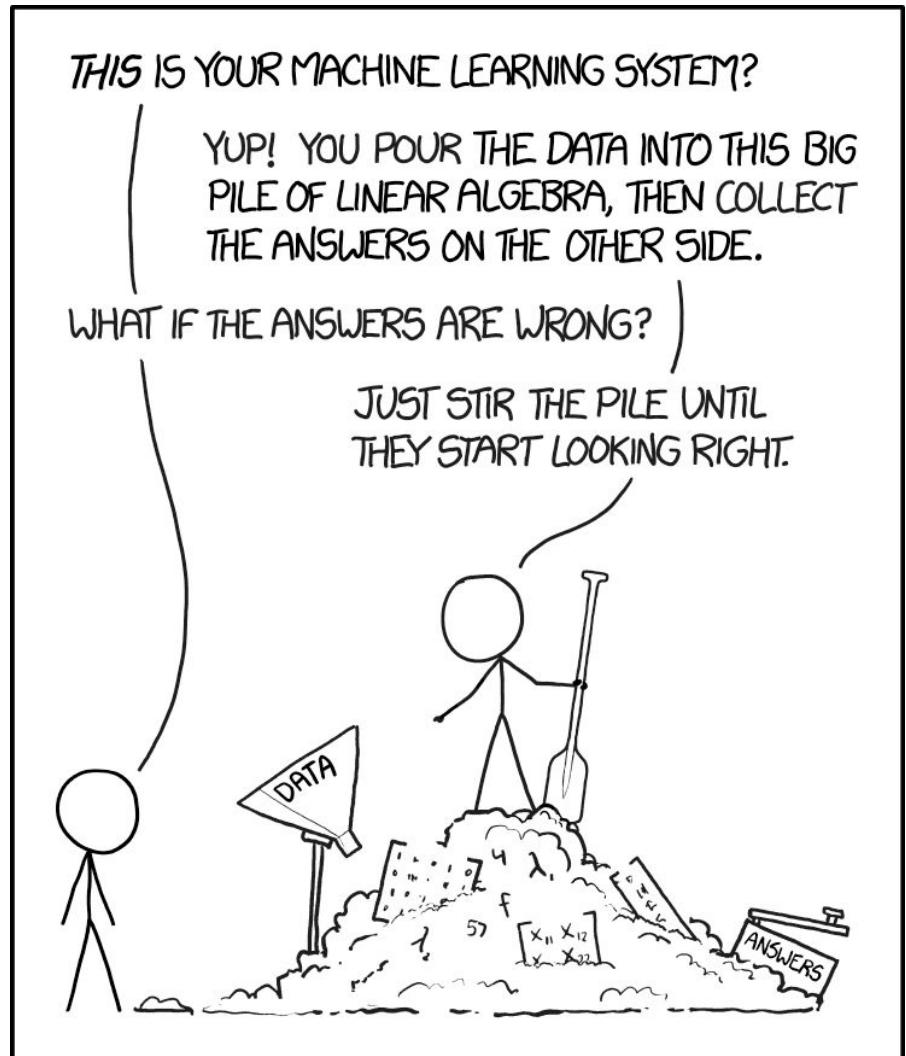
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So, it is just statistics?

Data Science (& Machine Learning): re-branded statistics?

Pitfalls (can be):

- Less rigorous/principled
- Prone to reinventing the wheel



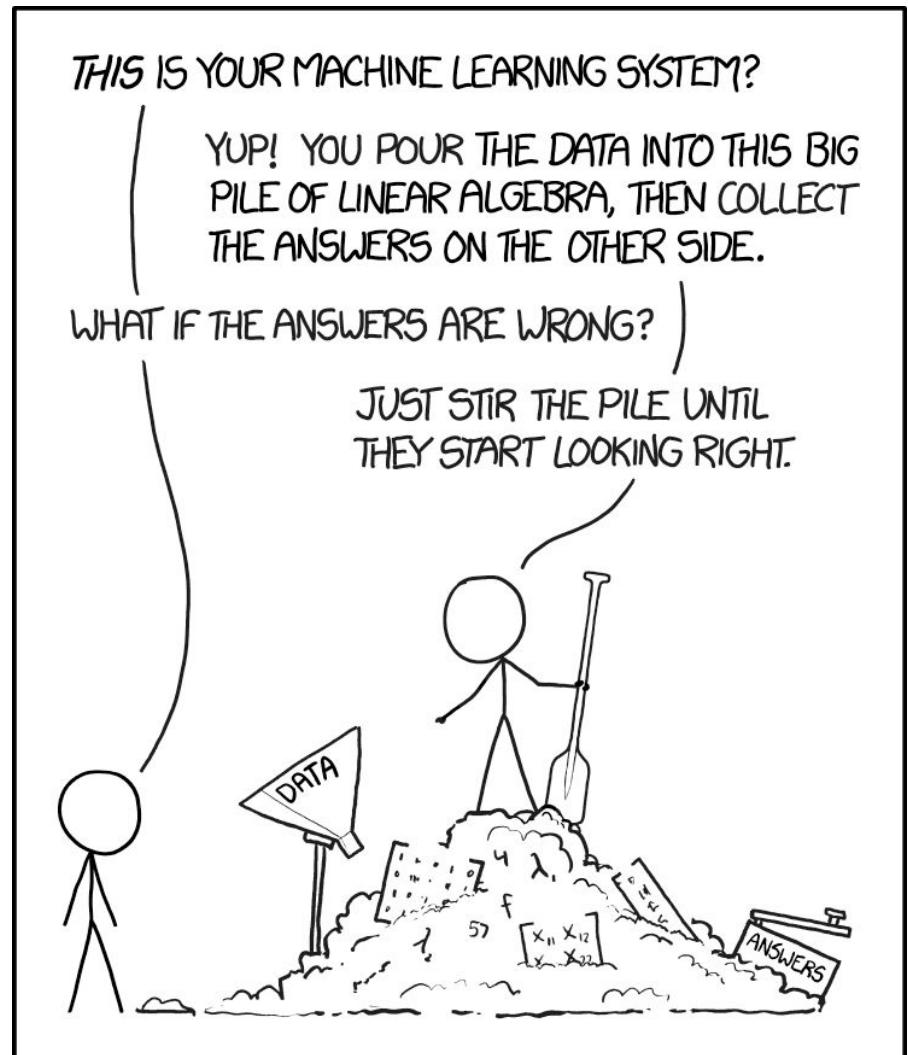
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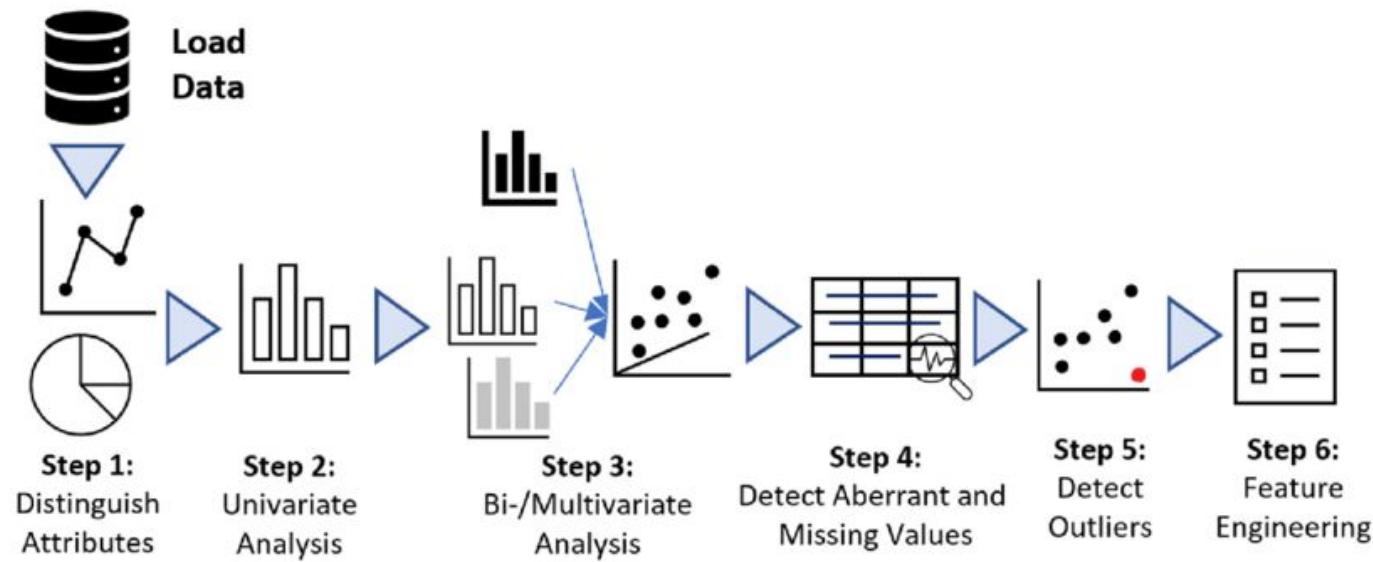
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Benefits (can be):

- More flexible
- Less prescriptive/intimidating



Data science centers exploratory data analysis

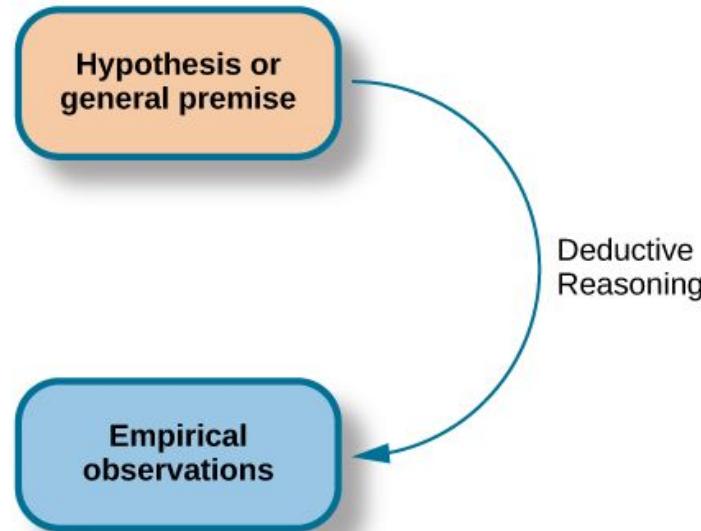


Data science supports inductive approaches

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Deductive:

- “Condition X, causes Y”
- Collect data
- Perform (typically) frequentist statistical tests
- Reject or confirm null hypothesis



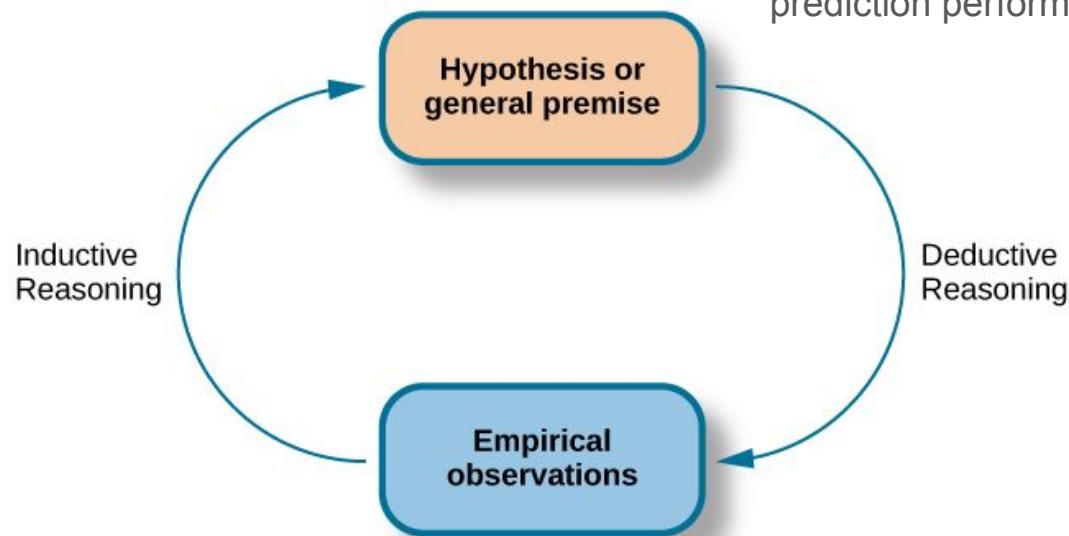
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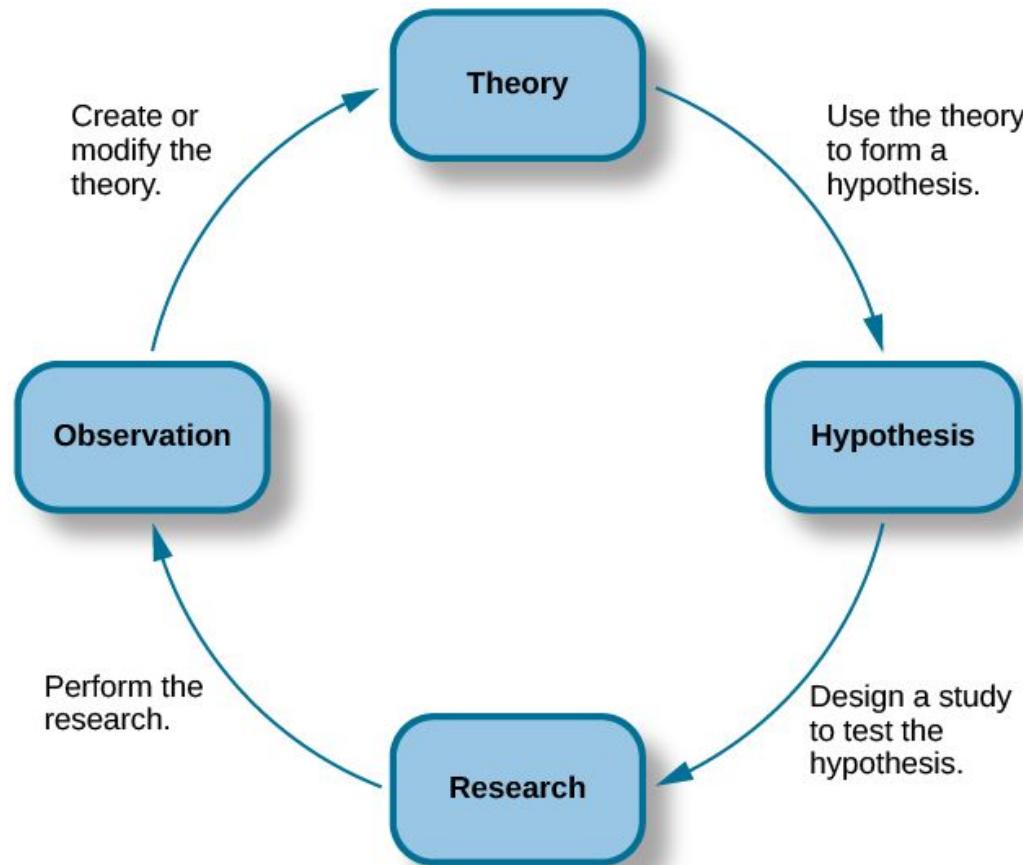
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Inductive:

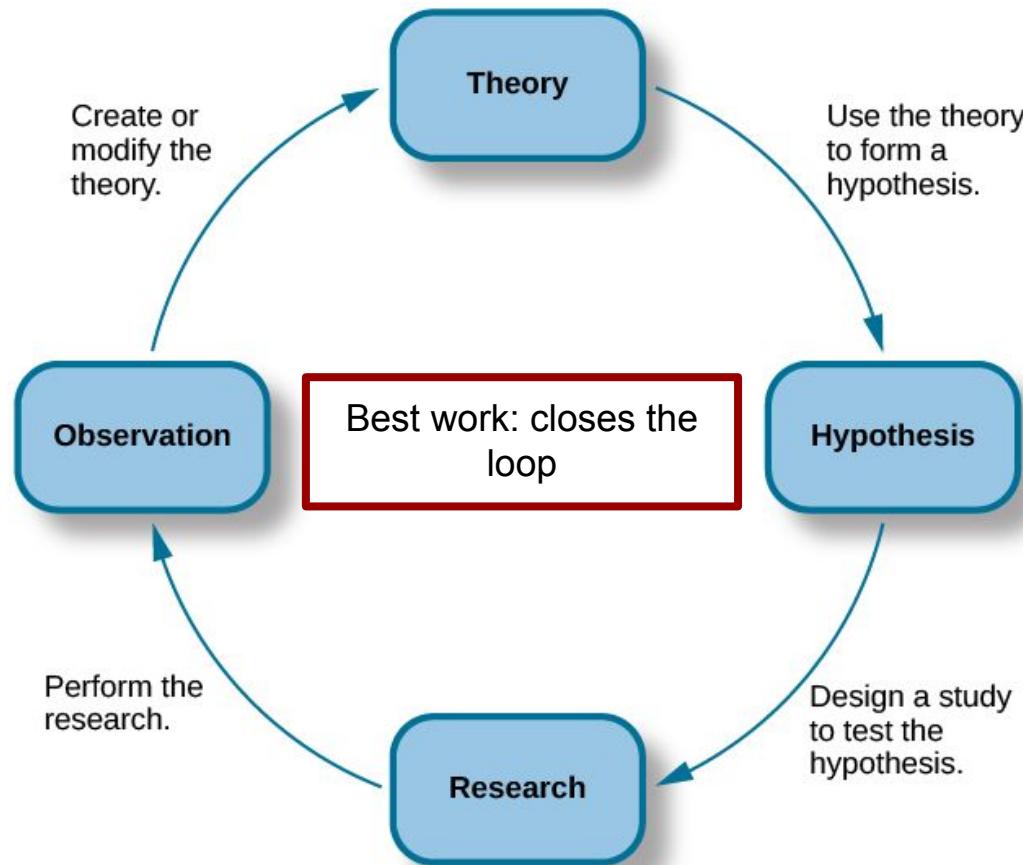
- Collect data
- Identify patterns in the data
- Observe X and Y seem connected somehow
- Quantify strength of association e.g., prediction performance



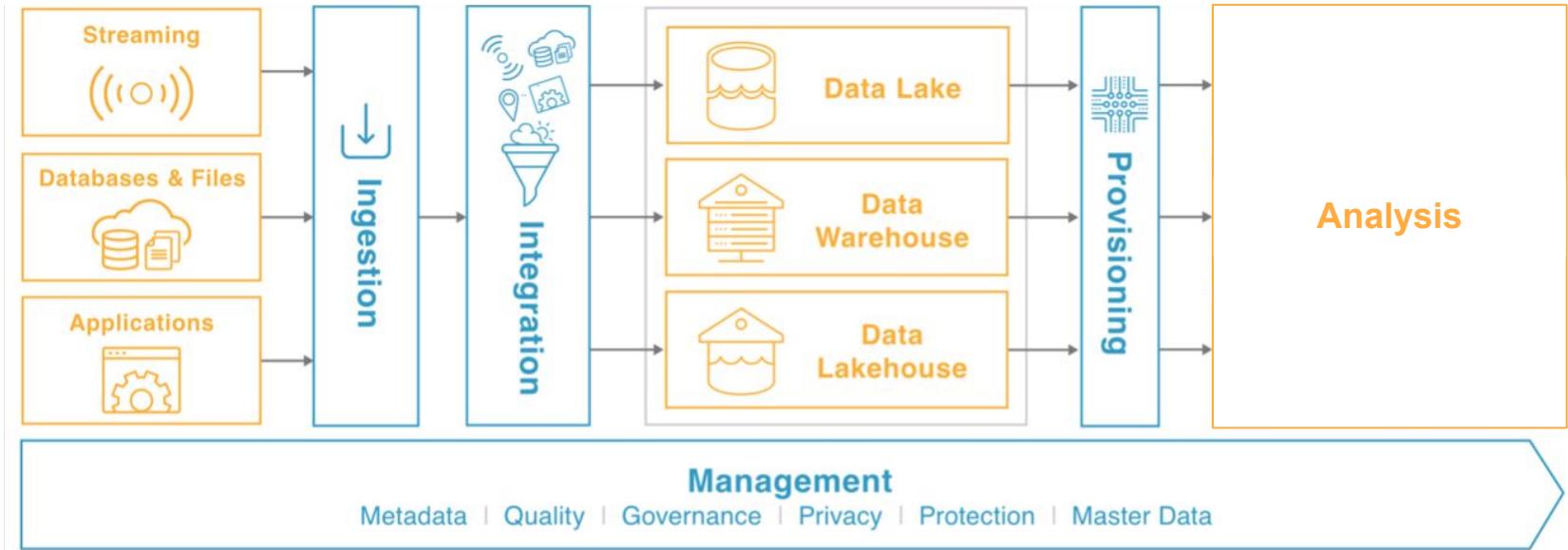
Data science aligns with knowledge cycle



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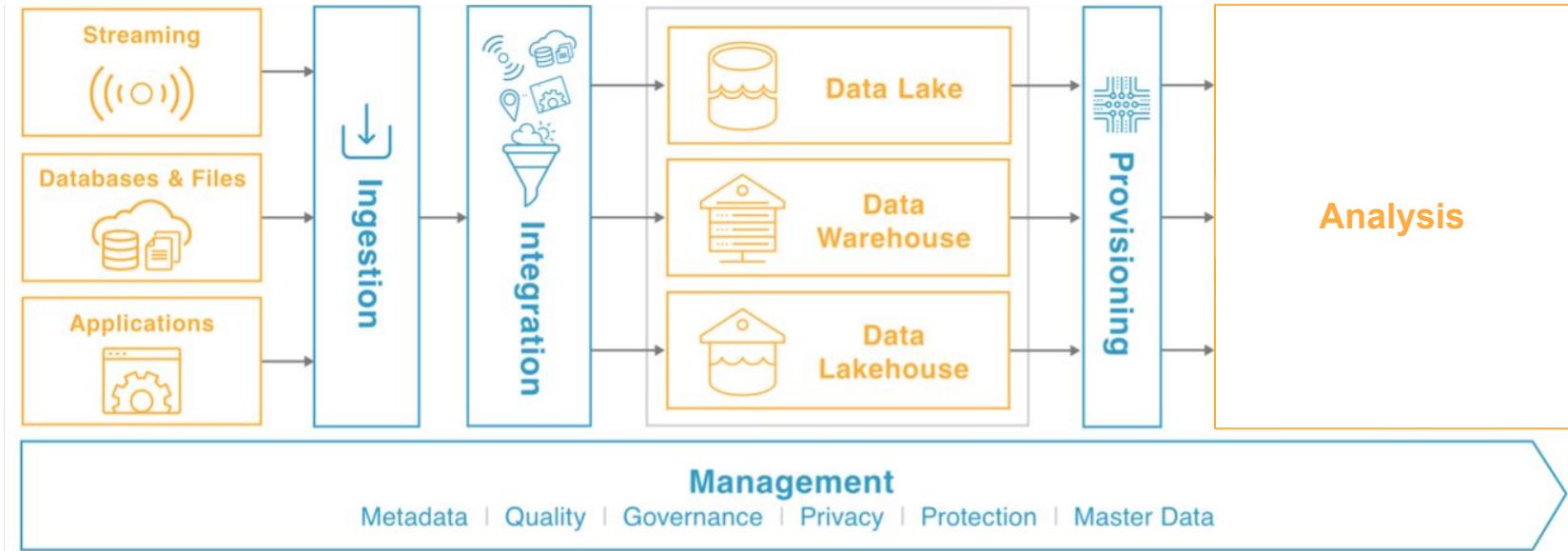


Data science is integrated into a data ecosystem

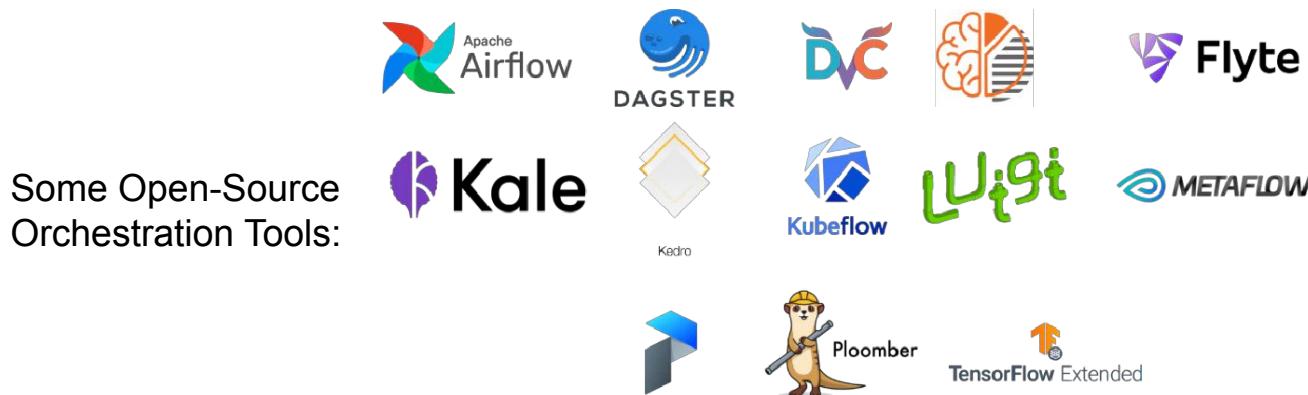


<https://www.2ndwatch.com/blog/what-is-a-data-pipeline-and-how-to-build-one/>

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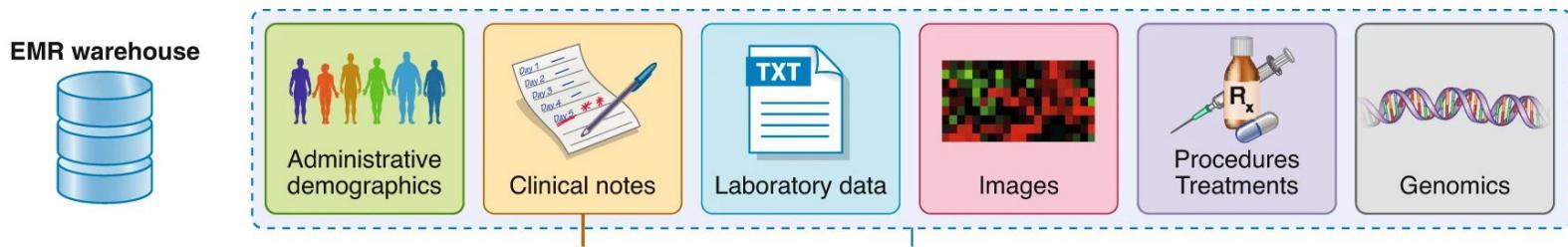
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<https://ploomber.io/blog/survey/>

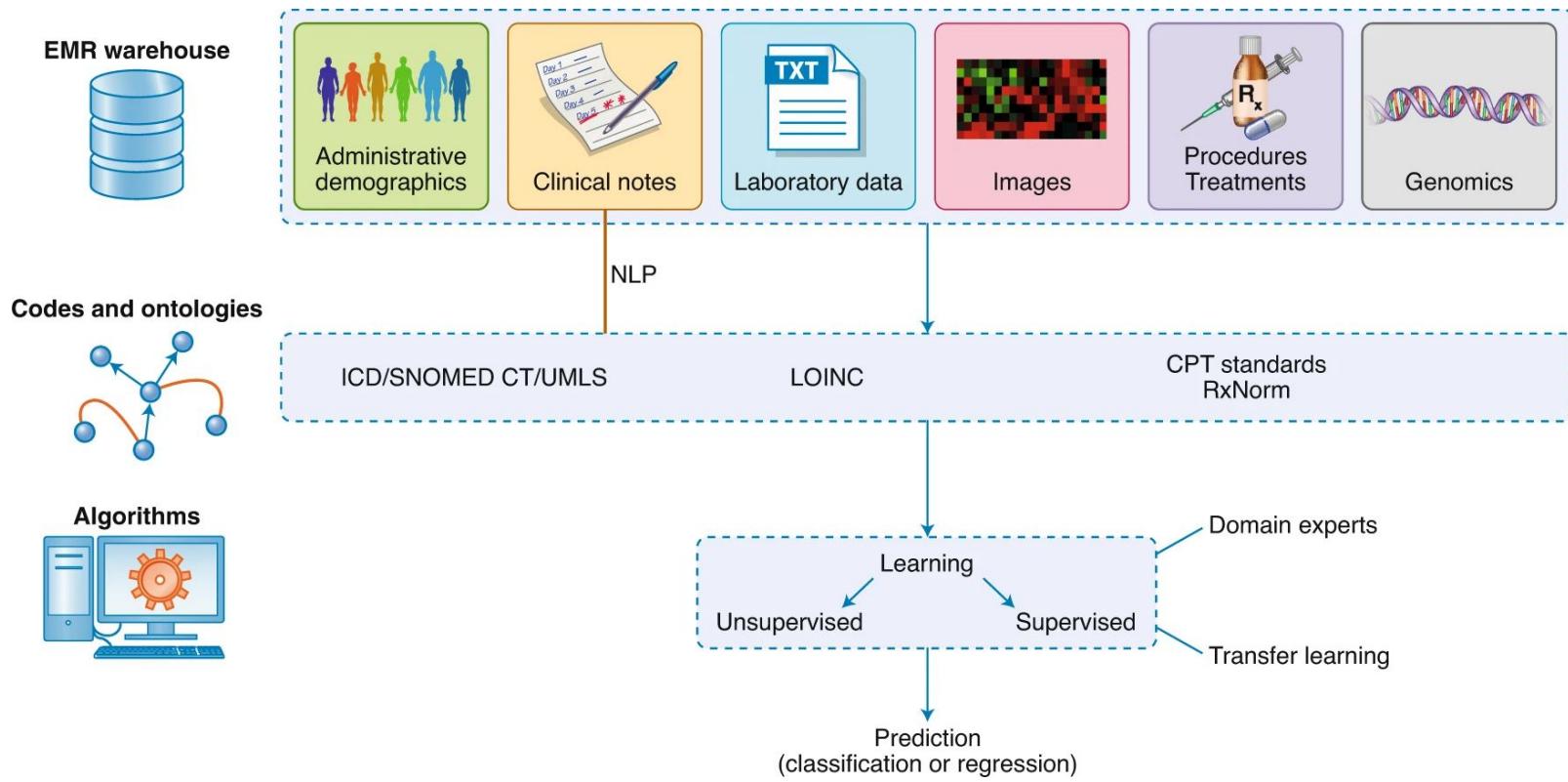
OK, what is **Health** Data Science?

Data Science applied to Health Data



Why “health data” instead of “medical data”: health encompasses medical (**contentious**)

Data Science applied to Health Data



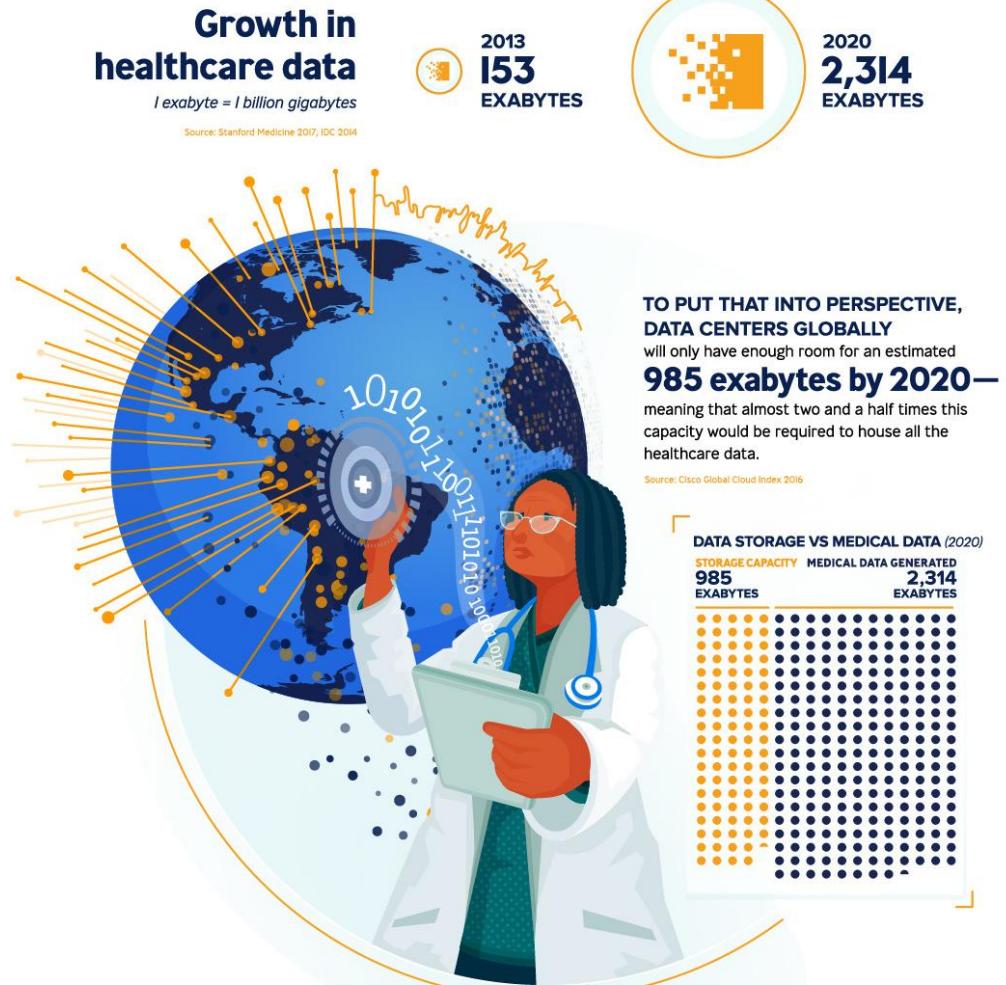
<https://www.nature.com/articles/s41588-020-0698-y/figures/2>

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Opportunity of Health Data Science

Benefits (and pitfalls!) of data science in general combined with:

- Huge amounts of health data

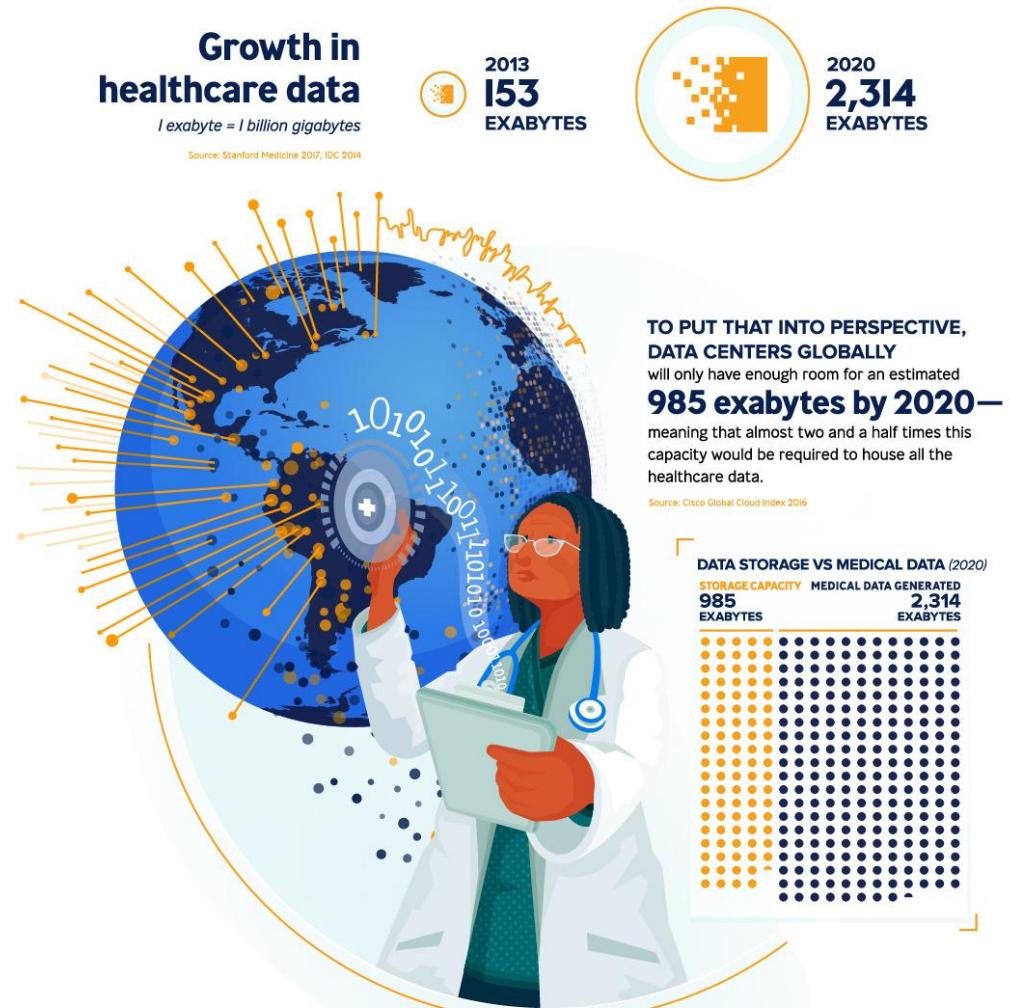


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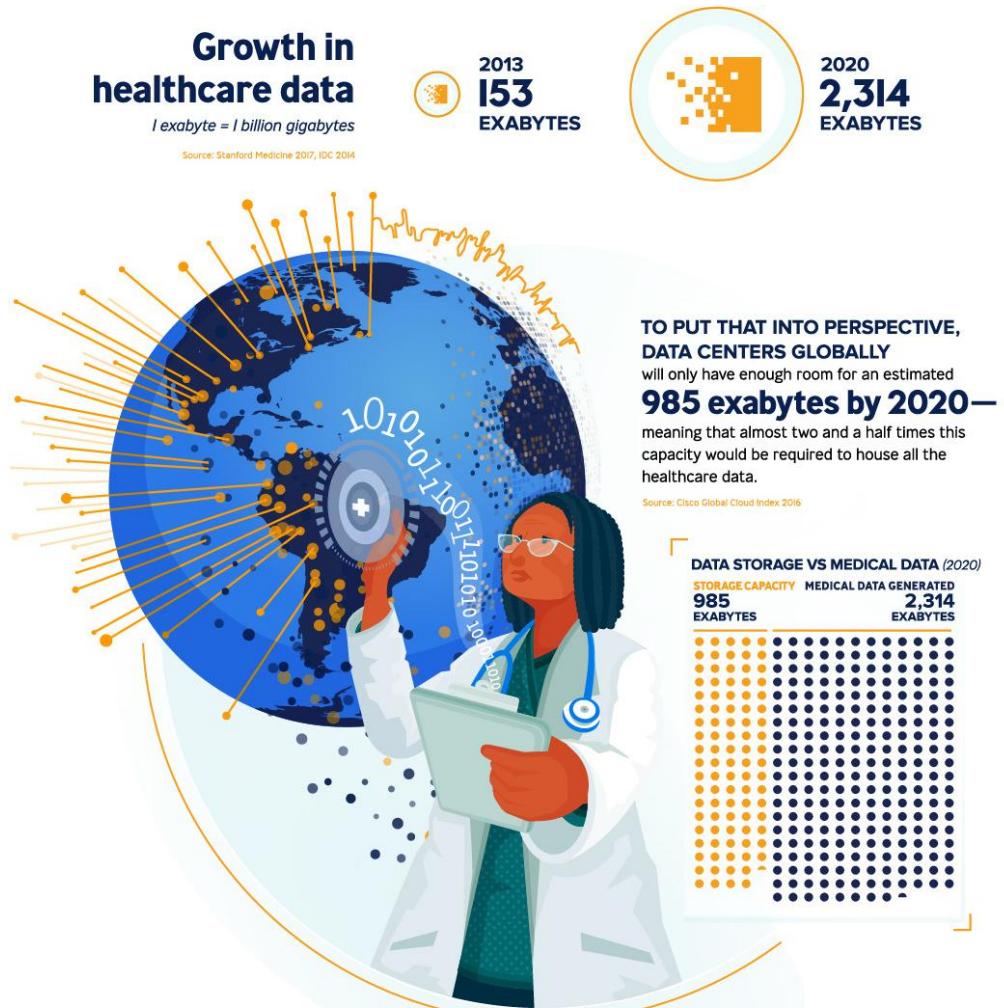


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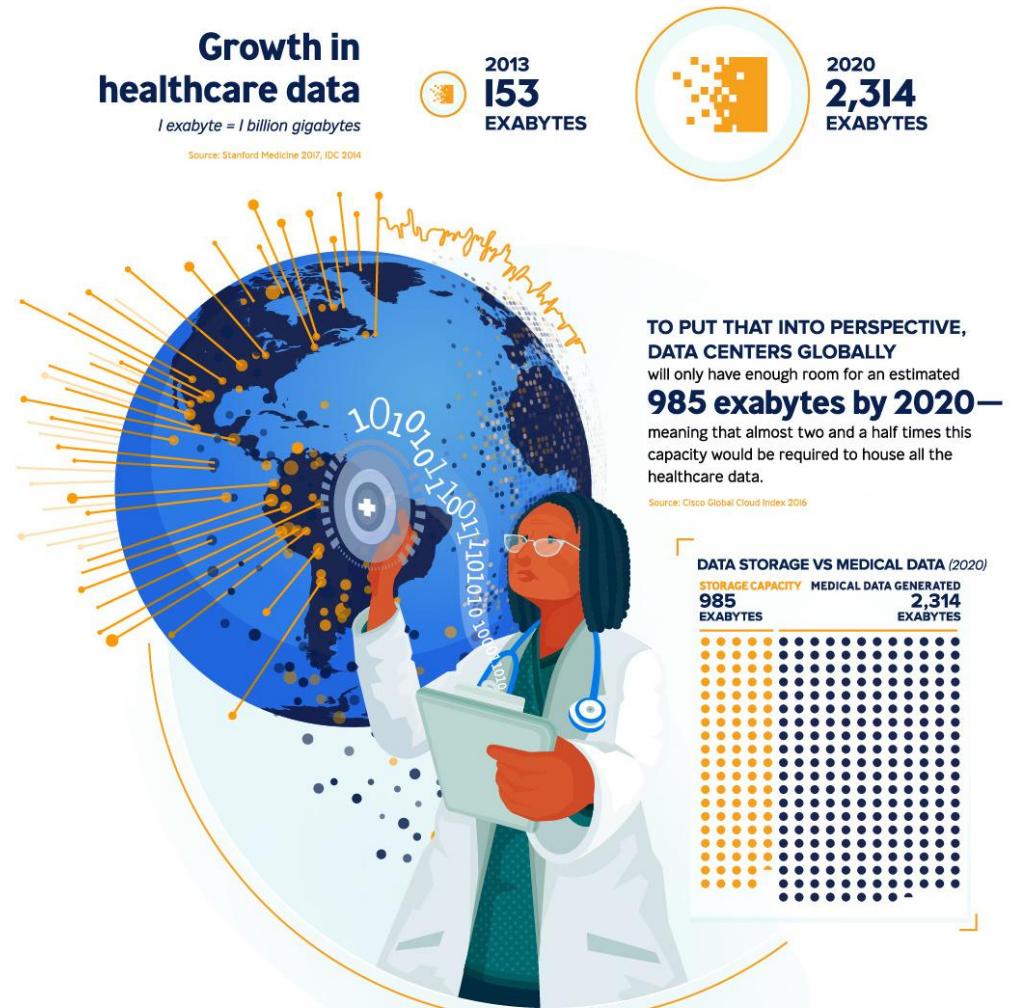


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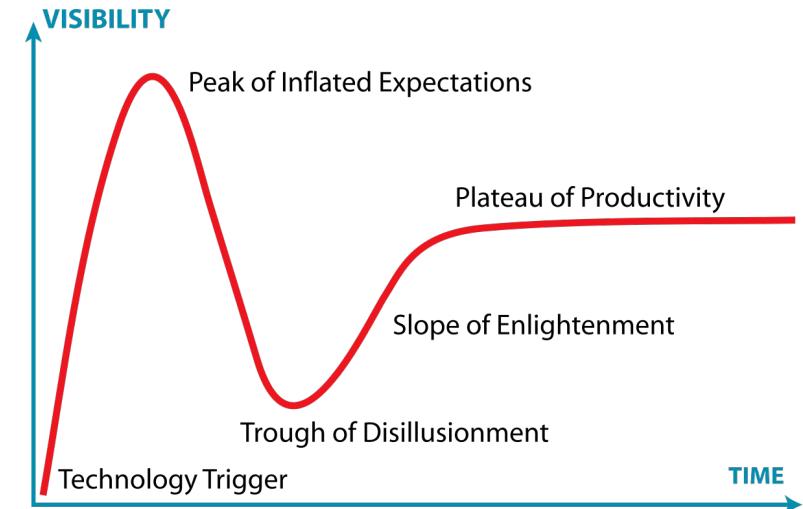
- Huge amounts of health data
- Many **interesting and important problems**
- Many domain experts desperate for data-related help with these problems
- Relative few skilled data science practitioners



<https://www.visualcapitalist.com/big-data-healthcare/>

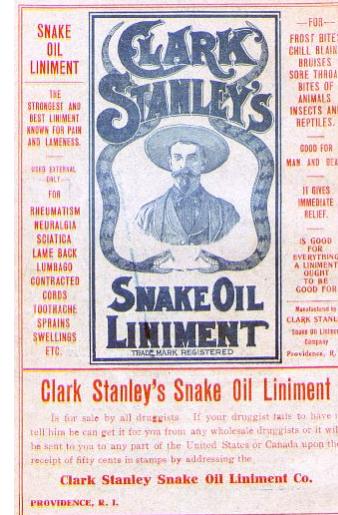
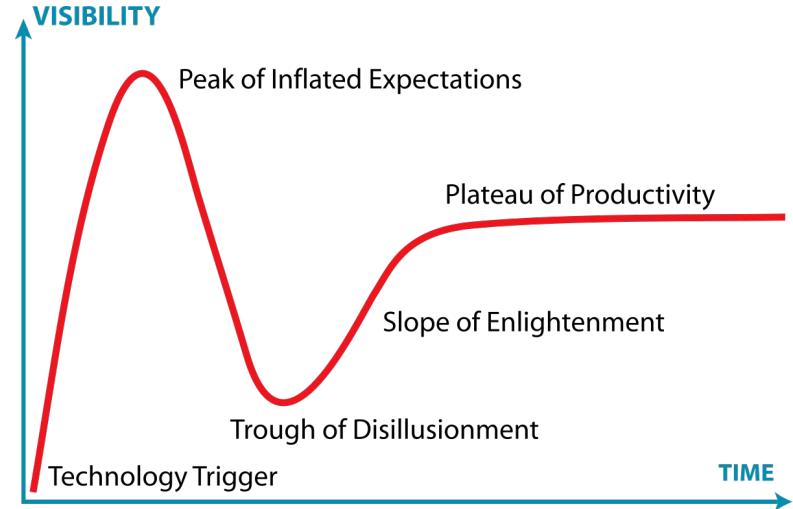
(Some) Challenges of Health Data Science

- Lots of hype



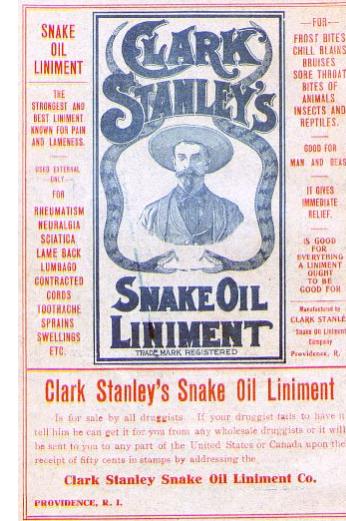
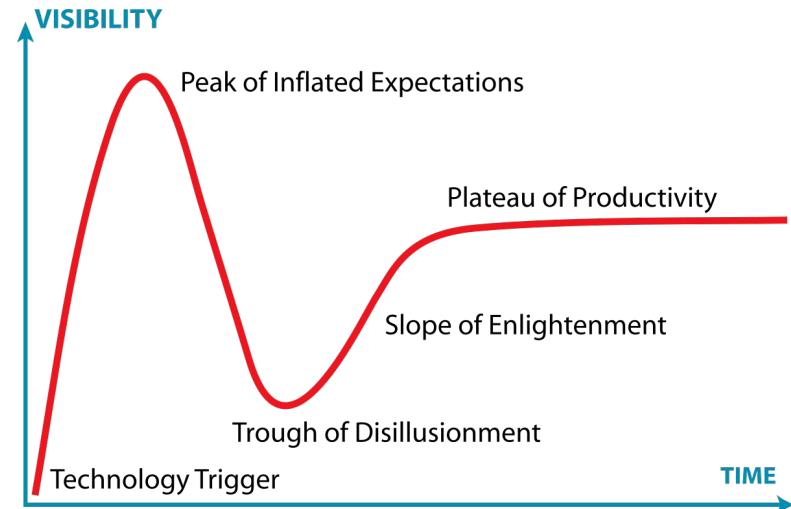
(Some) Challenges of Health Data Science

- Lots of hype
- Lots of grifters



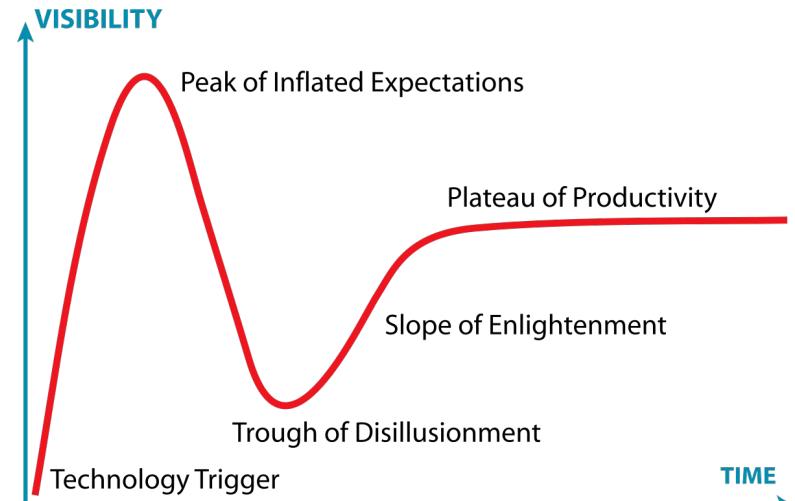
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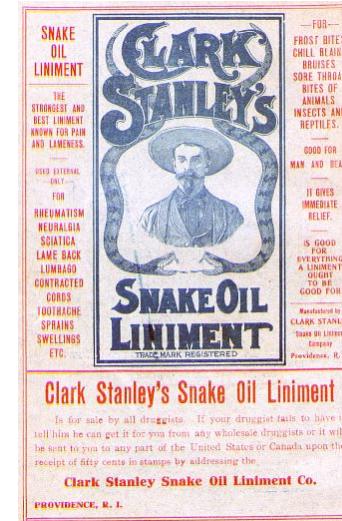


(Some) Challenges of Health Data Science

- Lots of hype
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- Data quality issues
- Contextual/Metadata quality issues
- Regulatory challenges
- Influence of US health system
- Ethical pitfalls
- Treatment to the mean



<https://www.r-bloggers.com/2019/08/new-course-learn-advanced-data-cleaning-in-r/>

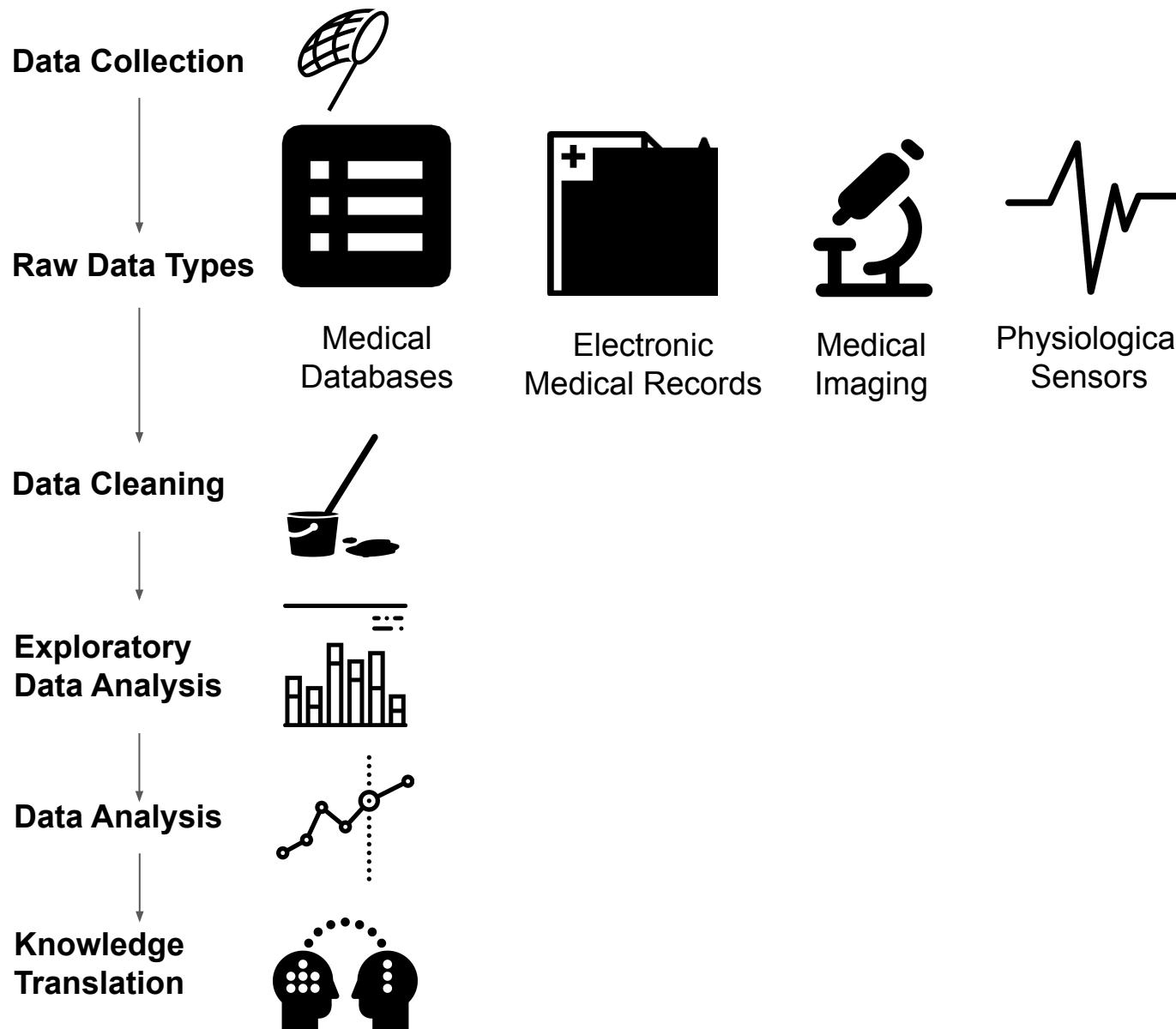


https://upload.wikimedia.org/wikipedia/commons/9/94/Gartner_Hype_Cycle.svg

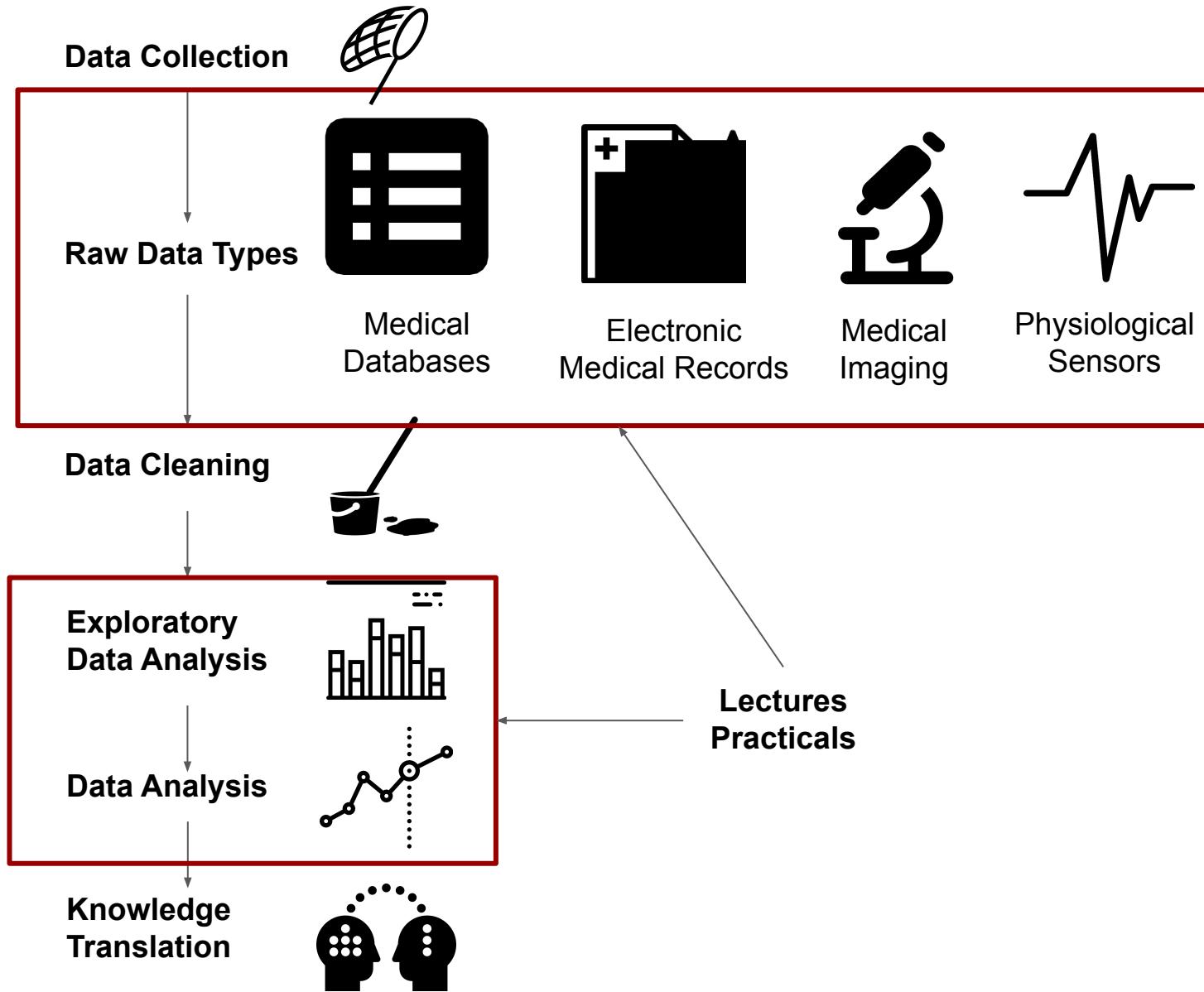
https://commons.wikimedia.org/wiki/File:Clark_Stanley%27s_Snake_Oil_Liniment.png

What parts of health data science will this course cover?

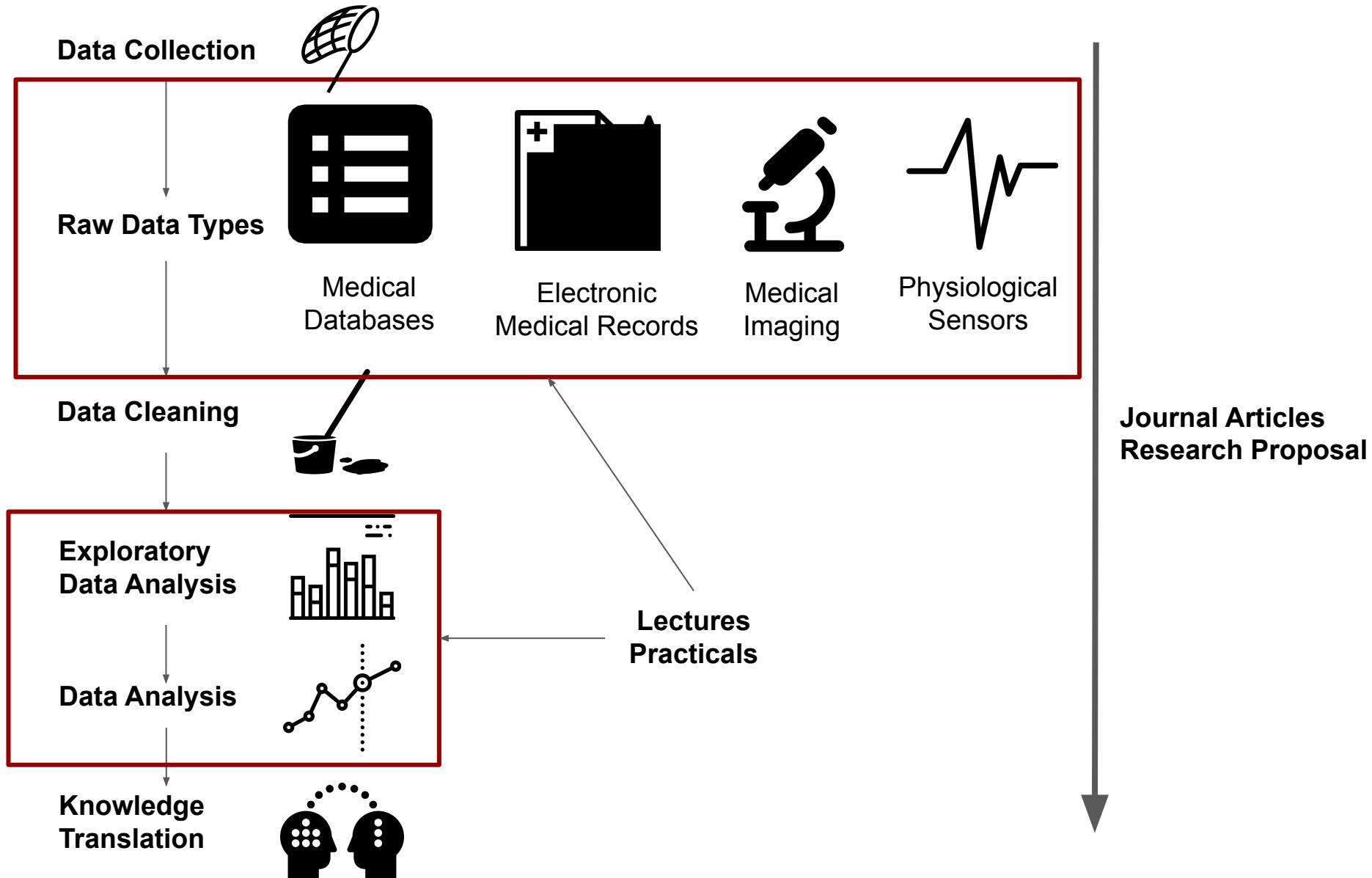
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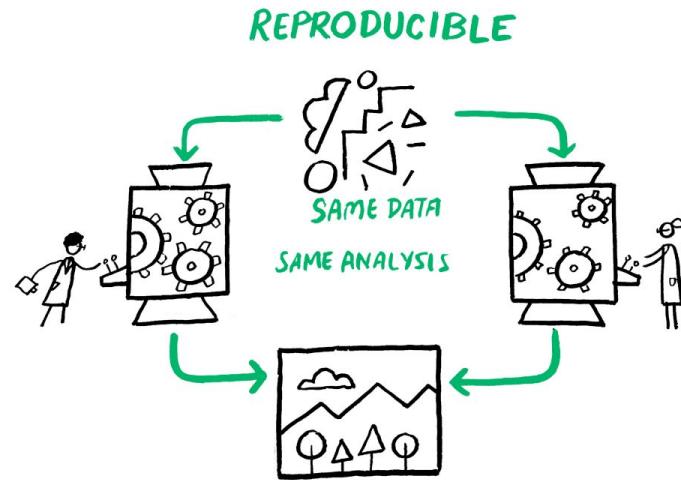
Let's take a 5 minute break!

Tools for Reproducible Health Data Science

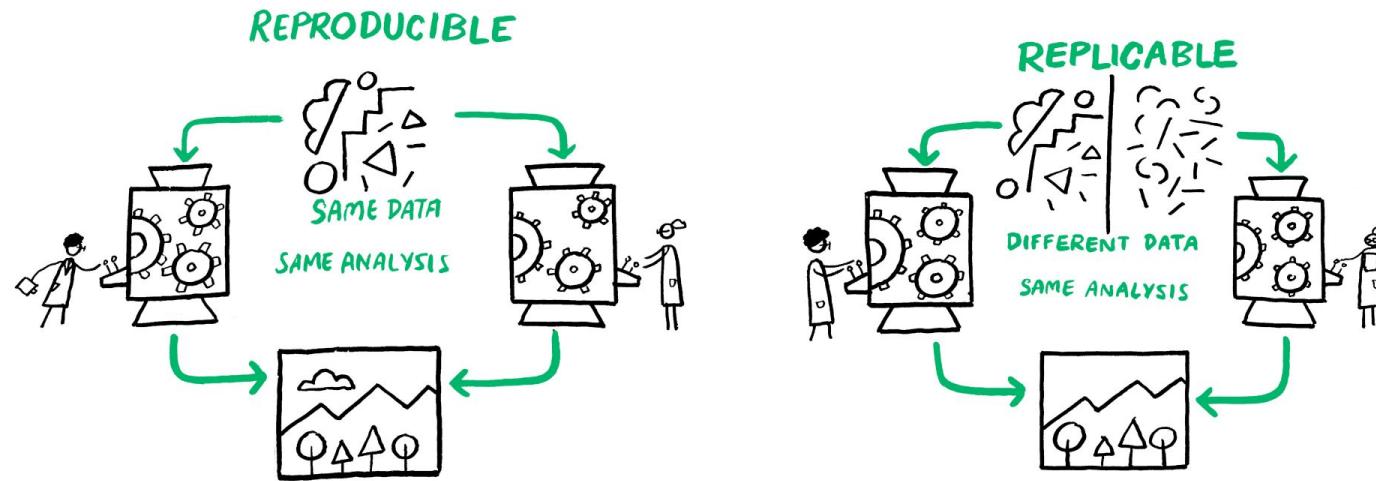
Rstudio, Rmarkdown, Git

Why do we care about reproducibility?

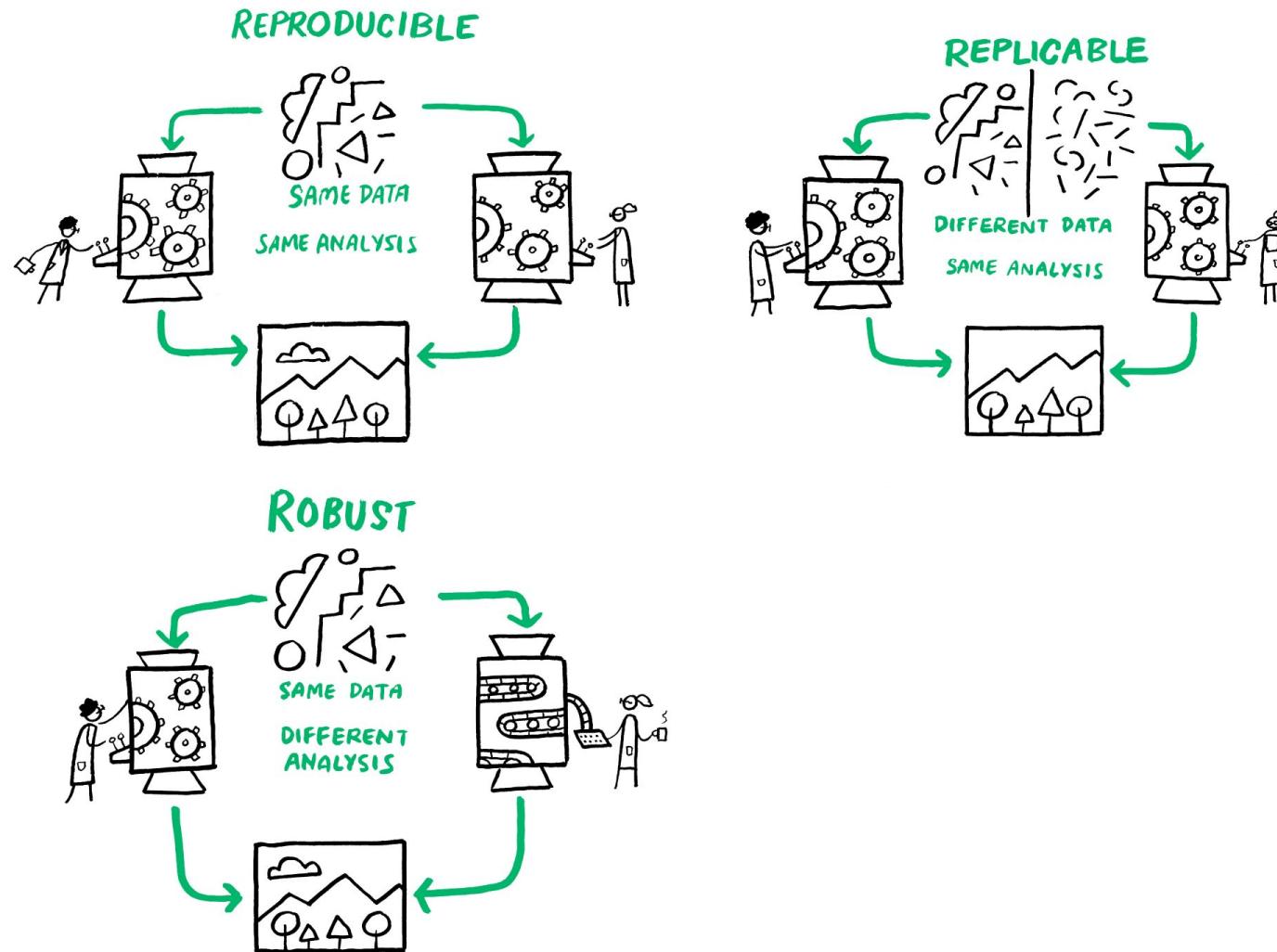
Reproducibility should be the bare minimum



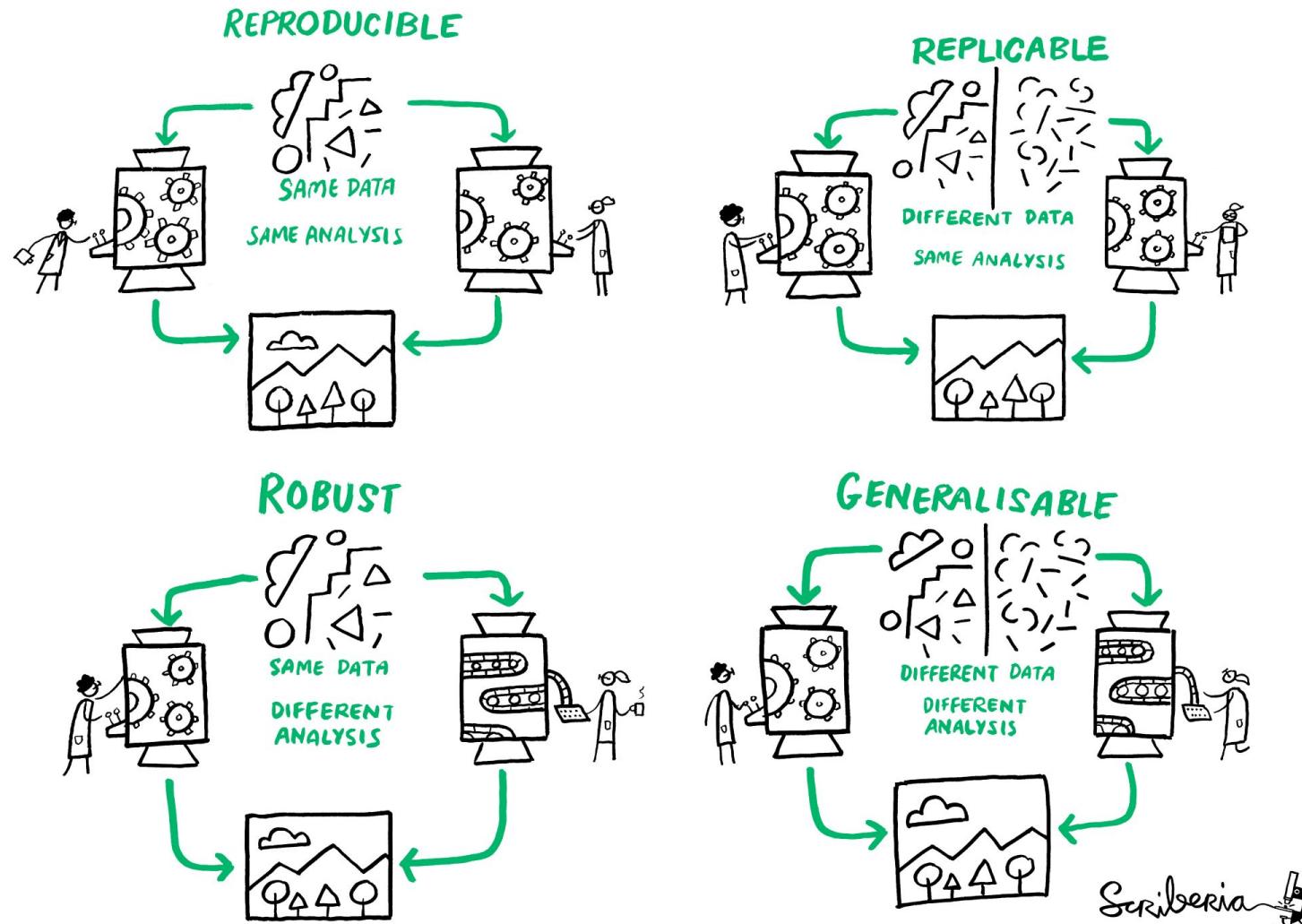
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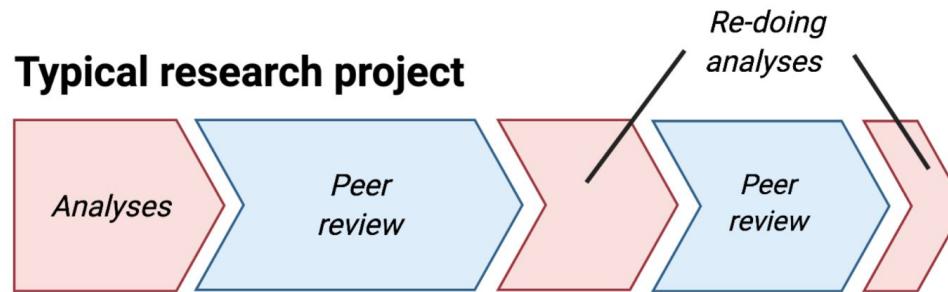
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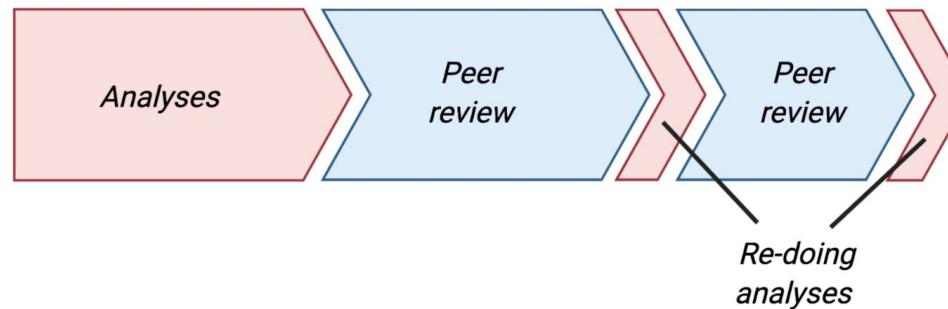
Reproducibility should be the bare minimum



Makes your own life easier



Research project using reproducible practices



@dsquintana

oliviergimenez.github.io/reproducible-science-workshop

What do we need to do to have reproducible research?

Reproducibility checklist

- Don't do anything by hand (even “one-off” tasks)

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- Script every interaction with data:
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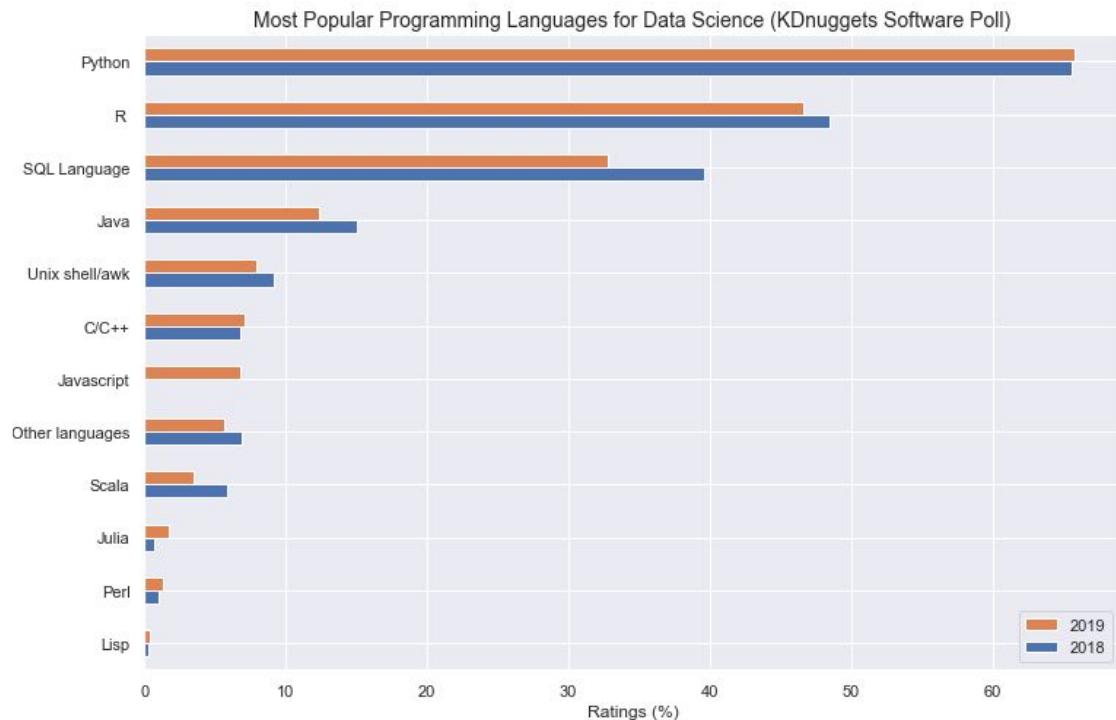
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- Keep track of the exact version of every library/program you use

How do we actually do these things?

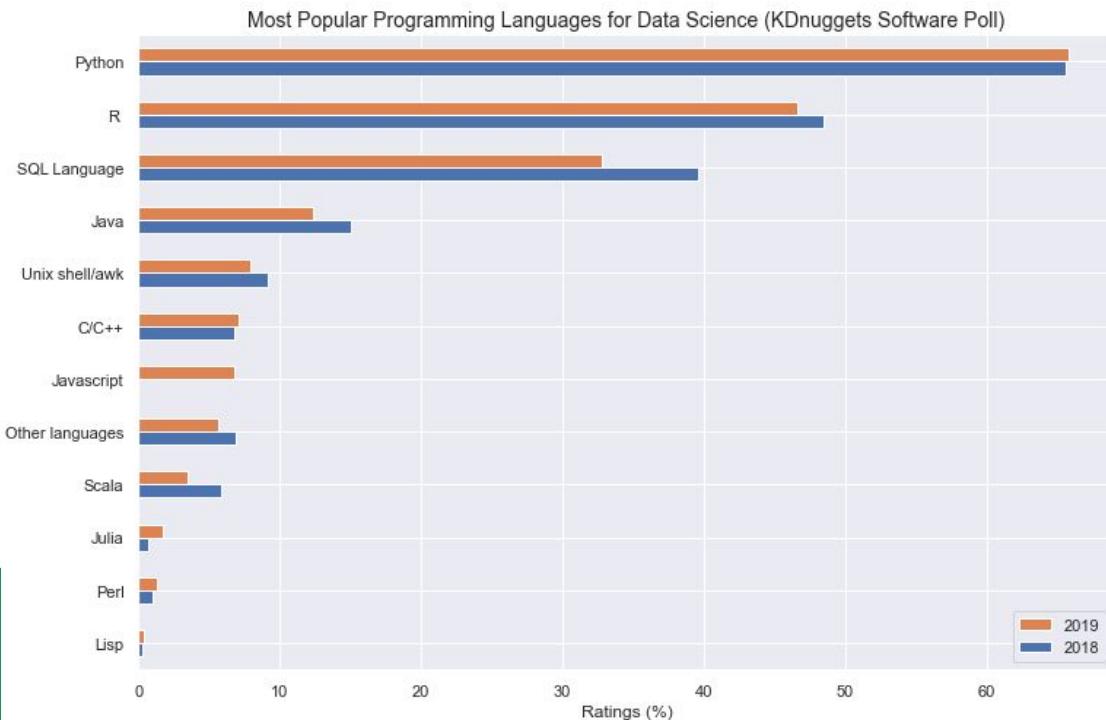
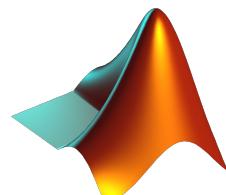
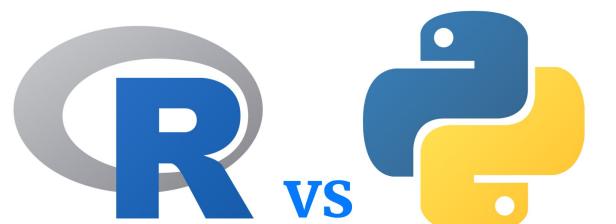
Choose a language that makes it easy to do most/all of your analysis

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<https://www.kdnuggets.com/2019/05/poll-top-data-science-machine-learning-platforms.html>

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Use a data science focused IDE: Rstudio

`set.seed()`
`sessionInfo()`

The screenshot shows the RStudio interface with the following components:

- Code Editor:** The "flights-example.R" script is open, displaying R code for loading the "nycflights13" dataset and creating a boxplot. The code includes imports for `nycflights13`, `lubridate`, `dplyr`, and `ggplot2`. It then filters the data to get daily counts, adds a weekday column, and creates a boxplot titled "Number of 2013 New York Flights Each Weekday".
- Console:** Shows the execution of the R code, including the creation of a tibble and the resulting boxplot.
- Environment:** The "daily" dataset is listed, showing 365 observations of 3 variables: date (Date[1:365]), n (int [1:365]), and wday (Ord.factor w/ 7 levels "Sun"<"Mon"<"Tue"<...: 3).
- Plots:** A boxplot titled "Number of 2013 New York Flights Each Weekday" is displayed, showing the distribution of flights per weekday. The x-axis is labeled "Weekday" and includes categories for Sun, Mon, Tue, Wed, Thu, Fri, and Sat. The y-axis is labeled "Flights" and ranges from 700 to 1000. The plot shows that flight volumes are highest on Monday and Friday, and lowest on Saturday.

Use notebooks to document analyses: Rmarkdown/Quarto

The screenshot shows the RStudio interface with an Rmarkdown notebook open. The left pane displays the Rmd file content, and the right pane shows the generated HTML output.

Rmd File Content:

```
1 ---  
2 title: "Viridis Notebook"  
3 output: html_notebook  
4 ---  
5  
6 ```{r include = FALSE}  
7 library(viridis)  
8 ```  
9  
10 The code below demonstrates two color palettes in the viridis package. Each plot displays a contour map of the Maunga Whau volcano in Auckland, New Zealand.  
11  
12 ## Viridis colors  
13  
14 ```{r}  
15 image(volcano, col = viridis(200))  
16 ```
```

Generated HTML Output:

Viridis Notebook

The code below demonstrates two color palettes in the [viridis](#) package. Each plot displays a contour map of the Maunga Whau volcano in Auckland, New Zealand.

Viridis colors

```
image(volcano, col = viridis(200))
```

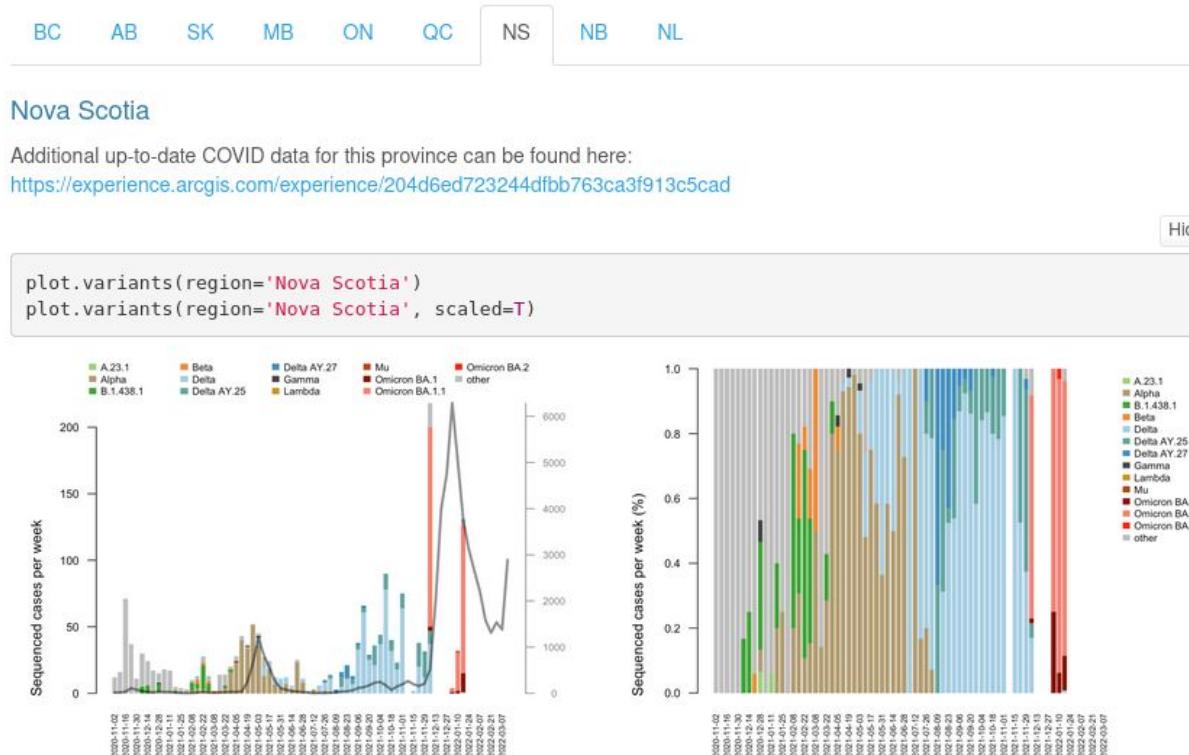
A contour plot of the Maunga Whau volcano in Auckland, New Zealand, using the Viridis color palette. The plot shows a central peak in yellow/green transitioning through green, blue, and purple towards the edges. The x-axis ranges from 0.0 to 1.0, and the y-axis ranges from 0.0 to 1.0.

Magma colors

A contour plot of the Maunga Whau volcano in Auckland, New Zealand, using the Magma color palette. The plot shows a central peak in bright yellow transitioning through orange, red, and dark red/purple towards the edges. The x-axis ranges from 0.0 to 1.0, and the y-axis ranges from 0.0 to 1.0.

Use notebooks to document analyses: Rmarkdown/Quarto

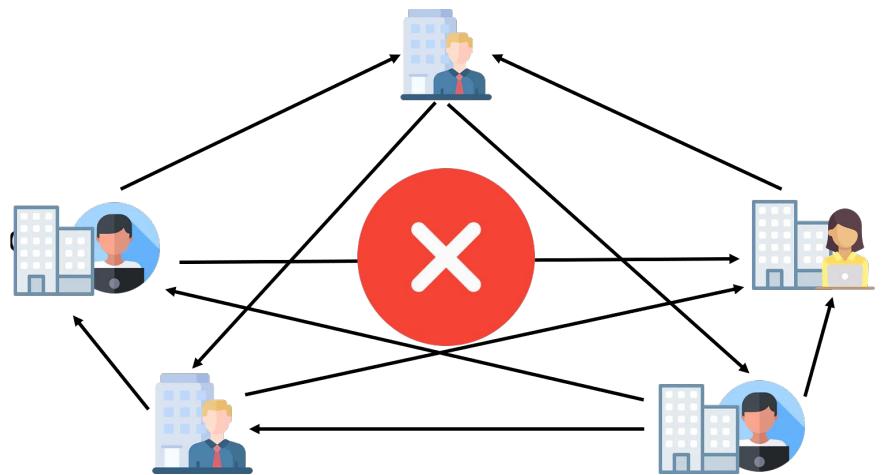
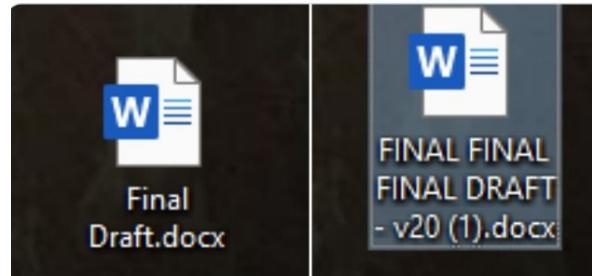
settings). Therefore, from this time onward, case counts are likely underestimated and the sequenced virus diversity is not necessarily representative of the virus circulating in the overall population.



<https://covarr-net.github.io/duotang/duotang.html#>

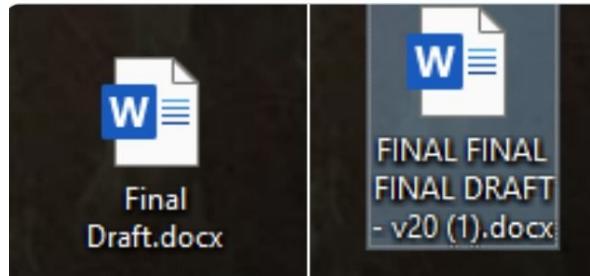
Use standard version control systems

- Ever had a nightmare of versioning even when just you?
- Add more people and the chaos grows exponentially!



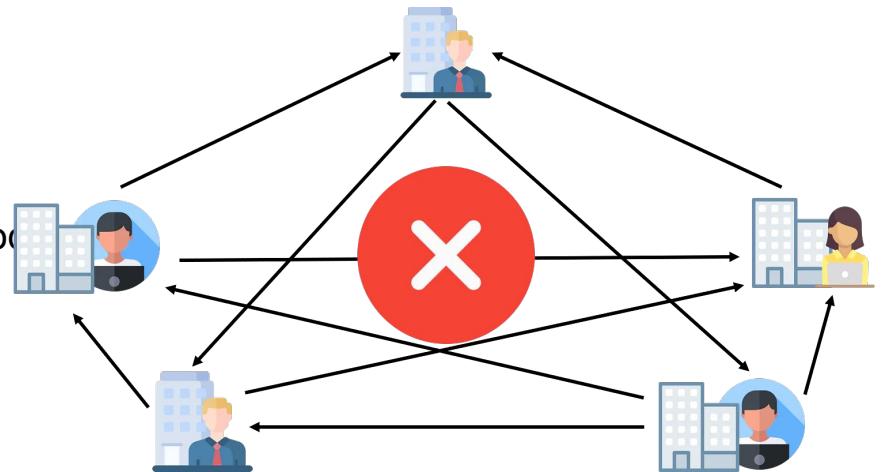
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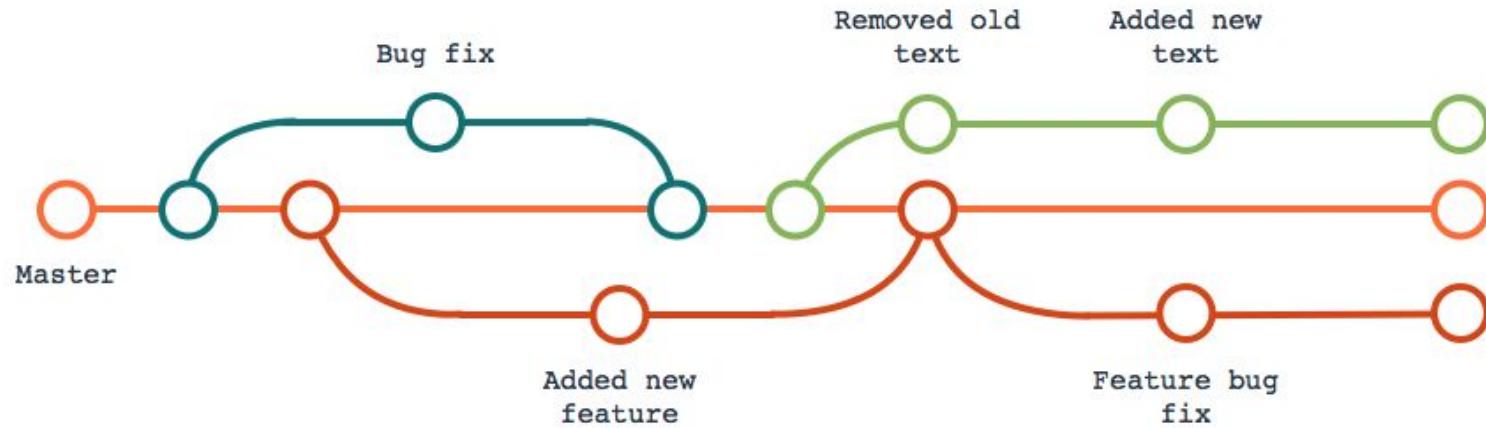


Version control let's you:

- Revert mistakes
- Acts as a comprehensive backup
- Let's you maintain multiple versions of your analysis
- Let's you compare different versions of your code
- Track down the who/what broke the analysis
- Work out why you did something in the past
- Build on someone else's work
- Share your own work
- Experiment without risk

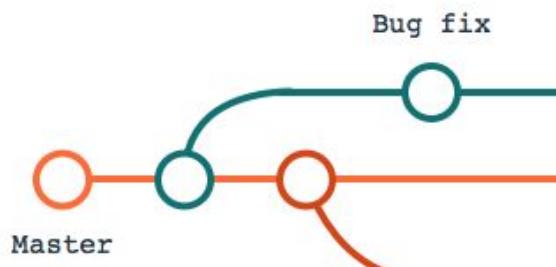


Git Version Control



- Most popular
- Decentralised
- Designed for
- GitLab/GitHub Services

Git Version Control

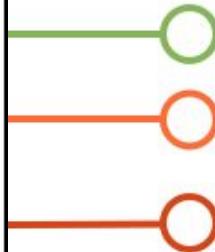


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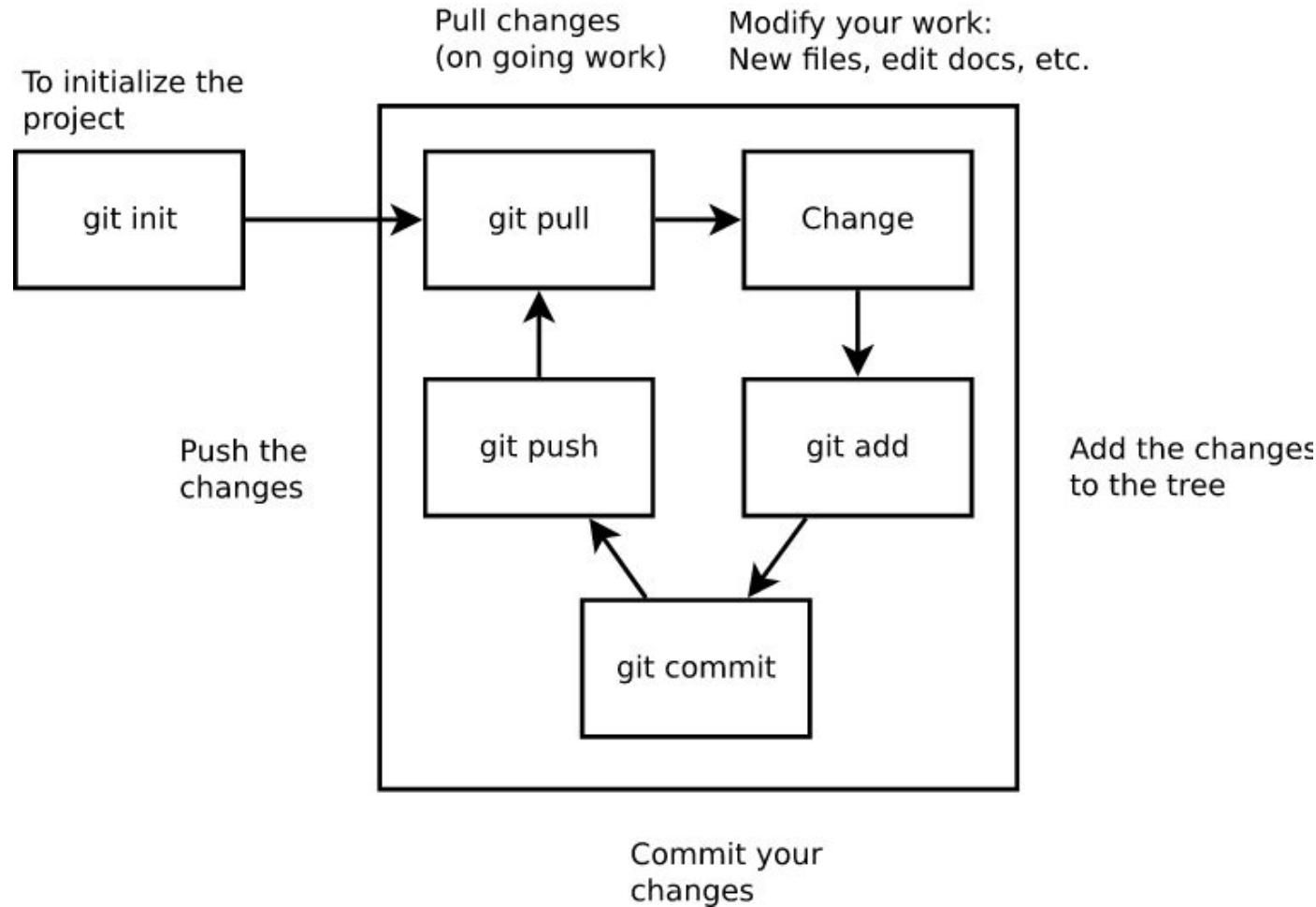
THIS IS GIT. IT TRACKS COLLABORATIVE WORK ON PROJECTS THROUGH A BEAUTIFUL DISTRIBUTED GRAPH THEORY TREE MODEL.

COOL. HOW DO WE USE IT?

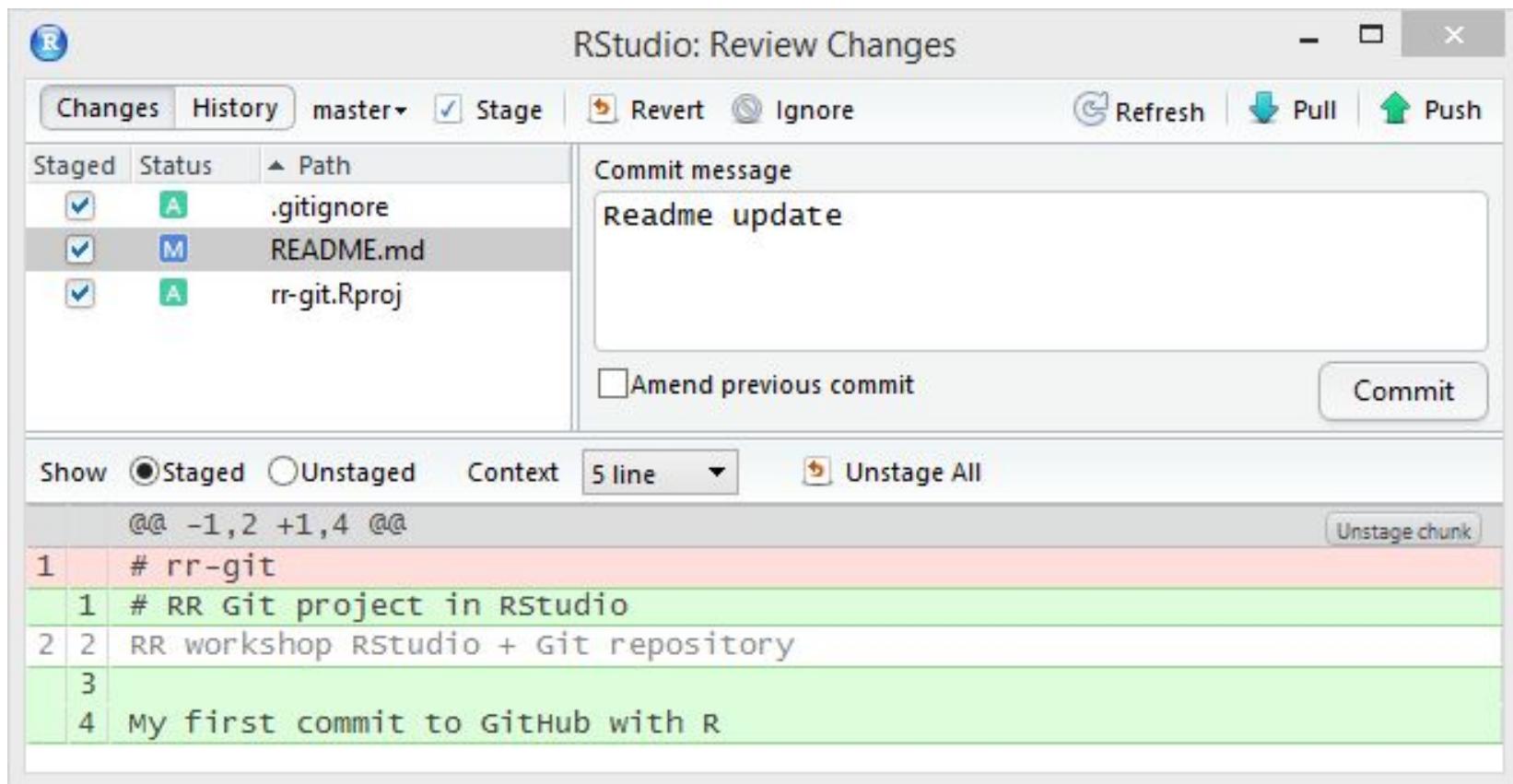
NO IDEA. JUST MEMORIZE THESE SHELL COMMANDS AND TYPE THEM TO SYNC UP.
IF YOU GET ERRORS, SAVE YOUR WORK ELSEWHERE, DELETE THE PROJECT, AND DOWNLOAD A FRESH COPY.



Git Workflow



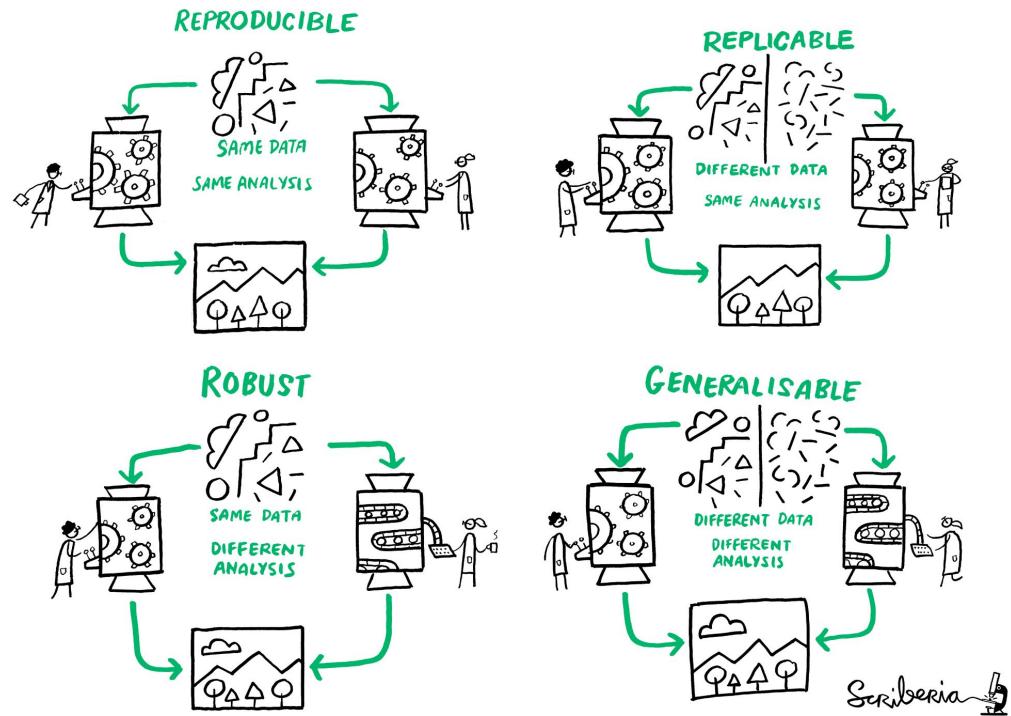
Git is integrated into Rstudio!



Combine Git+Rmd Notebooks for Reproducibility

1. Add analysis to notebook
2. Add changes to git
3. Find out you made a mistake
4. Revert changes

1. Share notebook with collaborator
2. They make changes
3. You make changes
4. Merge changes into single analysis



Summary

- Overview of course: Database/EMR/Imaging/Signal
- Main assessments: practicals, journal article presentations, research proposal
- Data science is statistics with an EDA/Inductive/Data-focused Spin
- Health Data Science is a massive and growing area with lots of opportunity and challenges
- R is a powerful and useful tool for health data science
- Reproducibility is vital to good ~~health data~~ science
- Rstudio, Rmarkdown notebooks and Git based version control facilitate that reproducibility

Friday's Practical

- Will go over the practical use of R, Rstudio, Rmd Notebooks, Git
- Try and install rstudio, git, and rmarkdown beforehand.
- 1st practical will not contribute to your course grade

Wednesday's Journal Articles

- **Reproducibility in machine learning for health research:
Still a ways to go**

[Matthew B. A. McDermott](#) [Shirly Wang](#) [Nikki Marinsek](#) [Rajesh Ranganath](#) [Luca Foschini](#) [Marzyeh Ghassemi](#)

Science Translational Medicine • 24 Mar 2021 • Vol 13, Issue 586 • [DOI: 10.1126/scitranslmed.abb1655](#)

- **A Beginner's Guide to Conducting Reproducible Research**

[Jesse M. Alston](#), [Jessica A. Rick](#) First published: 15 January 2021 <https://doi.org/10.1002/bes2.1801>