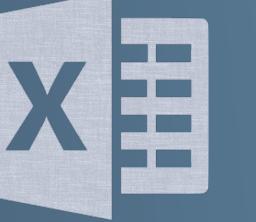


FROM  EXCEL TO 



# WHO ARE WE?

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

SUND Center, which includes a KU data lab

- **Consultation & Collaboration:**
  - Data science and bioinformatics analyses, e.g. big data, -omics analysis, machine learning.
- **Teaching; Courses & Workshops, Seminars, etc.**

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

Dep. of Math and Computer Science, Faculty of SCIENCE



Thilde Terkelsen



Diana Andrejeva



Tugce Karaderi



Henrike Zschach



Bo Markussen



Helle Sørensen



— FROM EXCEL TO R

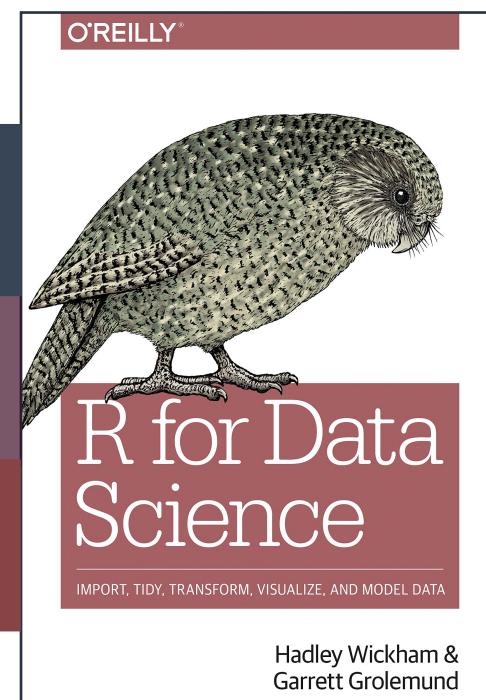
# THE PRACTICALS



Two days: 9.00-16.30. There will be coffee breaks, we promise ☕

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

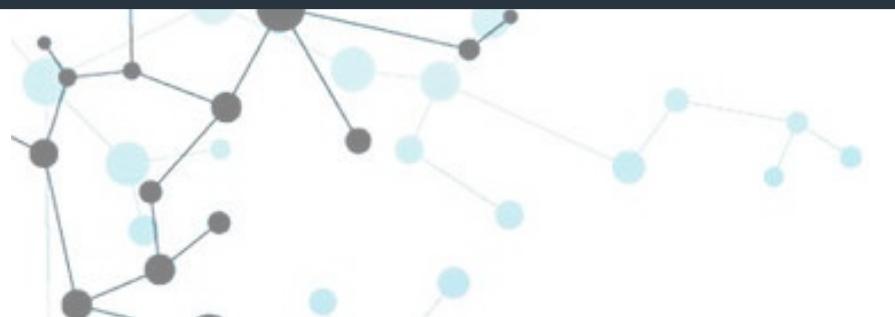
The course is build on hands-on presentations (.R, .Rmd) & exercises



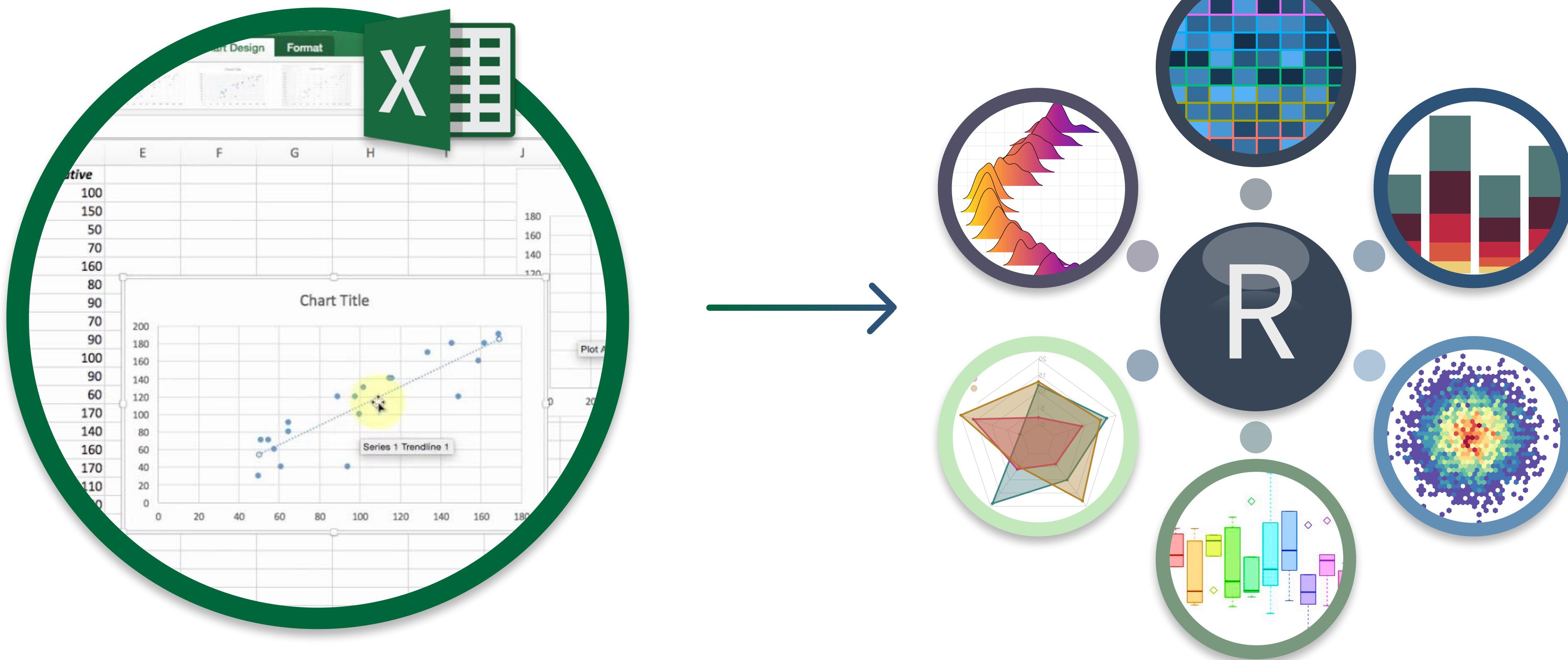
→ Download and install the newest version of R (<https://cran.r-project.org/>)

→ Download and install the newest version of R-studio (<http://www.rstudio.com/download>)

→ Download the course material and place it somewhere you can find it again!  
<https://github.com/Center-for-Health-Data-Science/FromExceltoR>



# WELCOME TO FROM EXCEL TO R

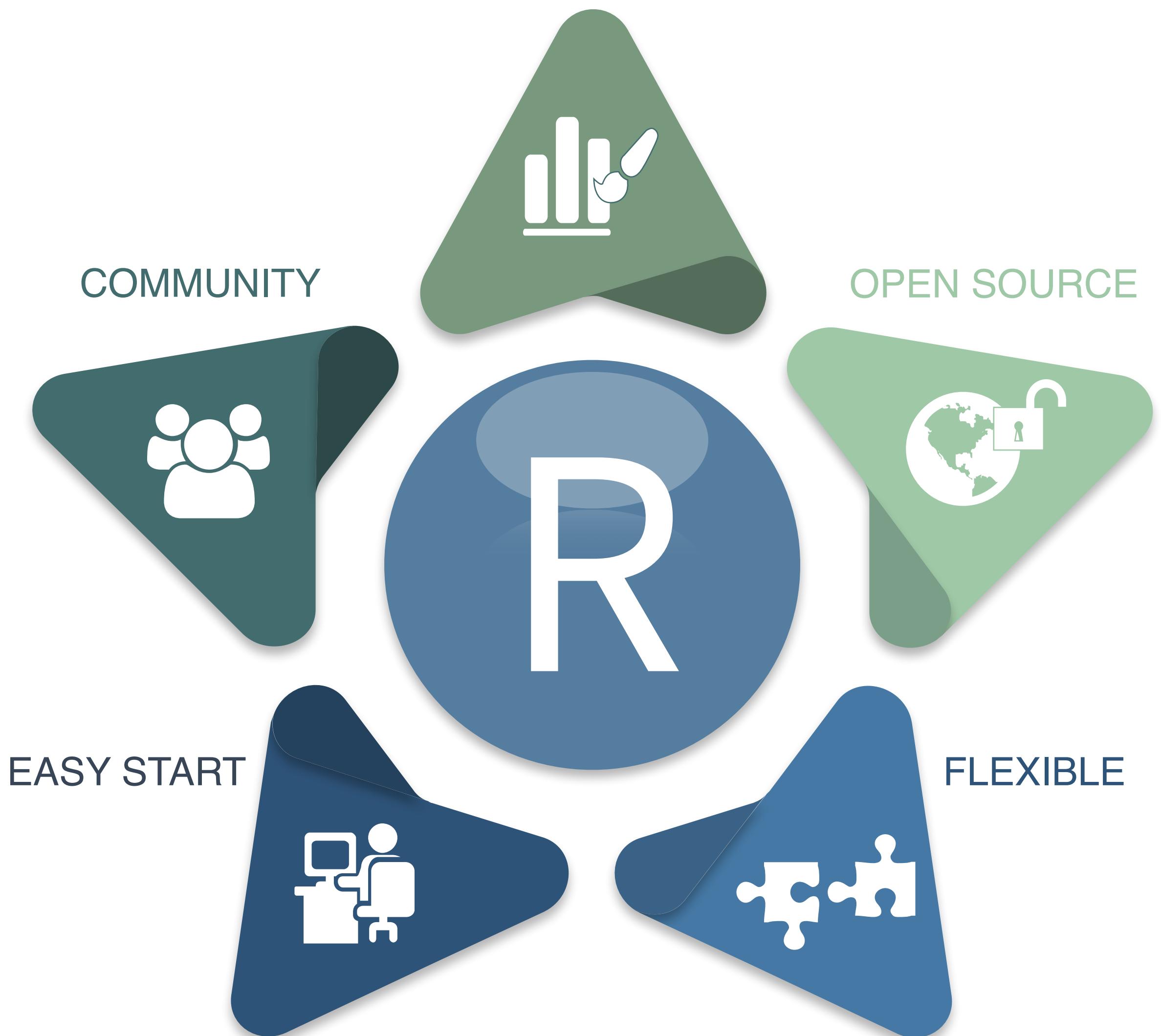


## WHY R ?

- **Open Source**
- **Easy to get started with:**  
Compatible with all systems, great support
- **Large Community:**  
R-packages, pipelines, tutorials, help pages
- **Flexible Language:**  
Plugins, C++, Python, git/github, markdown
- **Customisable Graphics**

R has its **limitations**, but now fewer than ever

## GRAPHICS



A COMPARISON

# FROM EXCEL TO R



# WHAT WILL YOU LEARN IN THIS COURSE?

## DATA WRANGLING



tidyverse  
Data Structures  
Useful Functions  
Pipe (“clean” code)

## THE BASICS



R base syntax  
R Studio  
Scripts, paths, files  
R project  
Help resources

## PLOTTING



ggplot2  
Code structure  
ggplot2 + tidy data



## STATISTICS IN R

## REPRODUCIBILITY



R Markdown  
Doc. types  
Good practices  
Other cool things

# PROGRAM

**DATES:** 15-06 & 16-06, 2022

**PLACE:** Faculty of Health and Medical Sciences,  
Panum, Holst Auditorium

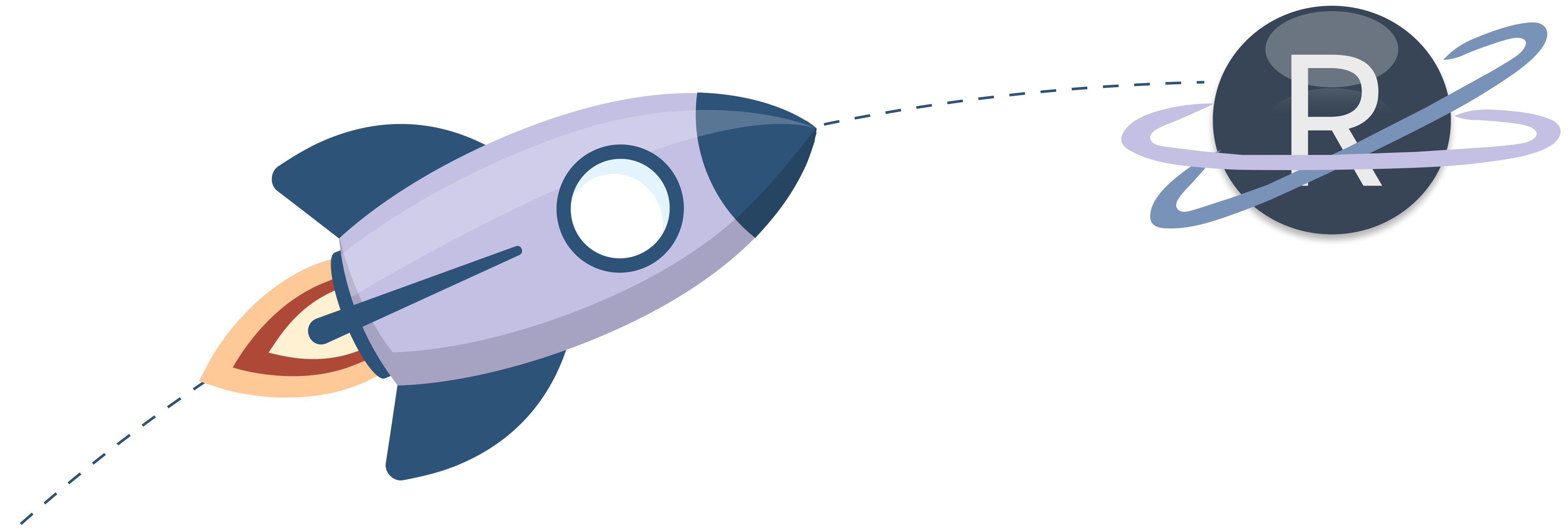
## DAY 1

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

## DAY 2

09:00 - Q&A  
09:20 - Rmarkdown  
09:50 - Rmarkdown Exercise  
10:15 - Break  
10:30 - Statistics in R  
12:00 - Lunch  
13:00 - Statistics Exercise  
14:00 - Q&A  
14:15 - Break & Course Evaluation  
14:30 - Own Dataset Exercise  
16:00 - Other cool things in R  
16:15 - Wrap up and see you

— FROM EXCEL TO R  
LET'S GET STARTED



## R & FRIENDS



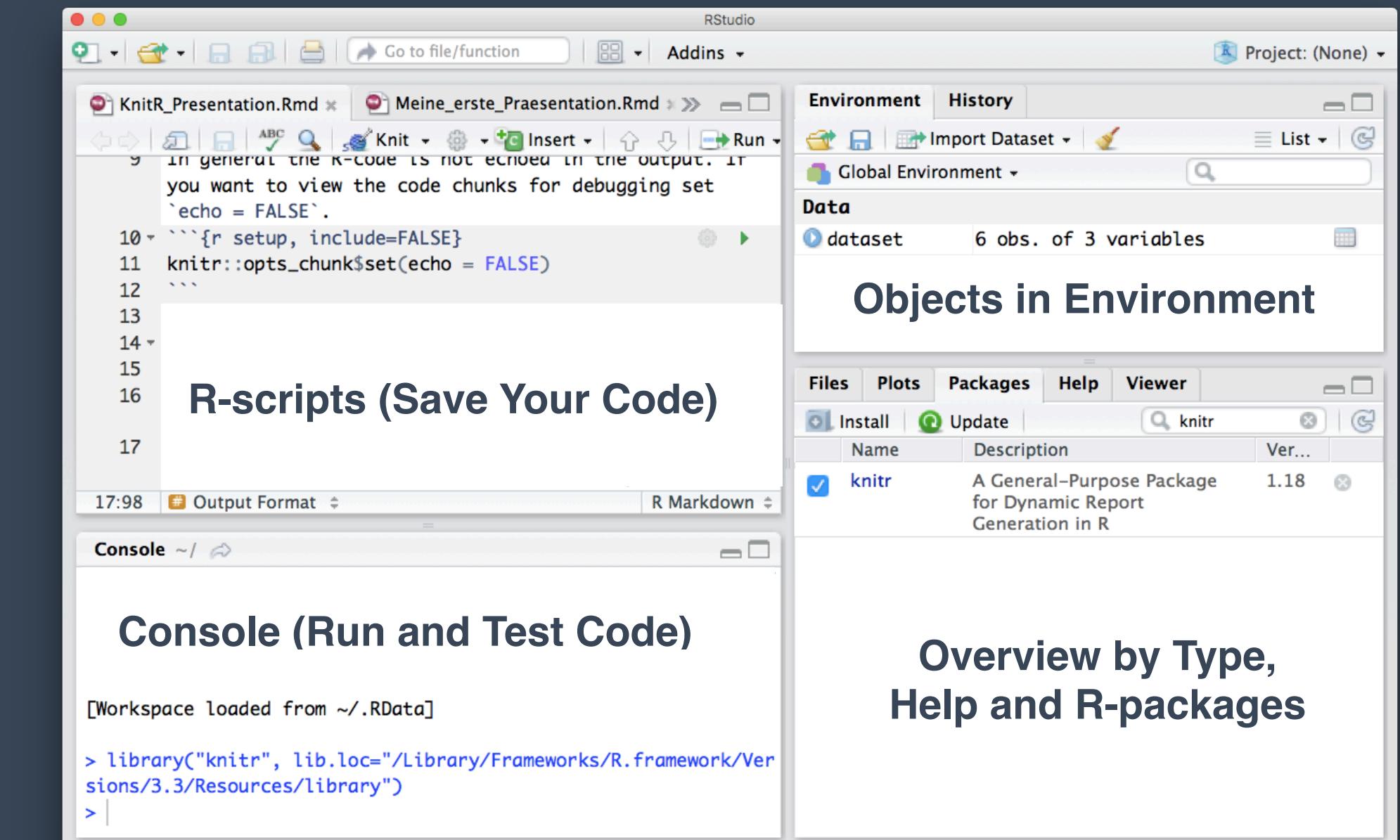
Scripting / Programming Language



Reports (html, pdf, latex)

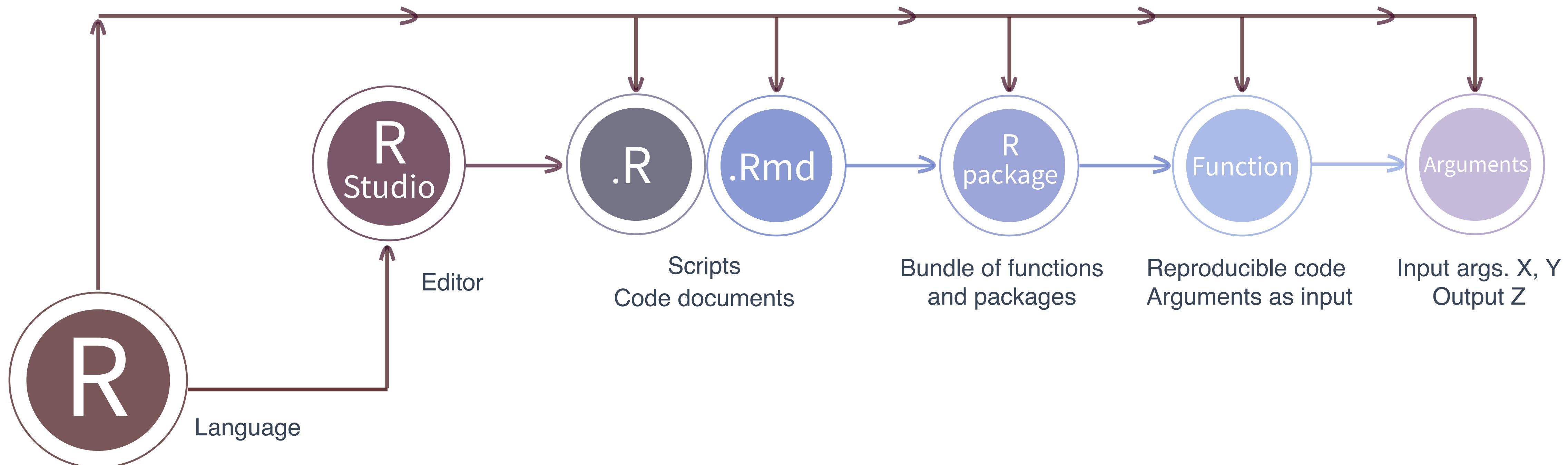


R Studio



R Code Interpreter and Editor

# THE ANATOMY OF R



# FIRST TIME IN R?

## PACKAGES & FUNCTIONS

?*my.package*, ?*my.function*

What is it? Input?

*install.packages()*, *remove.packages()*

## TIPS

Arrows↑↓ to find the code you ran

R studio tips: view, diagnostics

✖️⚠️ Auto-complete with tab

R-cheat sheets (<https://rstudio.com/resources/cheatsheets/>)



## WORKING DIRECTORY

*setwd()*, *getwd()*, *list.files()*, *list.dirs()*

Where am I working from? Full/relative path.

## SAVE YOUR WORK

.R, (or .Rmd)

The file with my code. Save it!

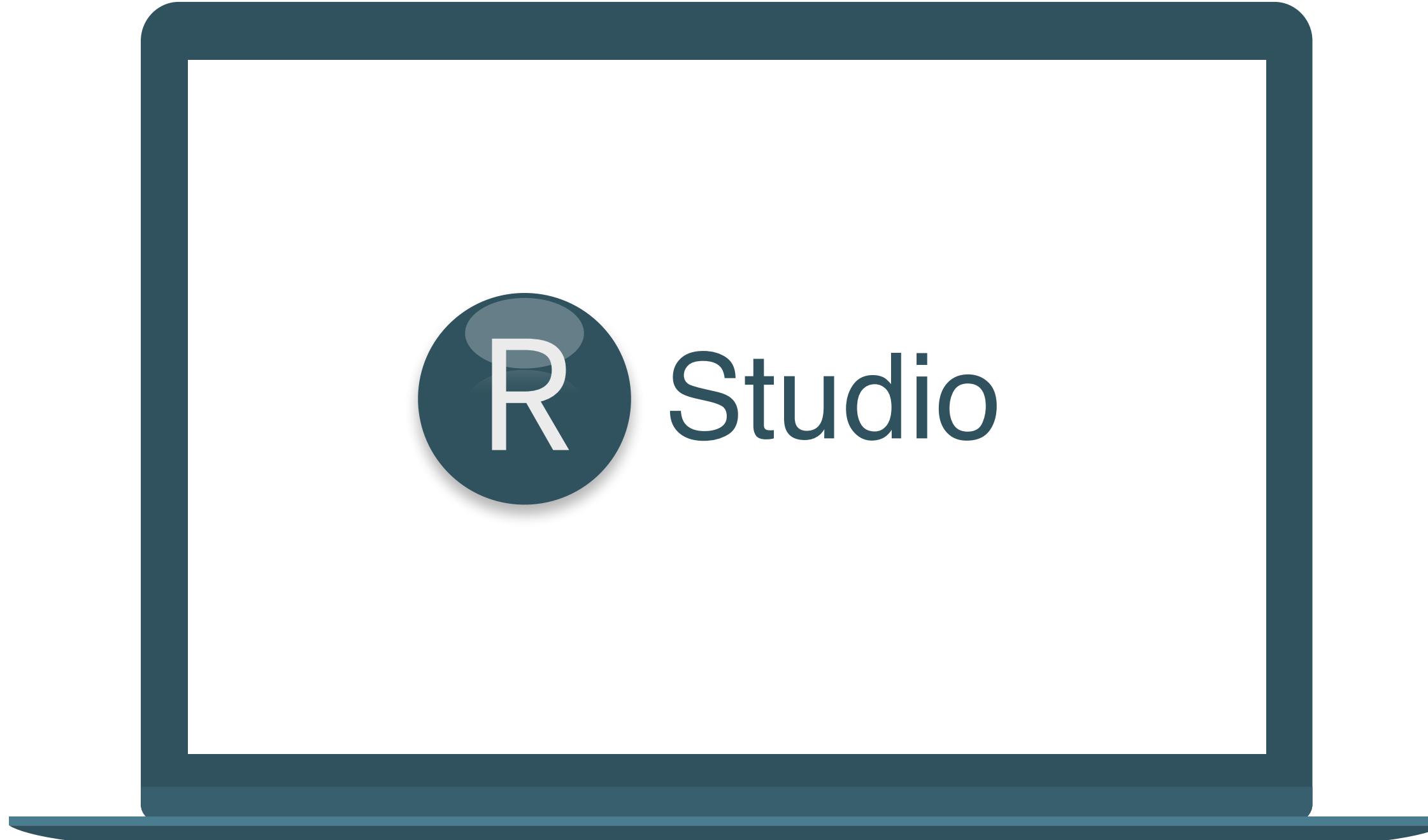
*R project*

Save Session, everything together

## RUN CODE

Run button, highlight enter, short-cut

# R STUDIO BASICS



## 1. R Project

*File —> New Project —> New/Existing —> Create Project*

## 2. Set Path

**getwd()** - Get directory  
**setwd()** - Set directory

**setwd("/Users/Tom/Rstuff")** - Full path  
**setwd("./Rstuff")** - Relative path

*Session —> Set Working Directory —> Choose Directory*

## 3. R Script

*Script Icon —> R Script —> File —> Save as ...*

## 4. Install and load a R package.

**install.packages("my.package")**  
**library (my.package)** - Load package.

*Tools —> Install packages —> my.package*

# ONLINE RESOURCES FOR R

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



## GET STARTED

<https://rseek.org/>

<https://rstudio.com/resources/cheatsheets/>

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

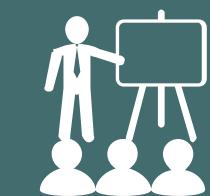
<https://www.statmethods.net/r-tutorial/index.html>



## 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>

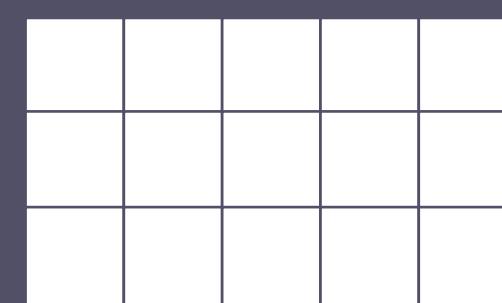
<https://blog.revolutionanalytics.com/>

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



# R DATA TYPES & STRUCTURES

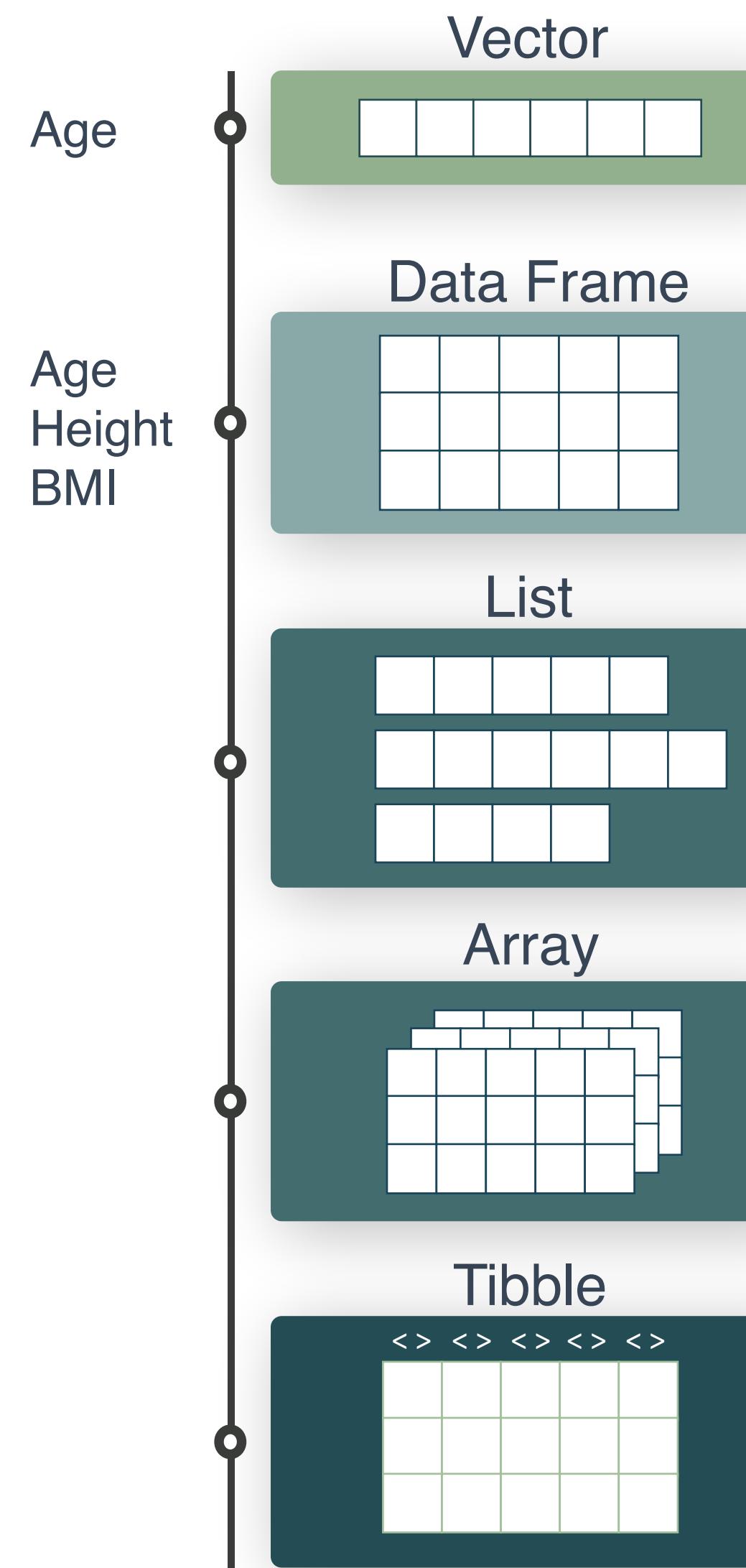
VARIABLES



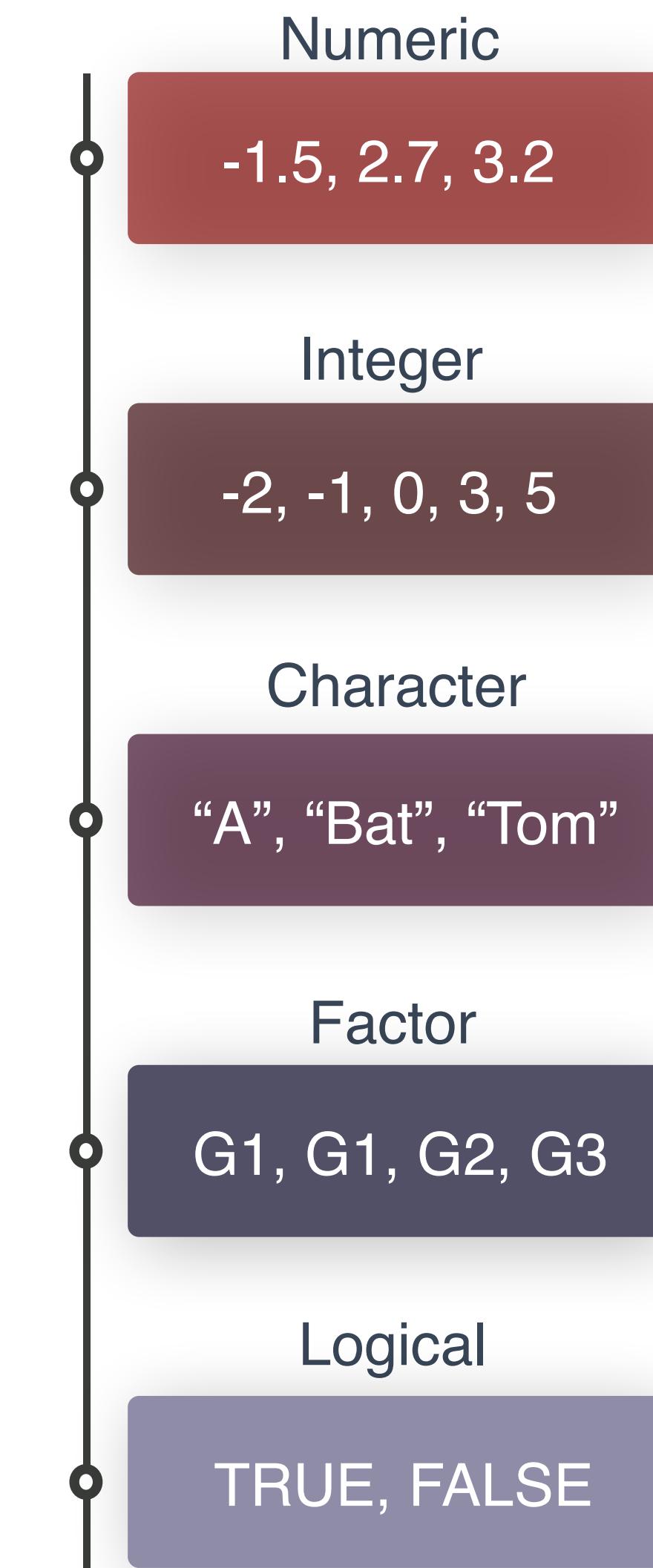
OBSERVATIONS

— FROM EXCEL TO R

## DATA STRUCTURES



## DATA TYPES



# R BASE SYNTAX - RUN THROUGH

## VARIABLE ASSIGNMENT

```
> a <- 'apple'  
> a  
[1] 'apple'
```

```
> x <- c(1.5, 2.6, 1.7, 3.2, 3.0, 2.9, ...)  
> x  
[1] 1.5 2.6 1.7 3.2 3.0 2.9 ...
```

## READING AND WRITING DATA

Input	Output	Description
<code>df &lt;- read.table('file.txt')</code>	<code>write.table(df, 'file.txt')</code>	Read and write a delimited text file.
<code>df &lt;- read.csv('file.csv')</code>	<code>write.csv(df, 'file.csv')</code>	Read and write a comma separated value file. This is a special case of read.table/write.table.
<code>load('file.RData')</code>	<code>save(df, file = 'file.Rdata')</code>	Read and write an R data file, a file type special for R.

## DON'T USE

Spaces in names

Special characters  
% ? / | \ & \$ @

Unspecific names

Short/long names

# R BASE SYNTAX - RUN THROUGH

## SELECTING ELEMENTS

**x[4]** The fourth element.

**x[-4]** All but the fourth.

**x[2:4]** Elements two to four.

**x[!(2:4)]** All elements except two to four.

**x[c(1, 5)]** Elements one and five.

### By Value

**x[x == 10]** Elements which are equal to 10.

**x[x < 0]** All elements less than zero.

**x[x %in% c(1, 2, 5)]** Elements in the set 1, 2, 5.

## R-BASE FUNCTIONS

**log(x)** Natural log.

**exp(x)** Exponential.

**max(x)** Largest element.

**min(x)** Smallest element.

**round(x, n)** Round to n decimal places.

**sig.fig(x, n)** Round to n significant figures.

**cor(x, y)** Correlation.

**sum(x)** Sum.

**mean(x)** Mean.

**median(x)** Median.

**quantile(x)** Percentage quantiles.

**rank(x)** Rank of elements.

**var(x)** The variance.

**sd(x)** The standard deviation.

## CONDITIONS

<b>a == b</b>	Are equal	<b>a &gt; b</b>	Greater than	<b>a &gt;= b</b>	Greater than or equal to	<b>is.na(a)</b>	Is missing
<b>a != b</b>	Not equal	<b>a &lt; b</b>	Less than	<b>a &lt;= b</b>	Less than or equal to	<b>is.null(a)</b>	Is null

# BASE R CHEAT SHEET

**Basics:** `getwd()`, `setwd() # location`  
`install.packages('pname')`, `library(pname)`  
`ls()`, `rm() # list, remove objects`  
`load()`, `data()`, `save() # load, save as .Rdata`

**Overview:** `head(df, n=10)`, `df[1:10, ]` `tail(df, n=10)`  
# first or last 10 rows  
`class()` # data structure  
`unique()`, `table() # unique vals, count vals`

**Is/As type:**

`is.numeric(x)` (character, factor, integer, etc.)  
`as.numeric(x)` (factor, matrix, data.frame, etc.)

**Other:** `seq(1, 10, by = 1.0) # sequence from-to`  
`rep(x, times) # replicate n times`  
`sort(), reverse() # sort or reverse vector`

**Read in data:**

`read.xlsx('name.xlsx')`,  
`read.delim('name.txt', sep = '\t')`  
`read.csv('name.csv', sep=';')`

**Make Data:** `c() # vector`

`data.frame(x=x,y=y)`  
`matrix(x, nrow = 3, ncol = 3)`  
`list(x=x, y=y)`

**Strings:**

`paste(x, y, sep = '')`  
`grep('pattern', x) # find str pattern`  
`gsub('pattern', 'replace', x) # replace with`

**Plots:**

`plot(x)`  
`plot(x,y) # scatter`  
`hist(x) # histogram`

**GETTING  
STARTED**

**DATA STRUCTURES  
& OVERVIEW**

**DATA TYPES &  
STRINGS**

**VECTORS &  
BASE PLOTS**

## GETTING HELP



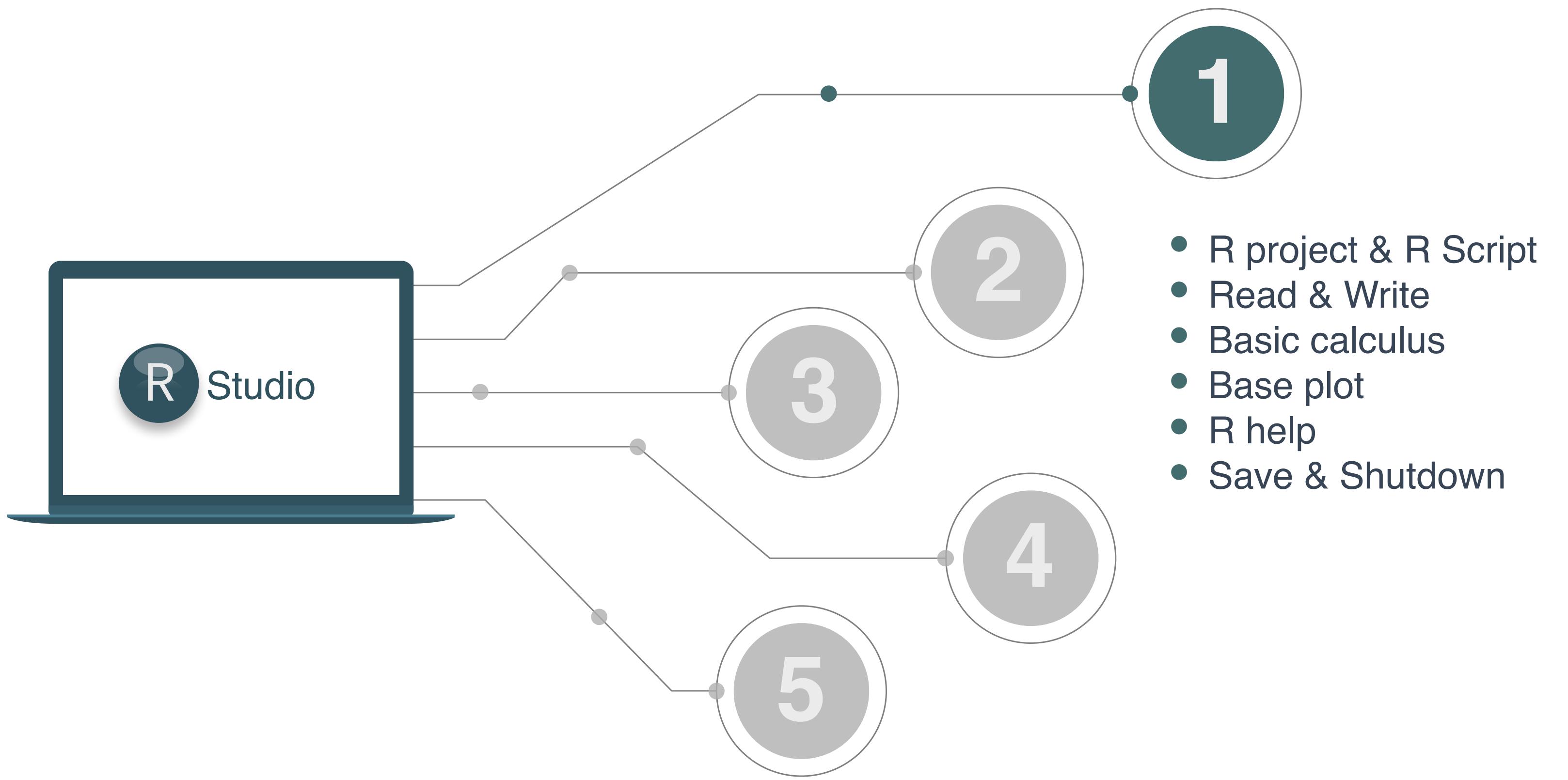
02

## GETTING HELP

1. Ask us, and ask people next to you.
2. Look at the R presentations we go through.
3. Use the **cheat sheets** in this presentation and online: <https://rstudio.com/resources/cheatsheets/>

**Google it!** Most important skill of all.

You will get the **solutions** to the exercises near the end of the day.



— FUNDAMENTALS  
**EXERCISE 1**

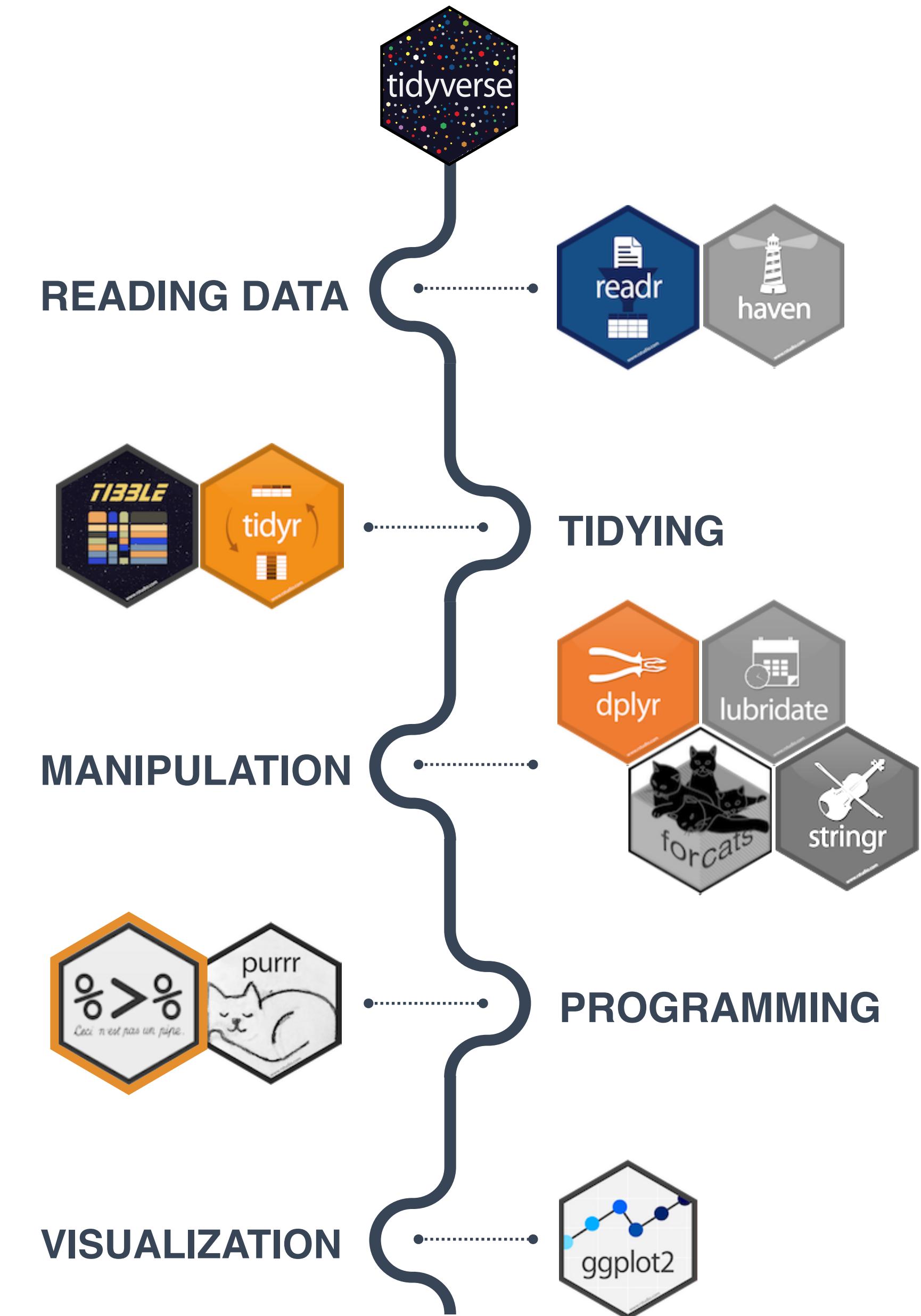
# TIDYVERSE

<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



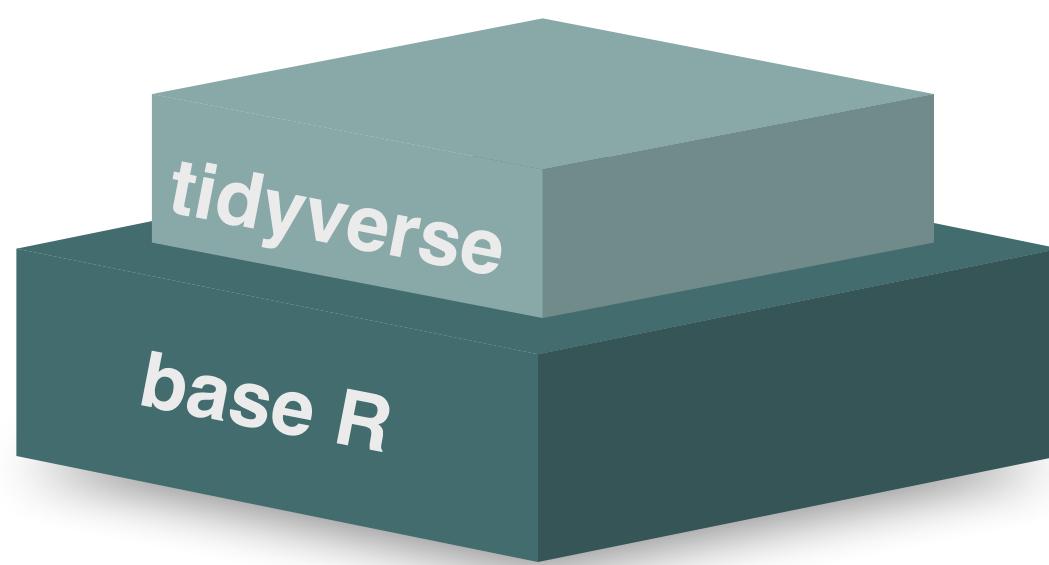
# CECI N'EST PAS UNE PIPE

## %>%

- 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

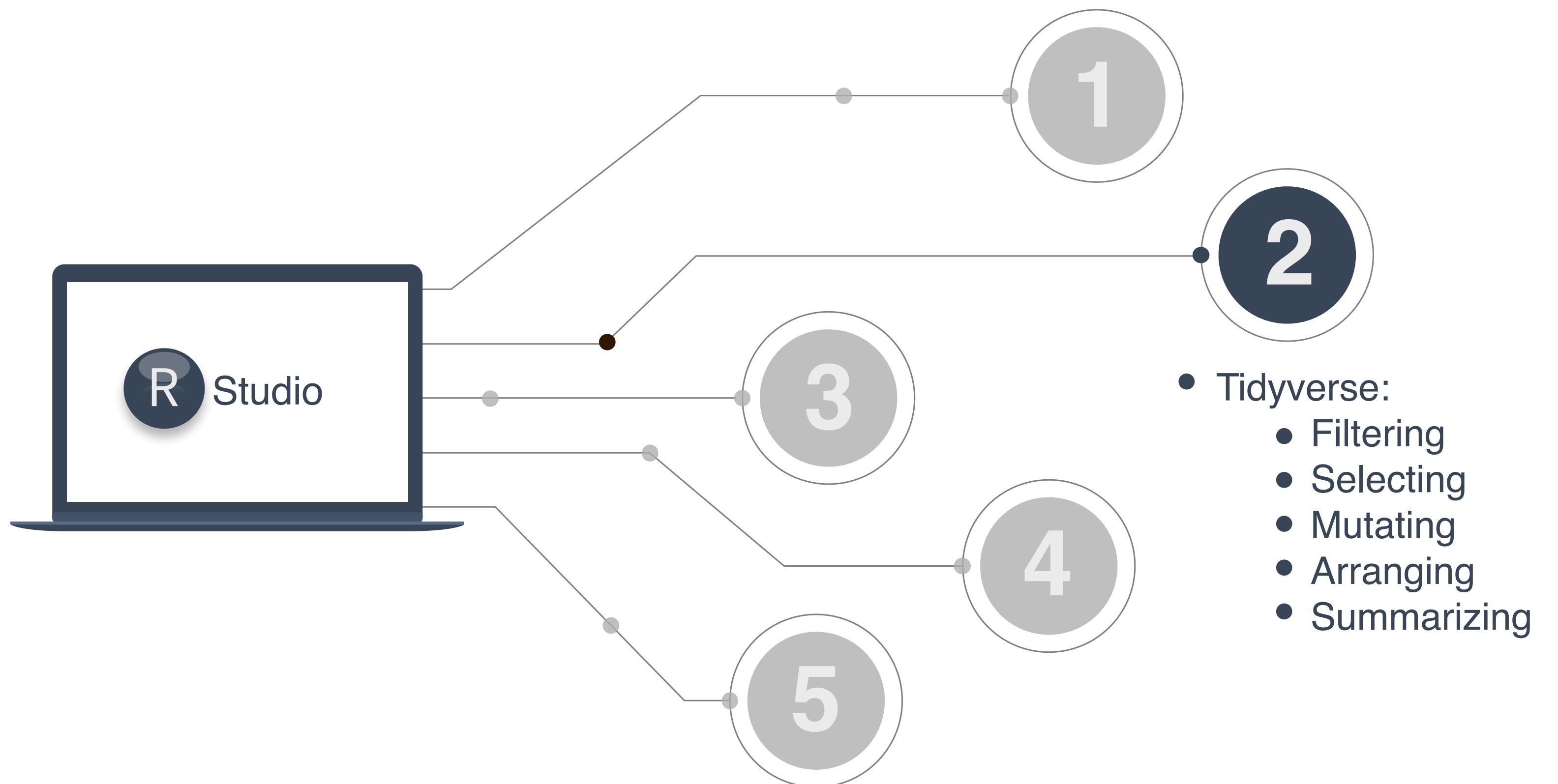
```
# think from the inside out  
g(f(x,y),z)
```

### tidyverse

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



pipe symbol



---

TIDYVERSE  
EXERCISE 2

# 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: ...")

## 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"

## Data Tidying (*tidyr*)

### Handle missing values

`drop_na()`  
`fill()`  
`replace_na()`

### Subsetting

`tibble[ :,1:5 ]` # returns a tibble  
`tibble$colname` # returns a vector  
(same as `tibble[[colname]]`)

### Reorganize layout

Change between long and wide format  
`gather()` # wide to long  
`spread()` # long to wide

## Data Manipulation (*dplyr*)

### Summary

`summarise()`/`summarize()`  
`count()`

### Group

`group_by()`

Functions will manipulate each group separately and combine results.

### Extract and sort observations # i.e. rows

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

### Manipulate variables # i.e. columns

`select()`  
`mutate(new_name = f(column))`

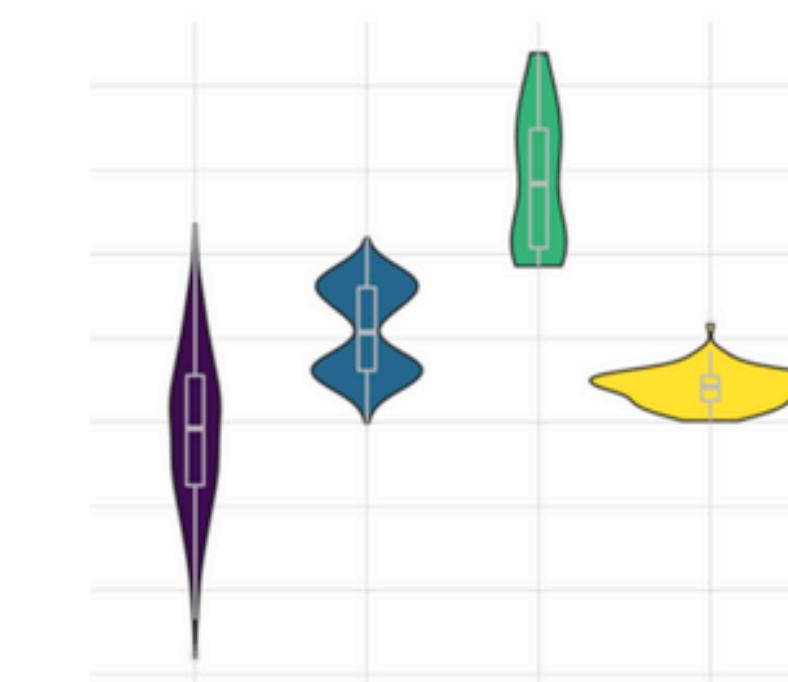
### Vectorised functions

Ranking: `percent_rank()`  
Math: Any arithmetic or logical operations, `between()`,  
`near()`  
`if_else()`

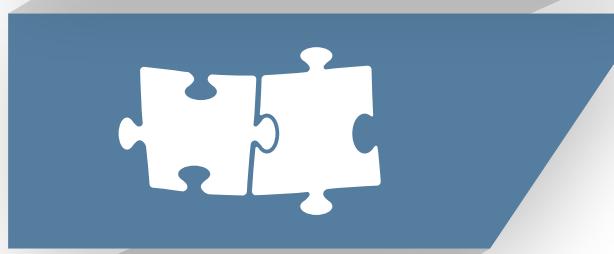
# GGPLOT2 - EASY GRAPHICS



Aesthetically pleasing graphics.



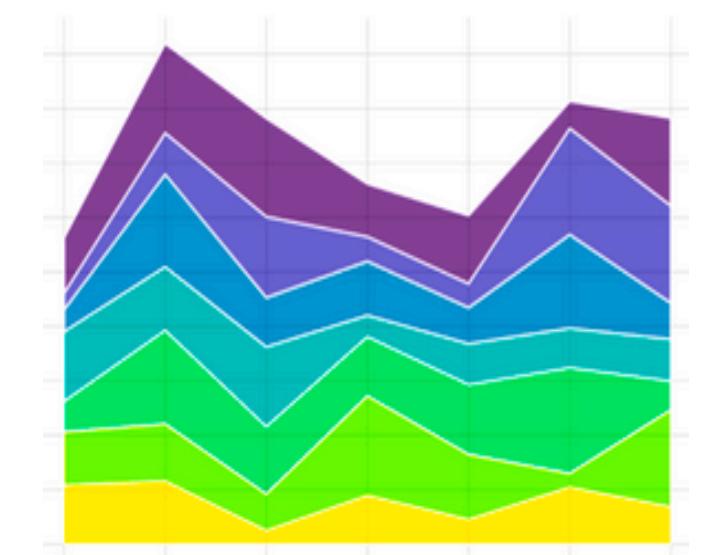
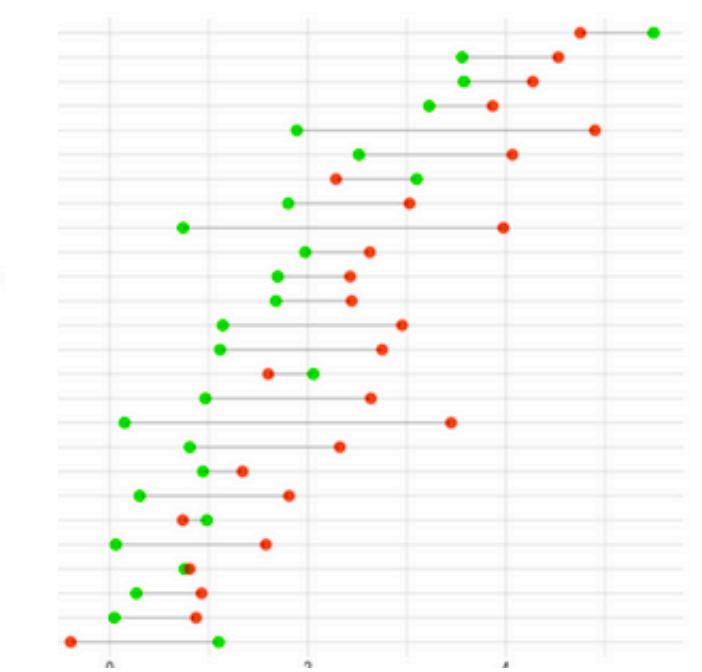
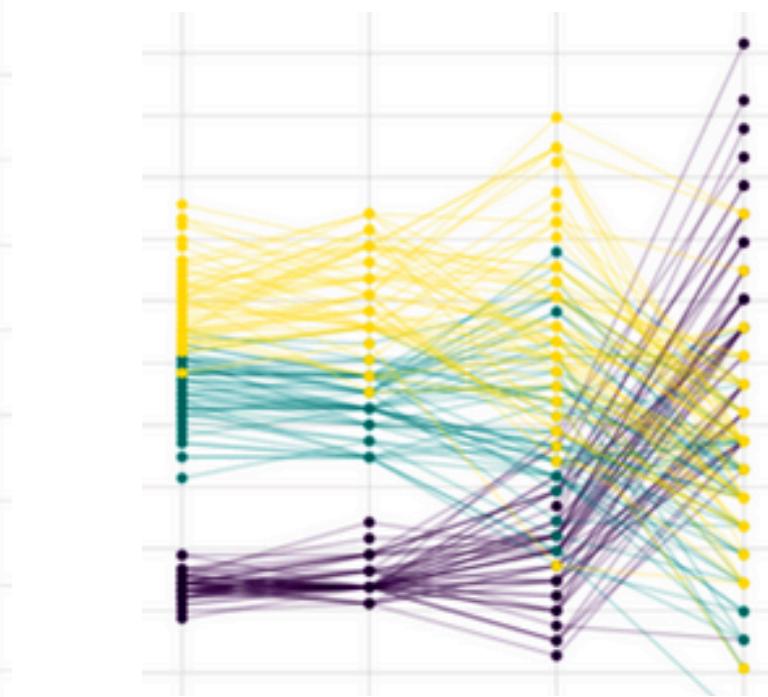
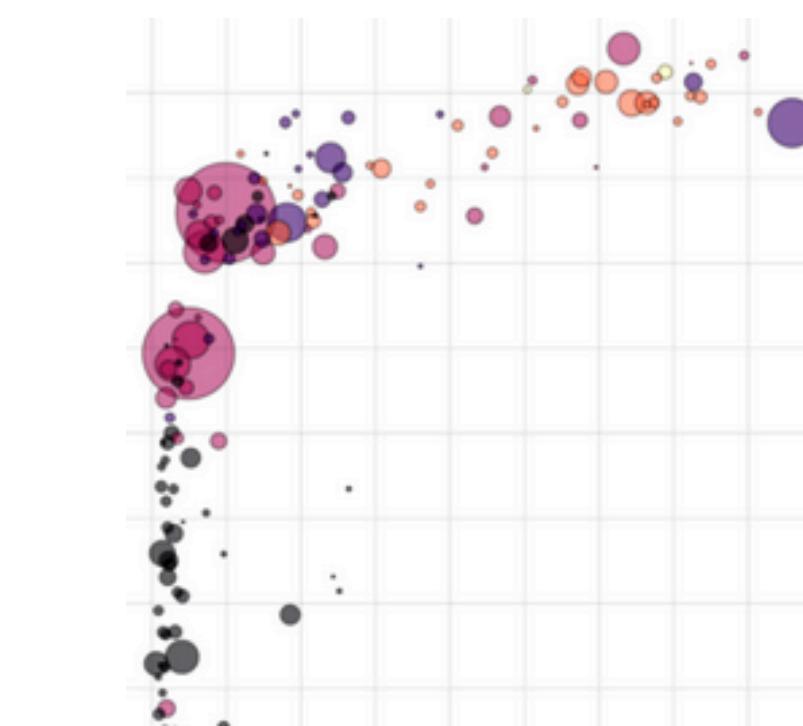
Well-defined “additive” (+) structure.



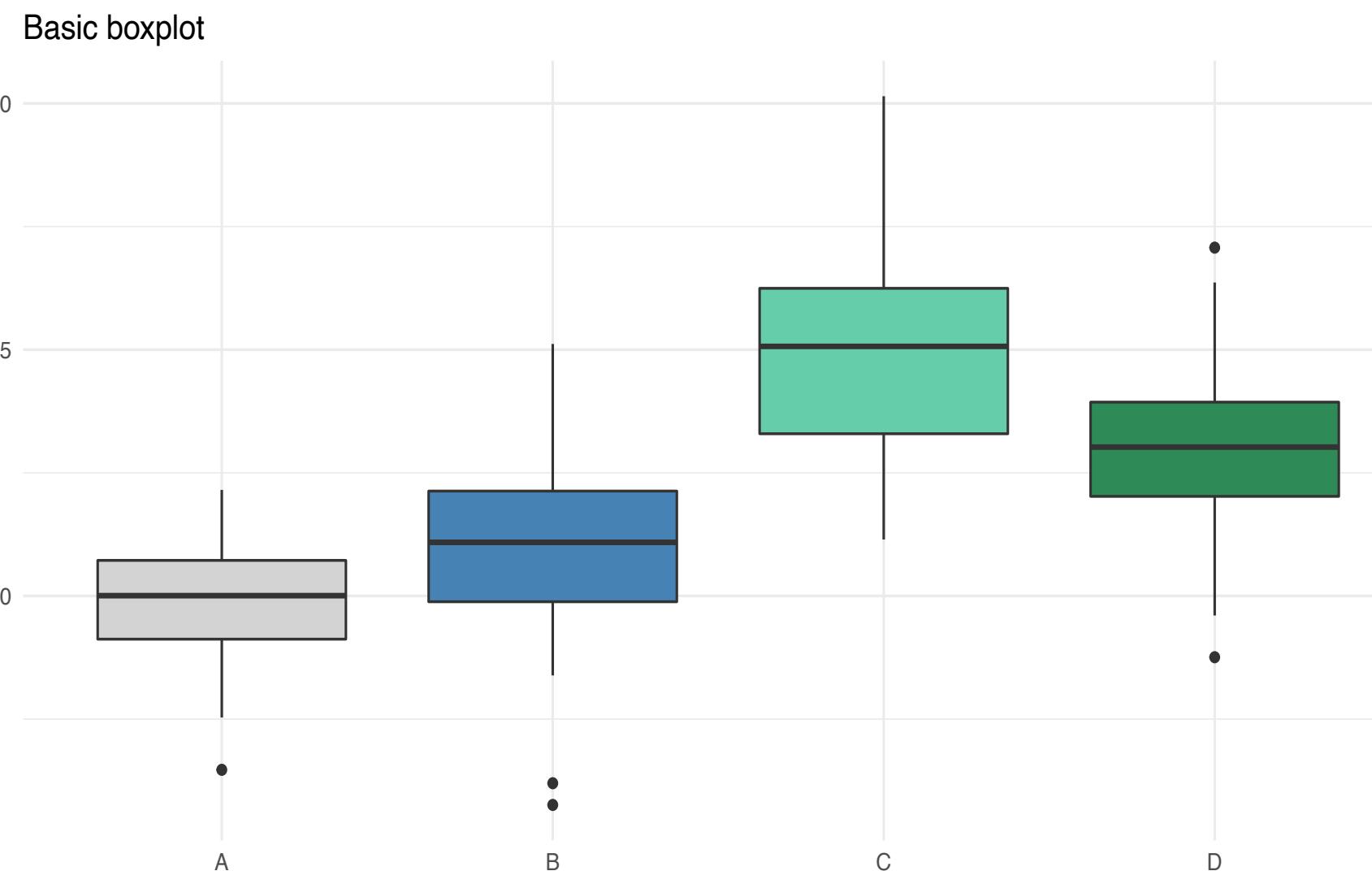
Integrates perfectly with tidy data.



Great documentation & community



# GGPLOT2 ADDITIVE STRUCTURE



DATASET, SAMPLES &  
OBSERVATIONS

```
ggplot(my.DS, aes(x=alphabet,  
y=measure))
```

DEFINE PLOT TYPE

```
ggplot(my.DS, aes(x=alphabet,  
y=measure))  
+ geom_boxplot()
```

COLOR BY GROUP

```
ggplot(my.DS, aes(x=alphabet,  
y=measure, fill=alphabet))  
+ geom_boxplot()
```

TITLE AND LEGEND

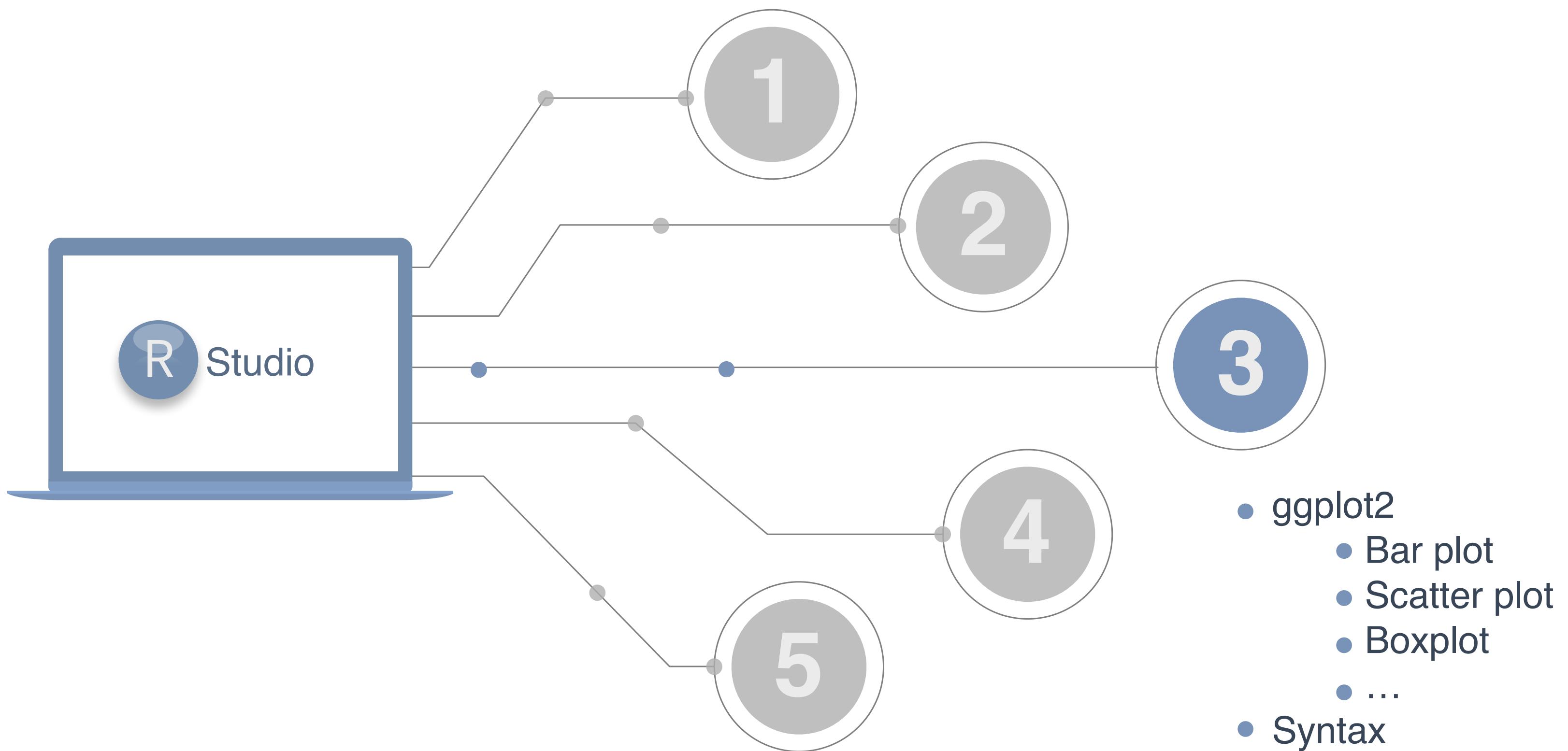
```
... + ggtitle("Basic boxplot") +  
theme(legend.position="none",  
plot.title = element_text(size=11))
```

CUSTOM COLORS

```
... + scale_fill_manual(values =  
c("lightgray", "steelblue",  
"aquamarine3", "seagreen4"))
```

BACKGROUND

```
+ theme_minimal()
```



## — GG PLOT 2 EXERCISE 3

# GGPLOT CHEAT SHEET

## Define Plot:

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

## Add Plot Type:

- + geom\_point()
- + geom\_line()
- + geom\_boxplot()
- + geom\_col()
- + geom\_density()
- + geom\_histogram()

## One Color:

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

## Color Fill by Group:

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

## More Colors:

- + scale\_fill\_grey(start = 0.2, end = 0.8)
- + scale\_fill\_gradient(low="white", high="red")

## Labels:

- + ggtitle("...")
- + xlab("...")
- + ylab("...")

## Text:

- + theme(\* = element\_text())
- + theme(axis.title = element\_text(angle = 90, colour= "red"),  
legend.text = element\_text(size = 8, face = "bold"))

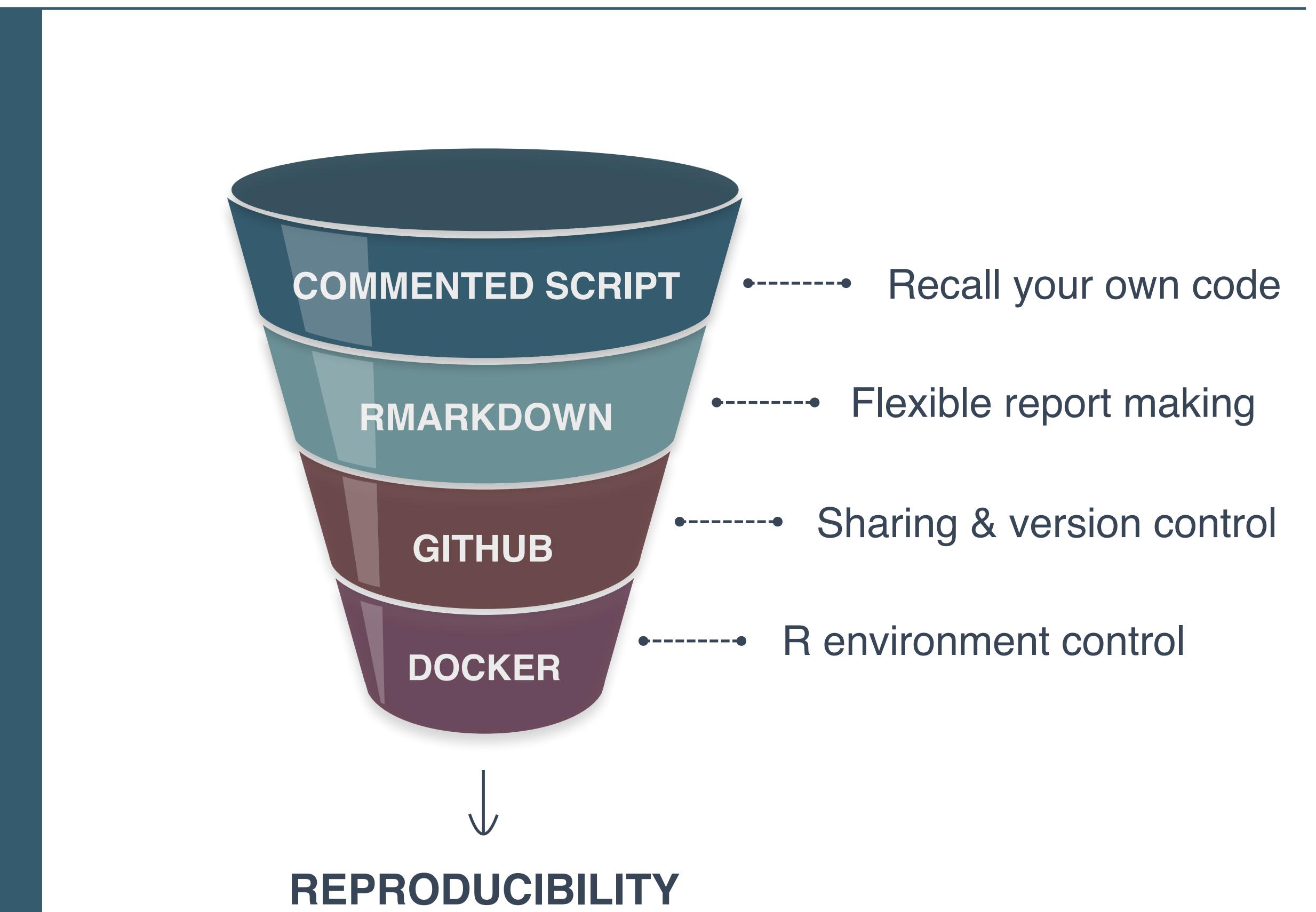
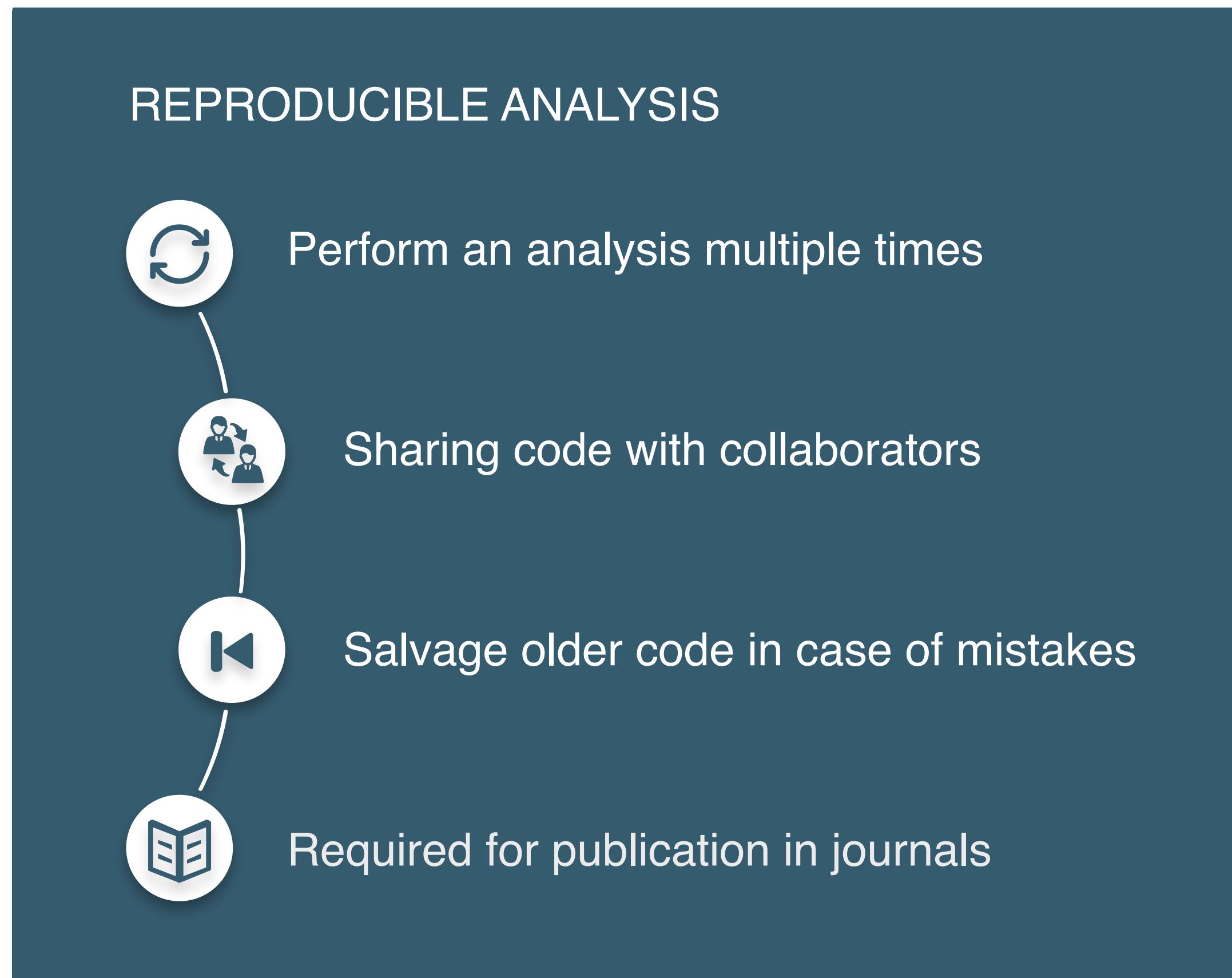
GET  
STARTED

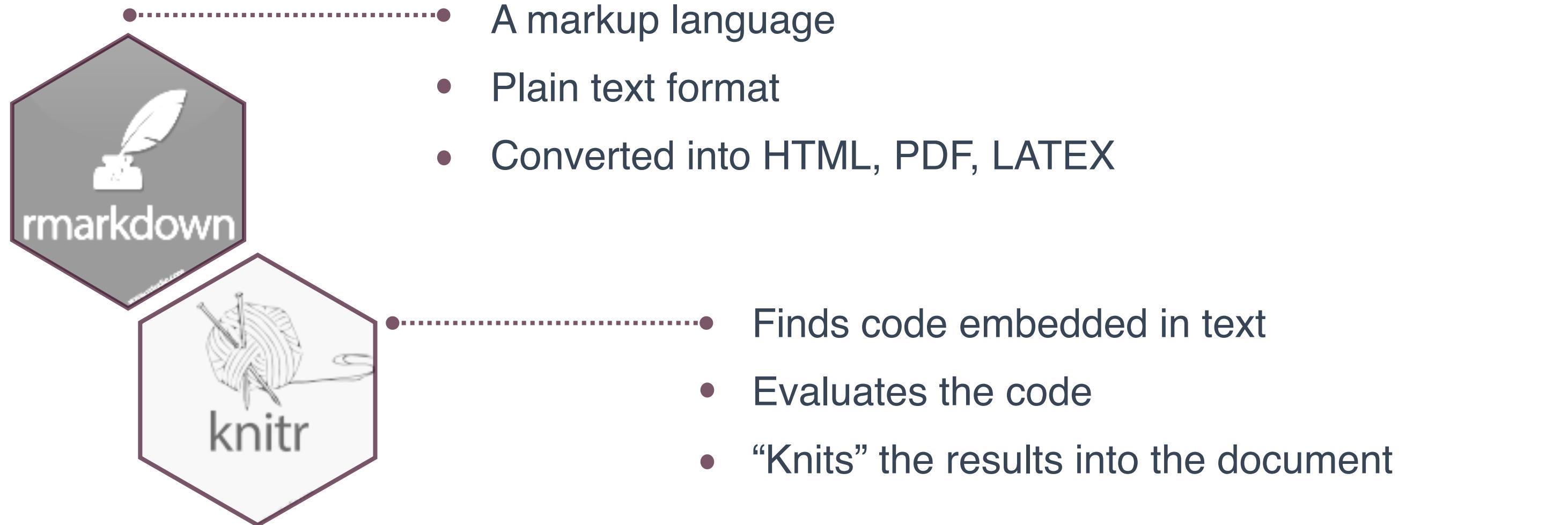
COLORS

COLOR SCALES  
& THEMES

TEXT

# REPRODUCIBILITY IN R





— <https://www.markdowntutorial.com/>

## R SCRIPT & RMARKDOWN

### HOW TO

Write code as normal •

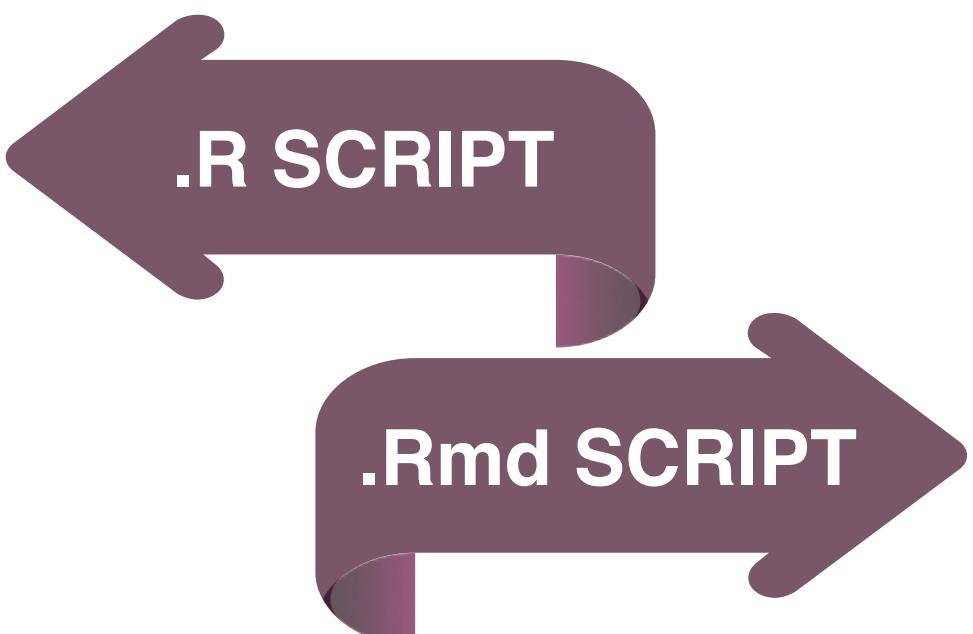
Comment text with # •

### USE FOR

Testing new code •

Big data analysis •

Software development •



### HOW TO

Write text as normal •

Embed code ``{r} my.code`` •

### USE FOR

Reports for yourself •

Reports for collaborators •

Tutorials •

# RMARKDOWN

The screenshot shows the RStudio interface with an R Markdown file open. The code editor contains the following content:

```
1 ---  
2 title: "Rcourse"  
3 author: "Data Science Lab"  
4 date: "9/14/2020"  
5 output: html_document  
---  
8 ```{r setup, include=FALSE}  
9 knitr::opts_chunk$set(echo = TRUE)  
10 ```  
11 ## R Markdown  
12  
13 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. The document is a flat text type document which can be read without opening it in RStudio. Making a markdown document is easy, For example, if you want to make something bold use two stars, For italics use underscore, etc. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.  
15  
16 When you click the Knit button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:  
17  
18 Here is a summary of the cars dataset  
19 ```{r cars}  
20 summary(cars)  
21 ...  
22  
23 Here is some math  
24 ```{r, eval=TRUE}  
25 ((5+6+7)/3)*12  
26 ...  
27  
28 Here is a plot
```

The status bar at the bottom left shows "4:18" and "R Markdown".

The screenshot shows the generated HTML document "RmarkdownTest.html". The content is as follows:

## Data Science Lab

9/14/2020

## R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. The document is a flat text type document which can be read without opening it in RStudio. Making a markdown document is easy, For example, if you want to make something **bold** use two stars, For *italics* use underscore, etc. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

Here is a summary of the cars dataset

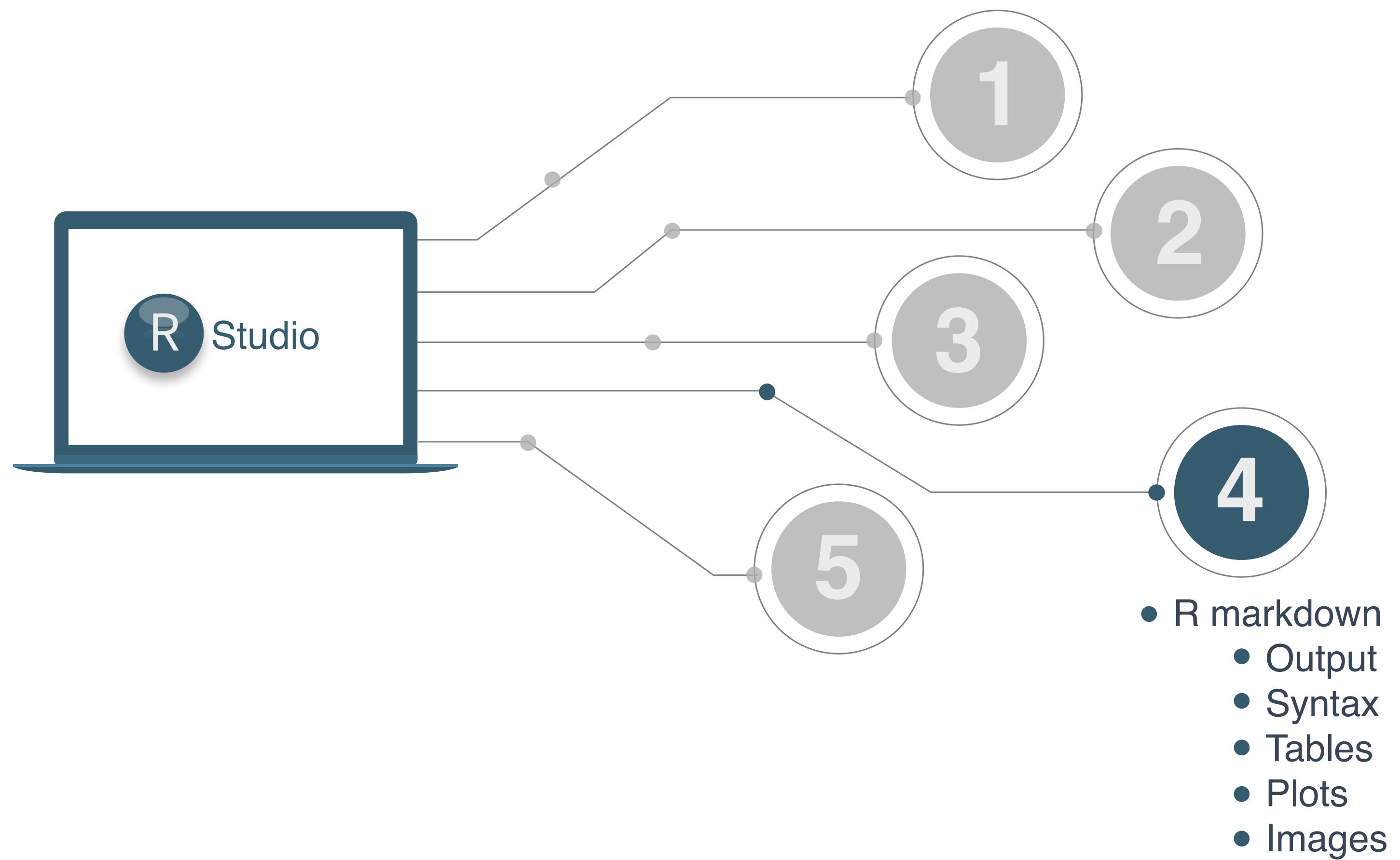
```
summary(cars)
```

```
##      speed      dist  
##  Min.   : 4.0   Min.   :  2.00  
##  1st Qu.:12.0   1st Qu.: 26.00  
##  Median :15.0   Median : 36.00  
##  Mean   :15.4   Mean   : 42.98  
##  3rd Qu.:19.0   3rd Qu.: 56.00  
##  Max.   :25.0   Max.   :120.00
```

Here is some math

```
((5+6+7)/3)*12
```

```
## [1] 72
```



— R markdown  
**EXERCISE 4**

# RMARKDOWN CHEAT

## Begin .Rmd:

```
---
```

```
title: My Project Name
```

```
output:
```

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

```
---
```

## Code Chunk:

```
```{r}  
some R code  
```
```

## Global Option:

```
```{r setup, include=FALSE}  
knitr::opts_chunk$set(echo = TRUE)  
```
```

GETTING  
STARTED

## Code Options:

```
echo (= TRUE or FALSE - print my code)  
eval (= TRUE or FALSE - run my code)  
warning (= TRUE or FALSE display warning messages)
```

## Figure Options:

```
fig.align (= 'left', 'right', 'center')  
fig.cap (= 'my figure caption')  
fig.height (= n), fig.width (= n)
```

CHUNK  
OPTIONS

## Header:

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

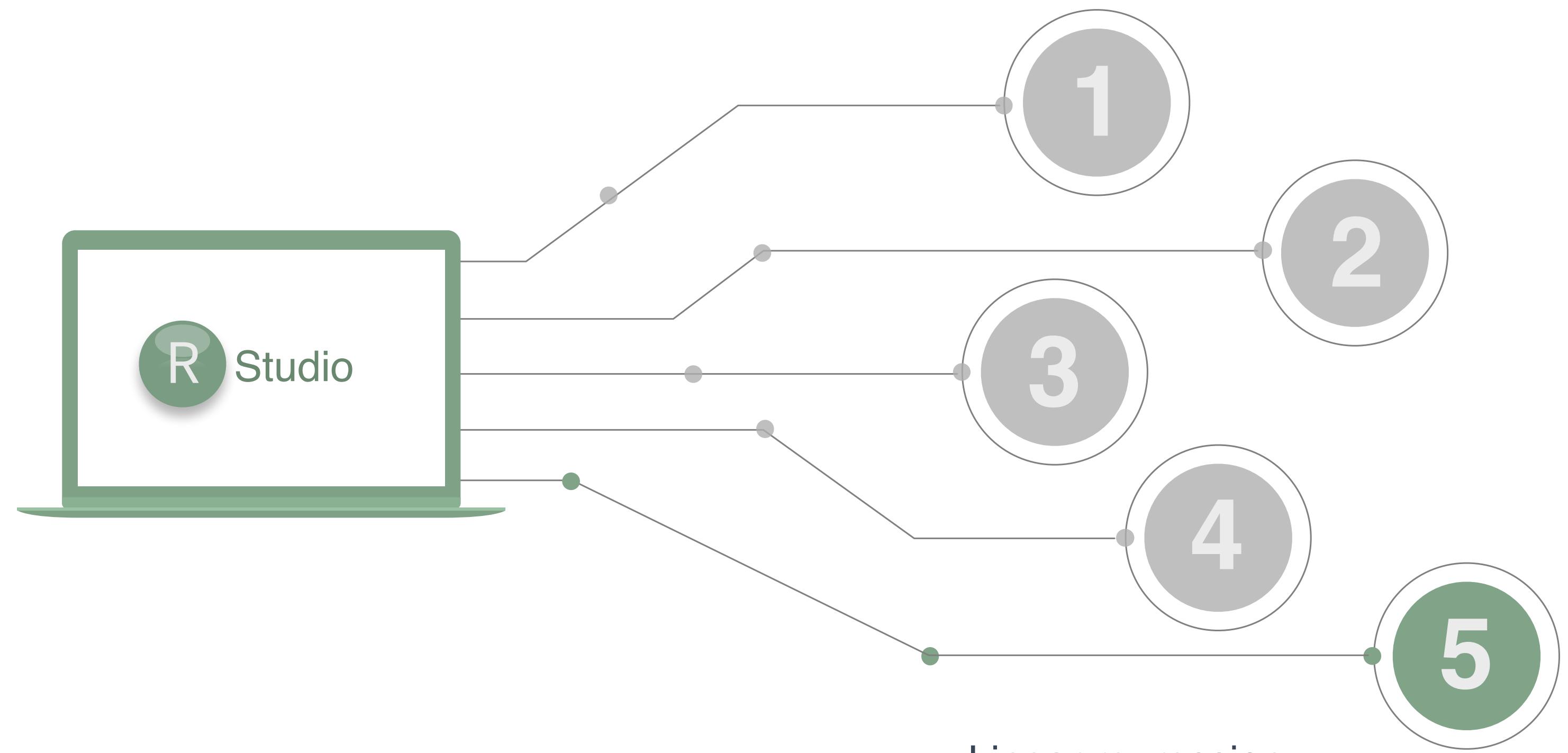
## Text:

\*italics\*  
\*\*bold\*\*  
`highlighted`

## Lists:

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

TEXT

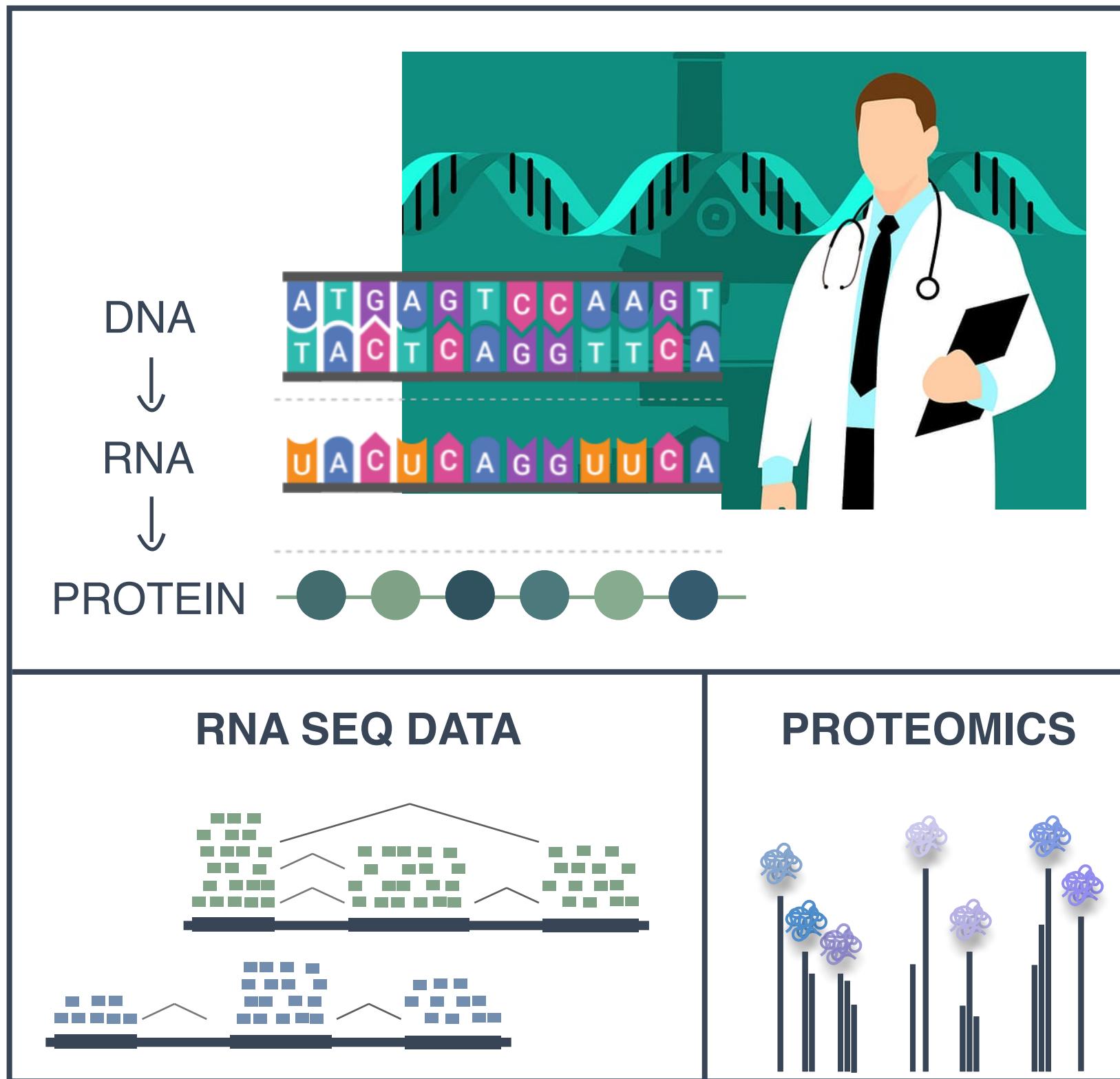


- Linear regression
- Summary Statistics
- ANOVA
- Logistic regression
- Clustering
- Correlation

— Statistics in R  
**EXERCISE 5**

# BIOINFORMATICS IN R

## HIGH THROUGHPUT DATA



## BIOINFORMATIC ANALYSIS

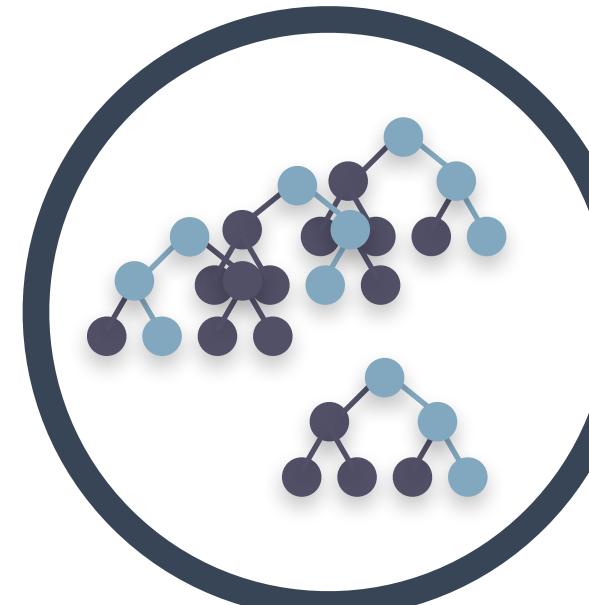
### DIMENSIONALITY REDUCTION



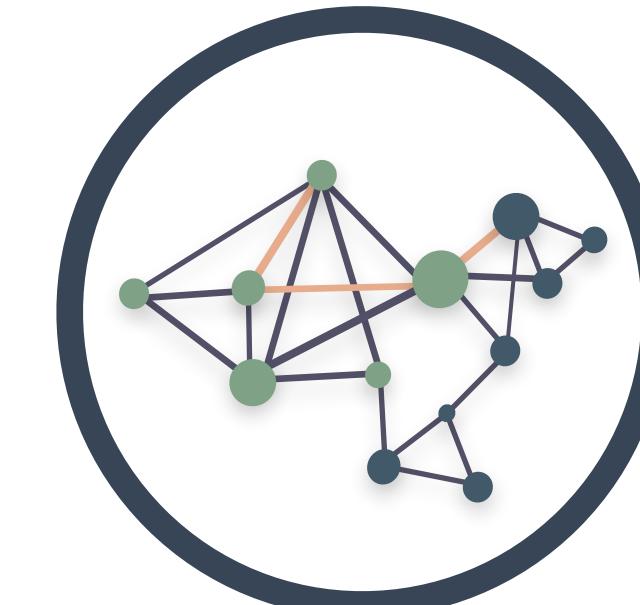
### CLUSTERING



### MACHINE LEARNING



### NETWORK ANALYSIS



## THE TOP OF THE R ICEBERG



### STATISTICAL ANALYSIS

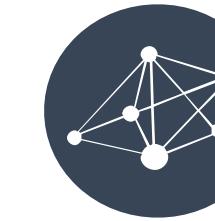
- Statistical models (linear, generalized, mixed, ...)
- Statistical tests (t-test, chisq, anova, ...)
- Survival analysis (Cox, Kaplan meier)



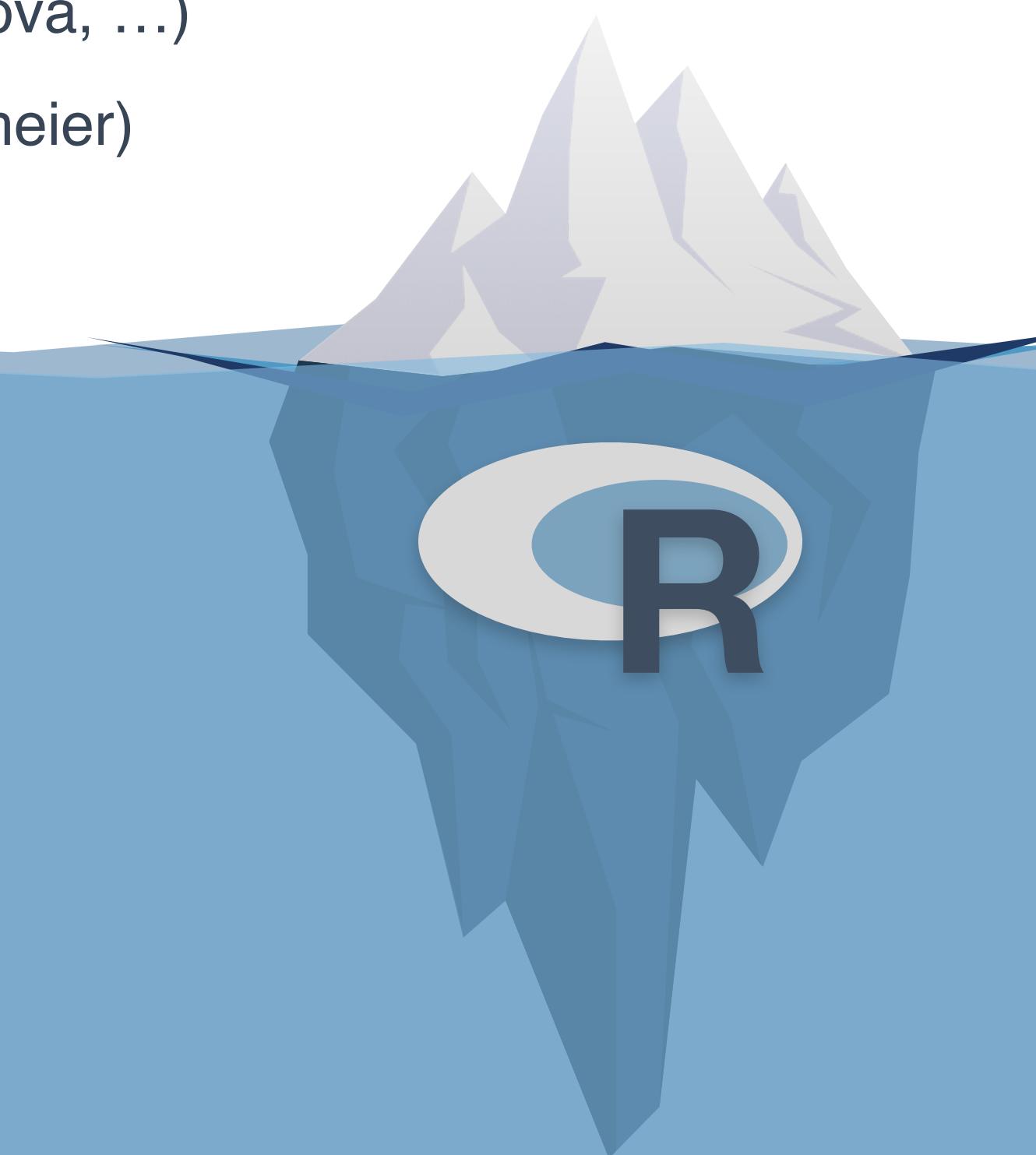
### DATA MANGEMENT



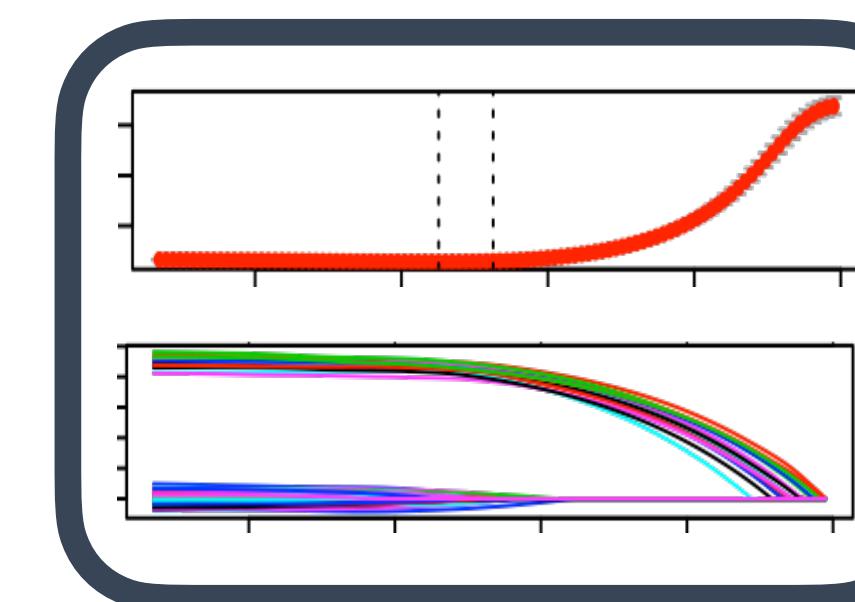
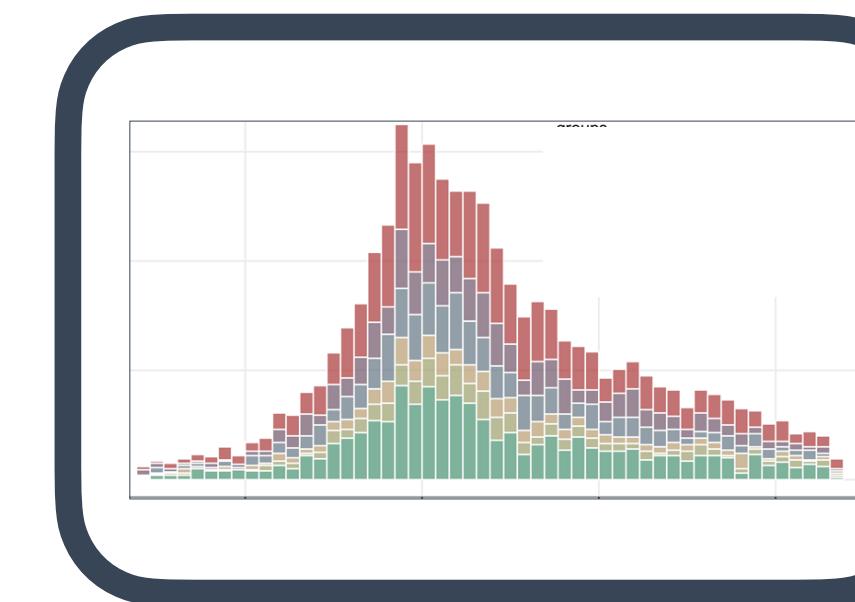
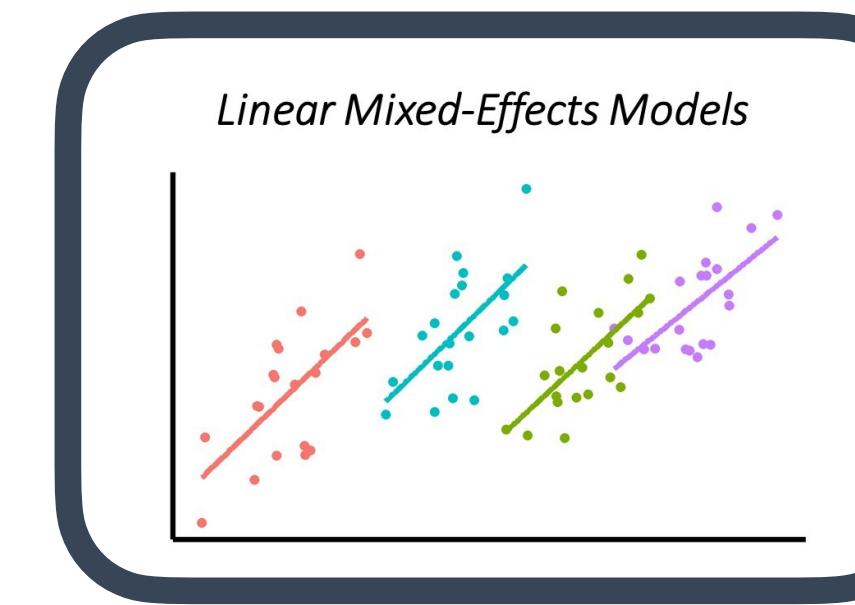
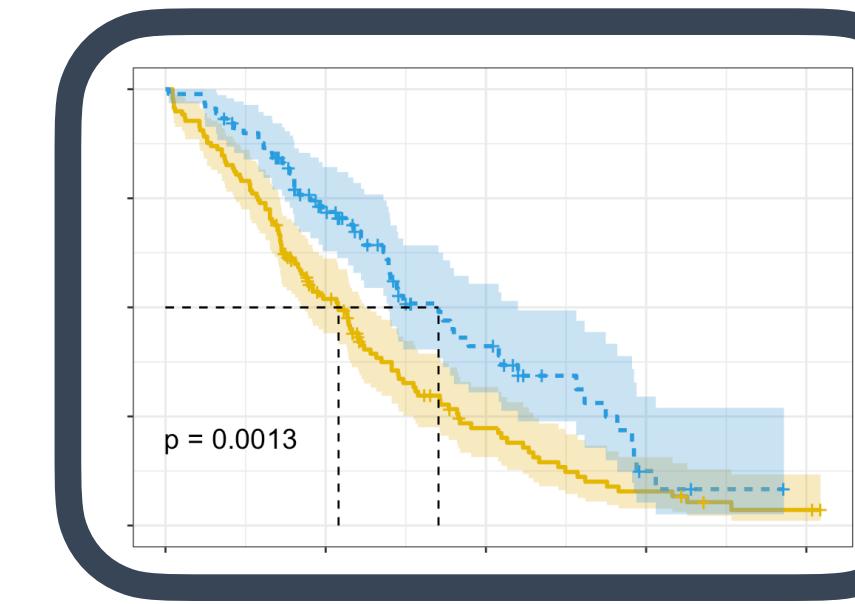
### EASY PLOTTING



### BIOINFORMATIC ANALYSIS



# — 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://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

`glmnet`: <https://cran.r-project.org/web/packages/glmnet/glmnet.pdf>

`elasticnet`: <https://cran.r-project.org/web/packages/elasticnet/elasticnet.pdf>

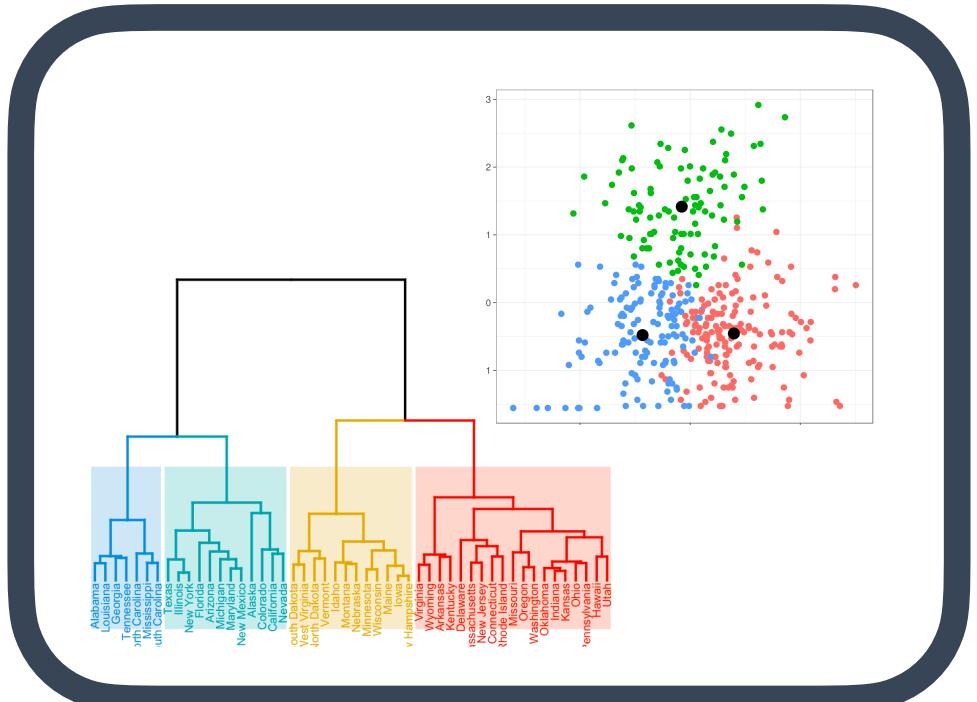
<https://www.datacamp.com/community/tutorials/tutorial-ridge-lasso-elastic-net>

## TEASER

# Machine Learning

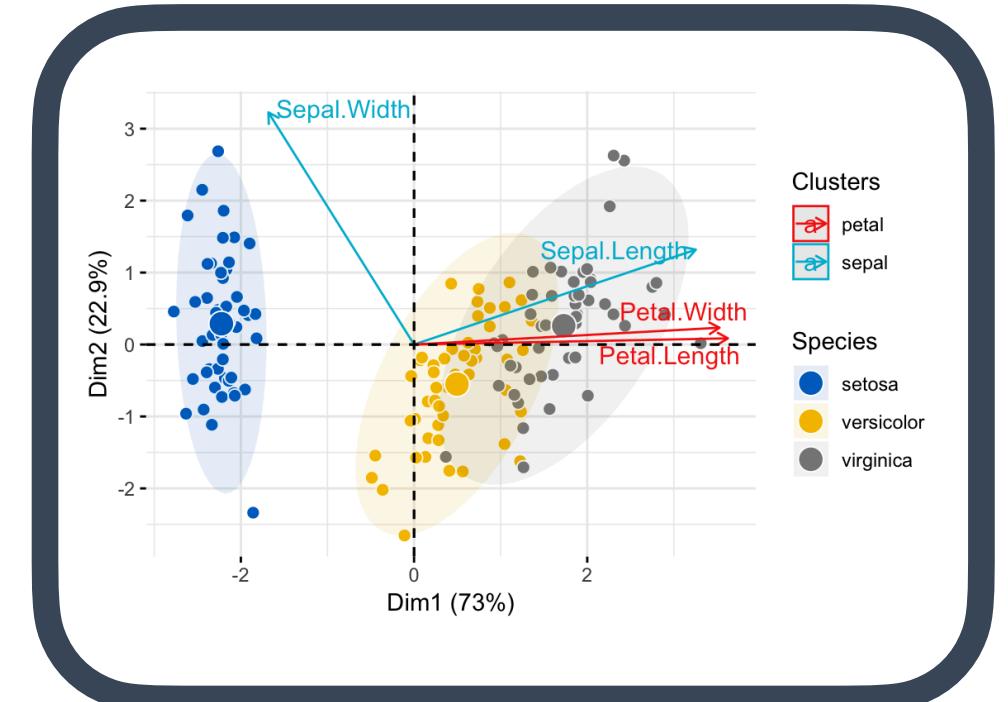
<https://lgatto.github.io/IntroMachineLearningWithR/an-introduction-to-machine-learning-with-r.html>

## Clustering



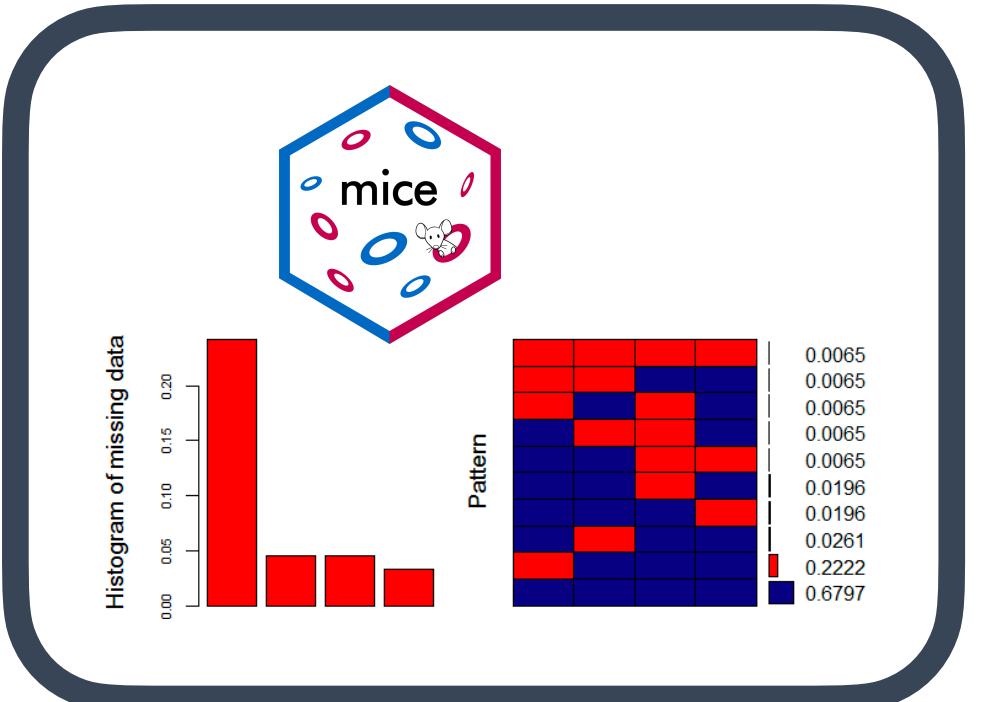
<https://statsandr.com/blog/clustering-analysis-k-means-and-hierarchical-clustering-by-hand-and-in-r/>

## Feature Selection: PCA



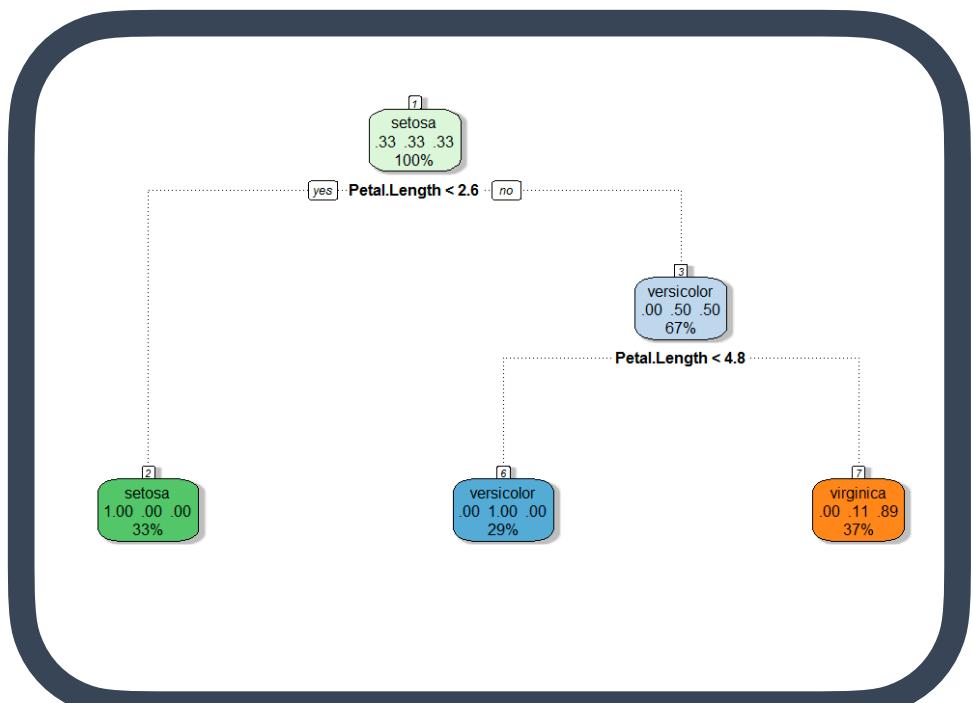
<https://bioconductor.org/packages/release/bioc/vignettes/PCATools/inst/doc/PCATools.html>

## Missing Data



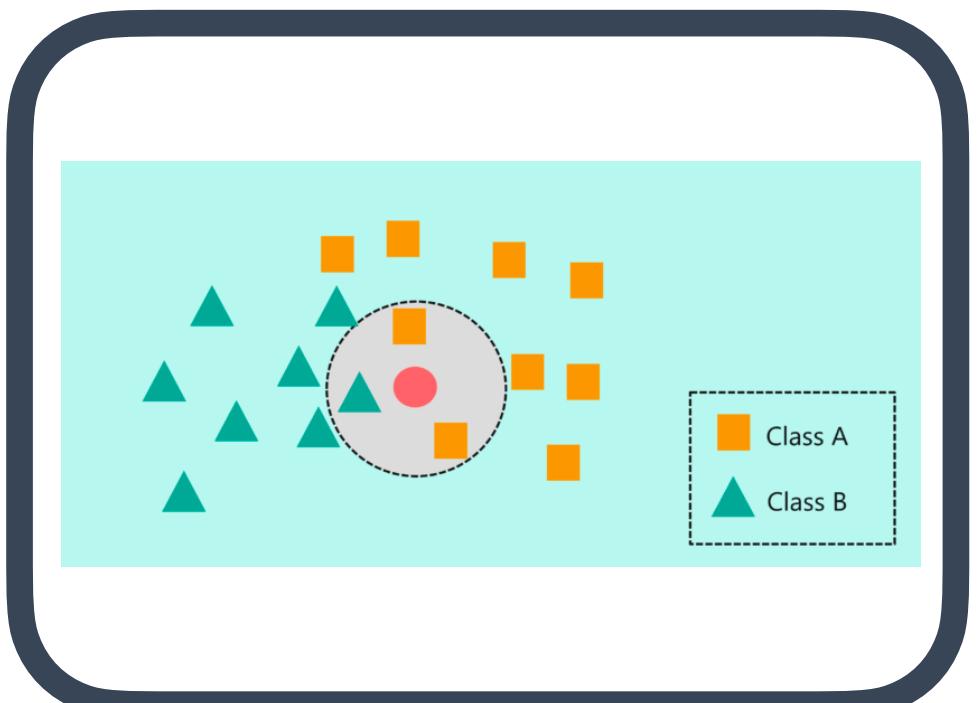
<https://amices.org/mice/>  
<https://datascienceplus.com/imputing-missing-data-with-r-mice-package/>

## Random Forest



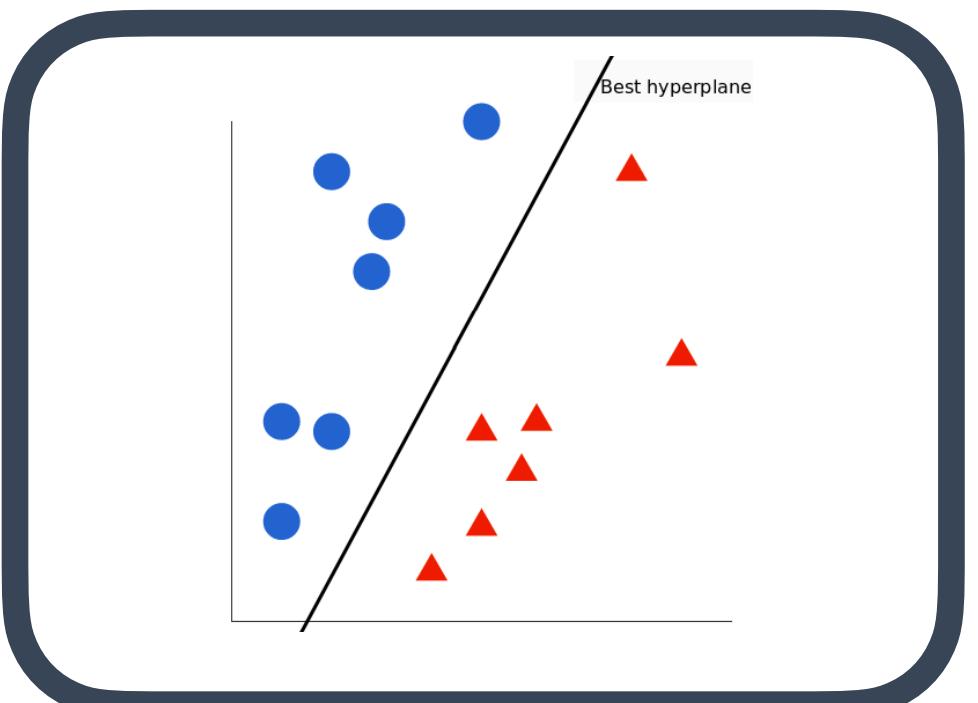
<https://www.blopig.com/blog/2017/04/a-very-basic-introduction-to-random-forests-using-r/>

## kNN



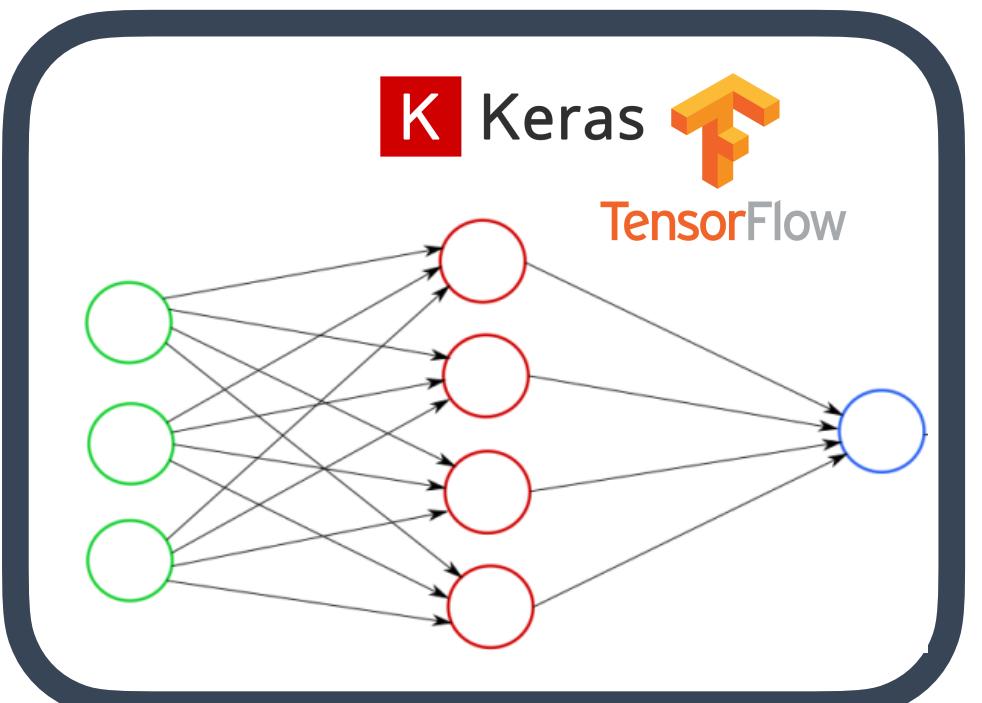
<https://www.edureka.co/blog/knn-algorithm-in-r/>

## SVM



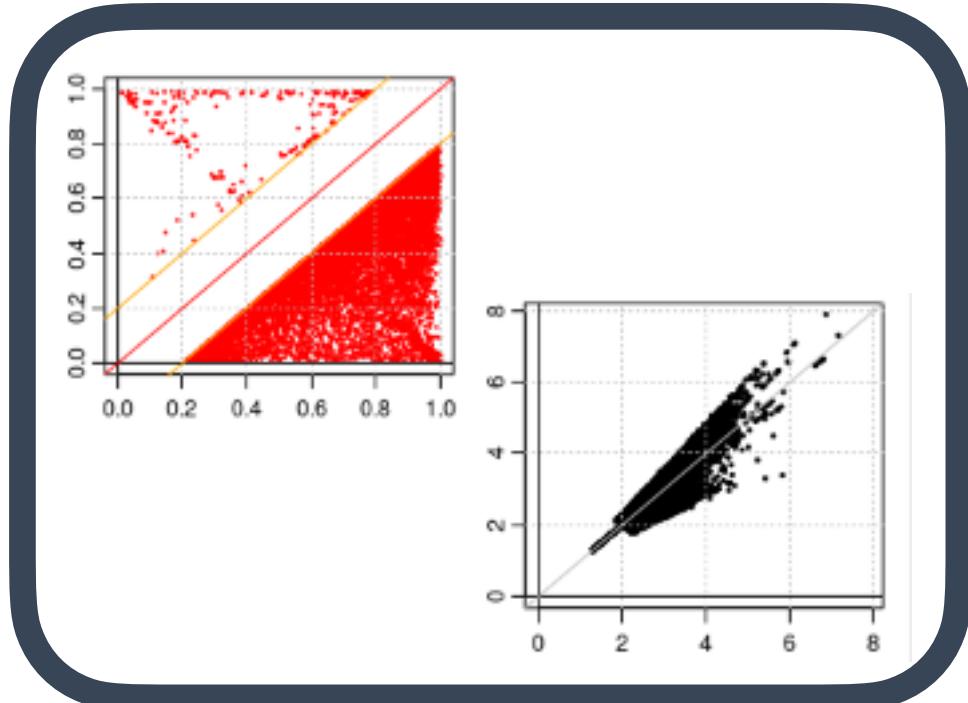
<https://cran.r-project.org/web/packages/e1071/vignettes/svmdoc.pdf>

## Neural Networks



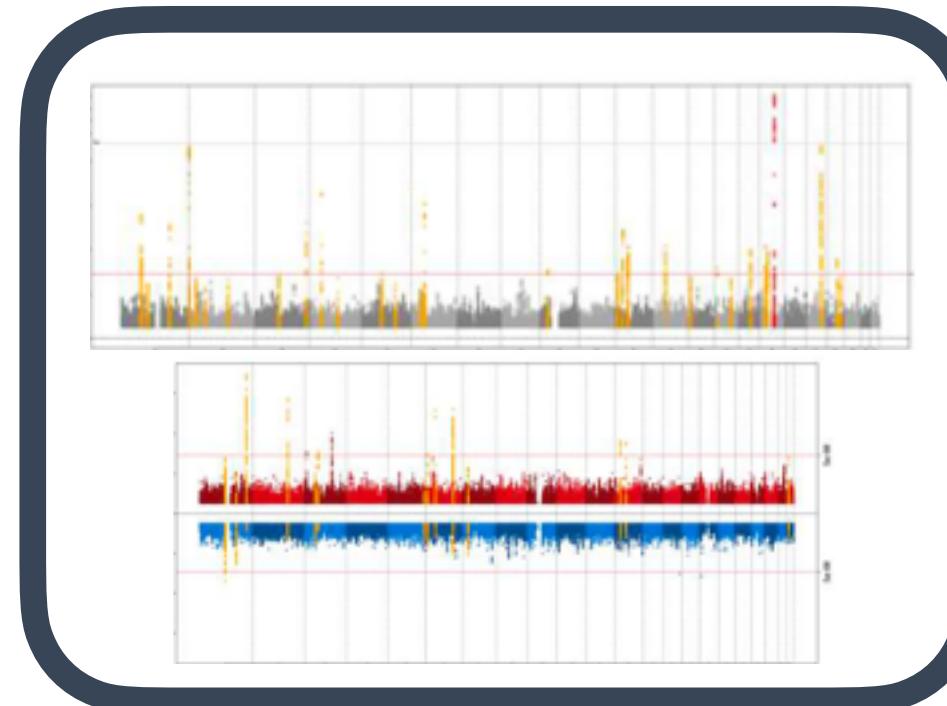
<https://keras.rstudio.com/>  
<https://tensorflow.rstudio.com/>

## GWAS - QC & Data Harmonization



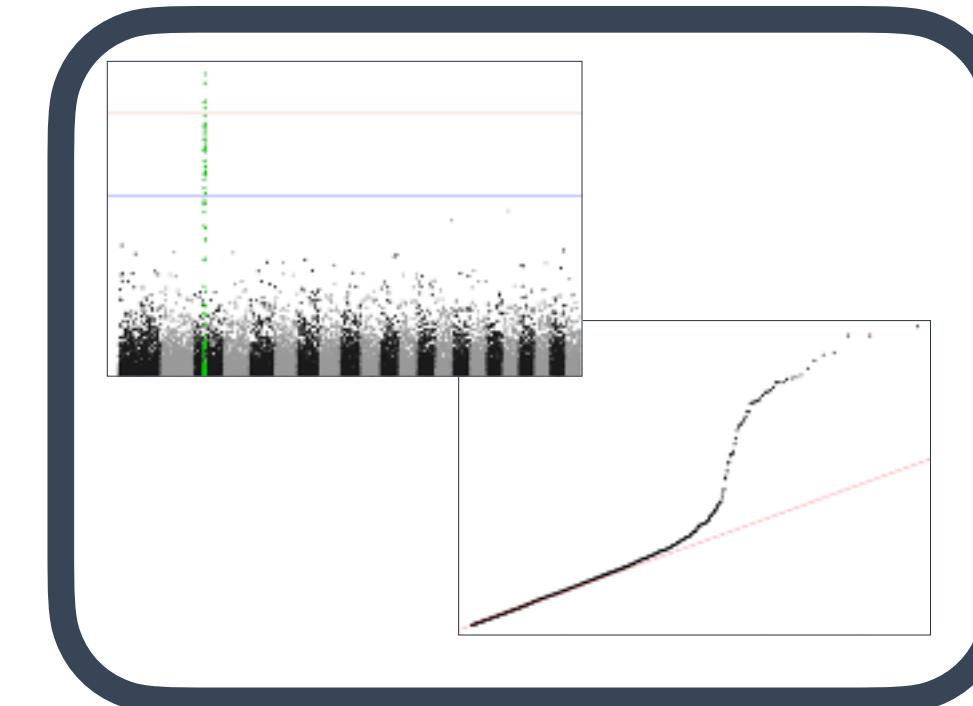
EasyQC: <https://www.uni-regensburg.de/medizin/epidemiologie-praeventivmedizin/genetische-epidemiologie/software/>

## GWAS Data Management & Plots



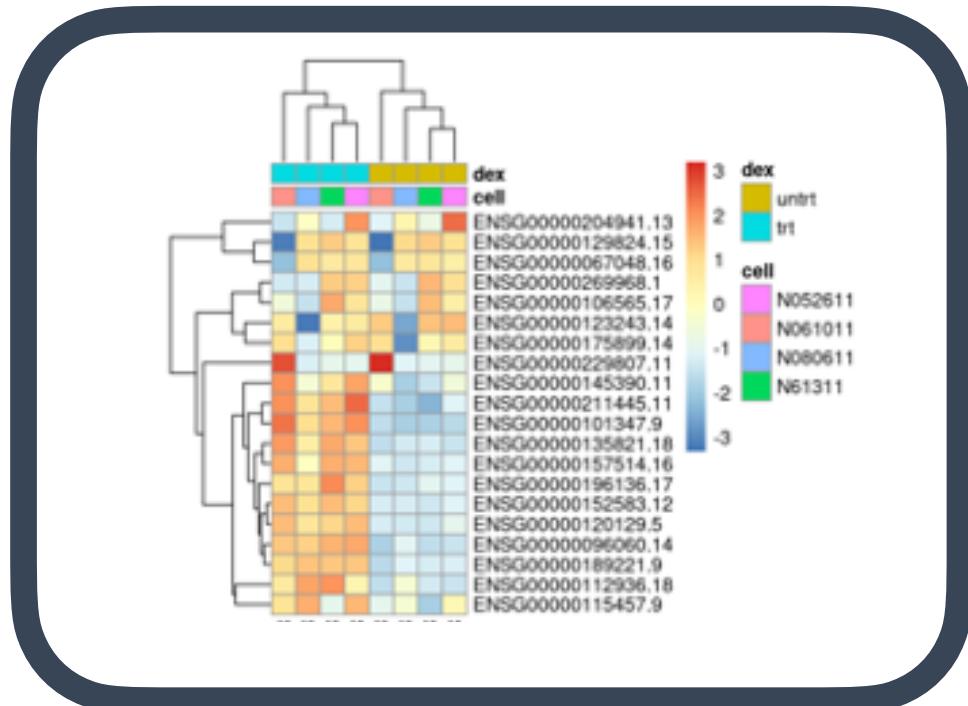
EasyStrata: <https://www.uni-regensburg.de/medizin/epidemiologie-praeventivmedizin/genetische-epidemiologie/software/>

## More Plotting...



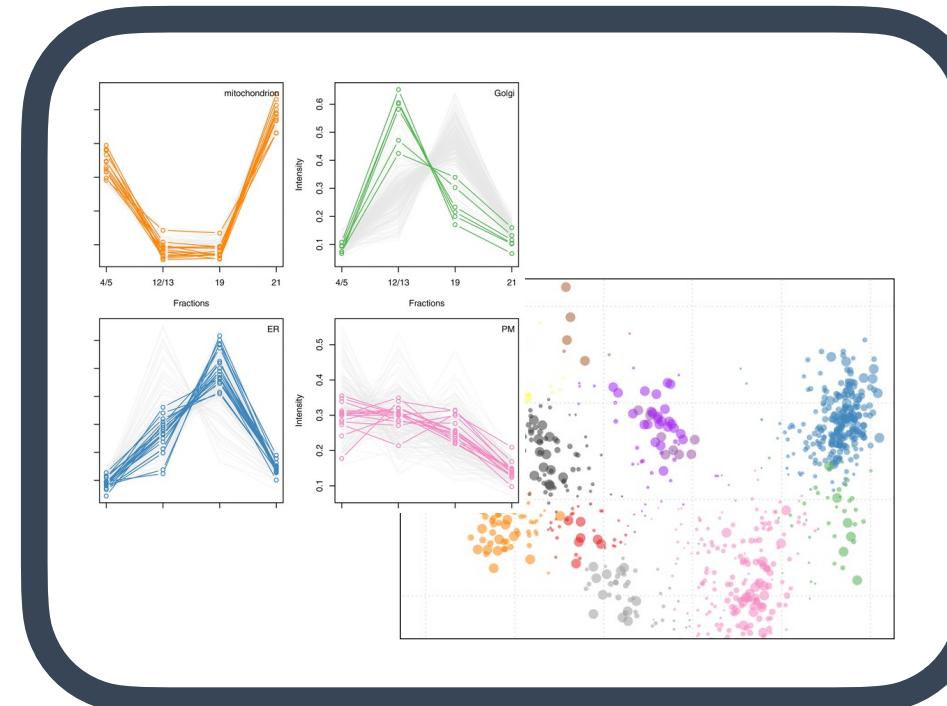
Manhattan and QQ plots: <https://cran.r-project.org/web/packages/qqman/vignettes/qqman.html>

## Gene Expression Analysis



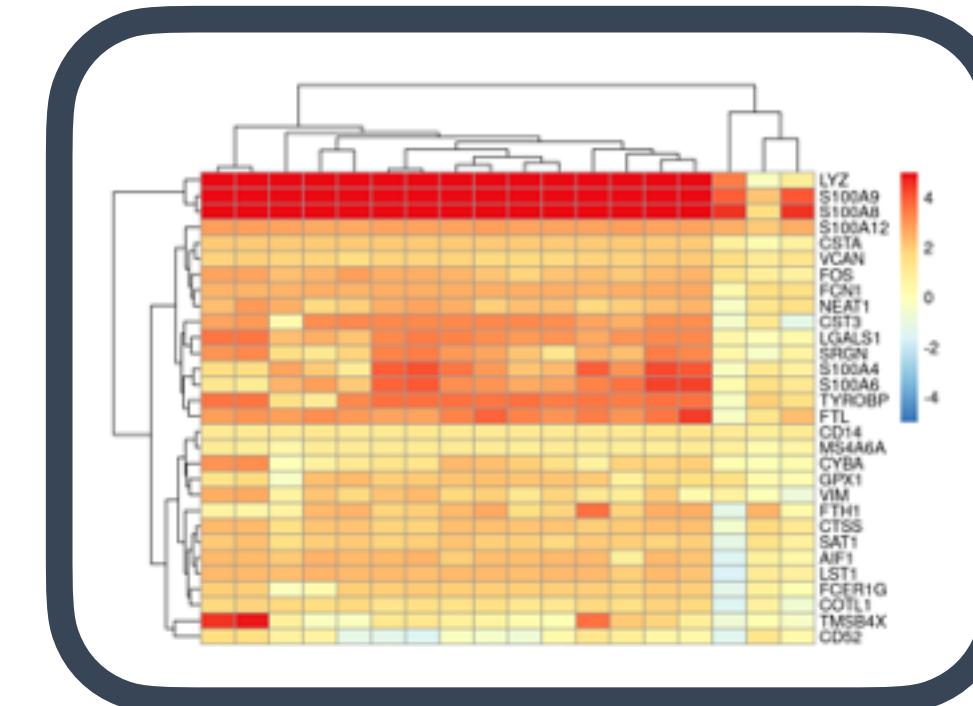
DESeq2, limma, EdgeR, etc.: [http://www.bioconductor.org/packages/release/BiocViews.html#\\_RNASeq](http://www.bioconductor.org/packages/release/BiocViews.html#_RNASeq)

## Proteomics Analysis



RforProteomics: [http://www.bioconductor.org/packages/release/BiocViews.html#\\_Proteomics](http://www.bioconductor.org/packages/release/BiocViews.html#_Proteomics)

## Single-Cell RNASeq



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

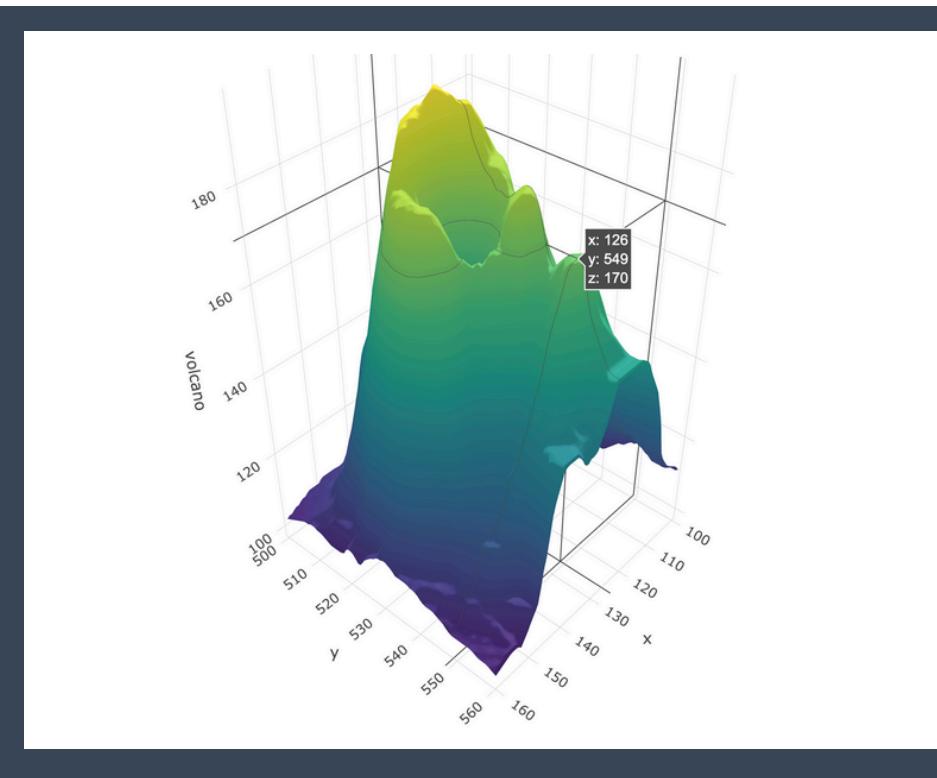
# — TEASER Omics Data

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

# COOL STUFF IN R

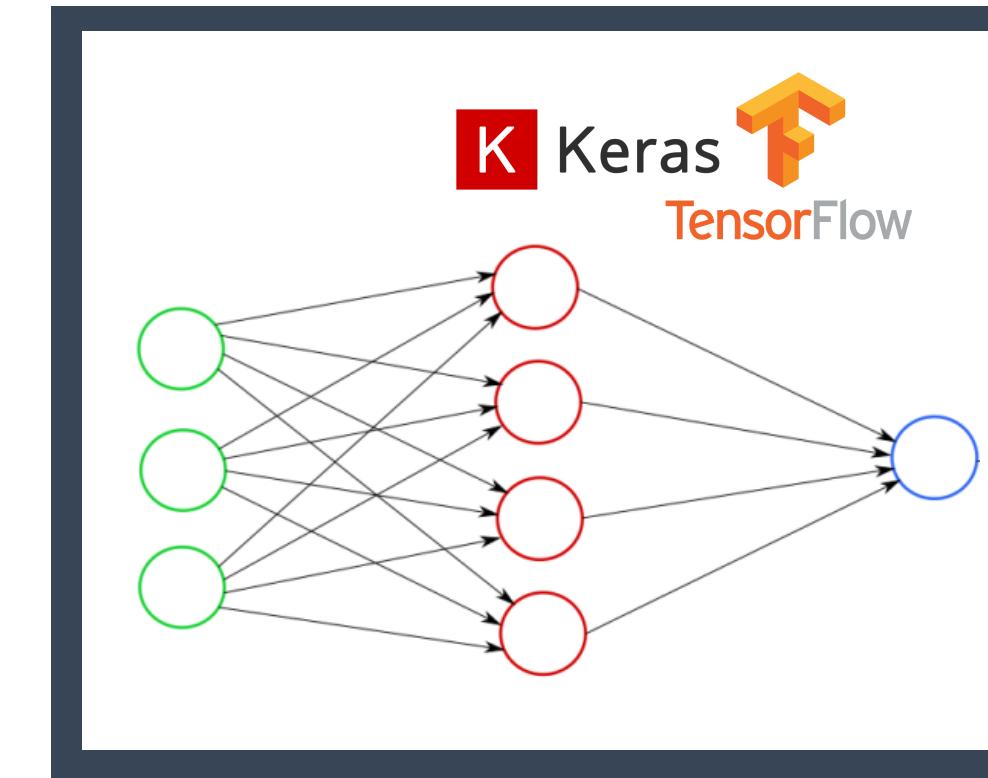
— FROM EXCEL TO R

## PLOTTING IN 3D



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

## DEEP LEARNING



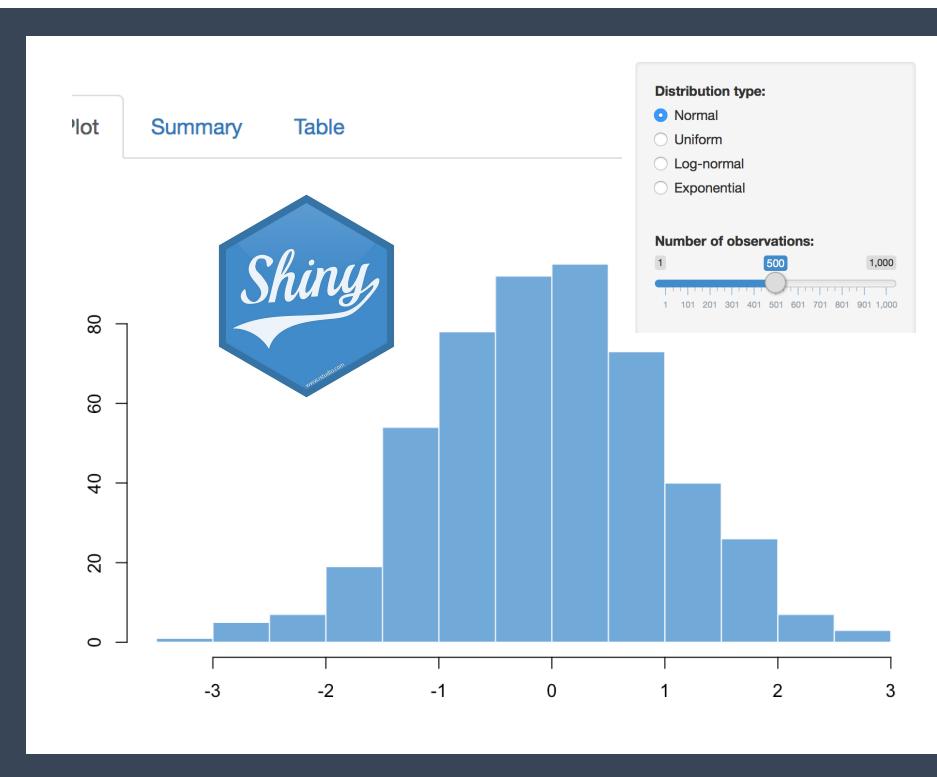
<https://keras.rstudio.com/>  
<https://tensorflow.rstudio.com/>

## BAYESIAN STATISTICS



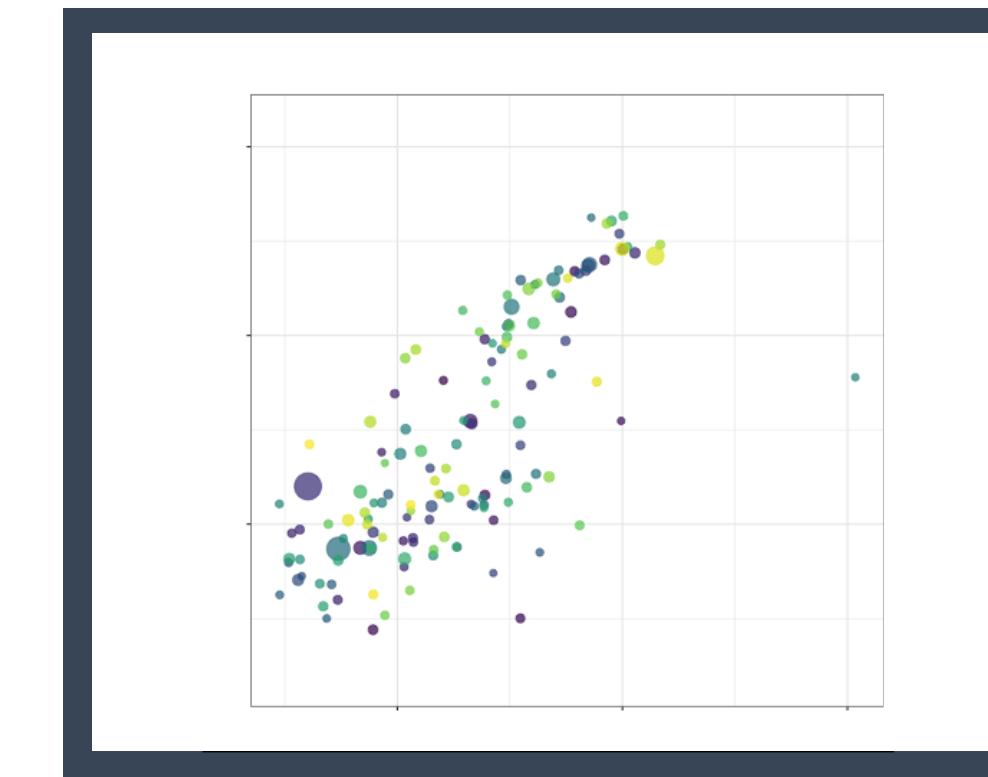
<https://mc-stan.org/users/interfaces/rstan>

## WEBPAGE WITH R SHINY



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

## INTERACTIVE PLOTS



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

## MAIL AND MESSAGES



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

# THANK YOU FOR LISTENING



This keynote presentation was created by Thilde Terkelsen,  
Data Scientist, Center for Health Data Science, SUND, KU.  
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