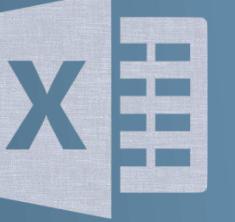


FROM  EXCEL TO 



WHO ARE WE?

1. Center for Health Data Science (HeaDS) - <https://heads.ku.dk/>

SUND Center, which includes a KU data lab

- Courses & Workshops, Seminars, etc.
- Health DS Consultations
- Commissioned Research
- Matchmaking
- Commissioned Supervision



Thilde Terkelsen ¹



Helene Wegener ¹



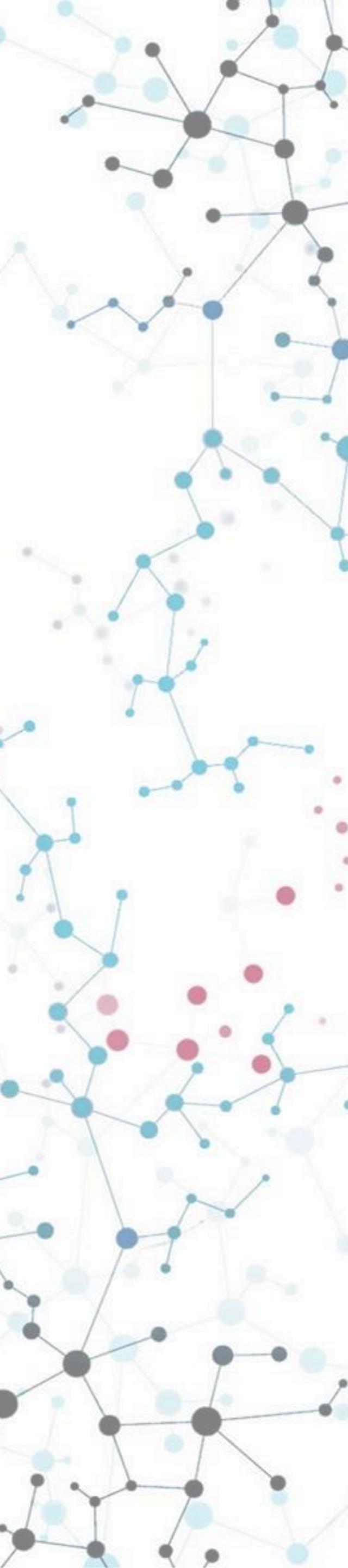
Tugce Karaderi ¹



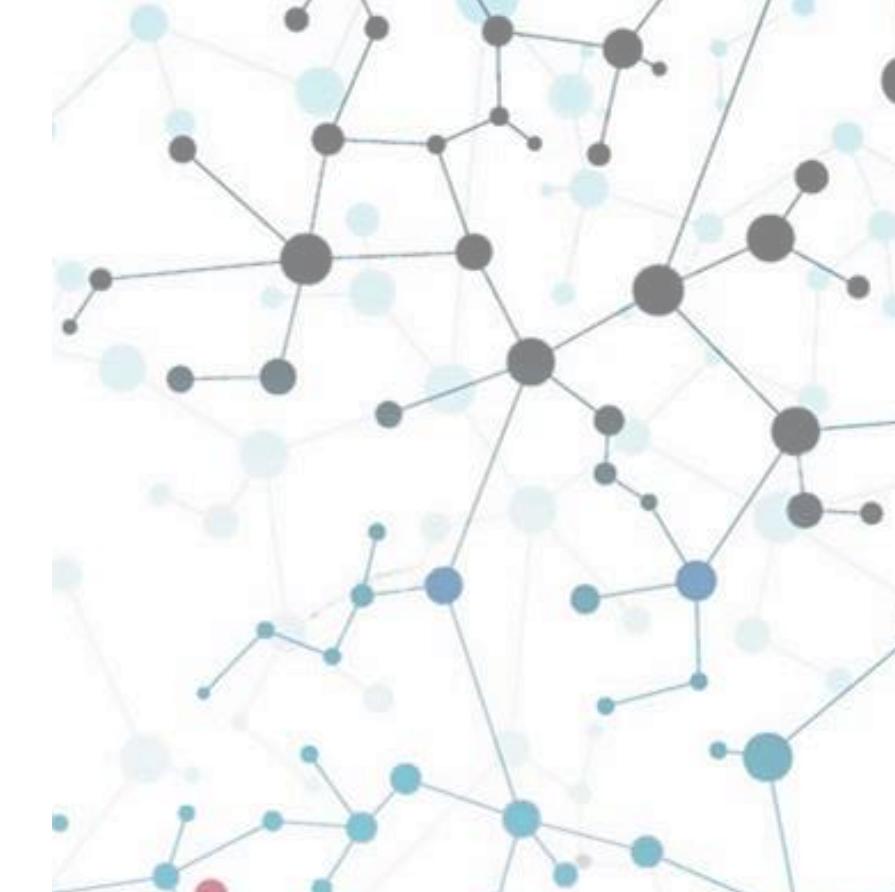
Adrija Kalvisa ²

2. ReNEW NNF Center for Stem Cell Medicine

3. Data Science Laboratory (DSL) - <https://datalab.science.ku.dk/>



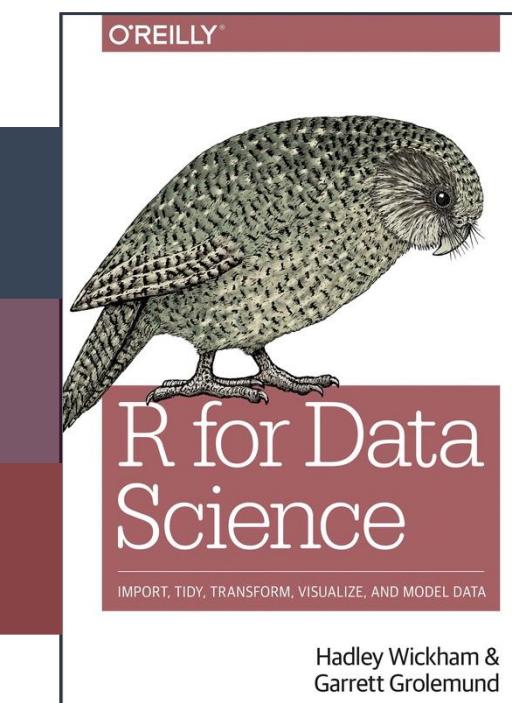
THE PRACTICALS



Two days: 9.00-16.00. There will be coffee breaks, we promise ☕

“R for Data Science” - a generally useful book on R, also for this course

The course is build on hands-on presentations (.R, .qmd) & exercises



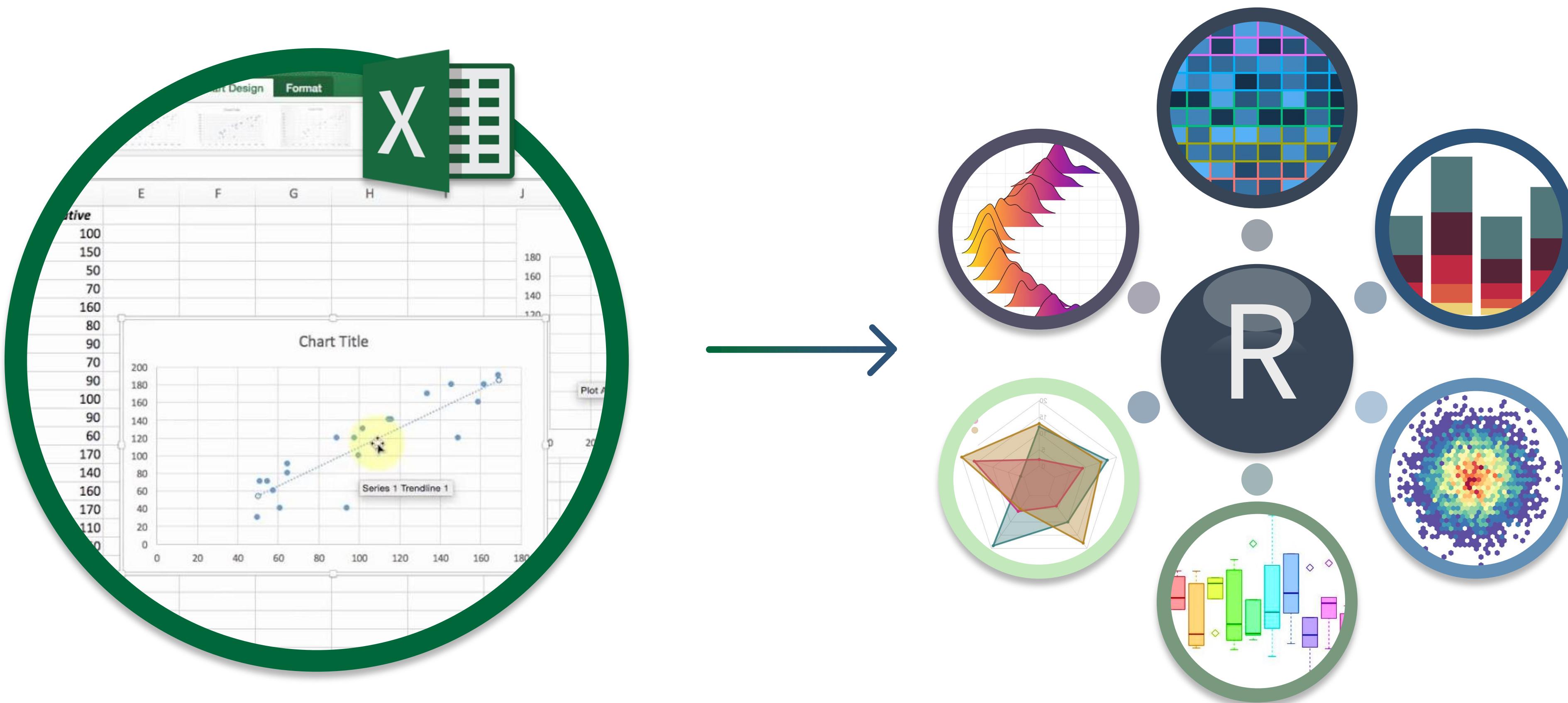
Download and install the newest version of R (<https://cran.r-project.org/>)

Download and install the newest version of R-studio (<https://posit.co/download/rstudio-desktop/>)

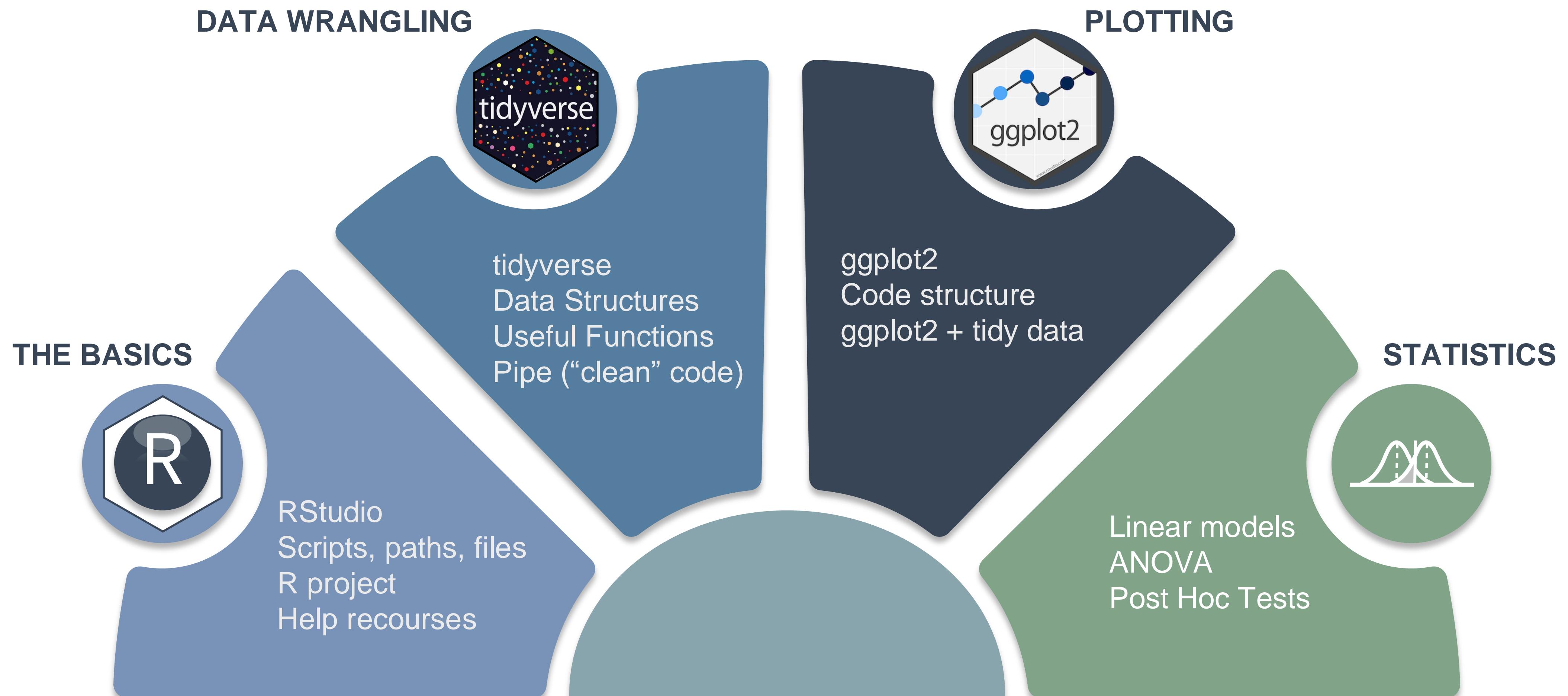
Go to course website: <https://center-for-health-data-science.github.io/FromExceltoR/>



— WELCOME TO
FROM EXCEL TO R



WHAT WILL I LEARN?



PROGRAM

DAY 1

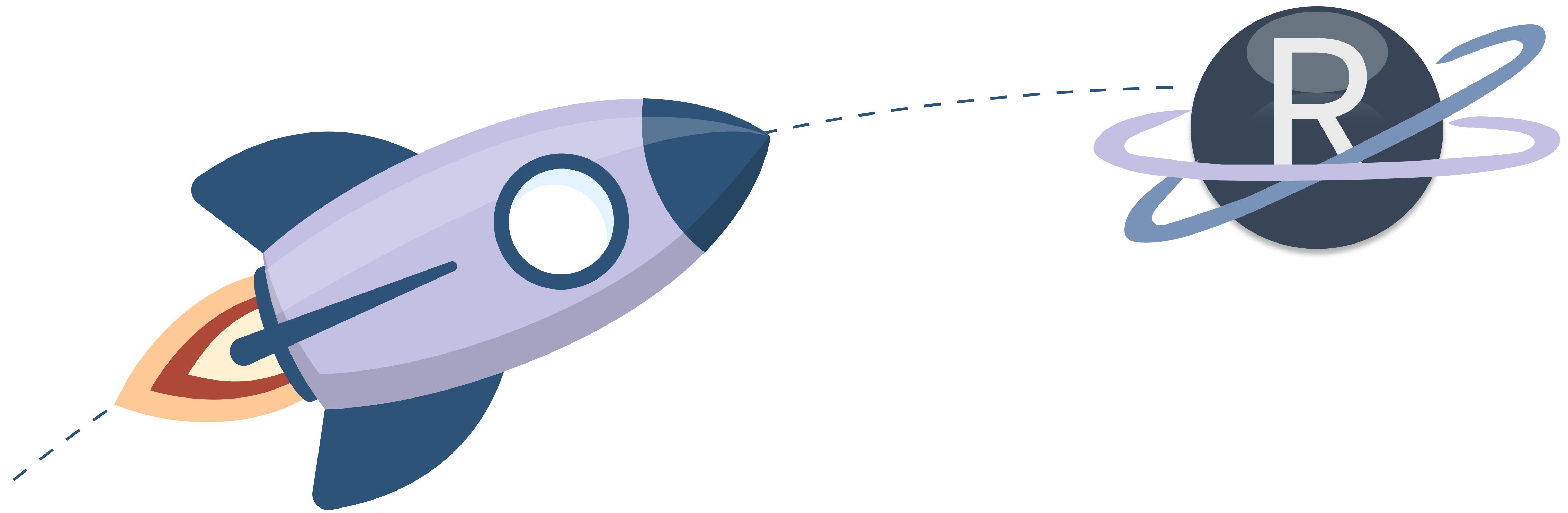
08:30 - Installation Issues + Coffee
09:00 - Introduction to R Basics
10:00 - Rstudio Exercise
10:45 - Break
11:00 - Tidyverse
12:00 - Lunch
13:00 - Tidyverse Exercise
14:30 - Break
14:45 - ggplot2
15:15 - ggplot2 Exercise
16:00 - See you tomorrow

DAY 2

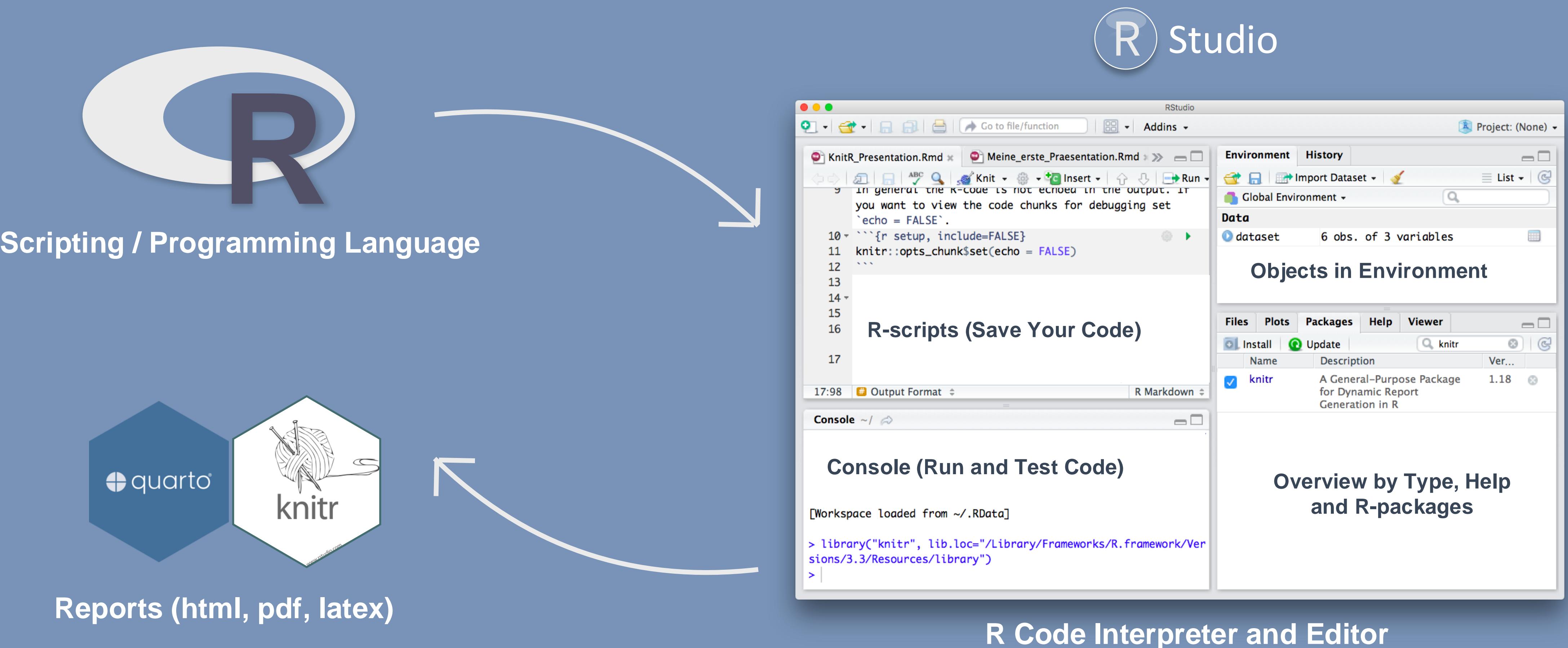
08:30 - Coffee + Optional Q&A
09:00 - Applied Statistics
10:00 - Applied Statistics Exercise
10:45 - Break
11:00 - Applied Statistics Exercise
12:00 - Lunch
13:00 - Data Analysis Exercise
14:30 - Break
14:45 - Data Analysis Exercise
15:45 - Cool things in R + Course Evaluation
16:00 - Bye Bye Bye!

— FROM EXCEL TO R

LET'S GET STARTED



R & FRIENDS



THE ANATOMY OF R

The coding language



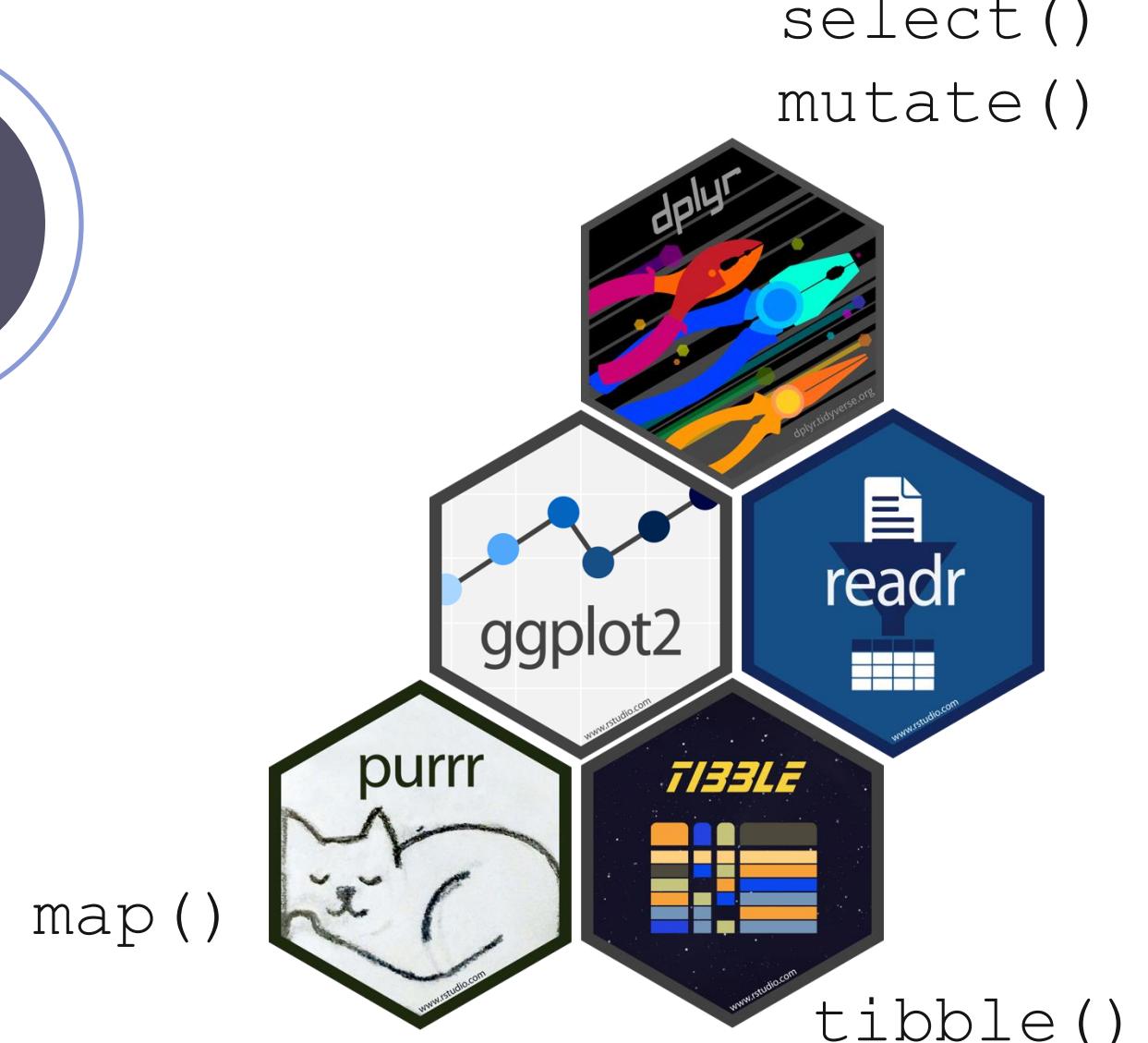
may be used from within in the Code Editor

The R code you write may be saved in **scripts** with extensions



Packages are libraries of functions.

Functions perform actions based on input arguments and return an output.



ONLINE RESOURCES FOR R

<https://www.r-project.org/>



GET STARTED

<https://rseek.org/>

https://rstudio.com/resources/c_heatsheets/

<http://www.cookbook-r.com/>

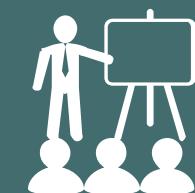
https://www.statmethods.net/r_tutorial/index.html



GRAPHICS

<https://www.r-graph-gallery.com/>

<http://r-statistics.co/Top50-Ggplot2-Visualizations-MasterList-R-Code.html>



BOOKS & COURSES

<https://www.r-bloggers.com/best-books-to-learn-r-programming/>

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

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

<https://www.coursera.org/>



OTHER RESOURCES

<https://github.com/trending/r>

https://blog.revolutionanalytic_s.com/

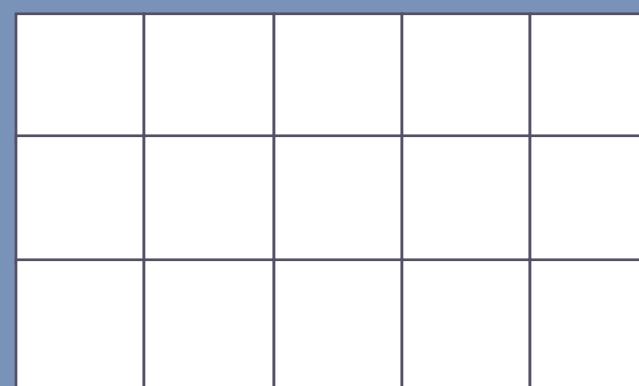
<https://stackoverflow.com/questions/tagged/r>



FROM EXCEL TO R

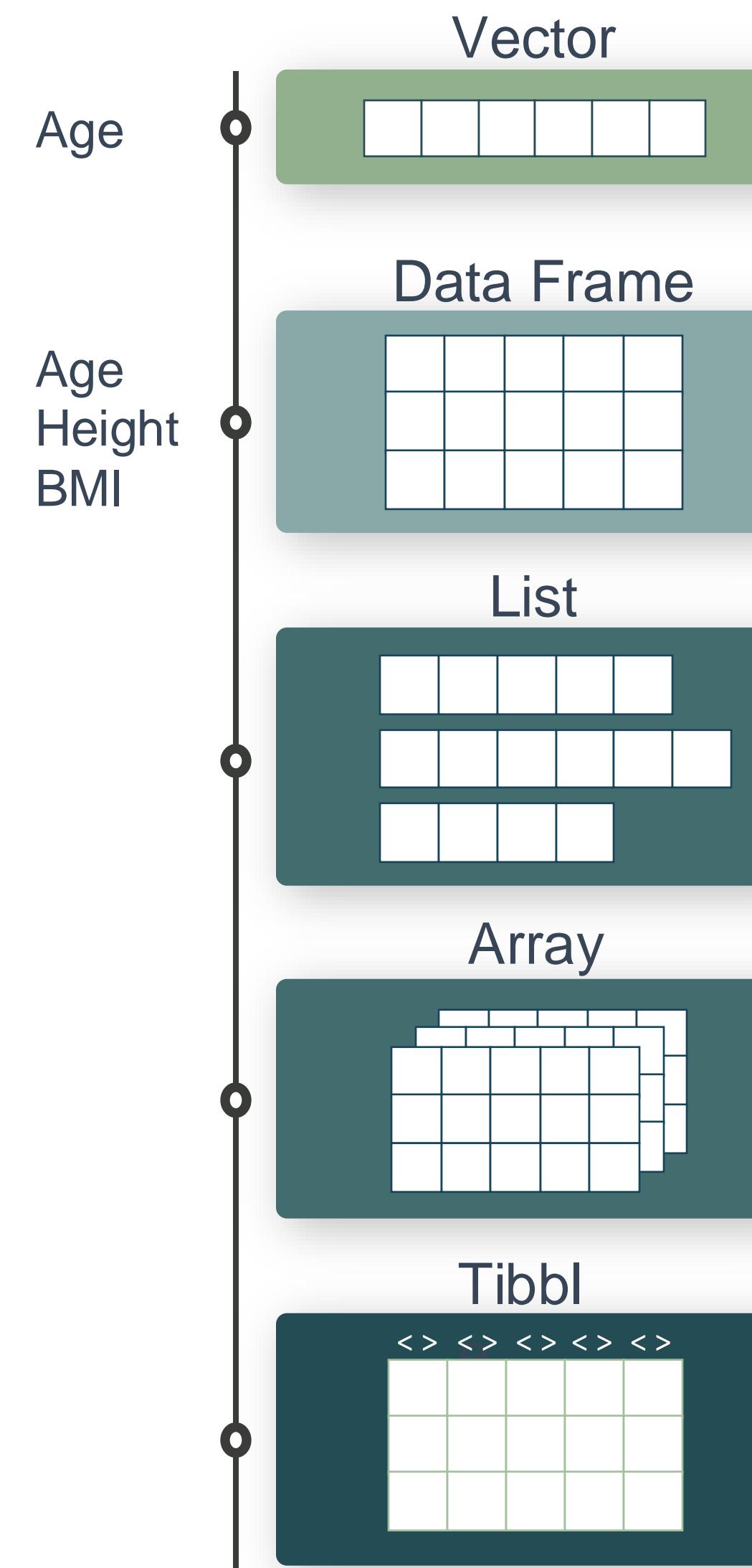
R DATA TYPES & STRUCTURES

VARIABLES

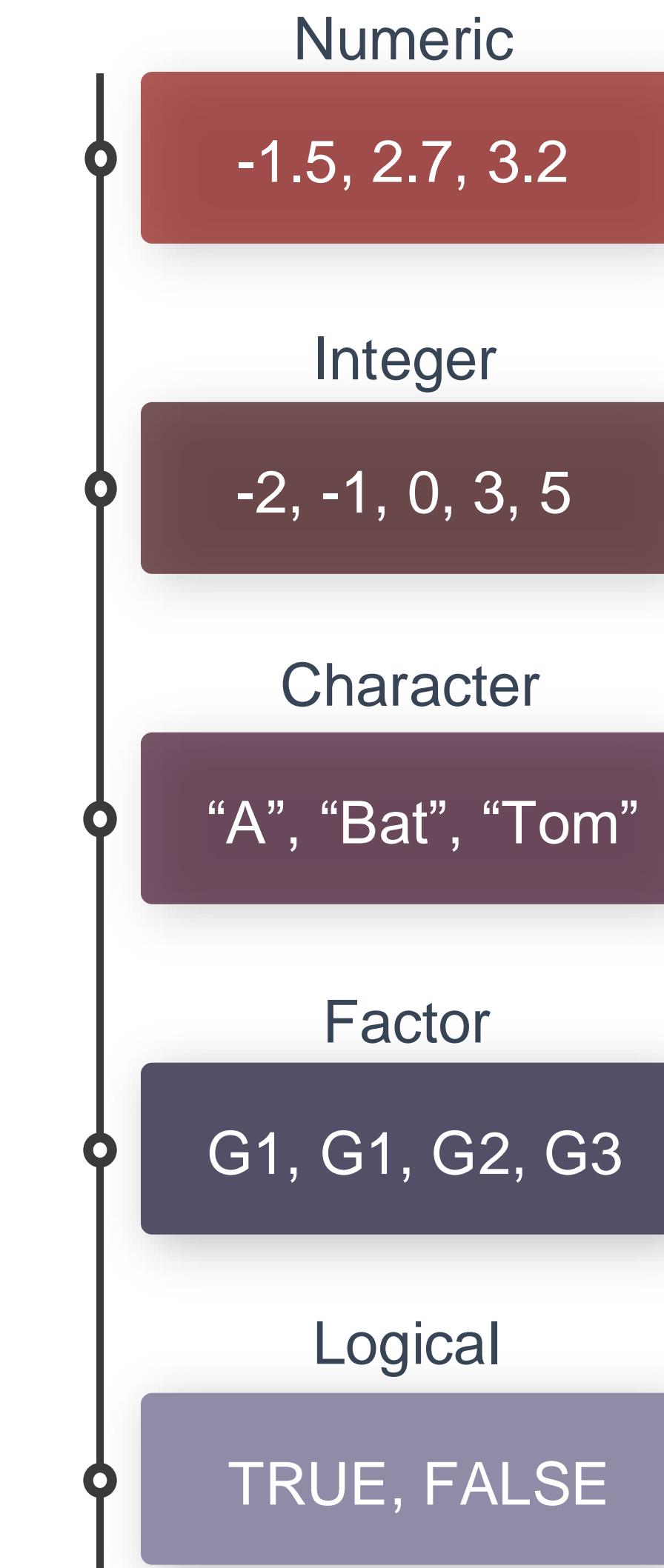


OBSERVATIONS

DATA STRUCTURES

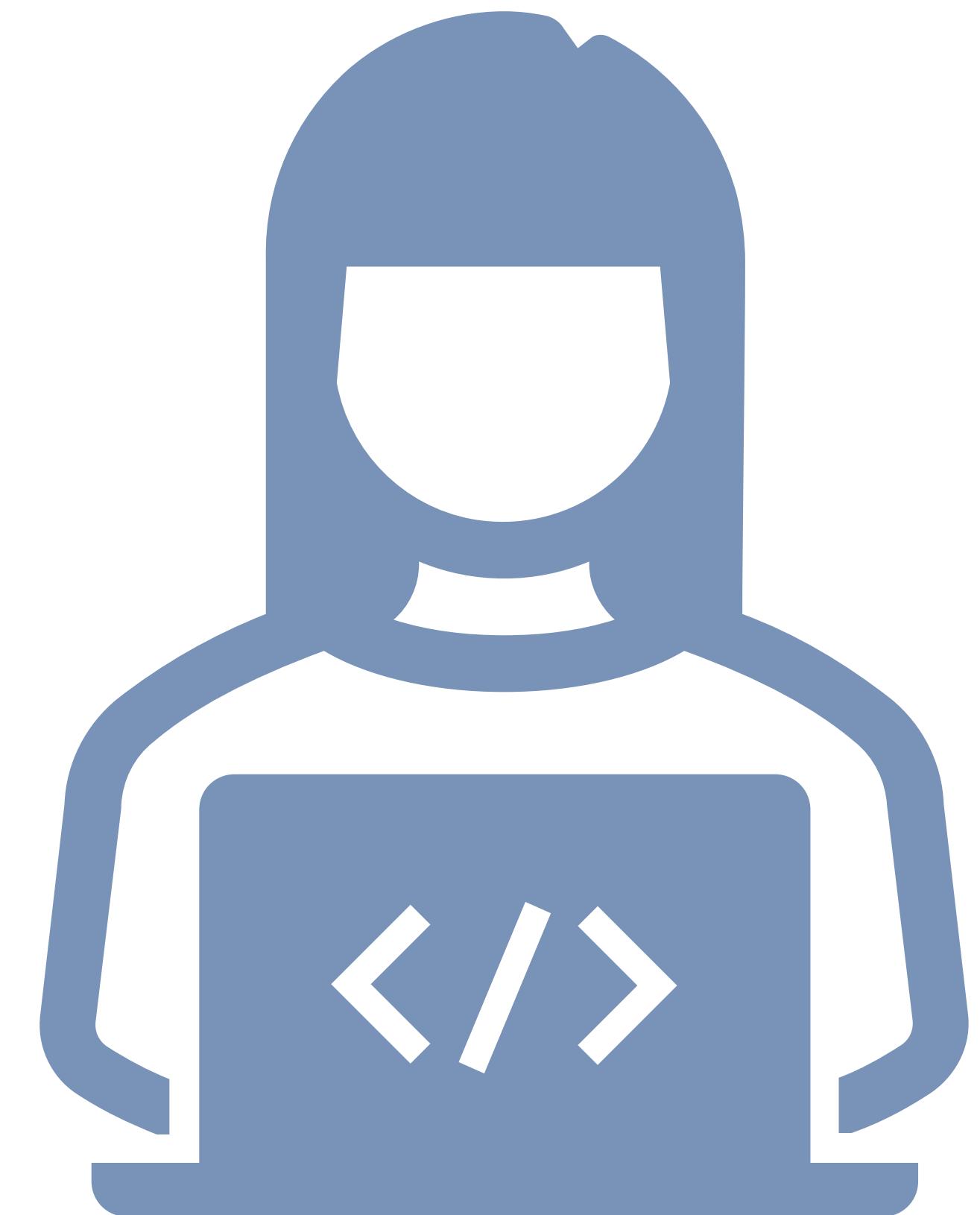


DATA TYPES



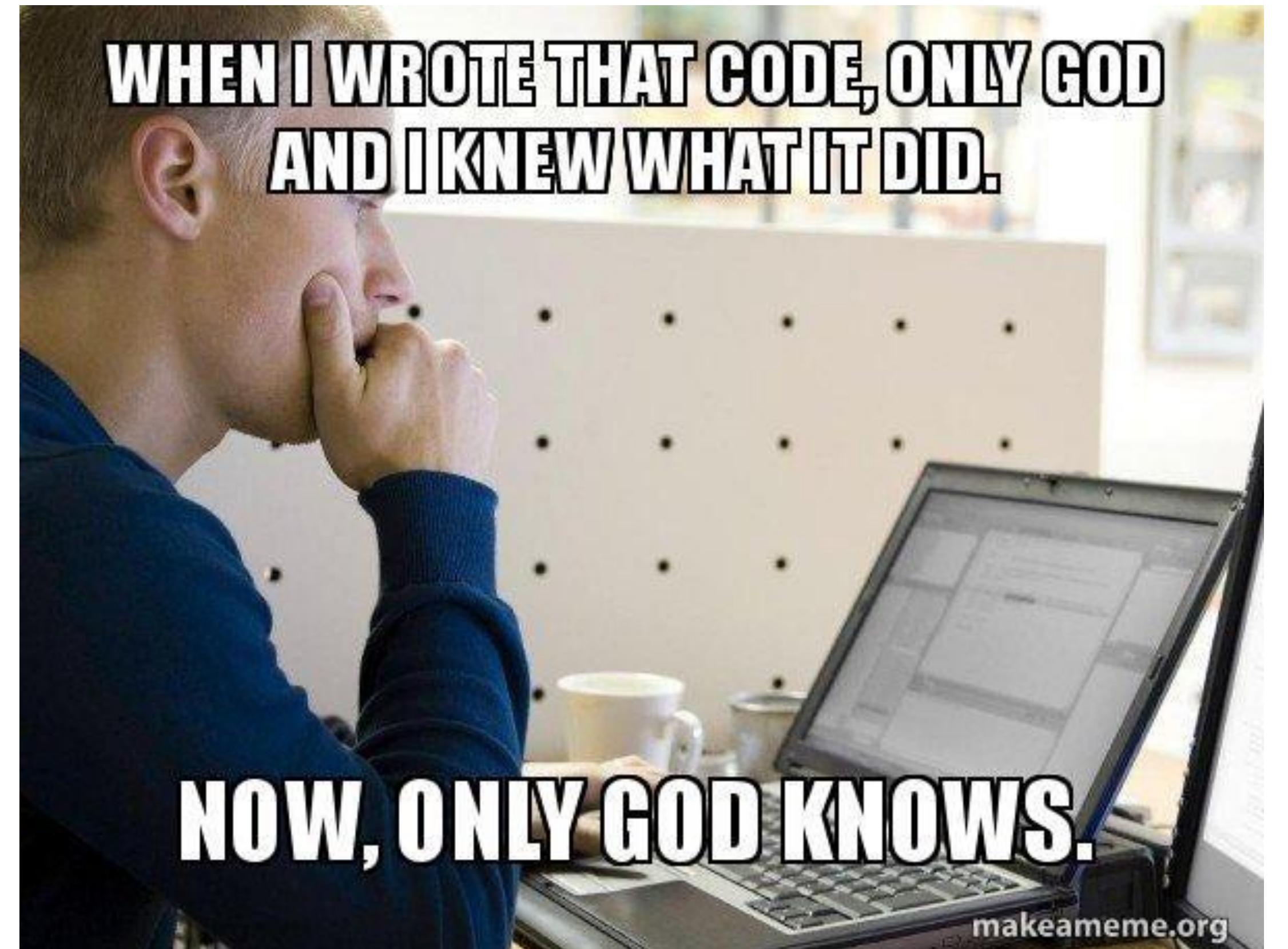
— FROM EXCEL TO R

LIVE CODING 1 – INTRO TO R



QUARTO STRUCTURE

- Separate sections with headers
- Do not overfill code chunks
- Think about when to use text and comments
- Code chunks are sequential!



INTRO CHEAT SHEET

Basics:

```
getwd() # location  
install.packages("package_name") # install packages  
library(package_name) # load packages
```

Overview:

```
head(df, n=10), tail(df, n=10) # first or last 10 rows  
unique(), table(), count() # unique vals, count vals
```

Type/Class:

```
class() # get data type/class  
is.numeric(x), is.character(), is.factor(), is.integer() # get data type  
as.numeric(x), as.character(), as.factor(), as.integer() # change data type
```

Summary statistics:

```
summary() # summary statistics  
mean(), median(), sd(), sum()  
n()
```

Read in data:

```
read.xlsx("name.xlsx") # library(readxl)  
read.delim("name.txt", sep ="\t")  
read.csv("name.csv", sep=";")
```

```
view() # view data as table  
df$col1 # extract column from dataframe  
nrow(df), ncol(df) # number of rows/columns
```

Plots:

```
plot(x)  
plot(x, y) or plot(col1, col2, df) # scatter  
hist(x) # histogram
```

GETTING STARTED

OVERVIEW

DATA TYPES

STATISTICS & BASE PLOTS

QUATO CHEAT SHEET

YAML parameter:

```
---
```

```
title: My Project Name
```

```
output:
```

```
    html_document (pdf_document, ...)
```

```
---
```

Code Chunk:



Source mode:

```
```{r}
```

```
some R code
```

```
```
```

Visual mode:

```
{r}
```

```
# some R code
```

GETTING STARTED

Code Options:

```
{r echo = FALSE} # don't print code (default is TRUE)
```

```
{r eval = FALSE} # don't run code (default is TRUE)
```

```
{r error = FALSE} # don't display error message (default is TRUE)
```

(Can also be set for warning and message)

Figure Options:

```
fig.align ('left', 'right', 'center')
```

```
fig.cap ('my figure caption')
```

```
fig.height (n), fig.width (n)
```

CHUNK OPTIONS

Source mode:

Header

Header size ranging from largest (one #) to smallest (six #):
my.text, ## my.text, ### my.text, etc.

Text

italics

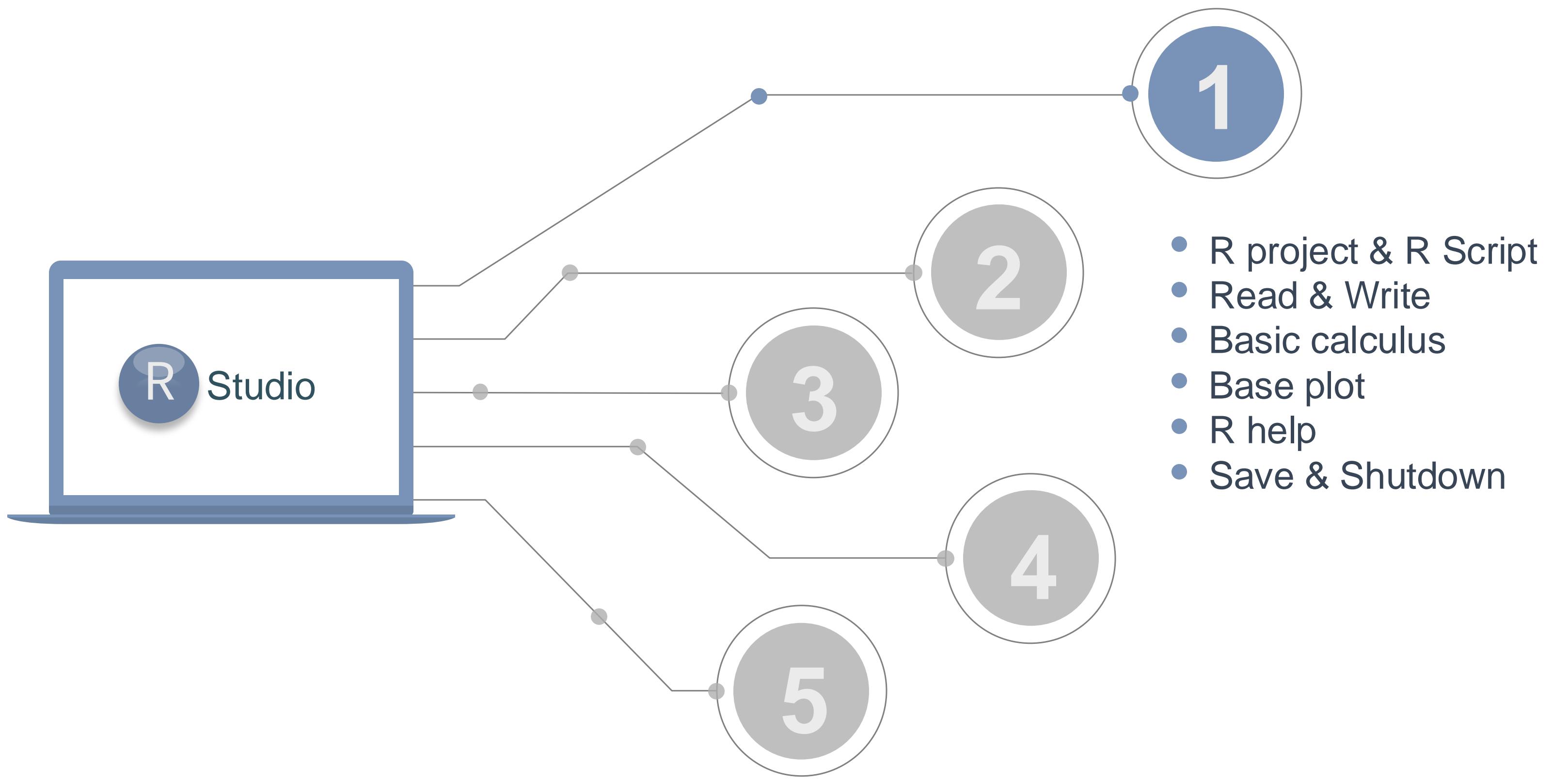
bold

`highlighted`

Lists

- * List item1 (filled dot)
 - + sub-item1 (open dot)
- 1. List item1 (numbered)
 - i) sub-item1 (roman)

TEXT



FUNDAMENTALS EXERCISE 1

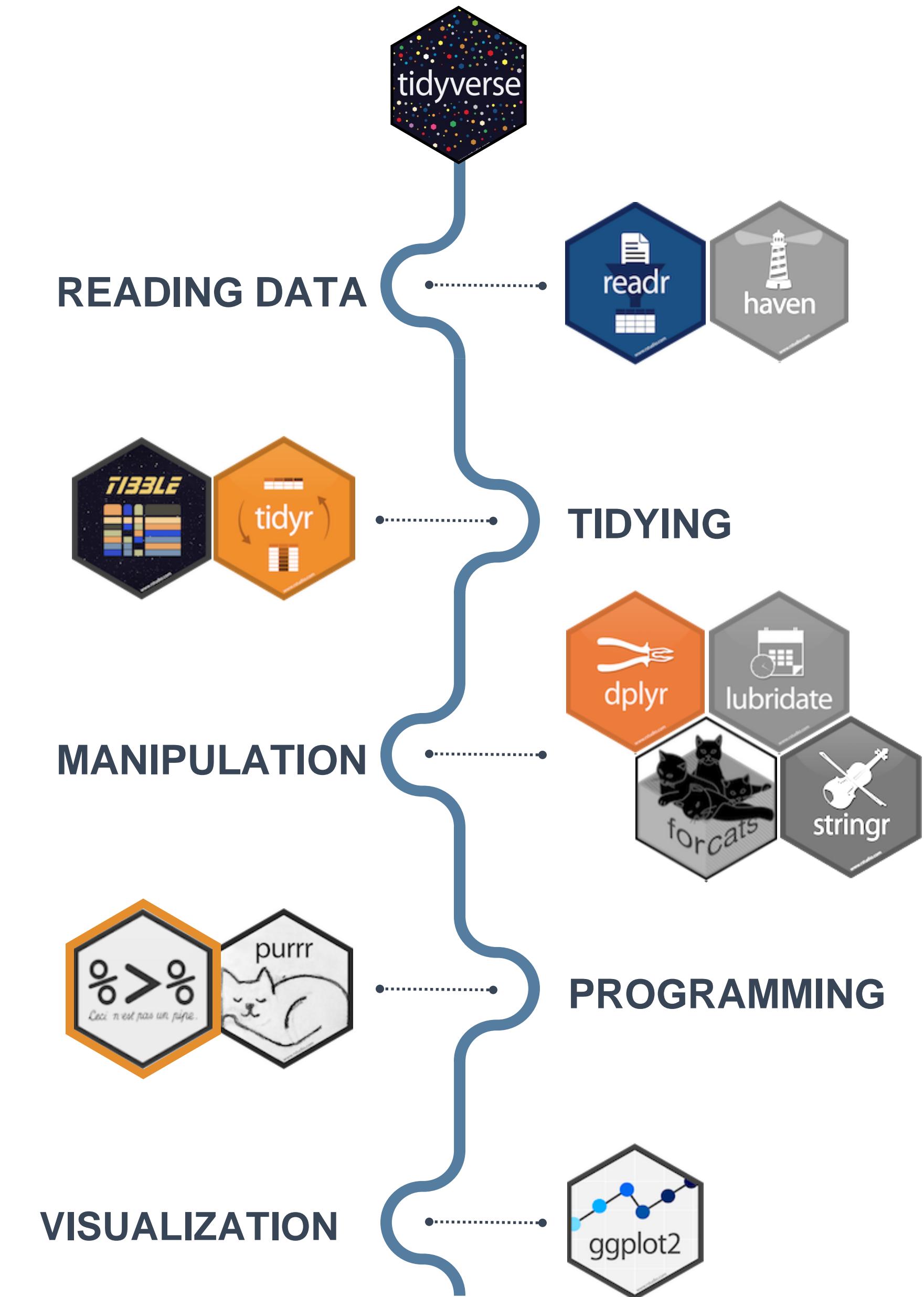
TIDYVERSE

<https://www.tidyverse.org/>

tidyverse is a collection of R packages for data science

“The packages share an underlying design philosophy, grammar, and data structures.” *Wickham and Grolemund*

tidyverse is used to “tidy up” your datasets, so they are easy to work with



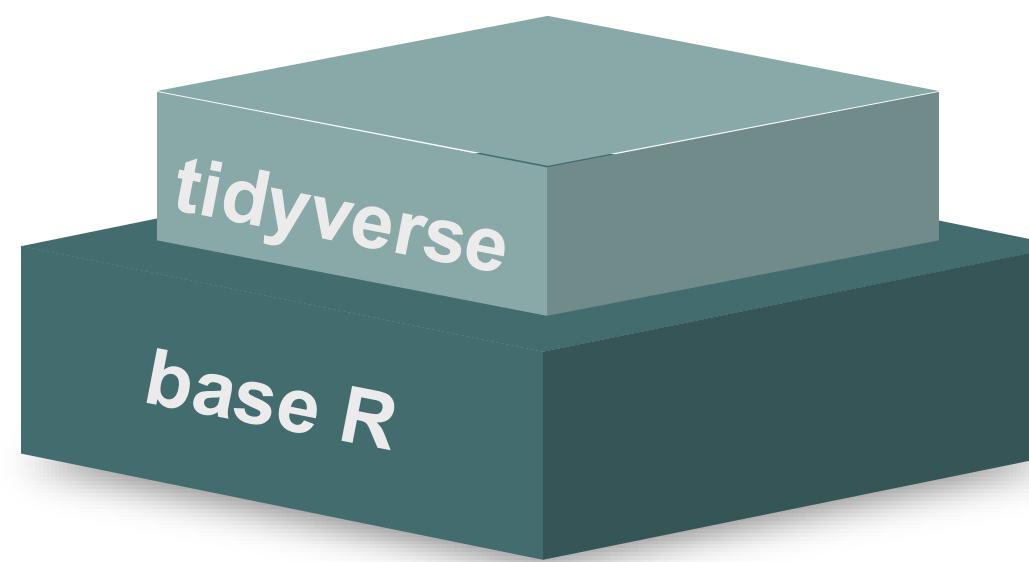
CECI N'EST PAS UNE PIPE

%>%

- You do NOT have to “choose” between tidyverse and base R

BENEFITS

- Short & well-organised code
- Tidy datasets, easy to work with
- Great documentation
- Functions with logical names & inputs



CONSIDERATIONS

- Can be less stable
- “Different syntax”
- Remember what tidyverse is made for!

base R

```
# think from the inside out  
g(f(x,y),z)
```

tidyverse

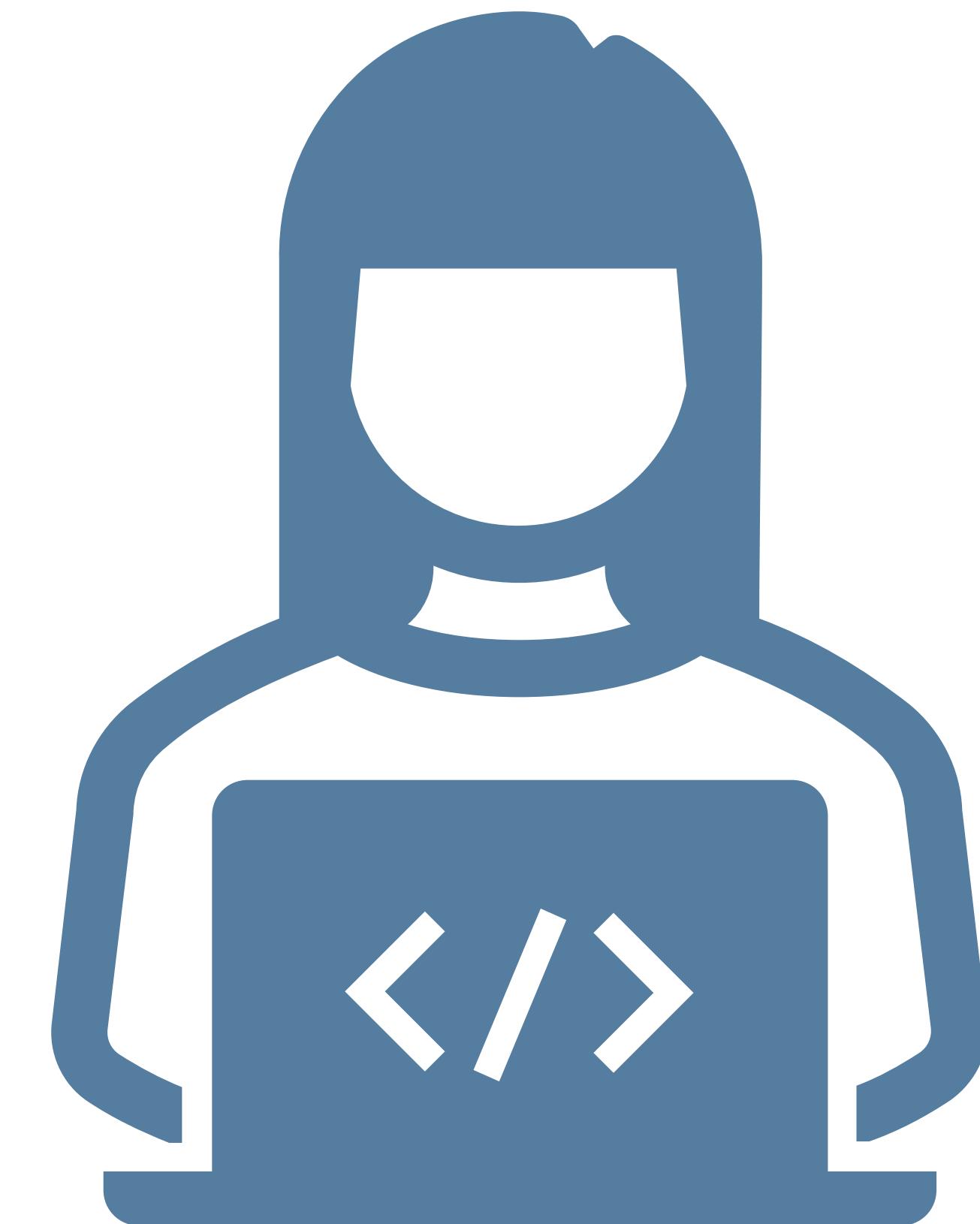
```
# no brain acrobatics  
x %>% f(y) %>% g(z)
```



pipe symbol

— FROM EXCEL TO R

LIVE CODING 2 – TIDYVERSE



TIDYVERSE CHEAT SHEET

readr, tidyverse, dplyr, ...

Read Data (*readr*)

Reading tabular data

There are solutions for multiple data types
`read_excel()` # using *readxl* package
`read_table()`
`read_csv()`

Useful arguments

Skip lines: `read_csv(file, skip=1)`
Read subset: `read_csv(file, n_max=1)`

Data types

readr guesses the types of each column and tells you about it
("Parsed with column specifications: ...")

Workflow

Tidyverse workflow

```
df %>%  
  select(col1)  
  
df %>%  
  filter(col1 < x)  
  
df %>%  
  summarize(n_1 = n(),  
            avg_1 = mean(col1),  
            sd_1 = sd(col1))
```

Select column

```
df$col1
```

Data Manipulation (*dplyr*)

Summary

```
summarize()  
count()
```

Group

```
group_by()
```

Functions will manipulate each group separately and combine results.

Extract and sort observations (rows)

```
filter() # subset rows by condition  
distinct() # subset to unique values  
top_n() # subset by position  
arrange() # sort low->high, other way with desc()
```

Manipulate variables (columns)

```
select() # subset rows by condition  
mutate(new_name = f(column))  
mutate(new_name = ifelse(col1 < x, "Yes", "No"))  
mutate(new_name = col1 + col2)
```

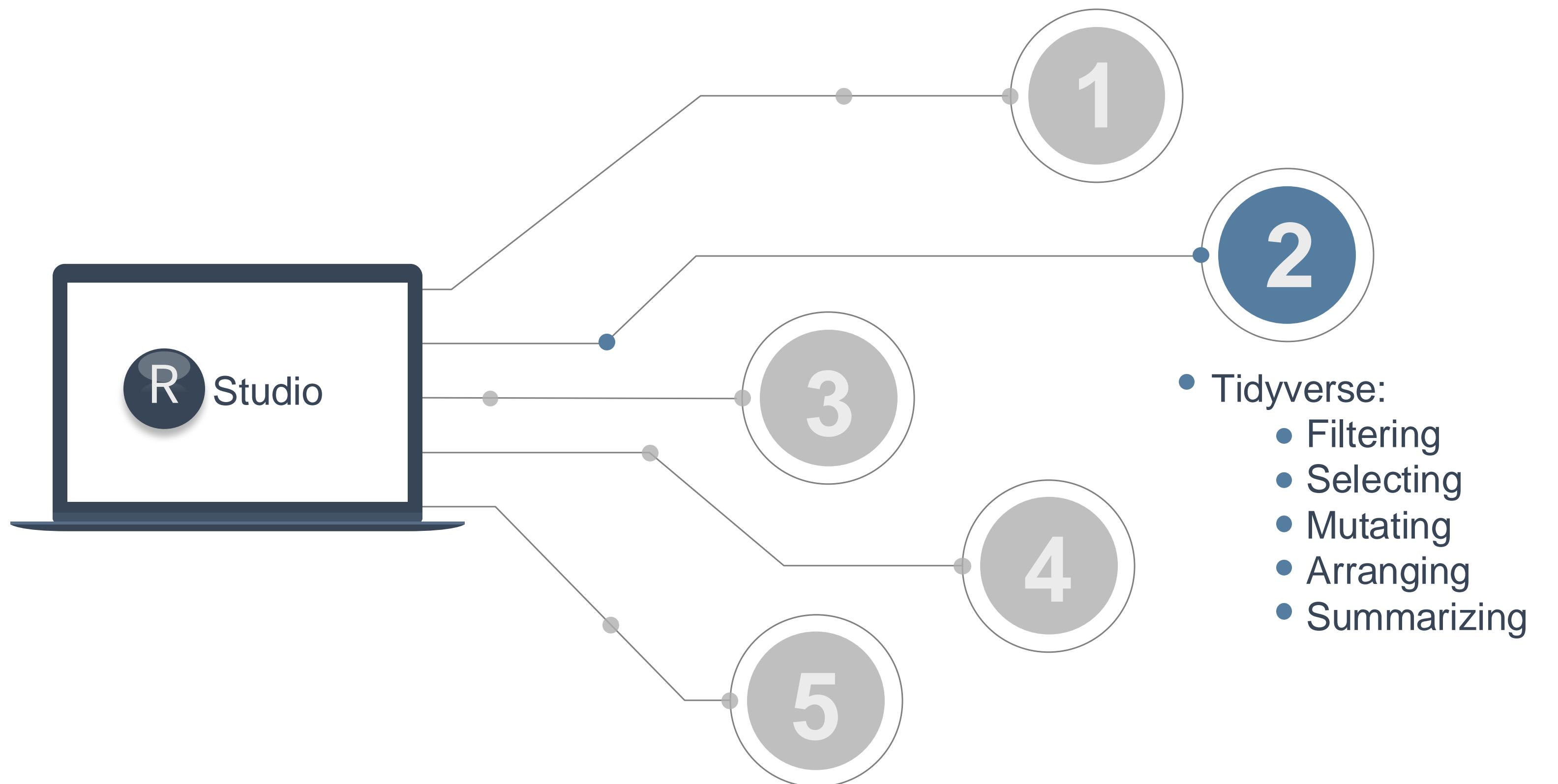
HELP

R Documentation (e.g. enter `?dplyr::filter` and see examples)

Much more info and detailed cheat sheets:

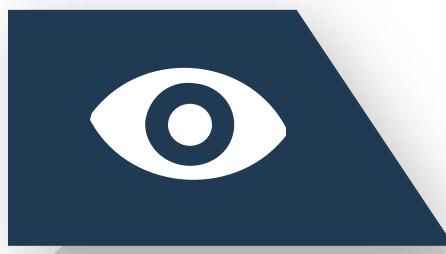
<https://brianward1428.medium.com/introduction-to-tidyverse-7b3dbf2337d5>

It also helps to google "tidyverse + whatever you want to do"

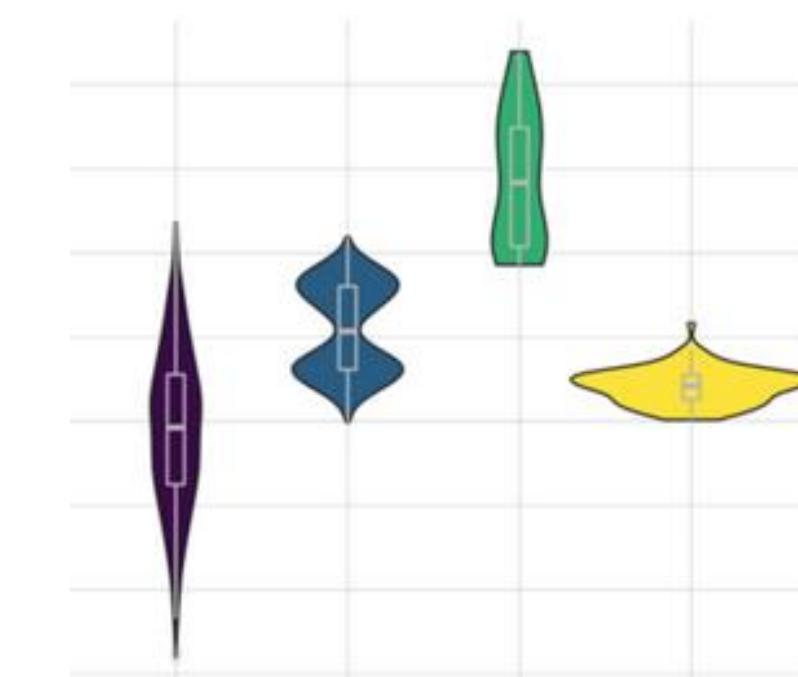


TIDYVERSE EXERCISE 2

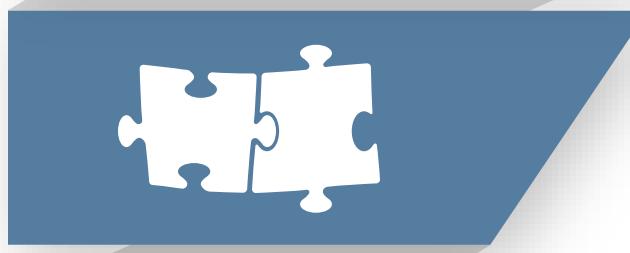
GGPLOT2 - EASY GRAPHICS



Aesthetically pleasing graphics.



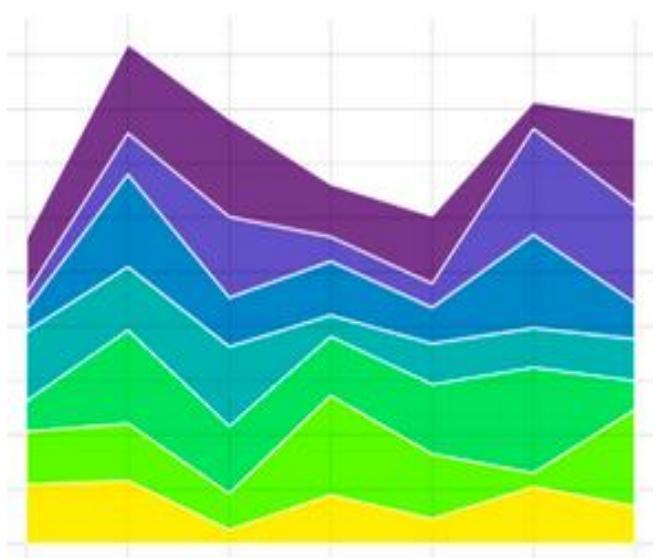
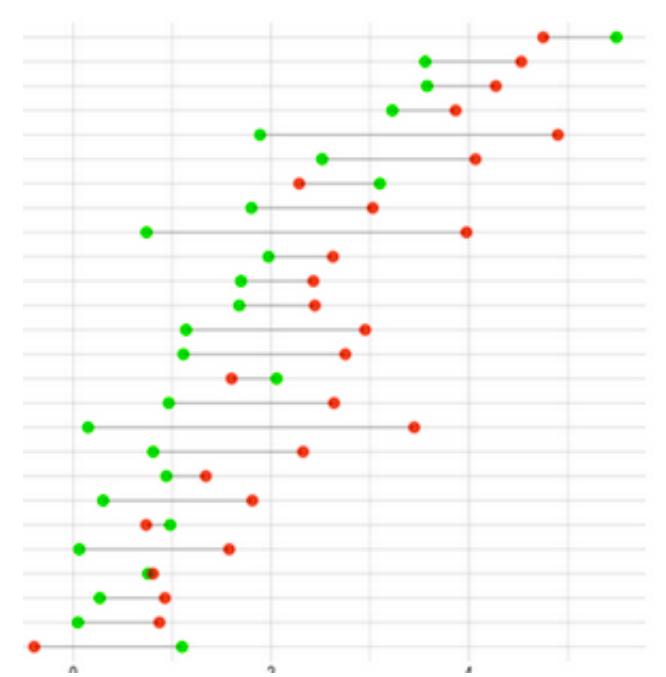
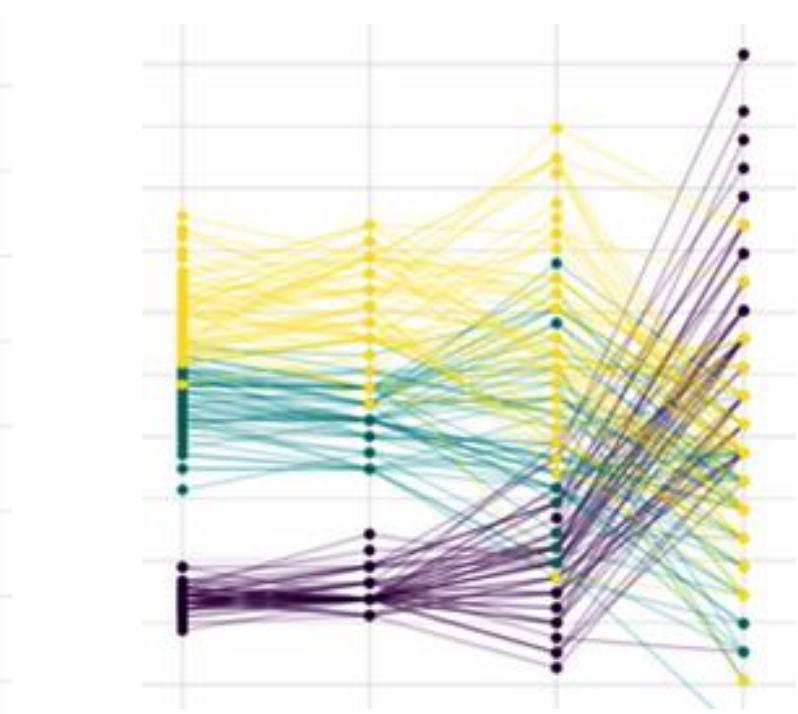
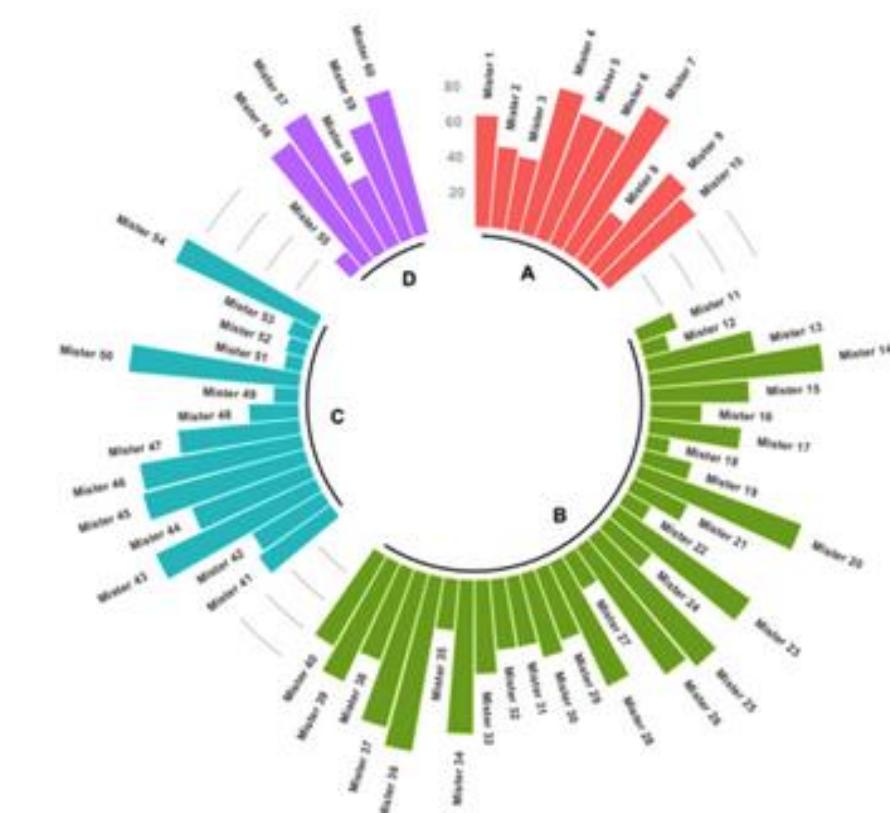
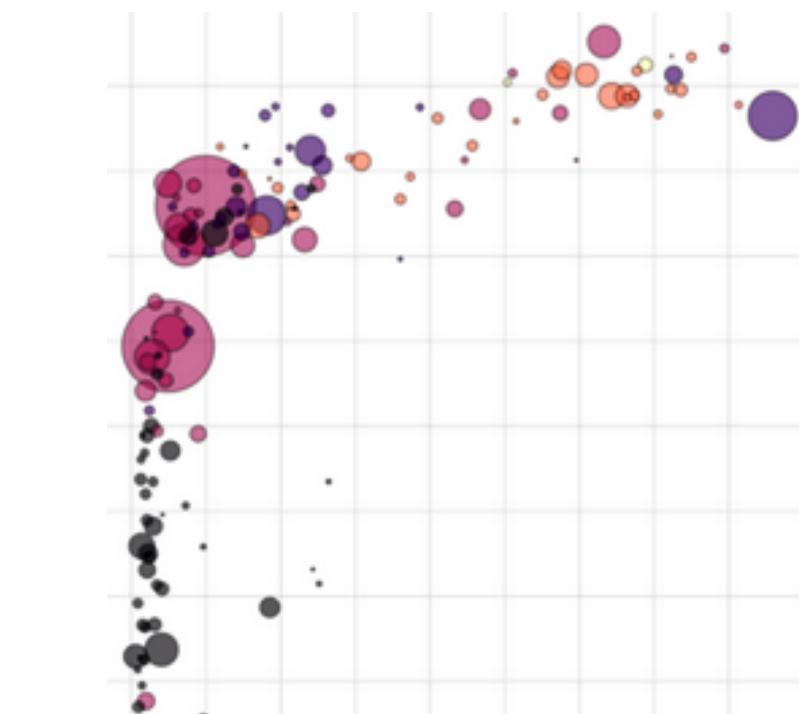
Well-defined “additive” (+) structure.



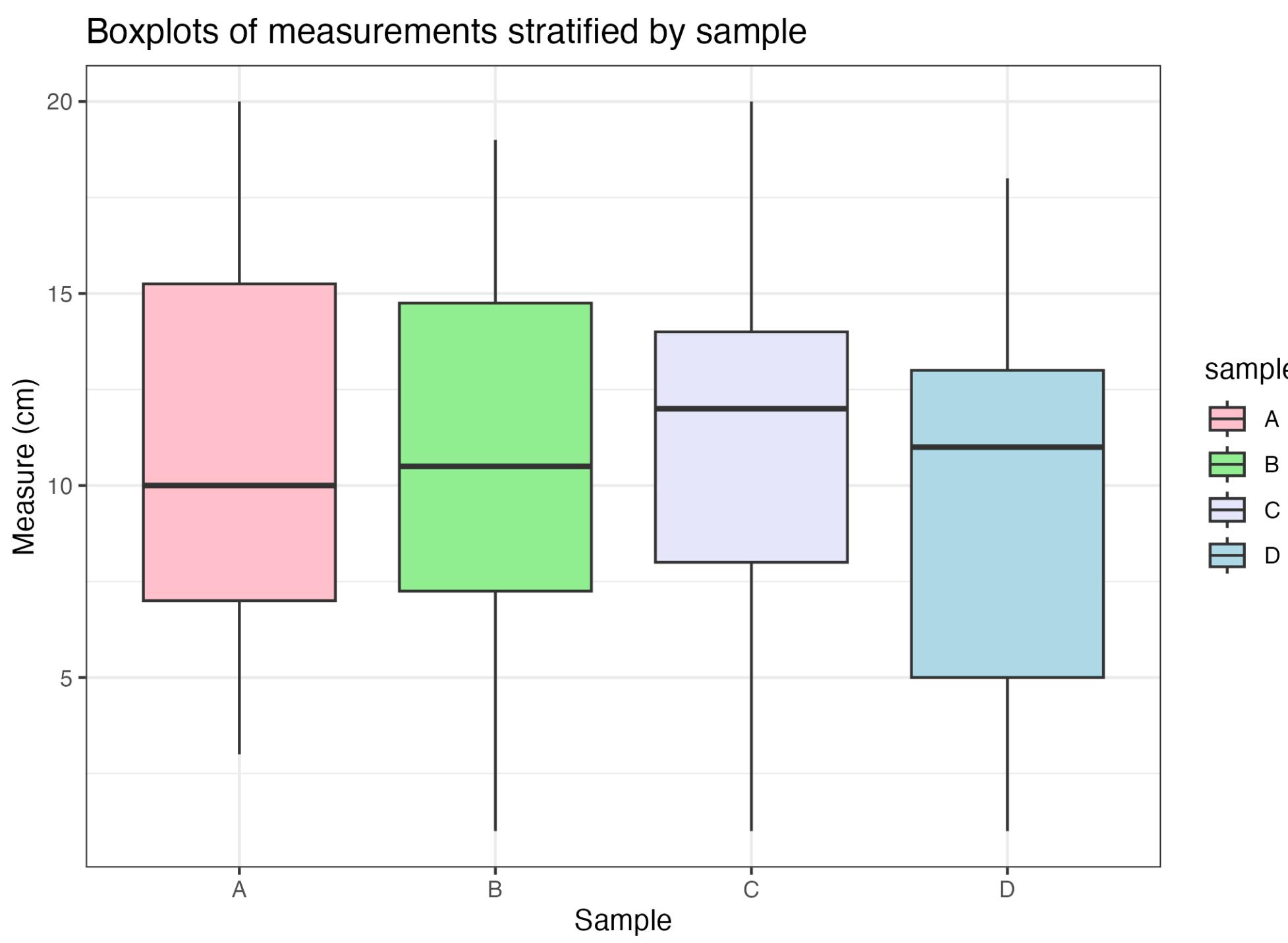
Integrates perfectly with tidy data.



Great documentation & community



GGPLOT2 ADDITIVE STRUCTURE



DATASET, SAMPLES & OBSERVATIONS



```
ggplot(df,
```

```
  aes(x = Sample, y = Measure))
```

DEFINE PLOT TYPE



```
ggplot(df,
```

```
  aes(x = Sample, y = Measure)) +  
  geom_boxplot()
```

COLOR BY GROUP



```
ggplot(df,
```

```
  aes(x = Sample, y = Measure,  
      fill = Sample)) +  
  geom_boxplot()
```

TITLE AND LEGEND



```
... +  
  labs(title = "Boxplots of  
measurements stratified by sample")
```

CUSTOM COLORS



```
... +  
  scale_fill_manual(values =  
c("pink", "lightgreen", "lavender",  
"lightblue"))
```

BACKGROUND

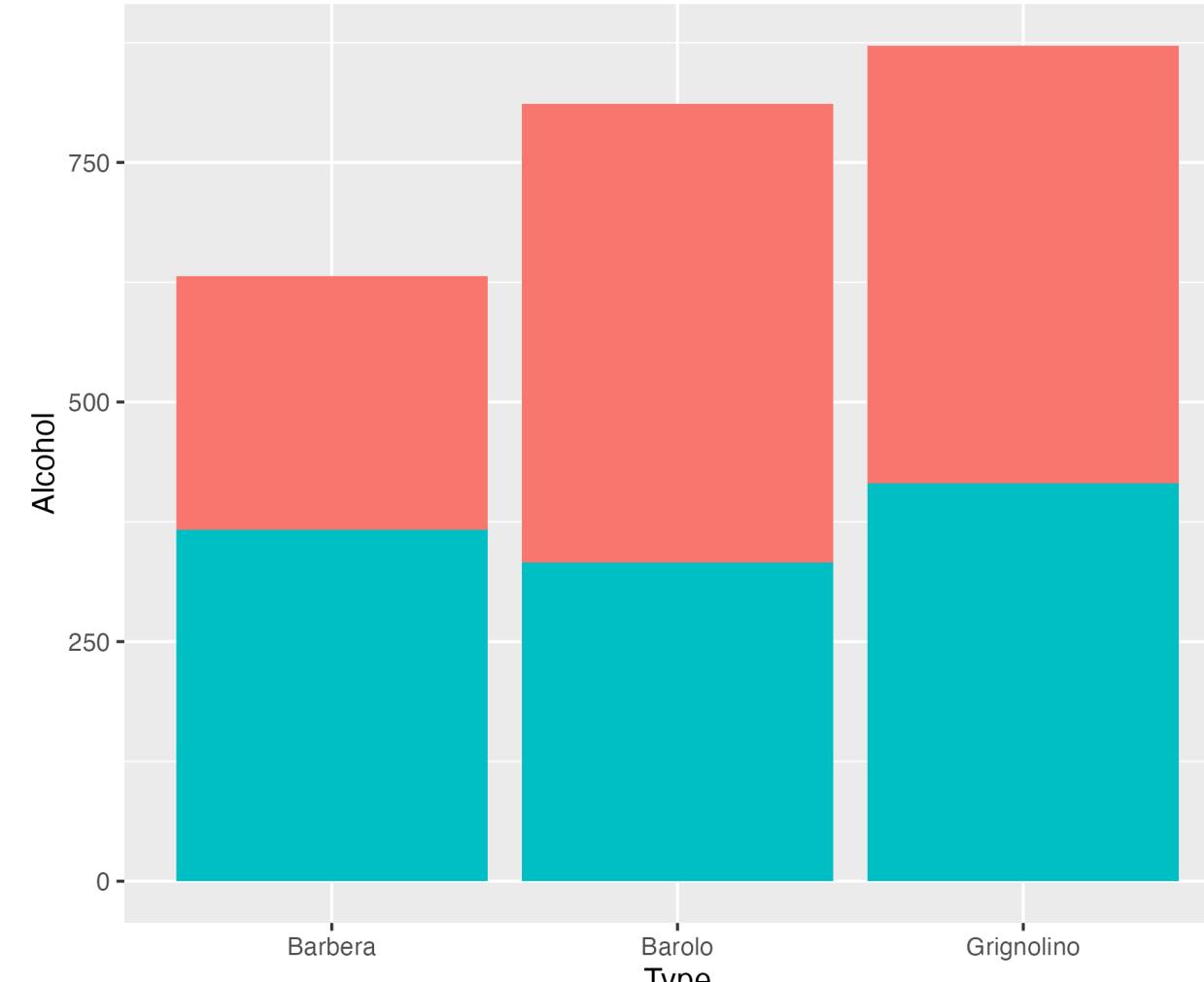


```
... +  
  theme_bw()
```

GGPLOT BASIC STRUCTURE

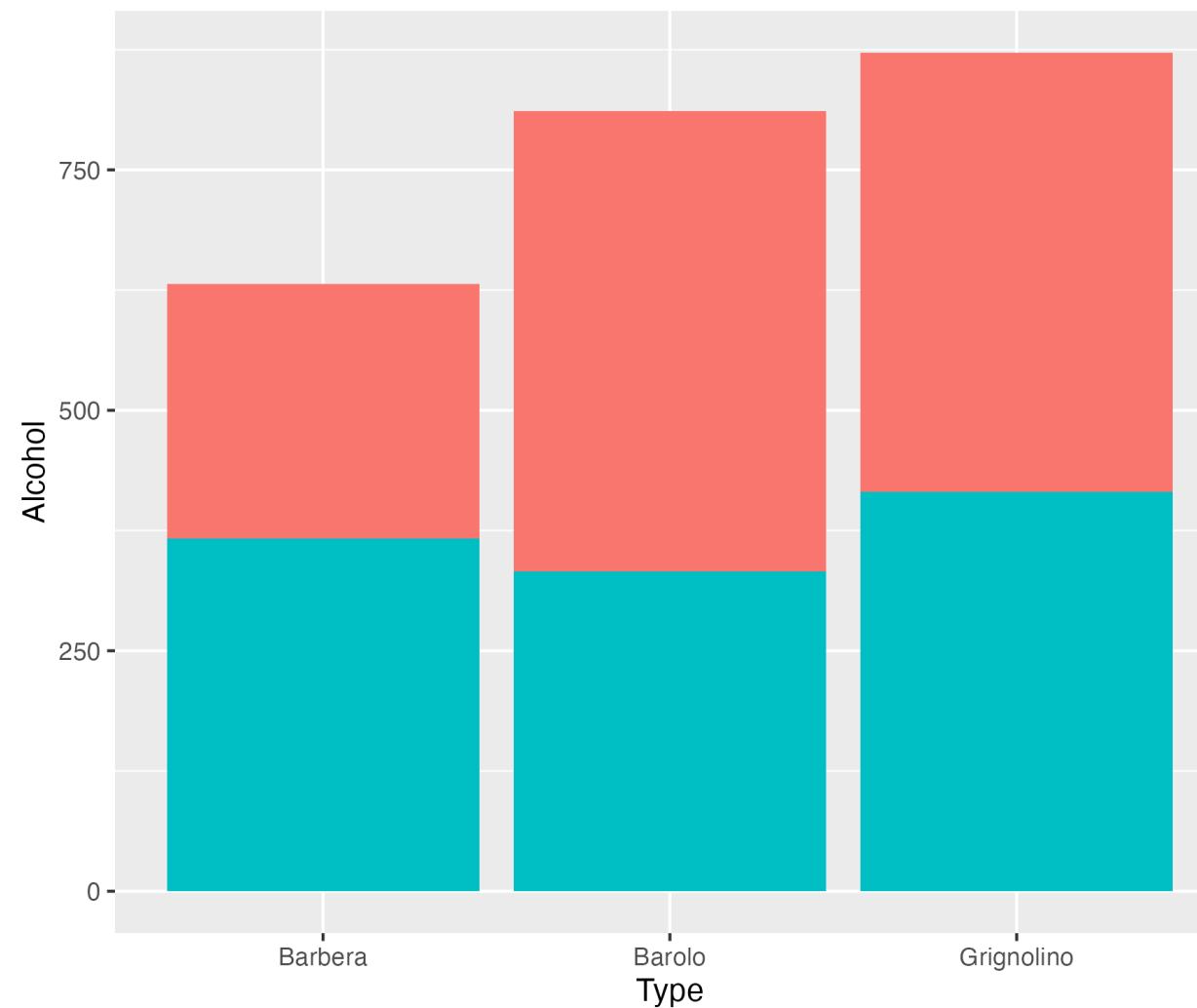
Geoms inherit the parameters from the ggplot they are added to:

```
ggplot(my_wine,
       aes(x = Type,
           y = Alcohol,
           fill = Country)) +
  geom_col()
```



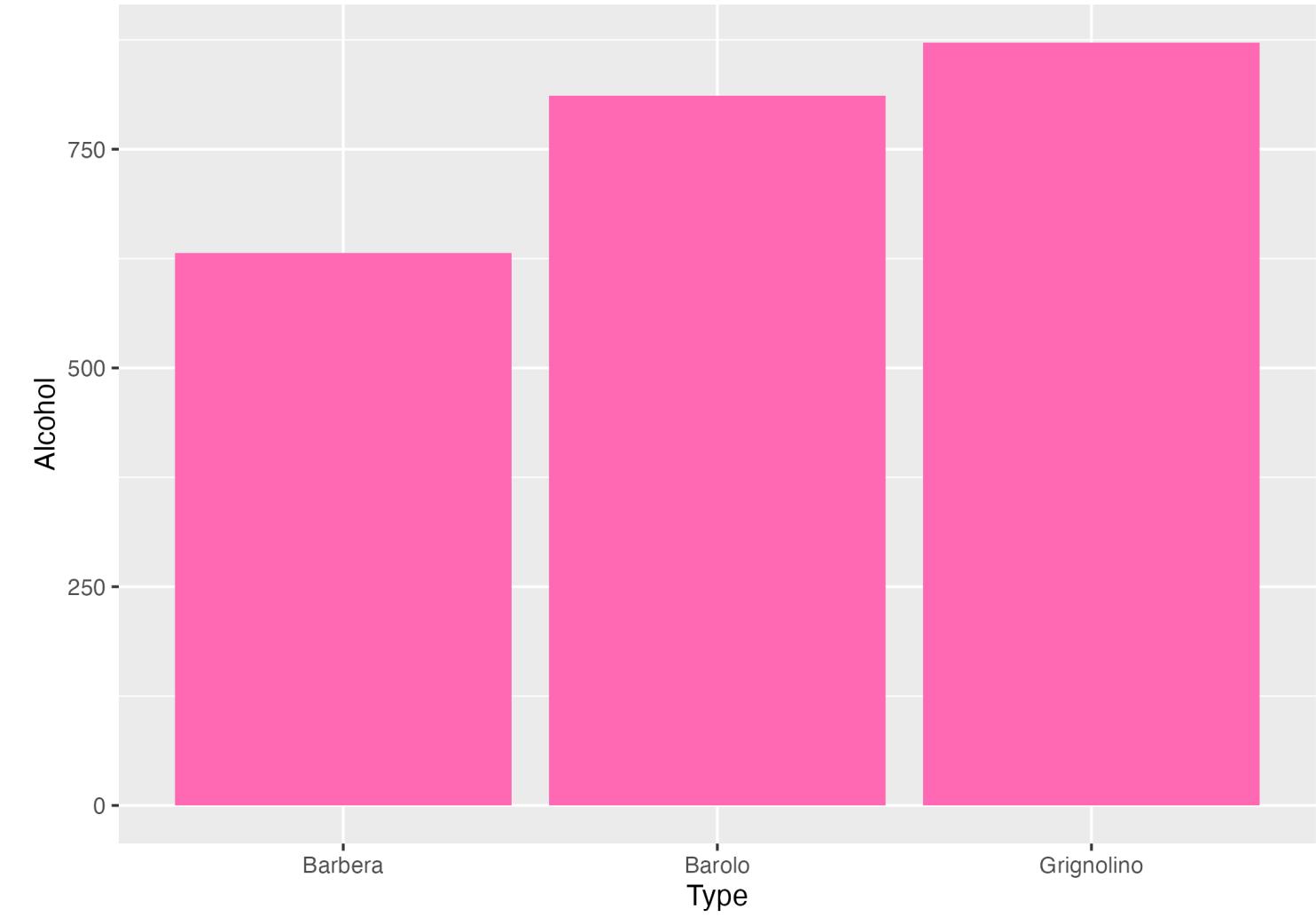
Alternatively, you can specify additional parameters directly in the geom:

```
ggplot(my_wine,
       aes(x = Type,
           y = Alcohol)) +
  geom_col(aes(fill = Country))
```



Things outside the aes are applied to everything!

```
ggplot(my_wine,
       aes(x = Type,
           y = Alcohol)) +
  geom_col(fill = "hotpink")
```



GGPLOT CHEAT SHEET

Define Plot:

```
ggplot(data = my.data,  
       aes(x = x.var,  
            y = y.var))
```

Add Plot Type:

```
... + geom_point() # scatter plot  
... + geom_line()  
... + geom_boxplot()
```

```
... + geom_col()  
... + geom_density()  
... + geom_histogram()
```

One Color:

```
ggplot(..., aes(...),  
       color = "green")
```

Color Fill by Group:

```
ggplot(..., aes(...,  
               fill = z.var))
```

Custom Colors:

```
... + scale_*_manual(values = c())  
ex: scale_color_manual(values = c("blue", "pink"))
```

More Colors:

```
... + scale_fill_grey(start = 0.2, end = 0.8)  
... + scale_fill_gradient(low="white", high="red")
```

Labels:

```
... + labs(title = "Title",  
          x = "X label",  
          y = "Y label")
```

Theme:

```
... + theme_bw()  
... + theme_minimal()  
... + theme_dark()  
... + theme_classic()
```

Text:

```
... + theme(legend.position = *)  
* = "none", "top", "bottom", "left", "right"
```

GET
STARTED

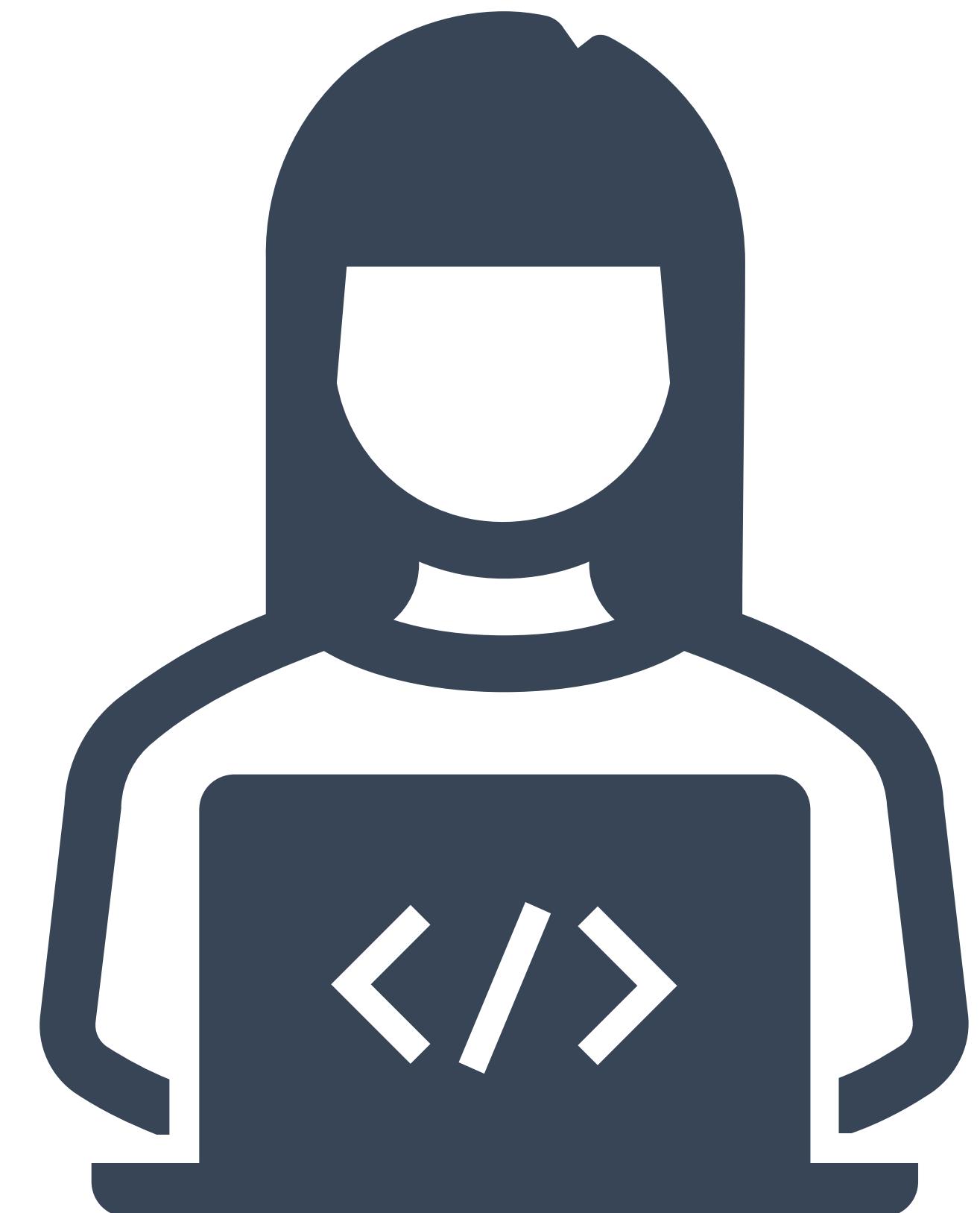
COLORS

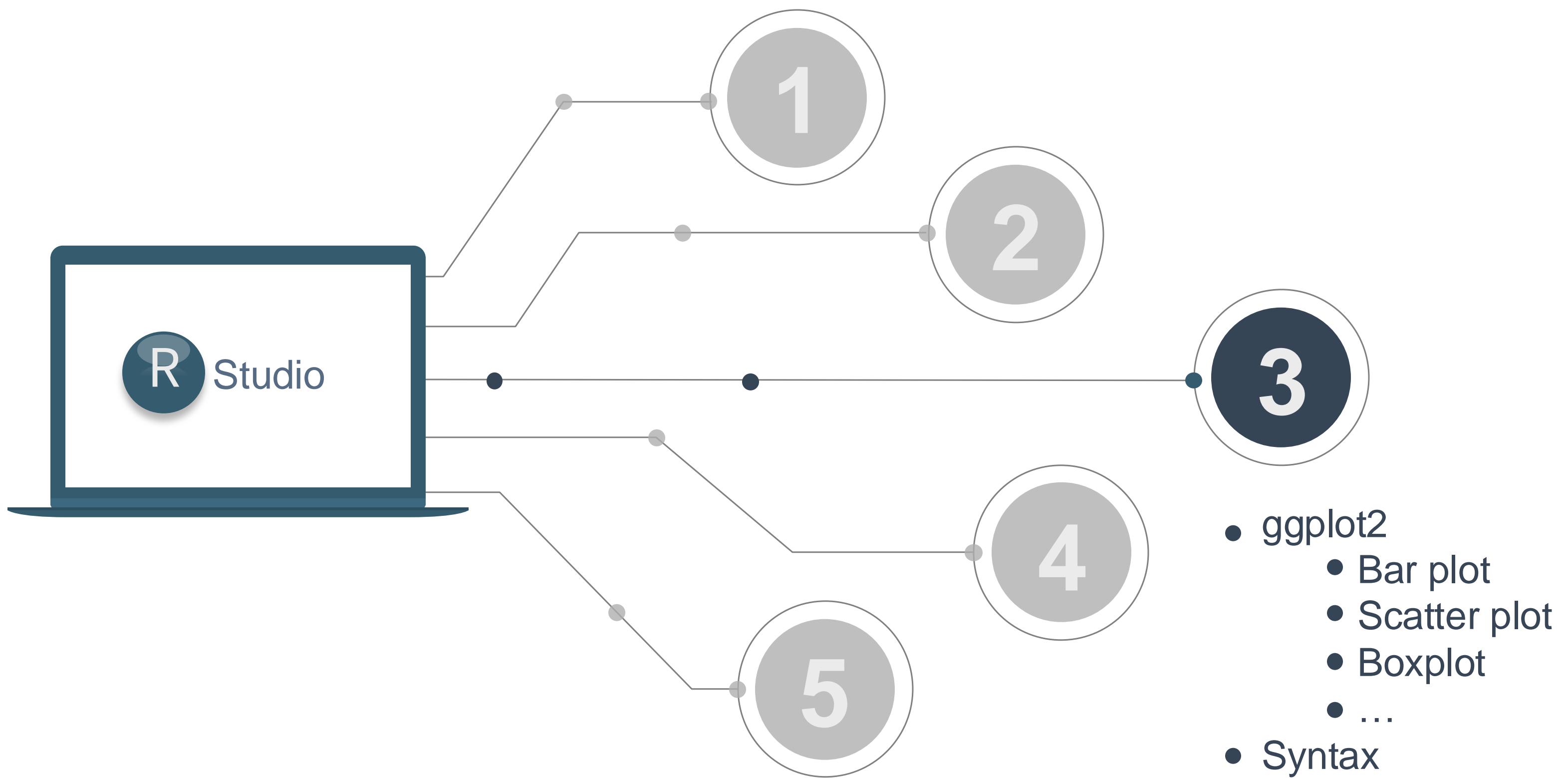
COLOR SCALES
& THEMES

TEXT

— FROM EXCEL TO R

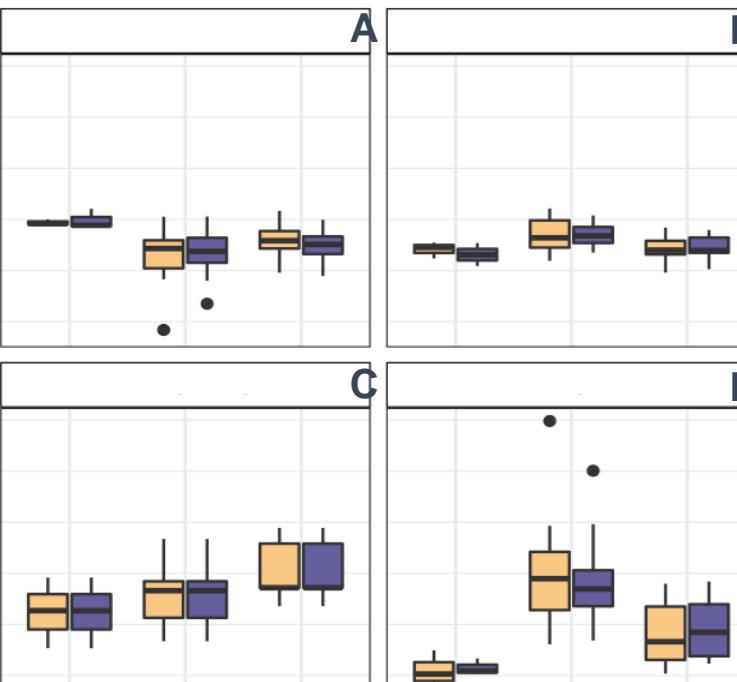
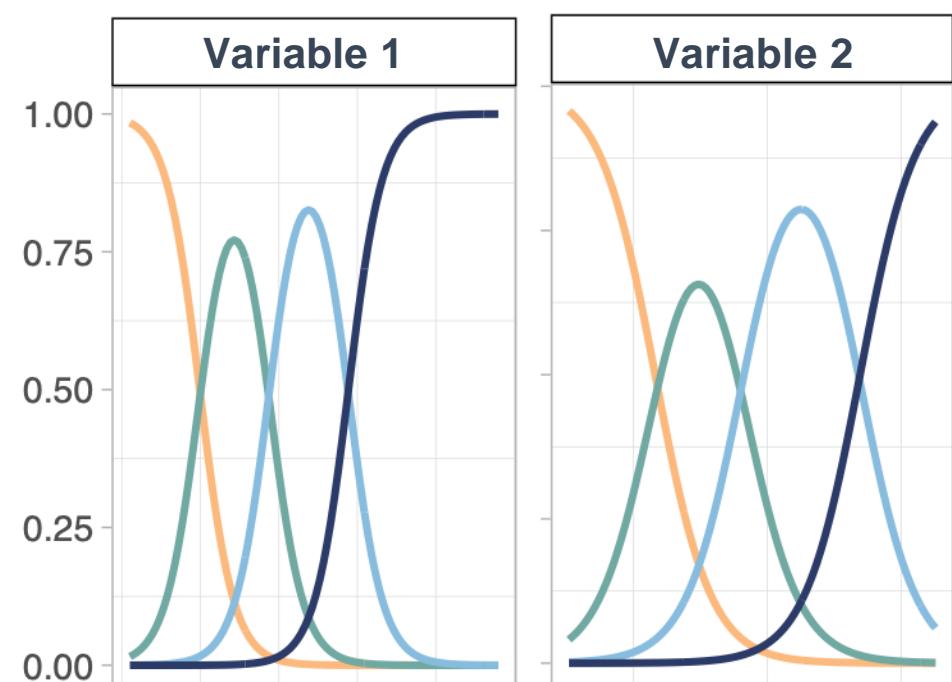
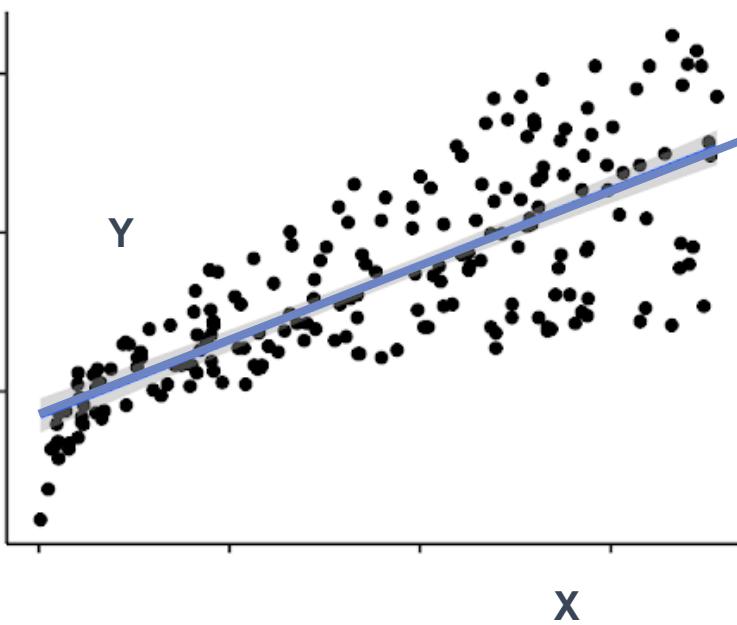
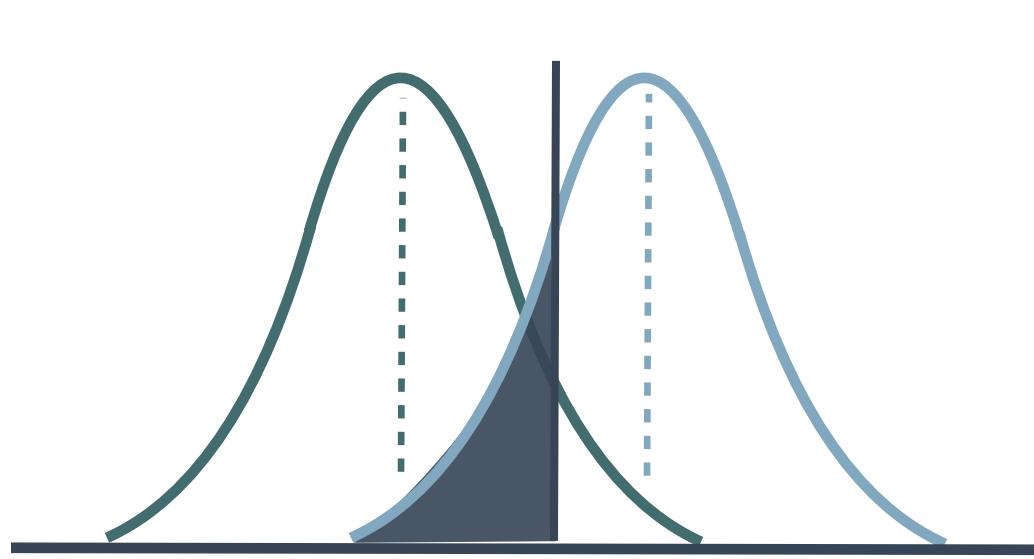
LIVE CODING 3 – GGPLOT 2





— GG PLOT2 EXERCISE 3

R - A STATISTICAL SCRIPTING LANGUAGE



MODEL FUNCTIONS

`lm()`, `glm()`,
`lmer()`, `glmer()`,
`nls()`, ...

EMMEANS PACKAGE

`emmeans()`,
`pairs()`, `cld()`

APPLY TO MODEL

`summary()`, `anova()`,
`confint()`, `predict()`,
`drop1()`, `update()`,
`step()`, ...

MORE FUNCTIONS

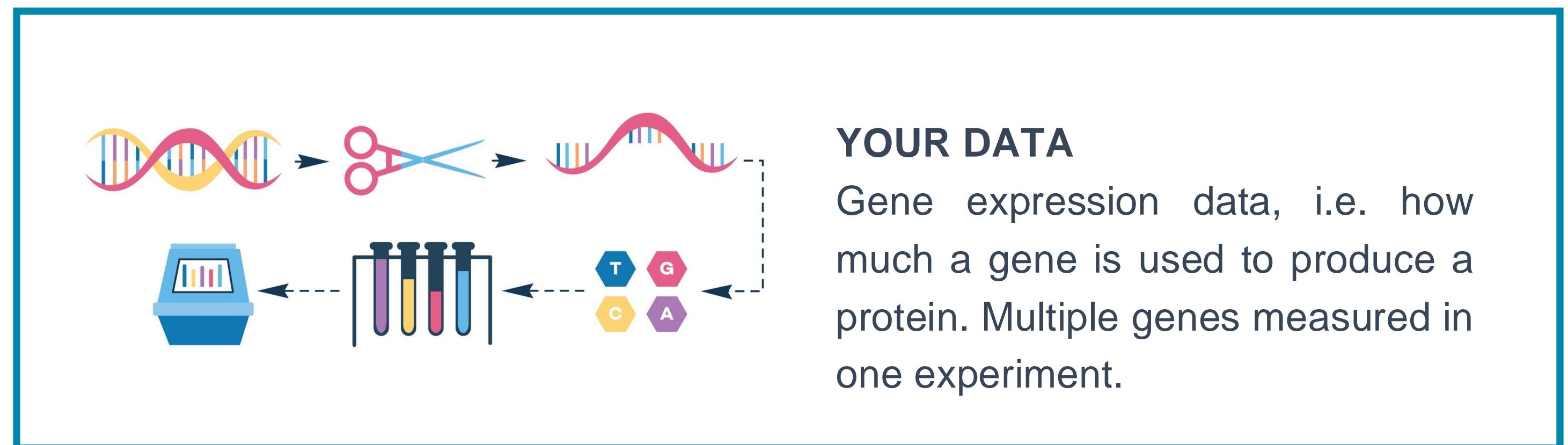
`t.test()`, `cor()`,
`cor.test()`, `aov()`,
`quantile()`,
`p.adjust()`,
`rank()`, ...

Let's use R in a statistical analysis



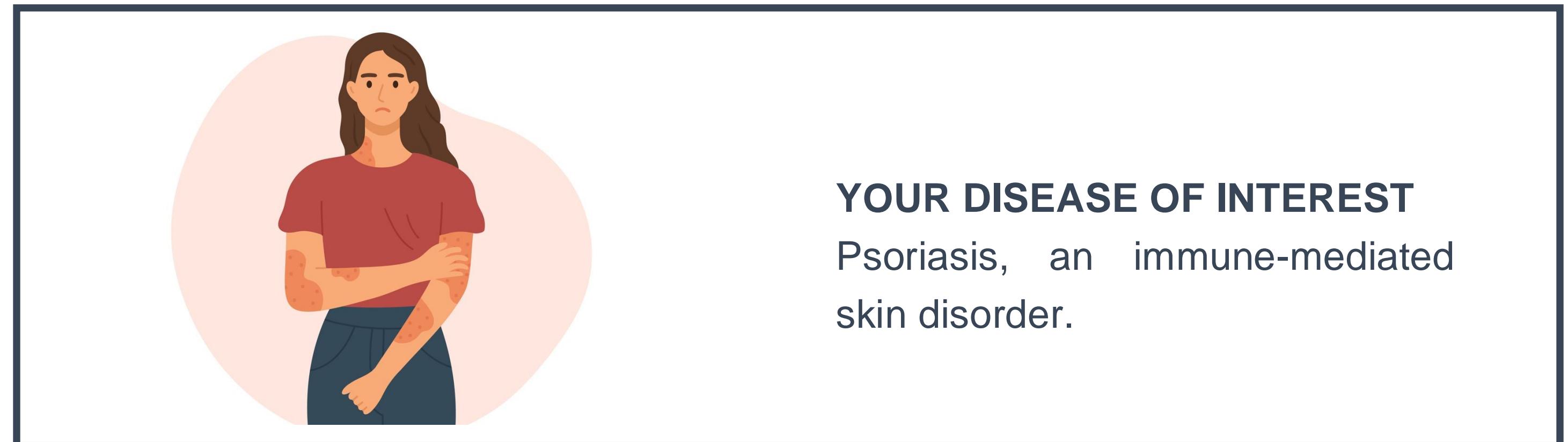
YOU

The researcher with R skills!



YOUR DATA

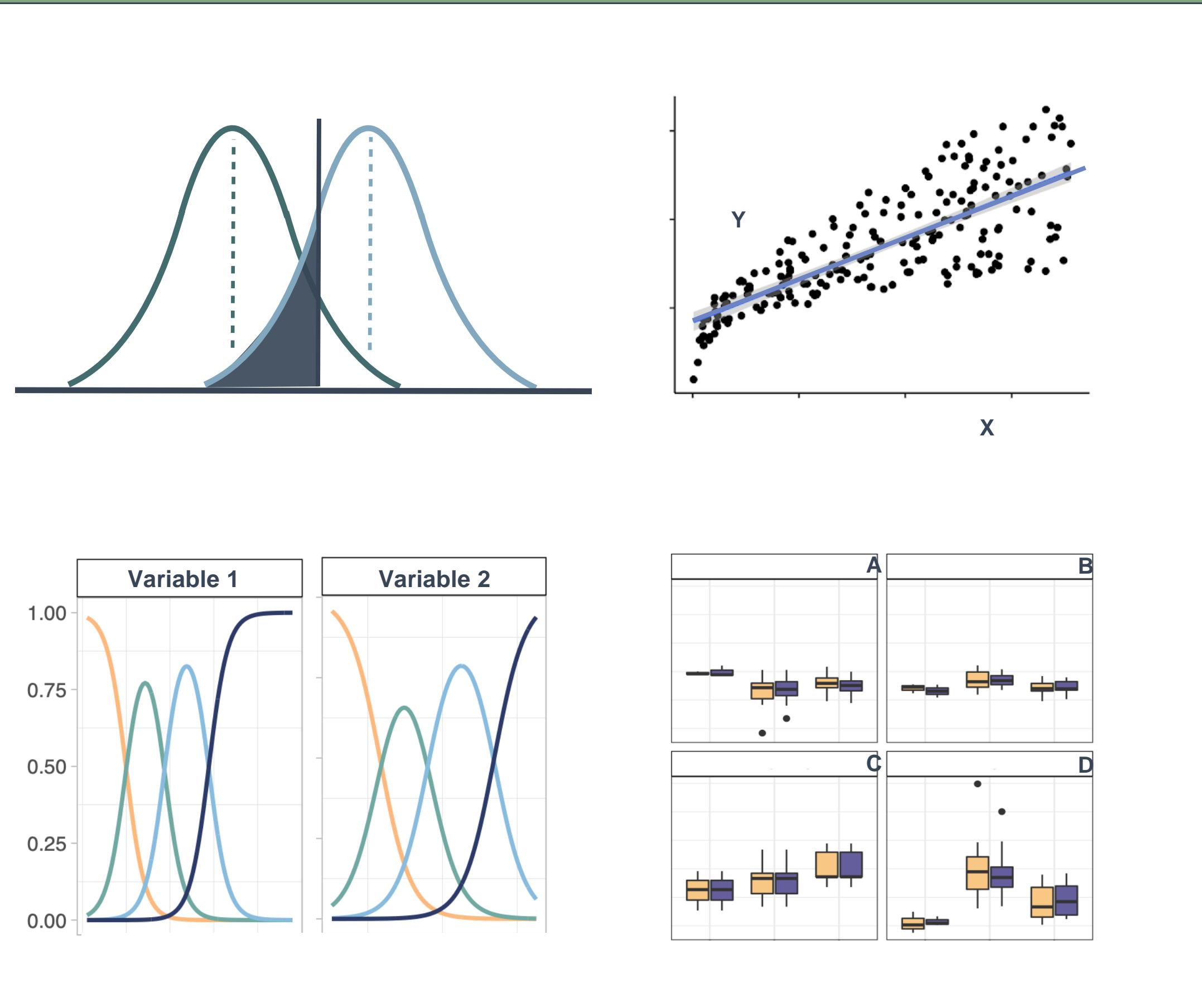
Gene expression data, i.e. how much a gene is used to produce a protein. Multiple genes measured in one experiment.



YOUR DISEASE OF INTEREST

Psoriasis, an immune-mediated skin disorder.

R - A STATISTICAL SCRIPTING LANGUAGE



During this session:

- *Cooperatively* discuss and share ideas about the data
- Apply steps of basic statistical analysis for hypothesis testing consistent with the given data
- Suggest conclusions based on your analysis, regarding the association between psoriasis and gene expression levels

<https://rstudio.com/resources/cheatsheets/> for various relevant cheat sheets.
Other example: <https://www.dummies.com/programming/r/statistical-analysis-with-r-for-dummies-cheat-sheet/>

STATS CHEAT SHEET

Import Data:

```
read_excel("my.data.xlsx")
```

Overview of Data:

```
summary(my.data)  
nrow(my.data)
```

```
length(my.data)  
names(my.data)
```

Linear:

```
lm(y~x, data=my.data)  
confint(model)
```

Logistic:

```
glm(y~x,  
data=my.data)
```

Linear Mixed:

```
lmer(y~x + (1|z),  
data=my.data)
```

Check Model:

```
summary(model)  
par(mfrow=c(2,2))  
plot(model)
```

ANOVA:

```
anova(model2, model1)
```

F-Test:

```
drop1(model, test="F")
```

Emmeans:

```
emmeans(model, ~x)  
pairs(emmeans(model, ~x))
```

Check Type:

```
table(my.data$x)  
is.numeric(my.data$x)  
is.factor(my.data$x)
```

Change Type:

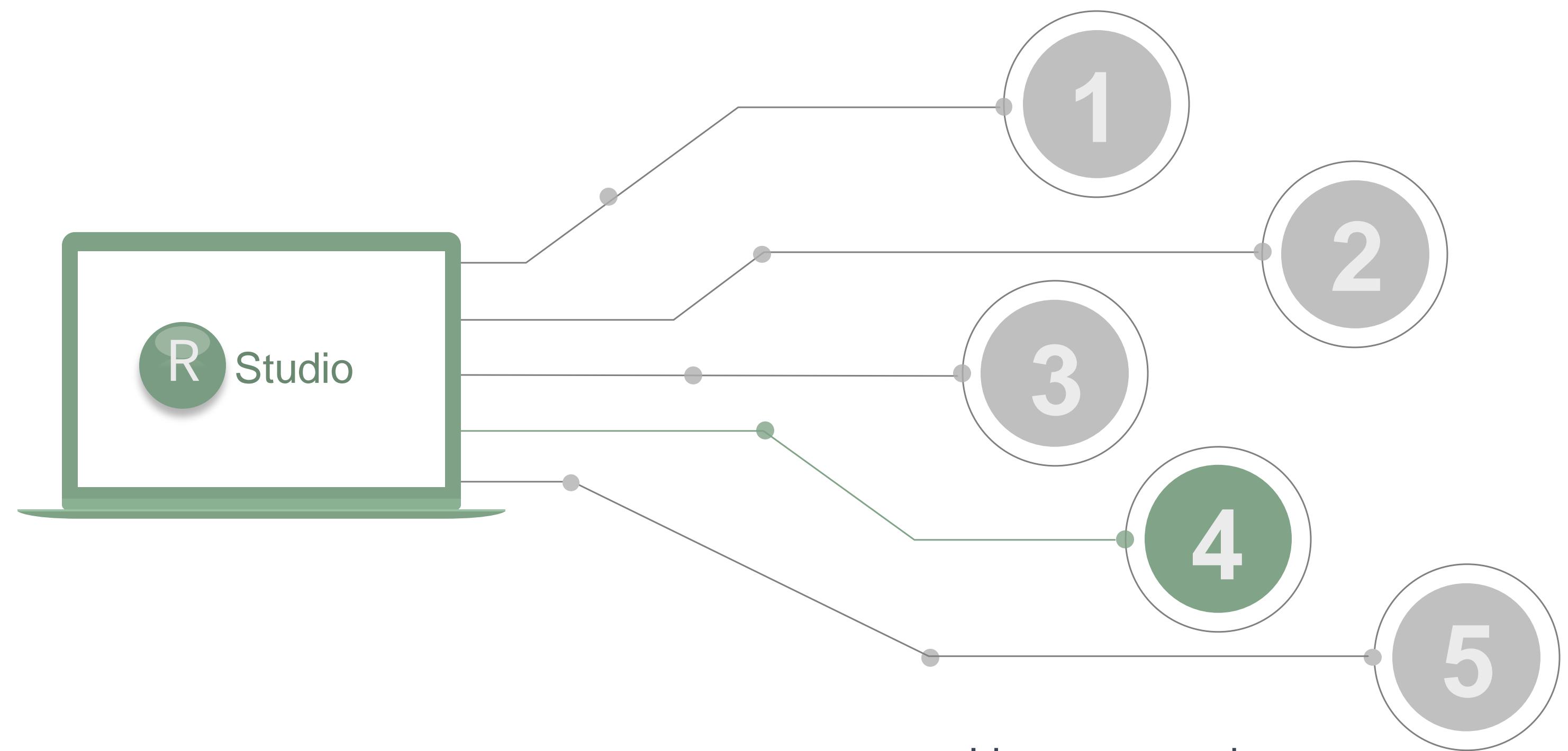
```
my.data <- mutate(my.data, x = factor(x))  
my.data$z <- as.numeric(my.data$z)
```

GET
STARTED

REGRESSION
MODELS

TESTS/COMPARISONS

VARIABLES

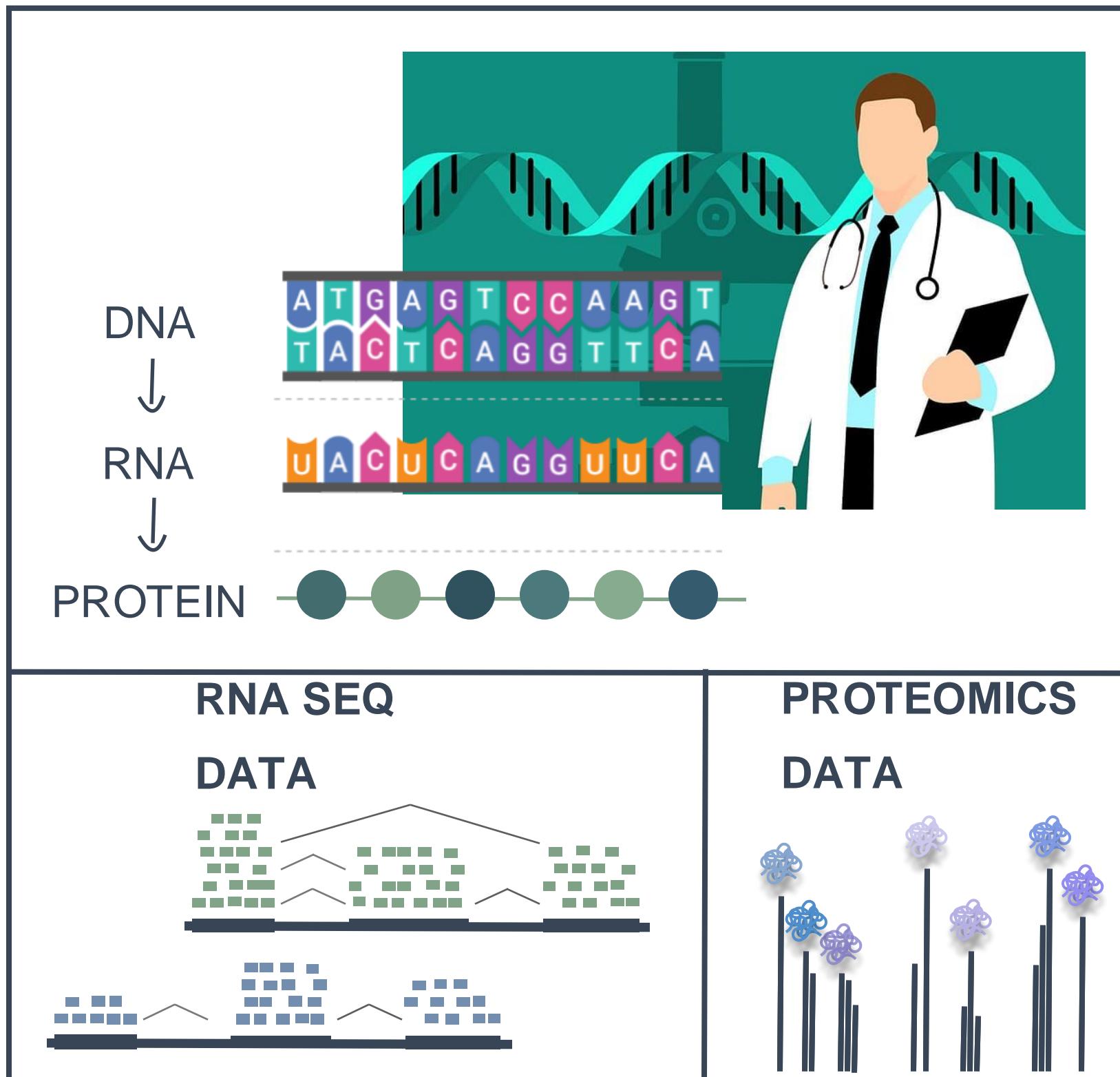


- Linear regression
- Summary Statistics
- ANOVA
- Logistic regression
- Clustering
- Correlation

— Statistics in R
EXERCISE 4

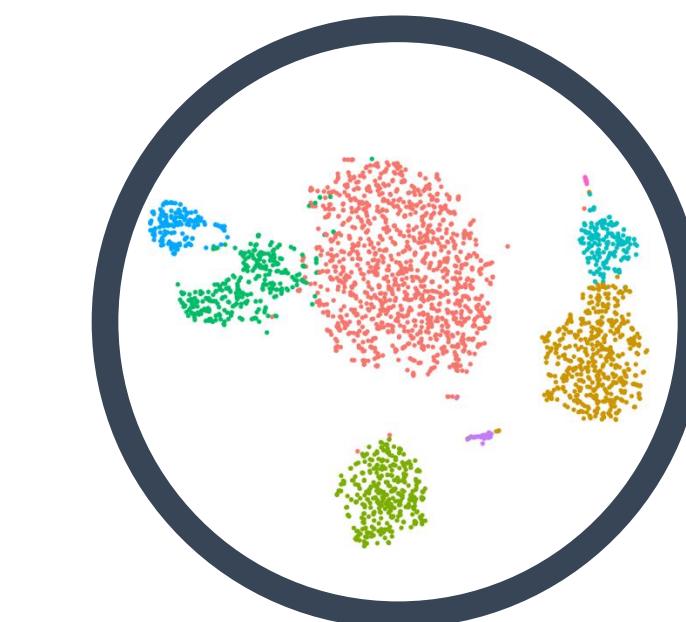
BIOINFORMATICS IN R

HIGH THROUGHPUT DATA



BIOINFORMATIC ANALYSIS

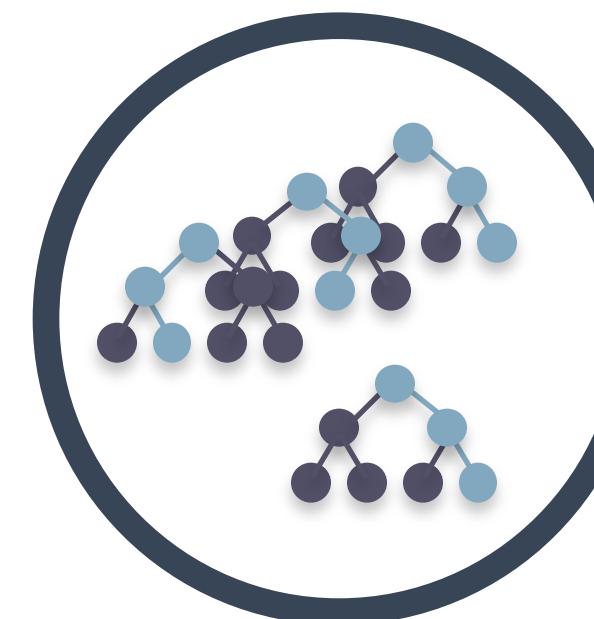
DIMENSIONALITY REDUCTION



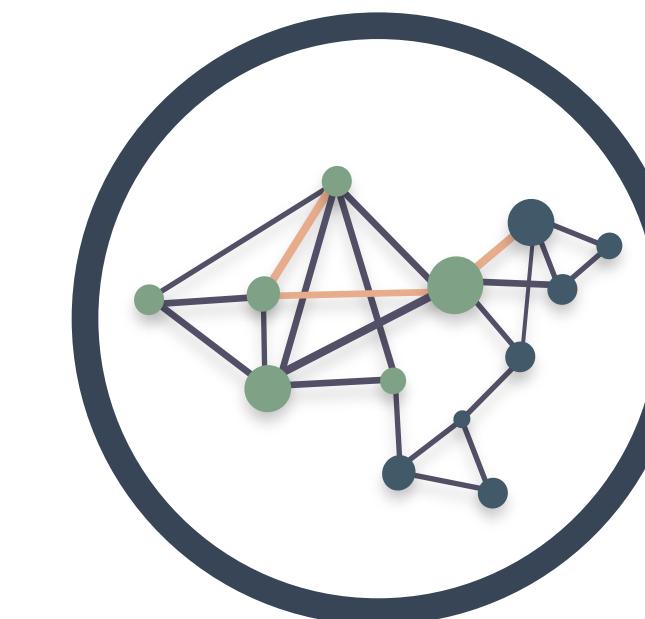
CLUSTERING

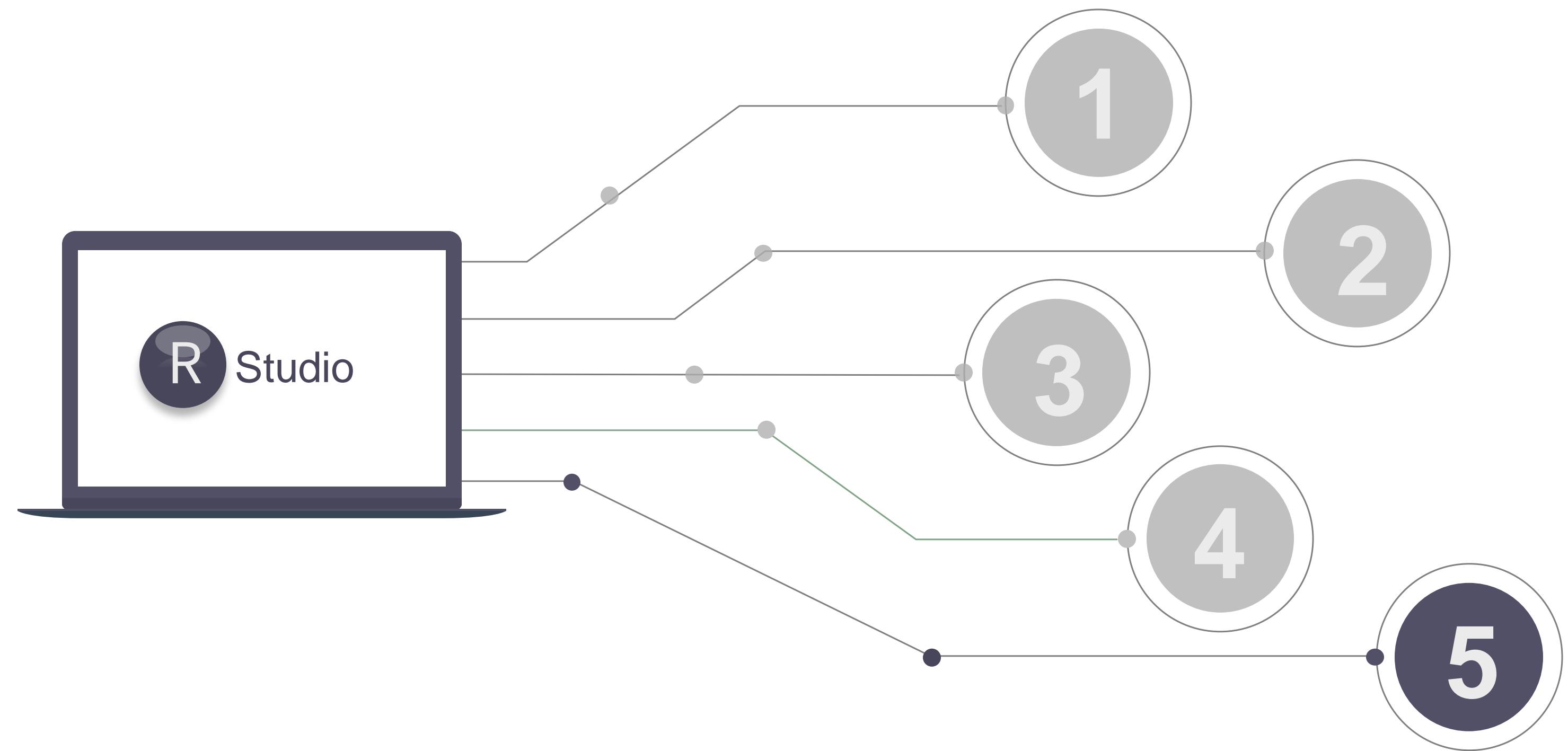


MACHINE LEARNING



NETWORK ANALYSIS





- Tidyverse
- ggplot
- Stats
- Quarto

— Statistics in R
EXERCISE 5

THE TOP OF THE R ICEBERG



STATISTICAL ANALYSIS

Statistical models (linear, generalized, mixed, ...)

Statistical tests (t-test, chisq, anova, ...)

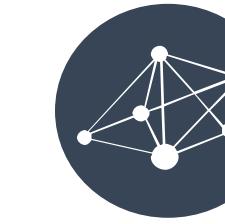
Survival analysis (Cox, Kaplan meier)



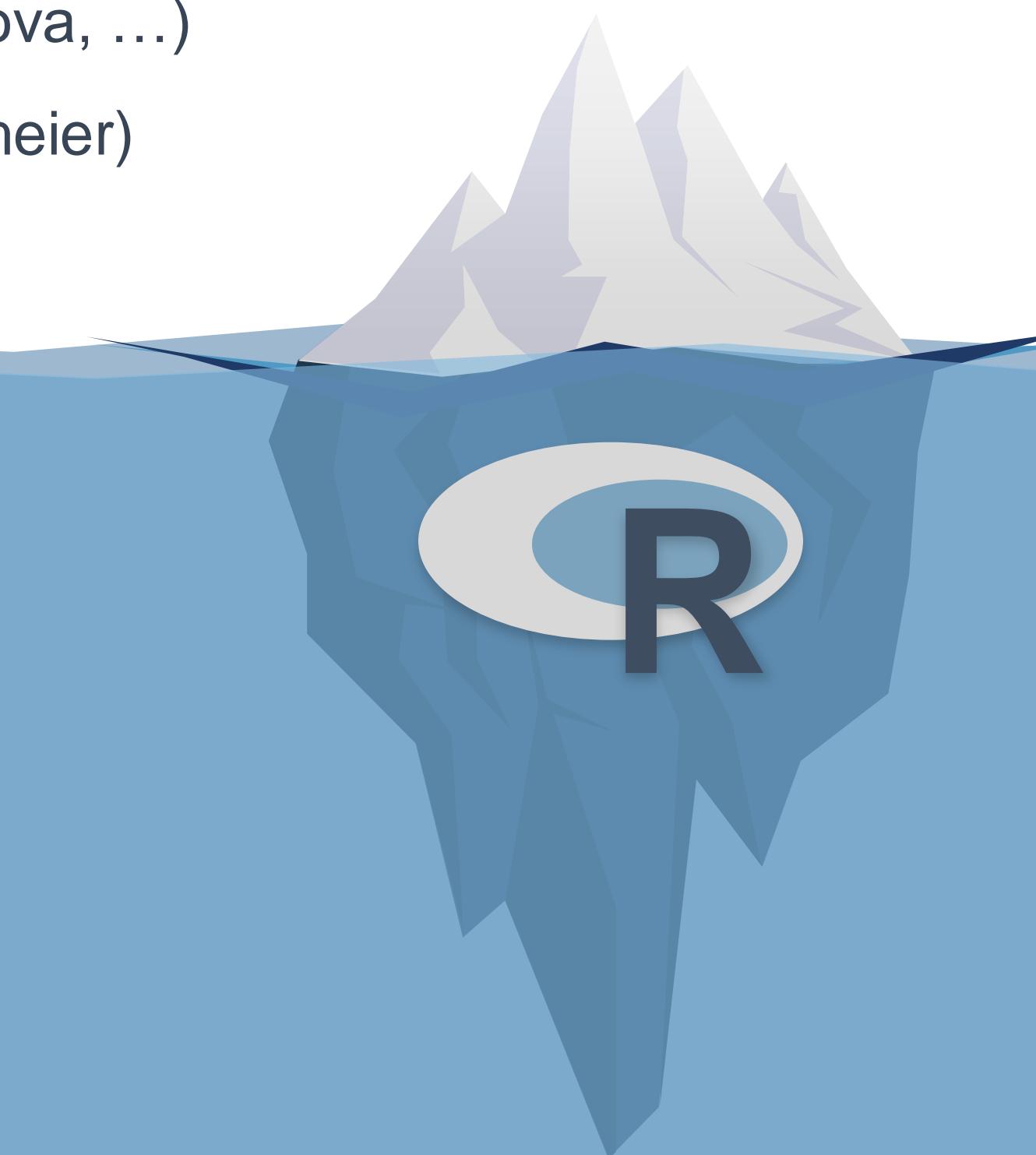
DATA MANGEMENT



EASY PLOTTING



BIOINFORMATIC ANALYSIS



— FROM EXCEL TO R

WANT MO-R-E?



The Section for Biostatistics offers a number statistics-oriented R courses:

Spring

[Basic Statistics for Health Researchers \(Danish course\)](#)

ECTS: 9,0

[Epidemiological methods in medical research](#)

ECTS: 7

[Advanced topics in health research B](#)

ECTS: 2,8

[Statistical methods in bioinformatics](#)

ECTS: 3,5

[Statistical analysis of survival data](#)

ECTS: 4,9

<https://publichealth.ku.dk/about-the-department/biostat/>

[Programming and statistical modelling in R](#)

ECTS: 1,6

[Bayesian methods in biomedical research](#)

ECTS: 2,4

[Psychometric validation of patient reported outcome measures](#)

ECTS: 2,5

[Introduction to validation of patient reported outcome measures](#)

[Causal inference I](#)

ECTS: 2,5

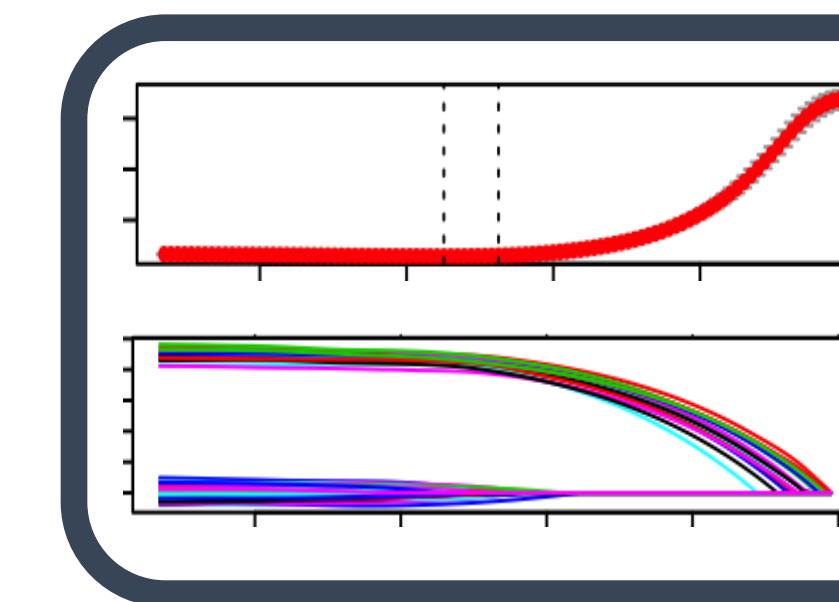
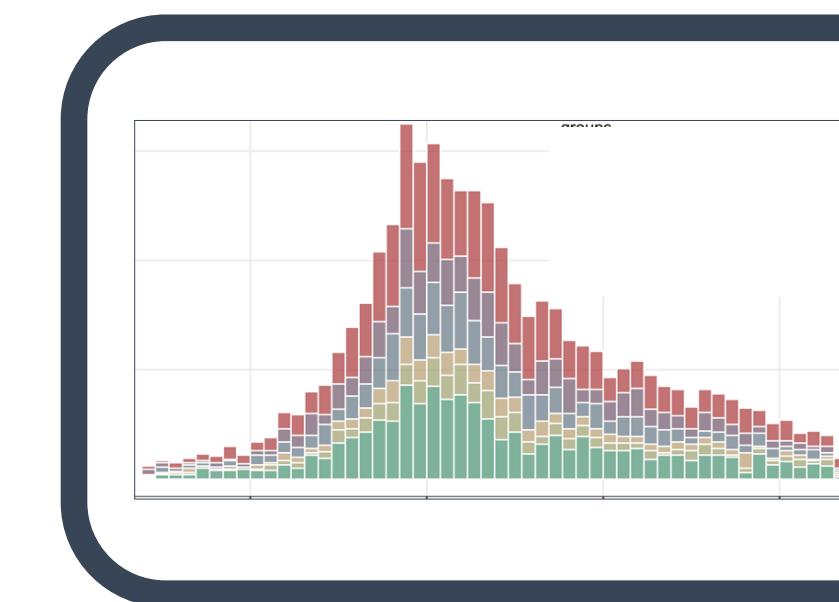
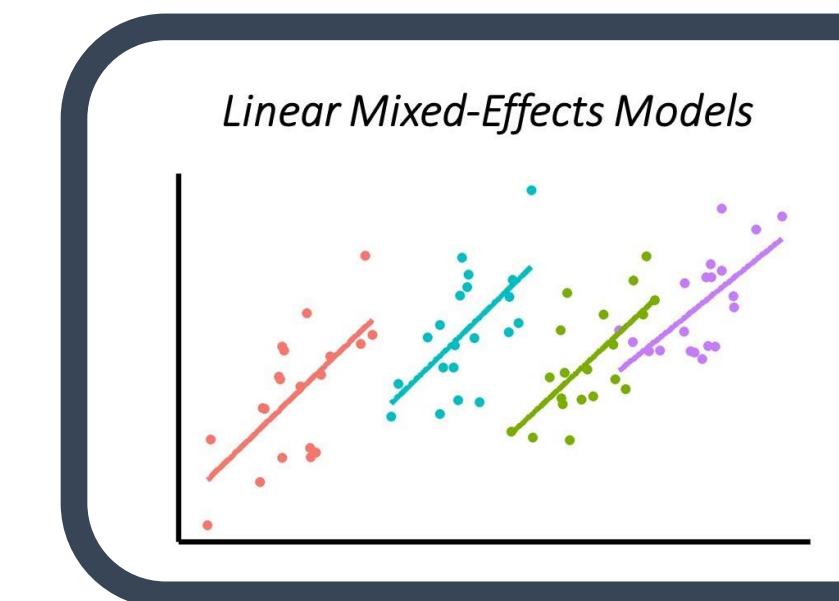
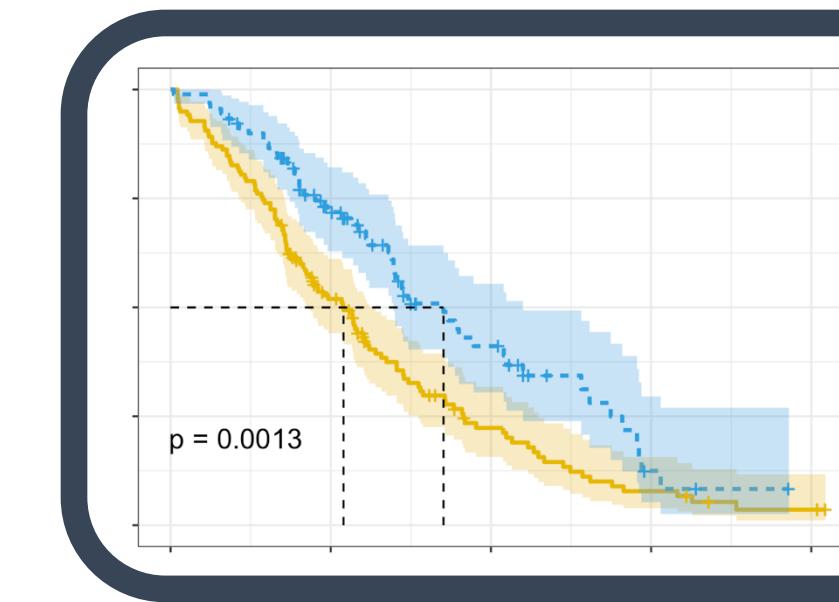
[Use of the statistical software R](#)

ECTS: 2,1

* These are screenshots. Go to the website and scroll down to 'Teaching'



— TEASER STATISTICS in R



Survival Analysis

survival: <https://rviews.rstudio.com/2017/09/25/survival-analysis-with-r/>
survminer: <https://cran.r-project.org/web/packages/survminer/survminer.pdf>
(<https://rpkgs.datanovia.com/survminer/>)

Mixed-Effects Models

lme4: <https://cran.r-project.org/web/packages/lme4/vignettes/lmer.pdf>
<https://cran.microsoft.com/snapshot/2017-08-01/web/packages/sjPlot/vignettes/sjplmer.html>
glmmTMB: <https://cran.r-project.org/web/packages/glmmTMB/index.html>

Epidemiological Analysis

Epi: <https://cran.r-project.org/web/packages/Epi/index.html>
pubh: <https://rviews.rstudio.com/2020/03/05/covid-19-epidemiology-with-r/>
https://cran.r-project.org/web/packages/incidence/vignettes/customize_plot.html
<https://rviews.rstudio.com/2020/03/05/covid-19-epidemiology-with-r/>

Elastic-Net Regression

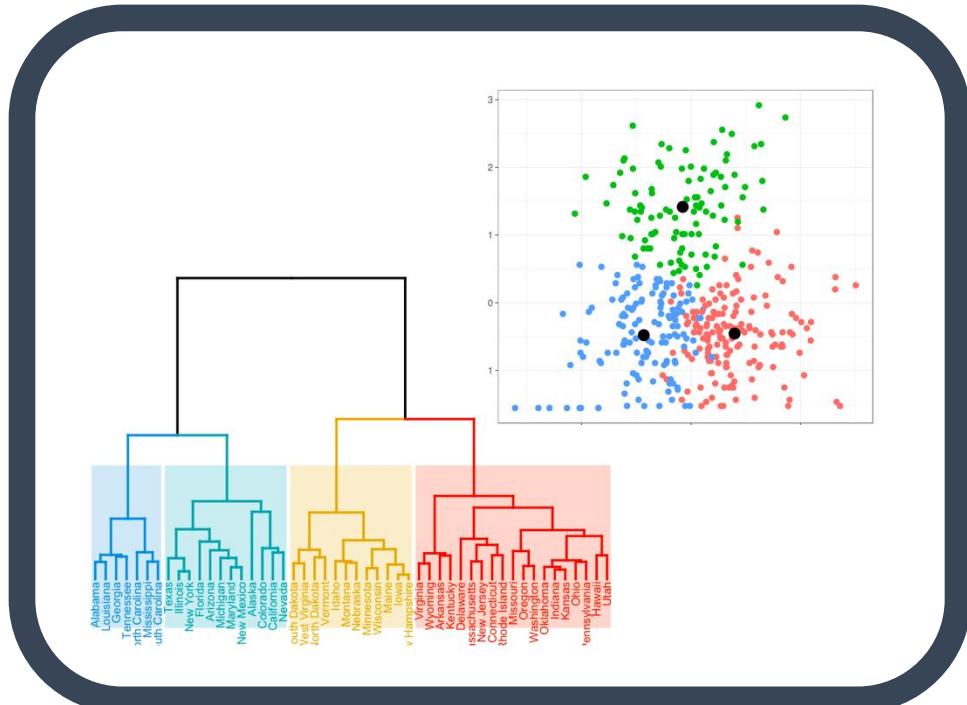
(R
glmnet: <https://cran.r-project.org/web/packages/glmnet/glmnet.pdf>
elasticnet: <https://cran.r-project.org/web/packages/elasticnet/elasticnet.pdf>
<https://www.datacamp.com/community/tutorials/tutorial-ridge-lasso-elastic-net>

TEASER

Machine Learning

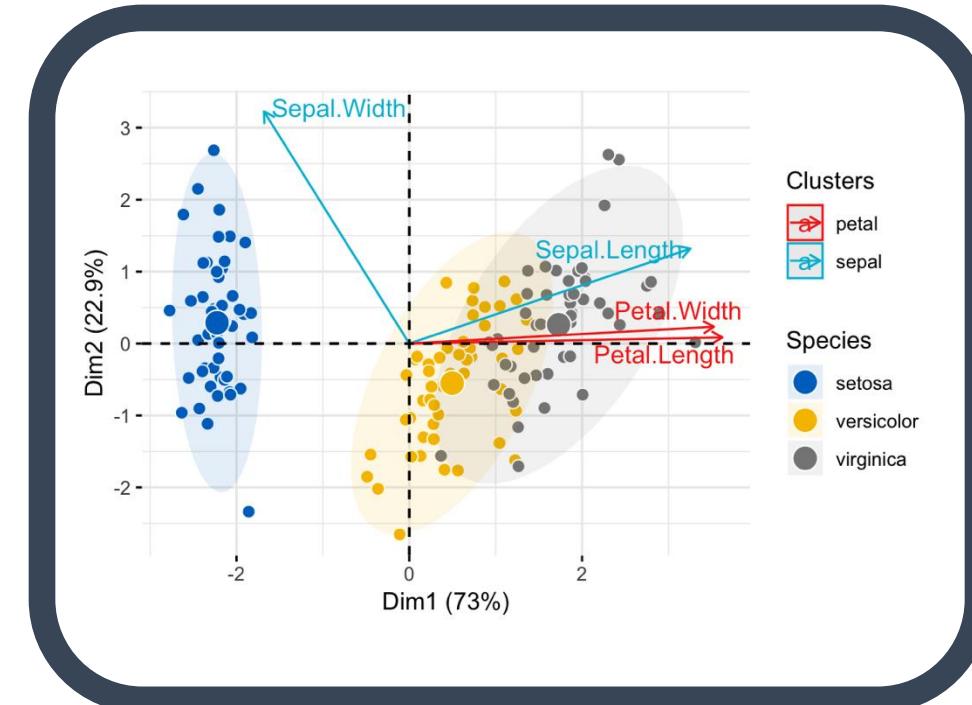
<https://lgatto.github.io/IntroMachineLearningWithR/an-introduction-to-machine-learning-with-r.html>

Clustering



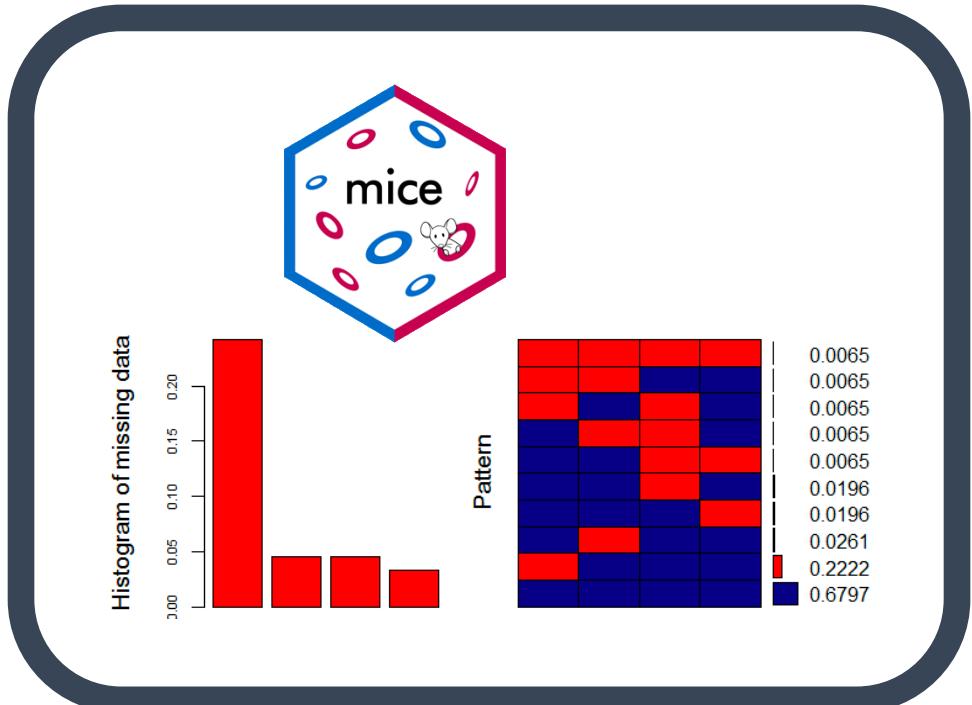
<https://statsandr.com/blog/clustering-analysis-k-means-and-hierarchical-clustering-by-hand-and-in-r/>

Feature Selection: PCA



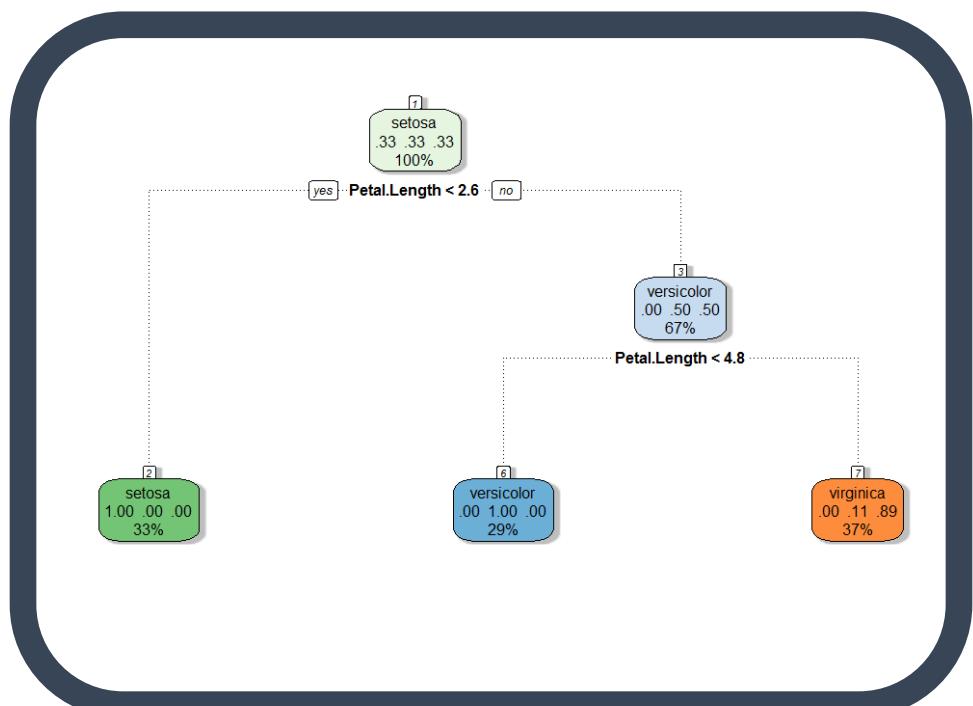
<https://bioconductor.org/packages/release/bioc/vignettes/PCAtools/inst/doc/PCAtools.html>

Missing Data



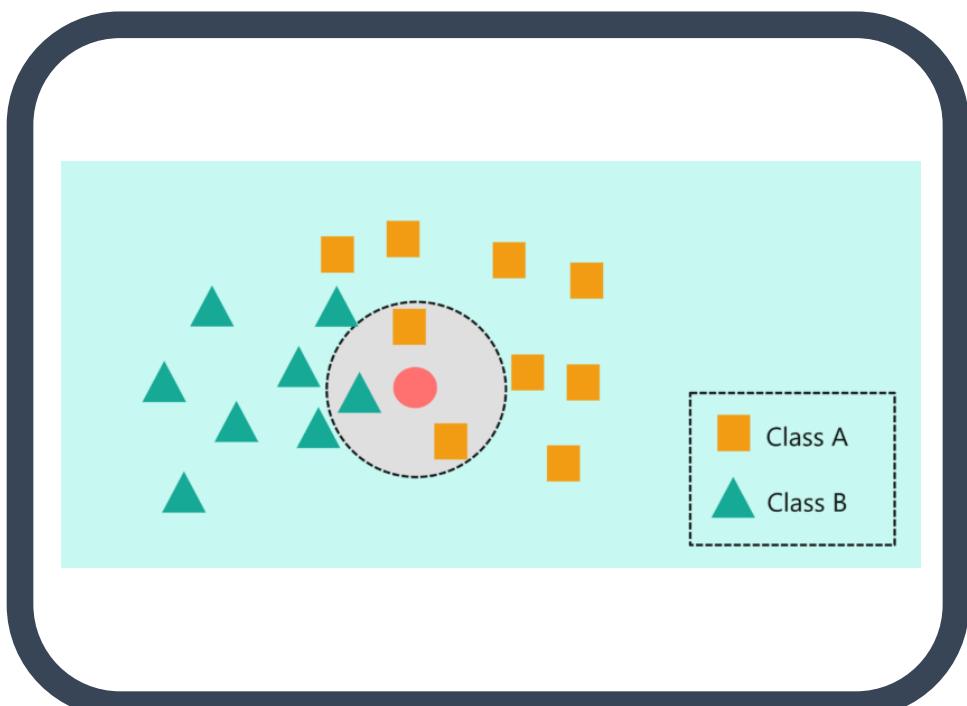
<https://amices.org/mice/>
<https://datascienceplus.com/imputing-missing-data-with-r-mice-package/>

Random Forest



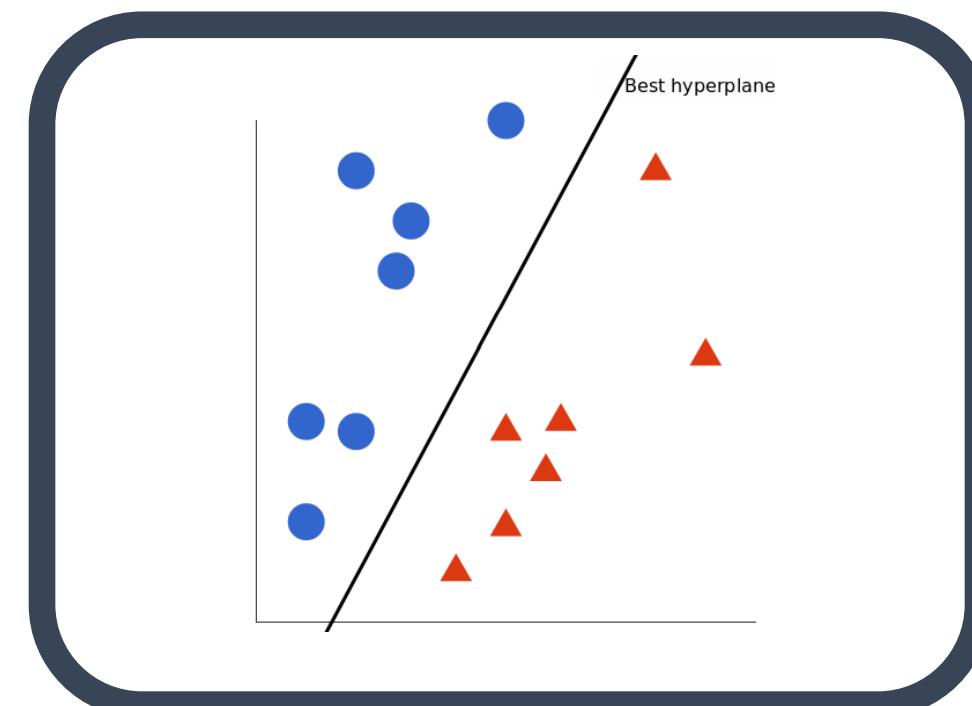
<https://www.blopig.com/blog/2017/04/a-very-basic-introduction-to-random-forests-using-r/>

kNN



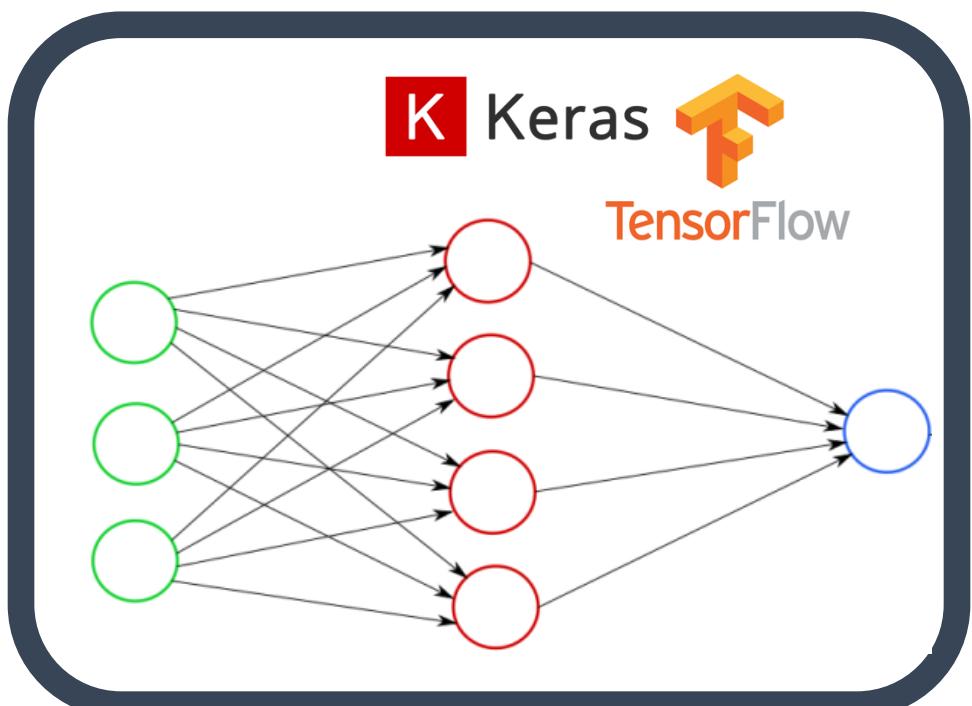
<https://www.edureka.co/blog/knn-algorithm-in-r/>

SVM



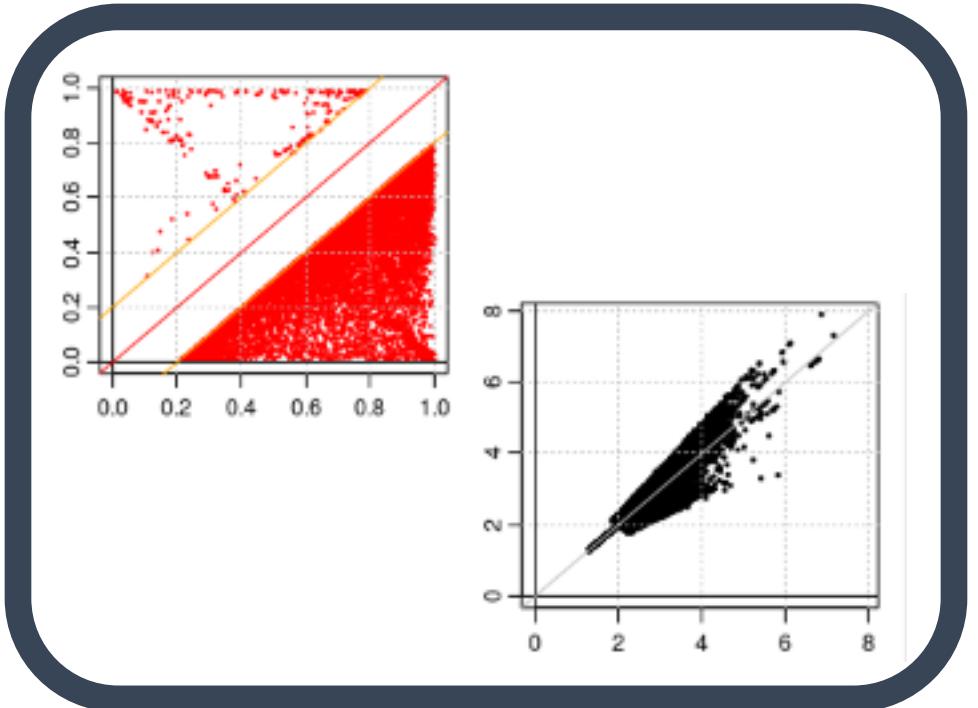
<https://cran.r-project.org/web/packages/e1071/vignettes/svmdoc.pdf>

Neural Networks



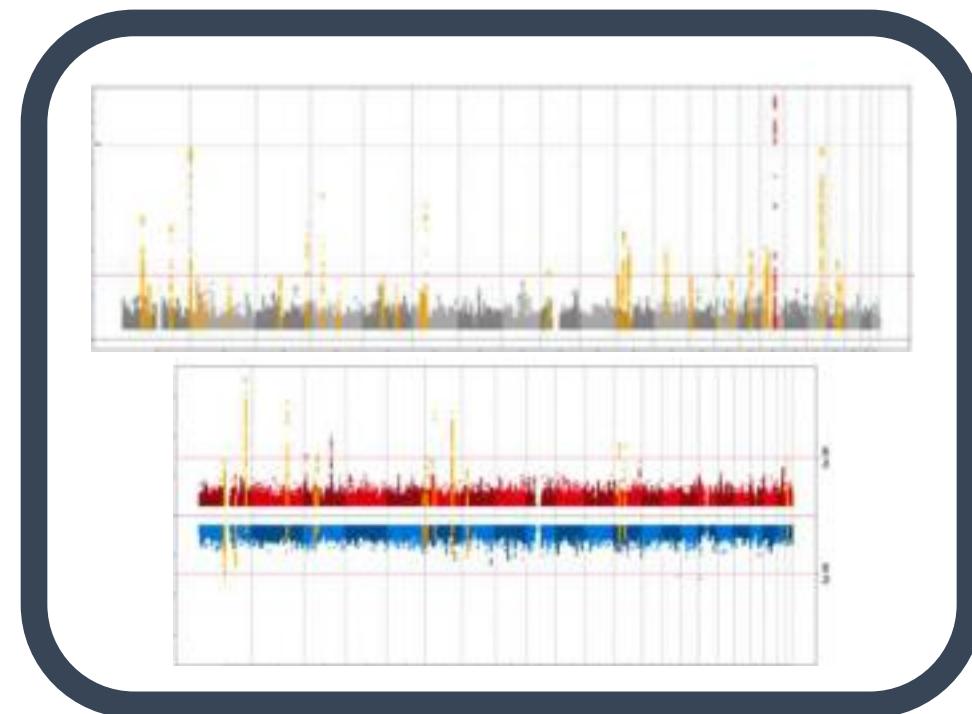
<https://keras.rstudio.com/>
<https://tensorflow.rstudio.com/>

GWAS - QC & Data Harmonization



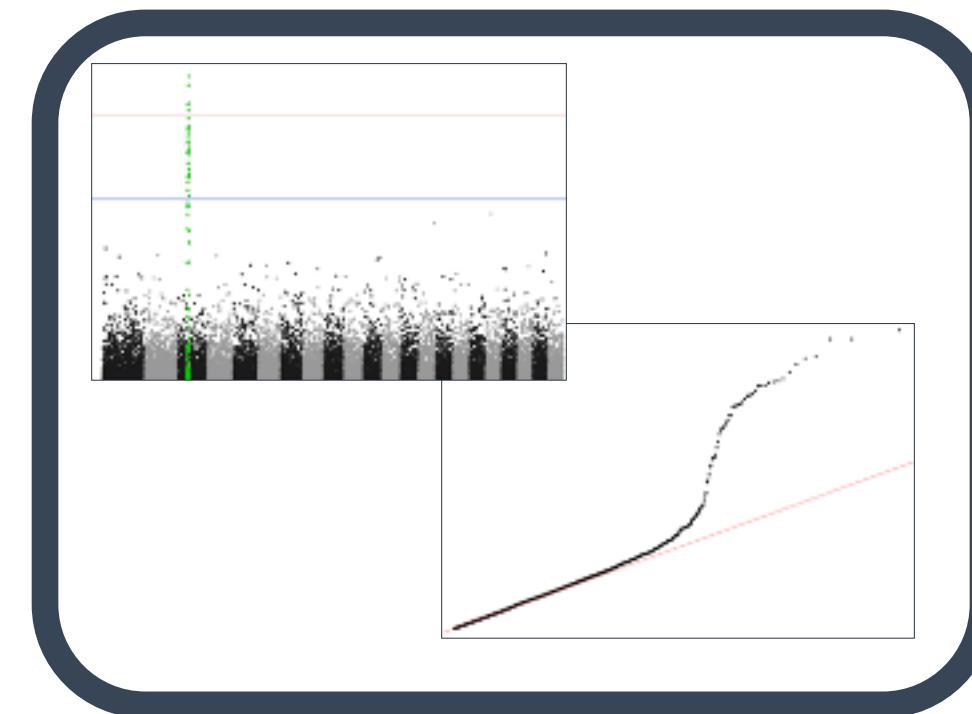
EasyQC: <https://www.uni-regensburg.de/medizin/epidemiologie-praeventivmedizin/genetische-epidemiologie/software/>

GWAS Data Management & Plots



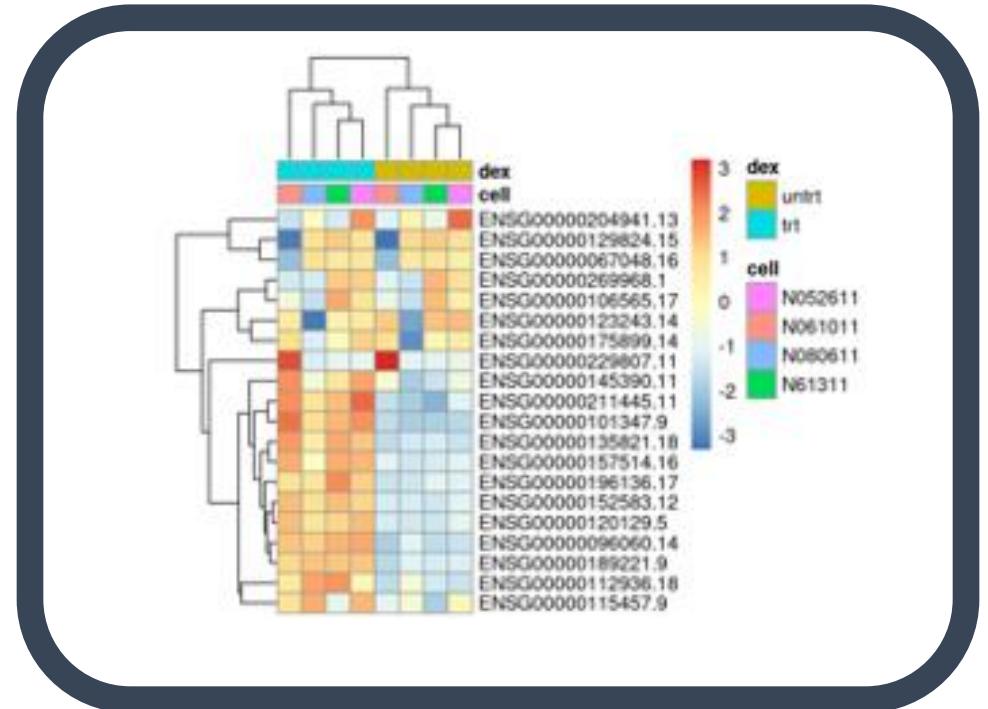
EasyStrata: <https://www.uni-regensburg.de/medizin/epidemiologie-praeventivmedizin/genetische-epidemiologie/software/>

More Plotting...



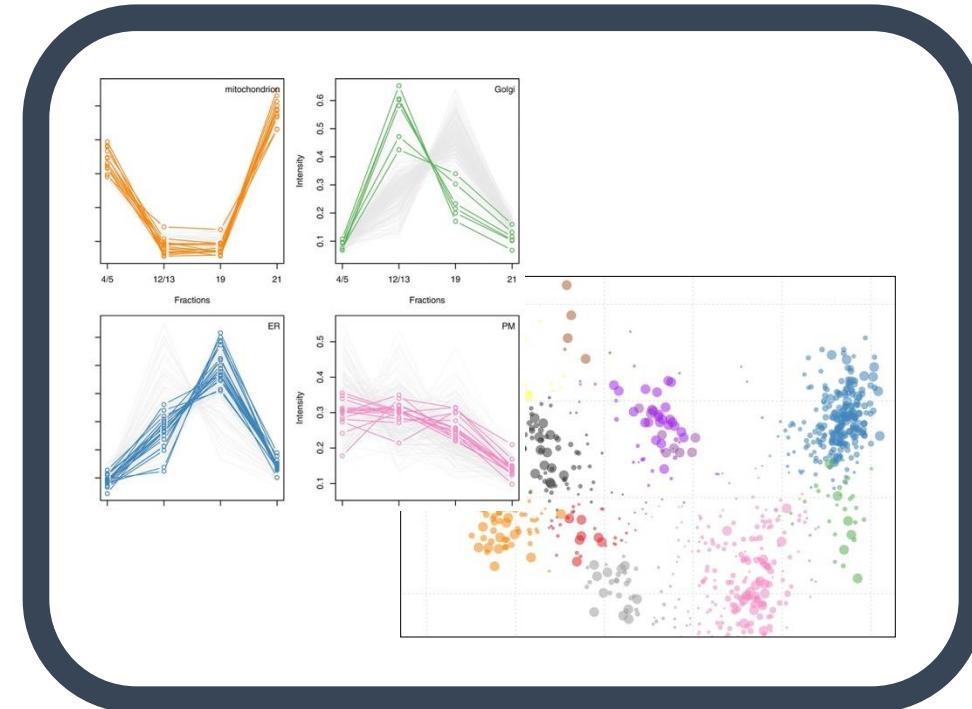
Manhattan and QQ plots:
<https://cran.r-project.org/web/packages/qqman/vignettes/qqman.html>

Gene Expression Analysis



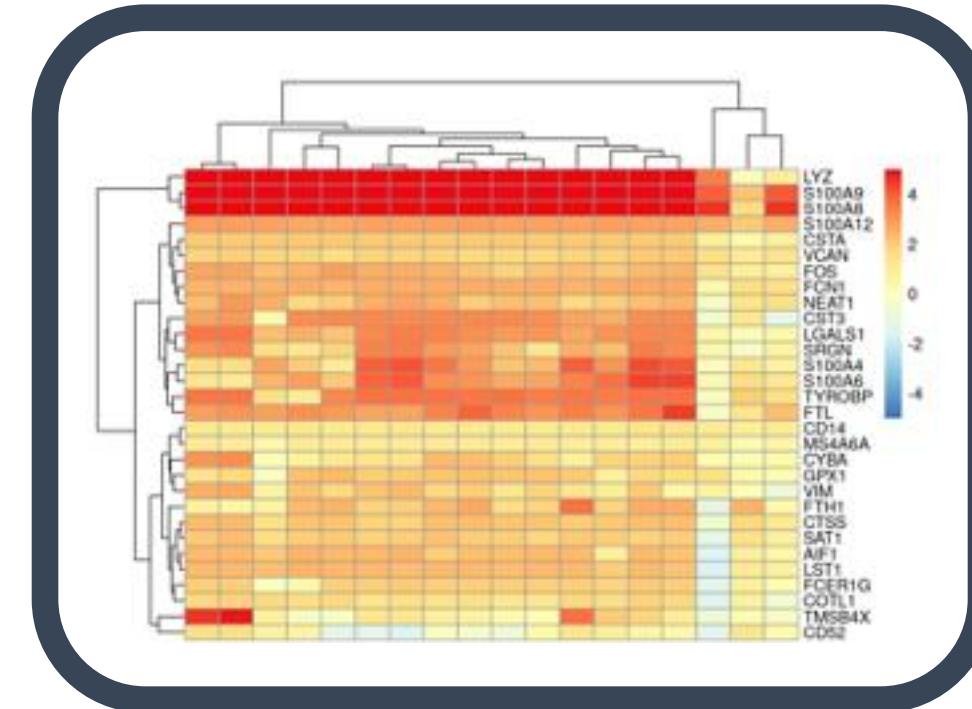
DESeq2, limma, EdgeR, etc.:
http://www.bioconductor.org/packages/release/BiocViews.html#_RNASeq

Proteomics Analysis



RforProteomics:
http://www.bioconductor.org/packages/release/BiocViews.html#__Proteomics_RforProteomics.html

Single-Cell RNASeq



<https://cran.r-project.org/web/packages/e1071/vignettes/svmdoc.pdf>

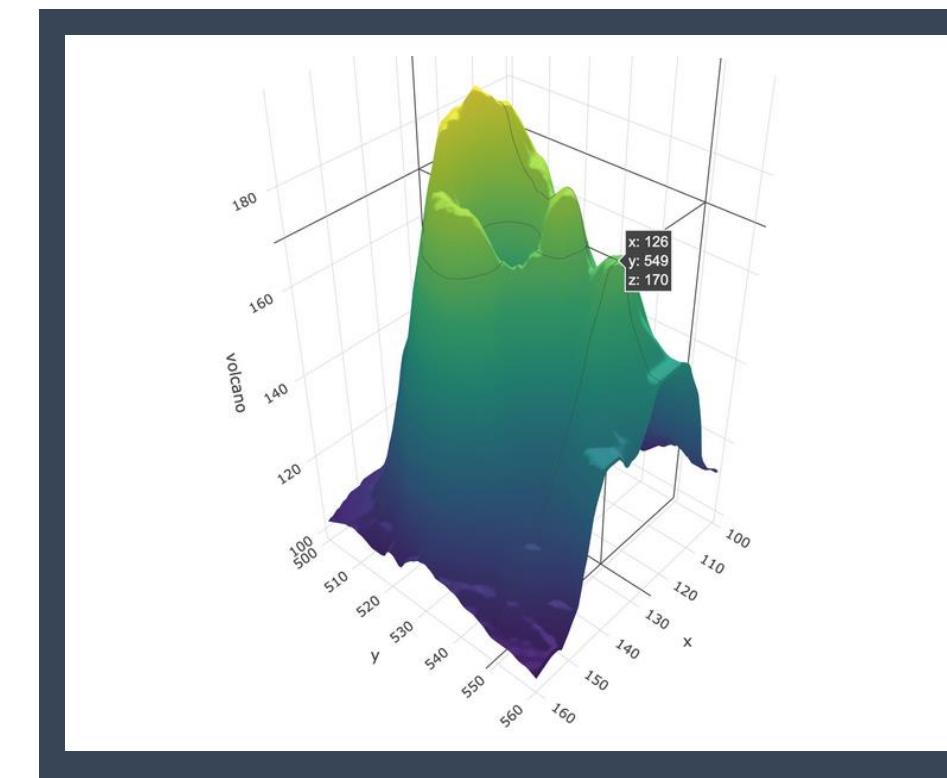
— TEASER Omics Data

<http://www.bioconductor.org/packages/release/BiocViews.html>

COOL STUFF IN R

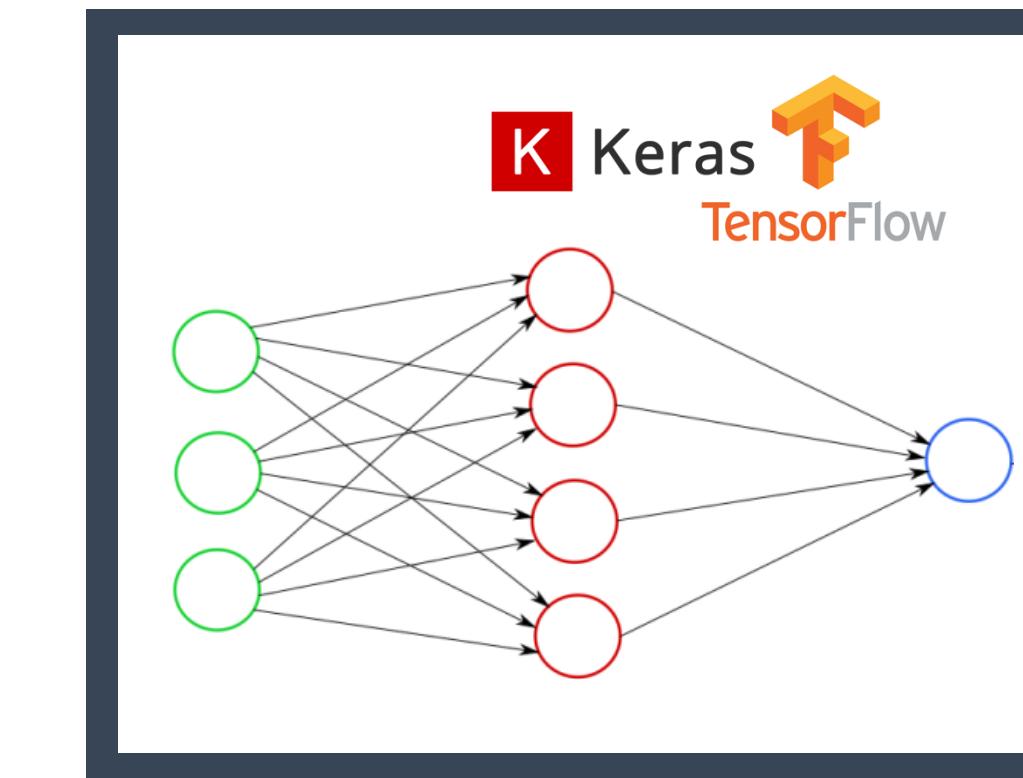
FROM EXCEL TO R

PLOTTING IN 3D



<https://plotly-r.com/d-charts.html>

DEEP LEARNING



<https://keras.rstudio.com/>
<https://tensorflow.rstudio.com/>

BAYESIAN STATISTICS



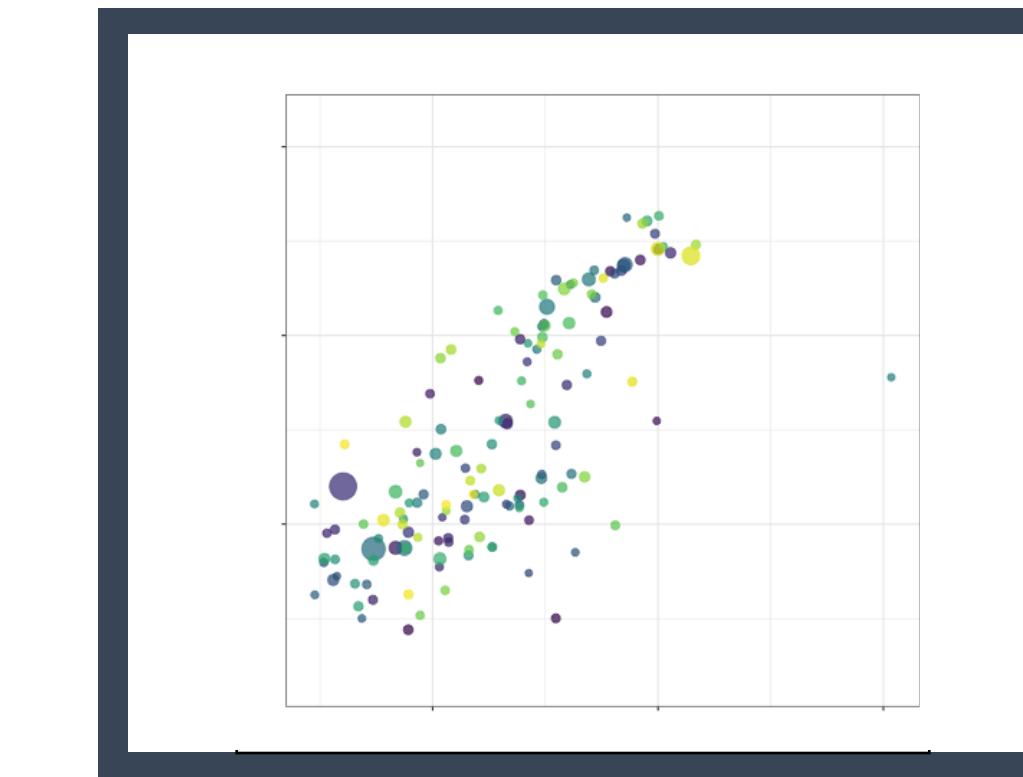
<https://mc-stan.org/users/interfaces/rstan>

WEBPAGE WITH R SHINY



<https://shiny.rstudio.com/>

INTERACTIVE PLOTS



<https://gganimate.com/articles/gganimate.html>

MAIL AND MESSAGES



<https://github.com/briandconnelly/pushoverr>

DATA SCIENCE WITH HEADS DATA LAB

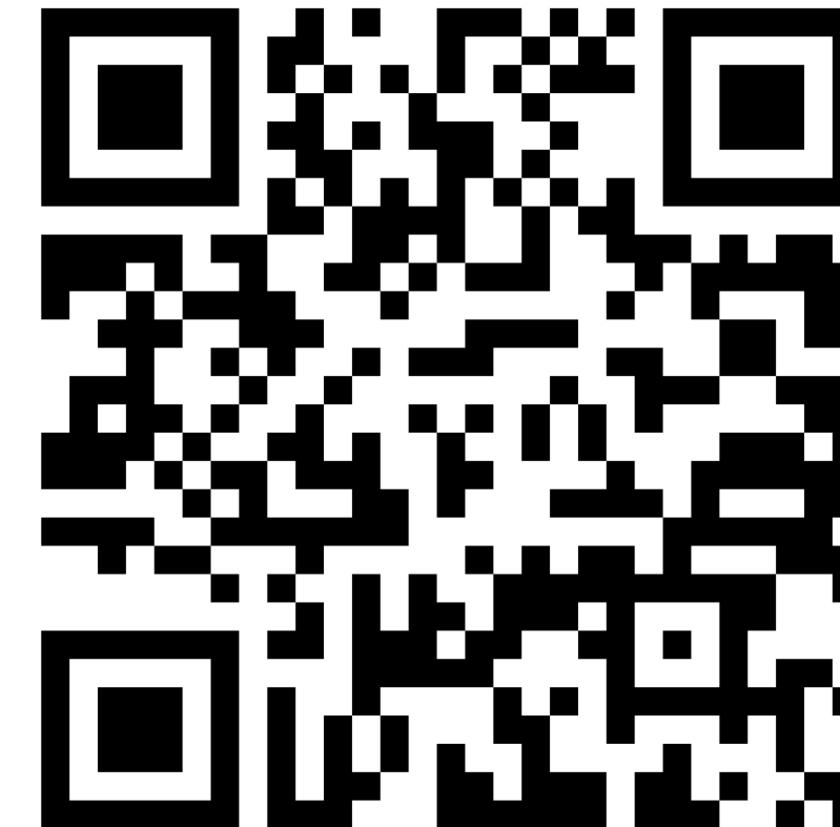
- Drop-in Thursday (13-15)
- Consultations
- Commission Research & Supervision

- Events and Conferences
- Course Reminders



Read more on HeaDS Website!

<https://heads.ku.dk>



Follow HeaDS on LinkedIn!

<https://www.linkedin.com/company/ucph-heads/>

THANK YOU FOR LISTENING



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