BIOS-IN5410

Introduction to R programming

Learning goals

Introduce you to R and Rstudio

Basic R functionality

Find and install packages

Be able to read package manuals and find help

Read and write files

Plotting data

(Very rough) time plan

Friday Nov 15

13:15-14:00

- Introduction to R and RStudio
- Set up and get going
- Do Exercise 1

14:15 - 16:00

- Go through Exercise 1
- R packages and the Tidyverse
- Rectangular and tidy data
- Working with files
- Exercise 2
- Go through Exercise 2

Thursday Nov 21

09:15 - 10:30

- Manipulating data with dplyr
- Exercise 3

10:45 - 12:30

- Go through Exercise 3
- Basic plotting
- Exercise 4
- Go through exercise 4 together

13:00 - 17:00

- Programming basics
  - For loops + Ex 5 (13:00 - 14:15)
  - Ex 5 + If statements + Ex 6 (14:30 - 15:30)
  - Go through exercise 6 (15:45 - 16:15)
- Wrap-up

Friday Nov 22

09:15 – 12:00

- R scripts
  - Running R on the command line
  - Command line arguments
- Plotting with ggplot2 (not curriculum – brief demo + exercise)

R resources

Introduction to Data Science - free online book (most of the material in this course is taken from here): https://rafalab.github.io/dsbook/

R for Data Science - free online book: R for Data Science (2e)

Software Carpentry - https://swcarpentry.github.io/r-novice-gapminder/

Course material and exercises: jonbra/BIOS-IN5410: Repository for the R lectures in BIOS-IN5410

The R project

Environment for statistical computing and graphics

It’s free

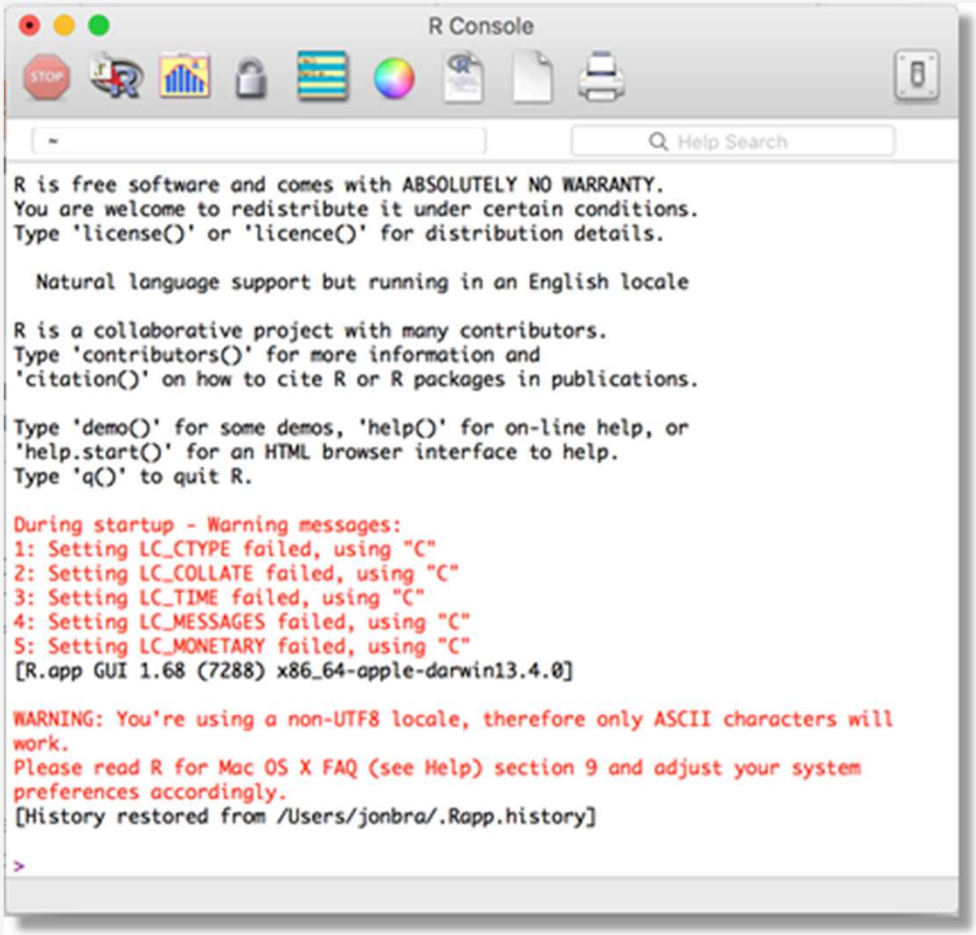
Can be run on Windows, Mac, Unix…

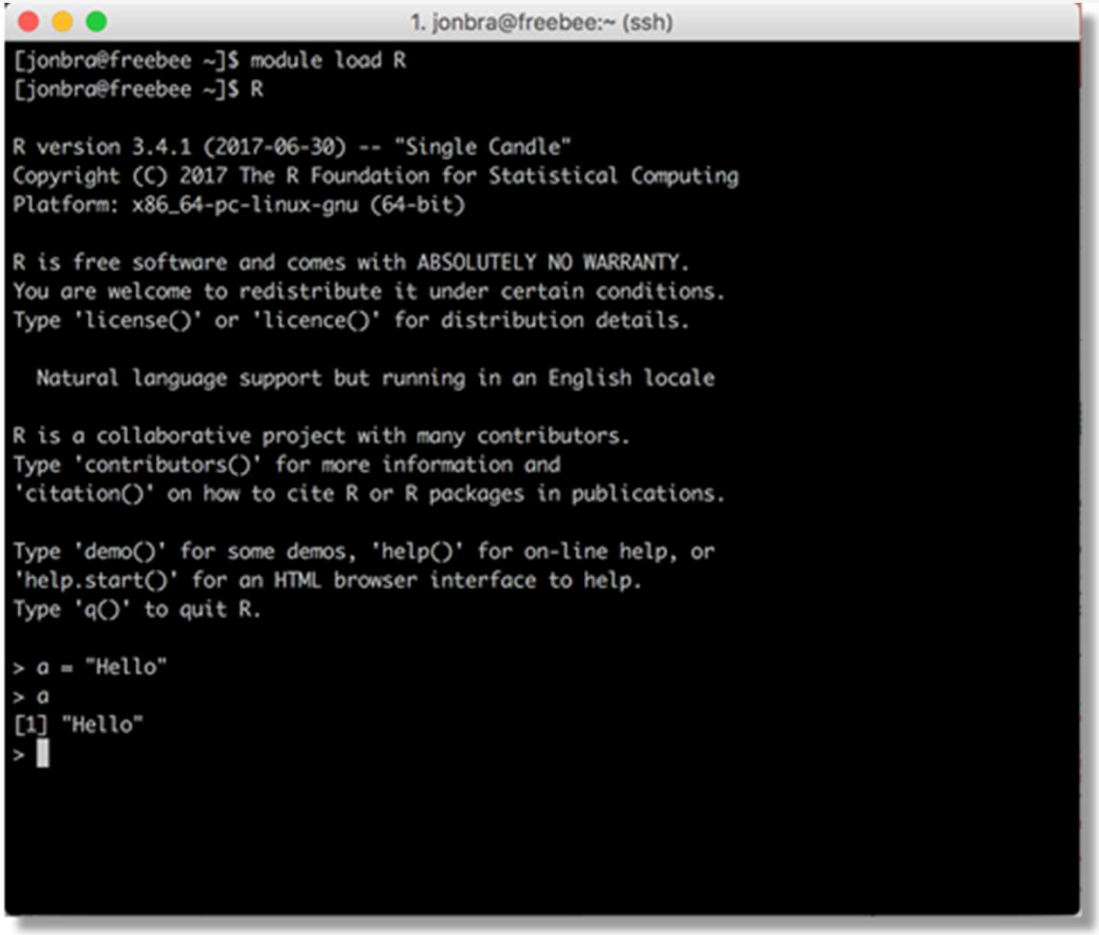
Extremely rich selection of packages

Analyze data, statistics, …

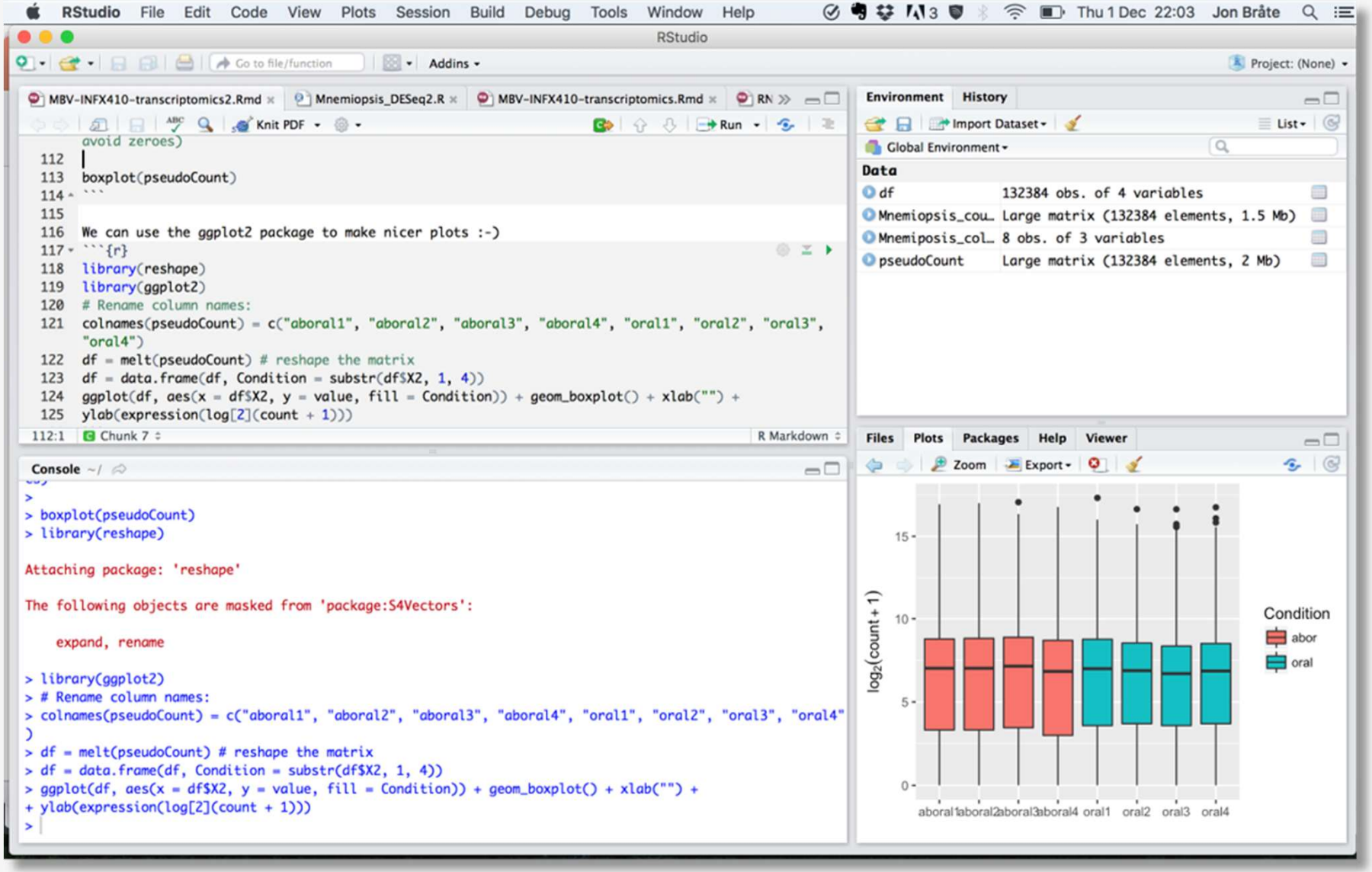
Very good for graphics and plotting

The R console

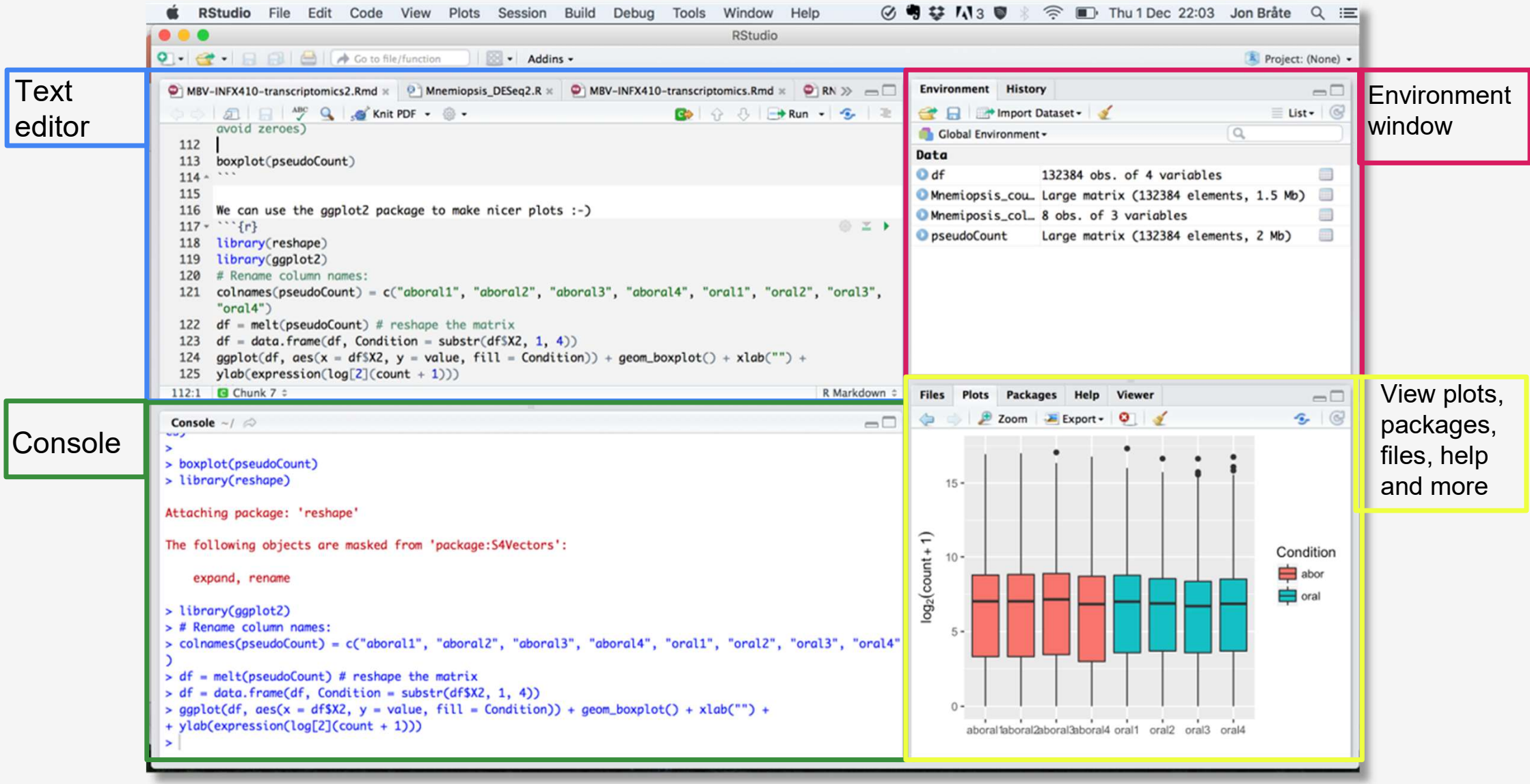




RStudio - an R IDE



RStudio - an R IDE



RStudio - cheat sheet

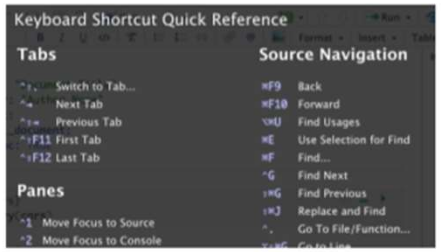
Check out the [RStudio cheat sheet] in the GitHub repo - especially the shortcuts.

Keyboard Shortcuts

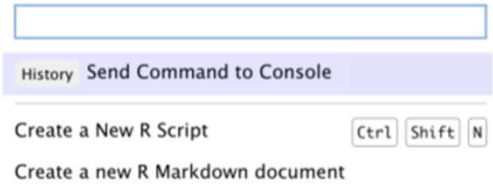
RUN CODE	Windows/Linux	Mac
Search command history	Ctrl+↑	Cmd+↑
Interrupt current command	Esc	Esc
Clear console	Ctrl+L	Ctrl+L
NAVIGATE CODE		
Go to File/Function	Ctrl+.	Ctrl+.
WRITE CODE		
Attempt completion	Tab or Ctrl+Space	Tab or Ctrl+Space
Insert <- (assignment operator)	Alt+-	Option+-
Insert %>% (pipe operator)	Ctrl+Shift+M	Cmd+Shift+M
(Un)Comment selection	Ctrl+Shift+C	Cmd+Shift+C
MAKE PACKAGES	Windows/Linux	Mac
Load All (devtools)	Ctrl+Shift+L	Cmd+Shift+L
Test Package (Desktop)	Ctrl+Shift+T	Cmd+Shift+T
Document Package	Ctrl+Shift+D	Cmd+Shift+D

DOCUMENTS AND APPS		
Knit Document (knitr)	Ctrl+Shift+K	Cmd+Shift+K
Insert chunk (Sweave & Knitr)	Ctrl+Alt+I	Cmd+Option+I
Run from start to current line	Ctrl+Alt+B	Cmd+Option+B
MORE KEYBOARD SHORTCUTS		
Keyboard Shortcuts Help	Alt+Shift+K	Option+Shift+K
Show Command Palette	Ctrl+Shift+P	Cmd+Shift+P

View the Keyboard Shortcut Quick Reference with **Tools > Keyboard Shortcuts** or **Alt/Option + Shift + K**



Search for keyboard shortcuts with **Tools > Show Command Palette** or **Ctrl/Cmd + Shift + P**.



A (super) short introduction to R functionality

(you don’t need to remember all the details. Use the slides as a reference)

Variable assignment

We assign values to variables with the assignment operator "<-" (can also use "=").
Just typing the variable by itself at the prompt will print out the value.

```
> x <- 1
> x
[1] 1
> x = 1
> x
[1] 1
> y <- 2
> x + y
[1] 3
```

The prompt (like the $ in the Unix terminal)

R is very good for mathematics

```
> 1+1 # Simple arithmetic
[1] 2
> 2 + 3 * 4 # Operator precedence
[1] 14
> 3 ^ 2 # Exponentiation
[1] 9
> exp(1) # Basic mathematical functions are available
[1] 2.718282
> sqrt(10)
[1] 3.162278
> pi # The constant pi is predefined
[1] 3.141593
> 2*pi*6378 # Circumference of earth at equator (in km)
[1] 40074.16
```

Functions

R functions are invoked by its name, then followed by the parenthesis, and zero or more arguments. The following apply the function c() to combine three numeric values into a vector.

```
> c(1, 2, 3)
[1] 1 2 3
```

Function name

Arguments (separated by comma)

Comments

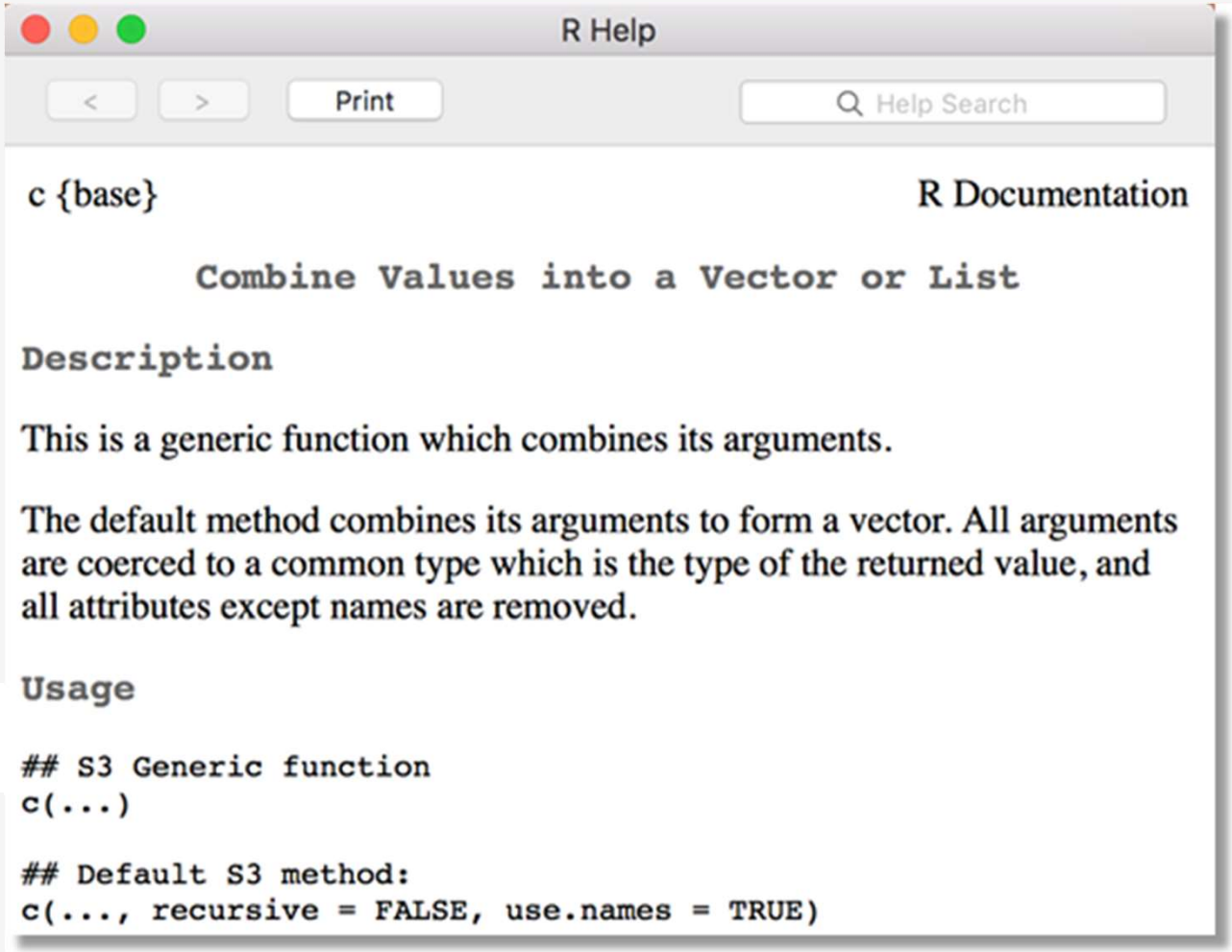
Just like in unix/bash, all text after the hash tag "#" within the same line is considered a comment.

```
> 1 + 1 # This is a comment
[1] 2
```

Getting help

R provides extensive documentation. For example, entering ?c or help(c) at the prompt gives documentation of the function c in R.

```
> help(c)
```



R Help

Print

Help Search

c {base} R Documentation

Combine Values into a Vector or List

Description

This is a generic function which combines its arguments.

The default method combines its arguments to form a vector. All arguments are coerced to a common type which is the type of the returned value, and all attributes except names are removed.

Usage

```
## S3 Generic function
c(...)

## Default S3 method:
c(..., recursive = FALSE, use.names = TRUE)
```

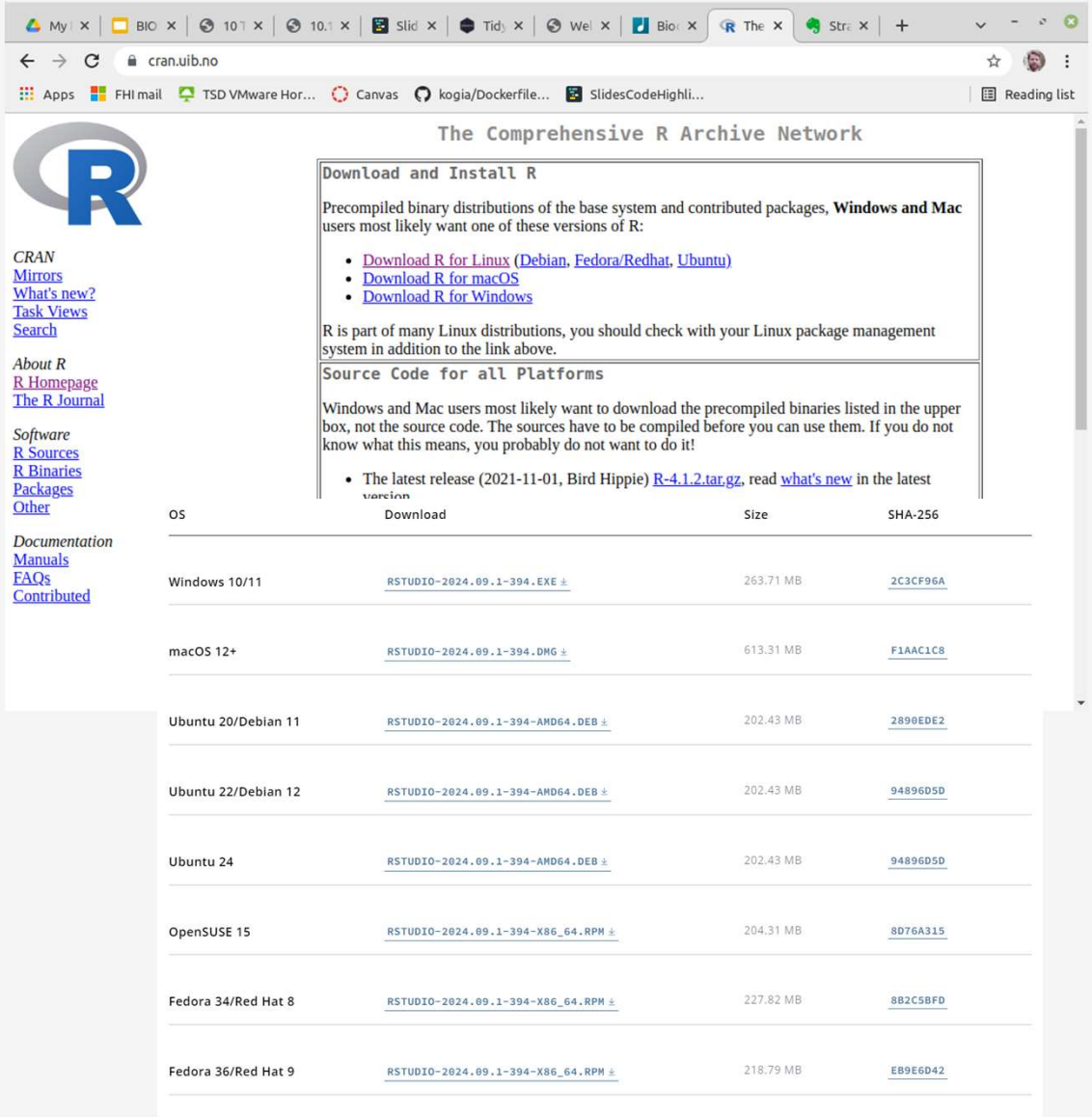
Get started with R

Install R (r-project.org)

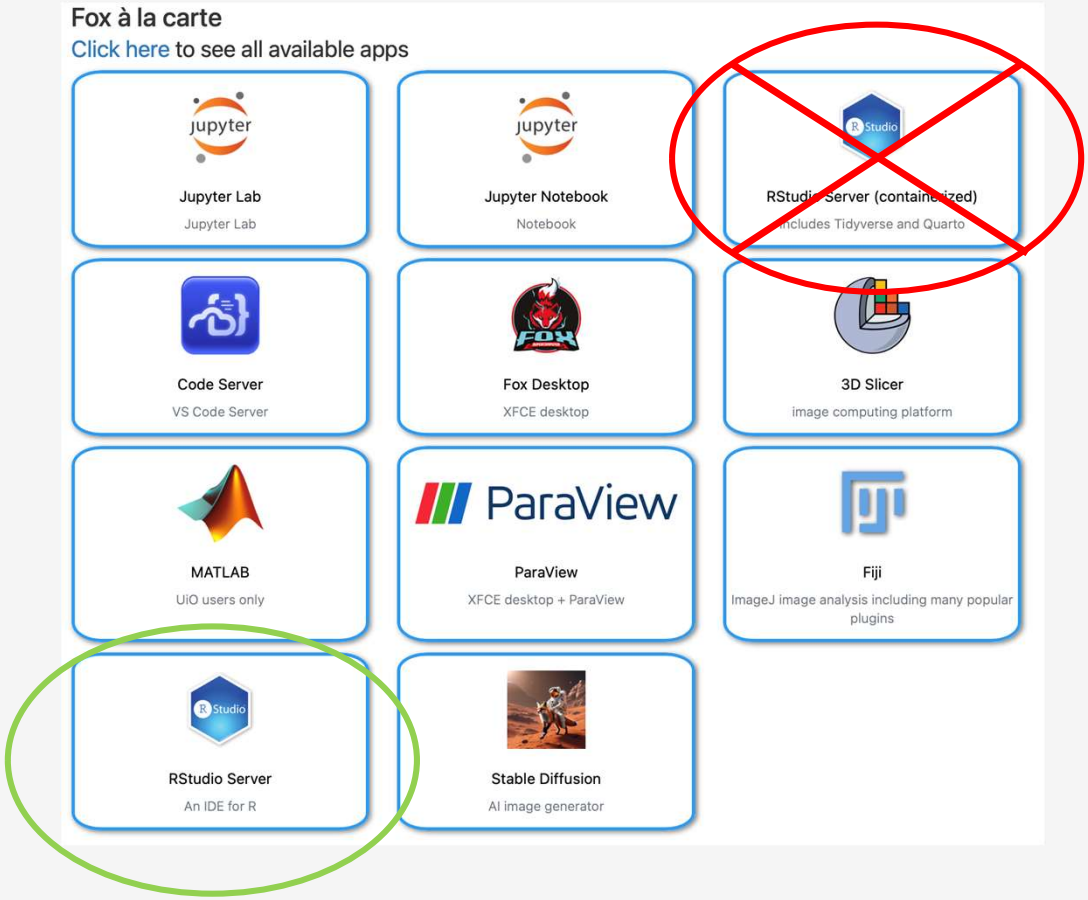
cran.uib.no

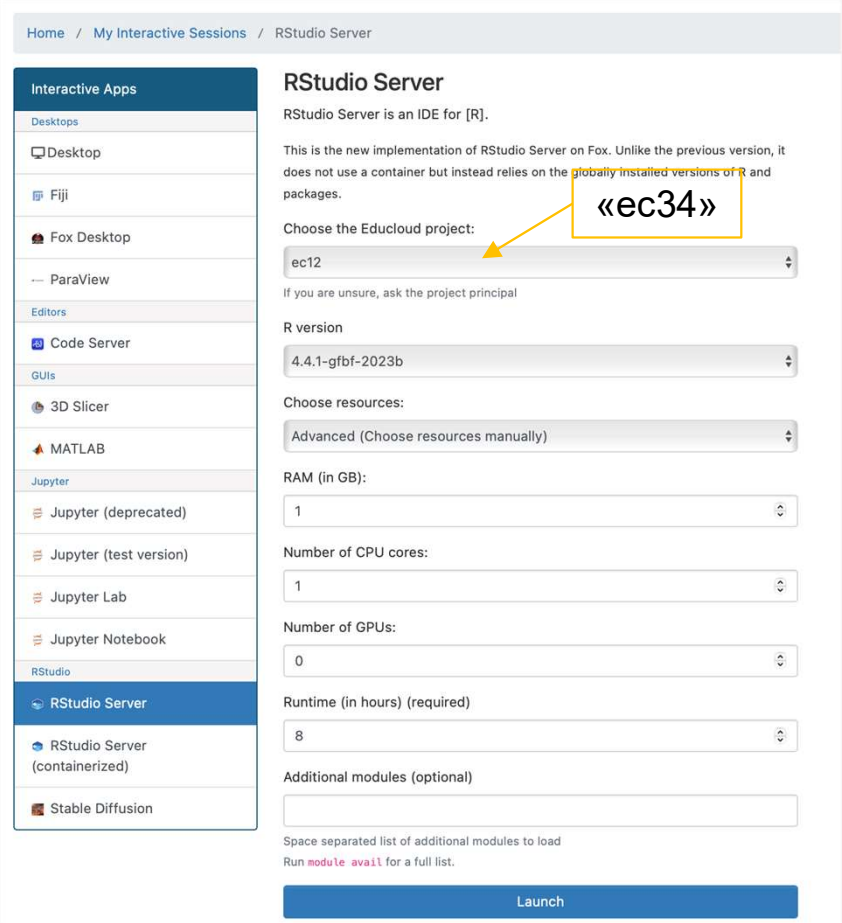
Choose the right OS

Download and install RStudio (RStudio Desktop - Posit). Choose the right OS



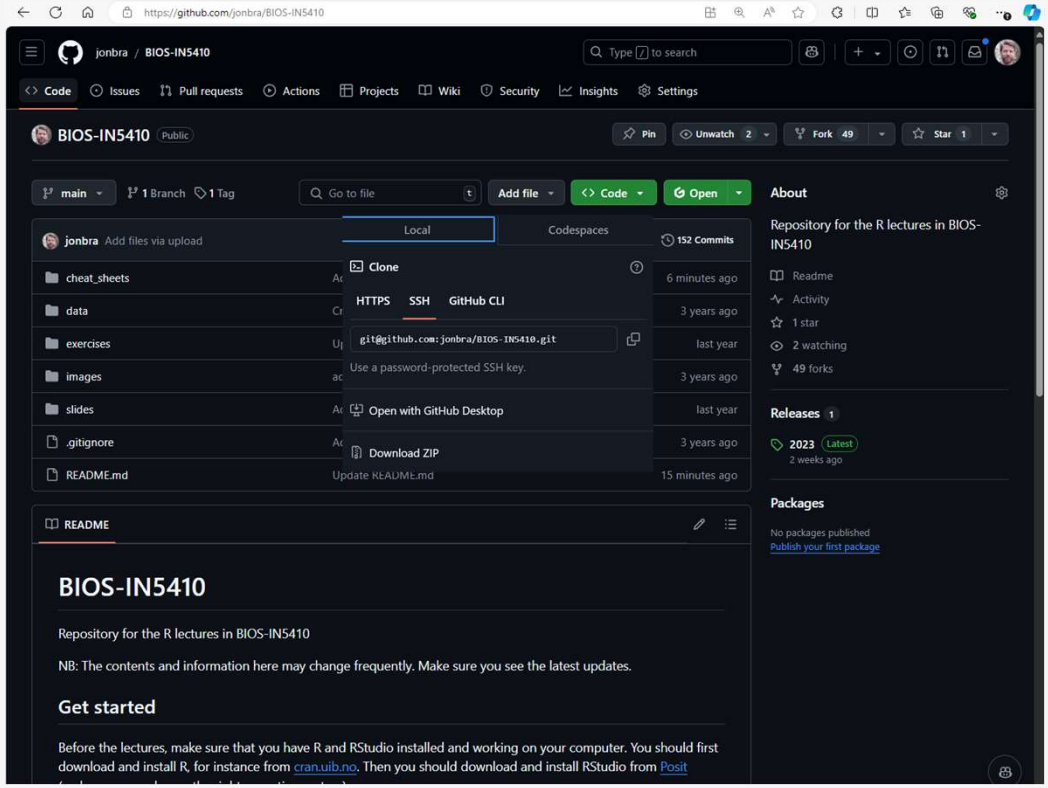
Experimental: use R and Rstudio on Educloud





Time to try R for yourself

- Make sure R and RStudio is installed and working.
- Test writing and executing commands, both in the editor and the console.
- Try to assign some variables, change them, etc.
- Download a copy of the GitHub repo (either by *git clone* or downloading a zip file)
- Do Exercise 1 in your repo (we will always go through the exercises together).
- And just play around in R and RStudio (e.g. check out the cheat sheet).
- ***And help each other! I haven't given you all the details you need so you need to check the help menus and search the web.***



First break

Go through exercise 1

R-packages

In addition to “base R”, there are thousands of so-called “packages” (libraries) that gives additional functionality to R.

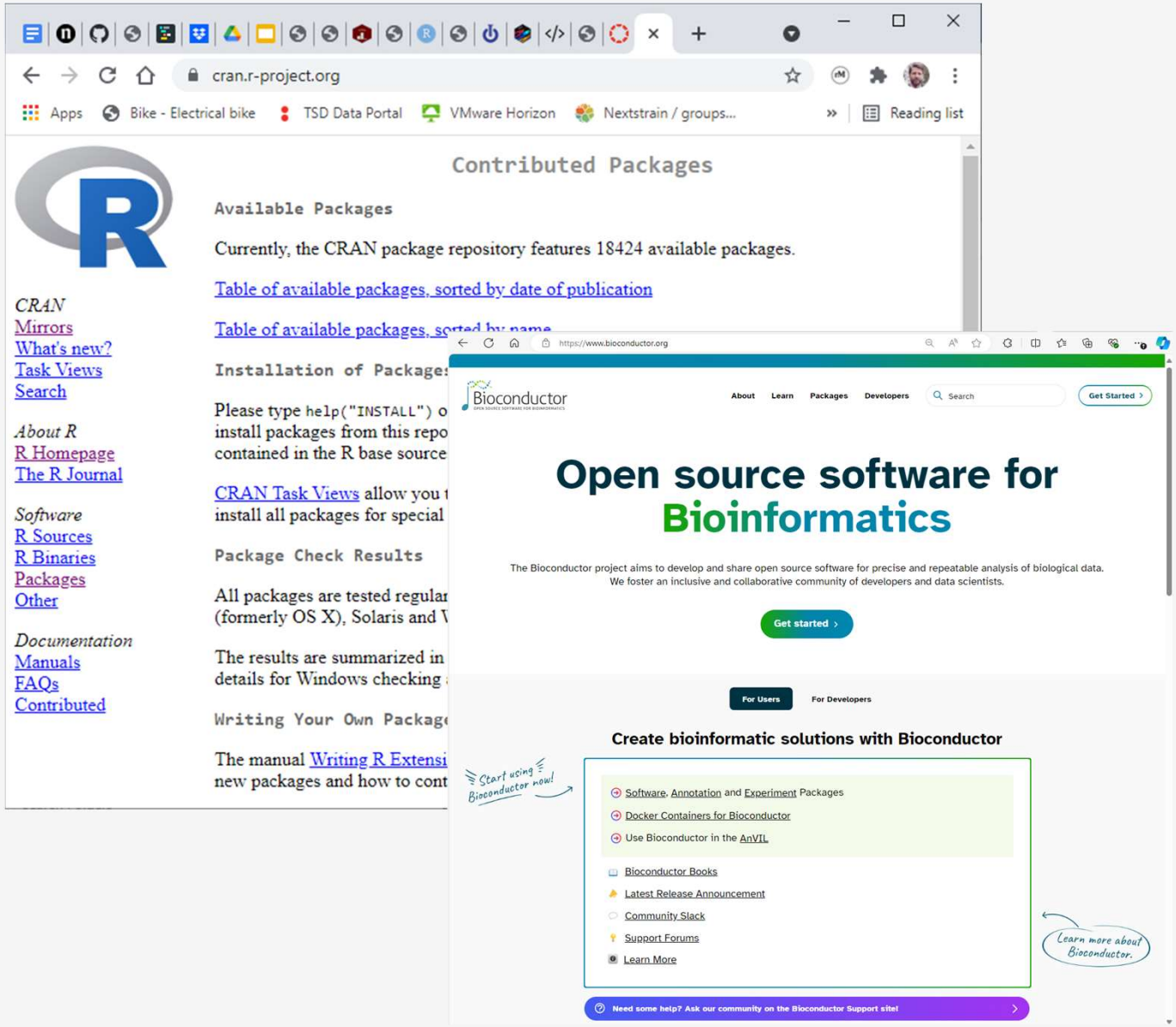
CRAN and Bioconductor are the main repositories for packages.

Packages needs to be installed, e.g. by typing

```
install.packages("package")
```

And activated before use by typing

```
library("package")
```



Tidyverse

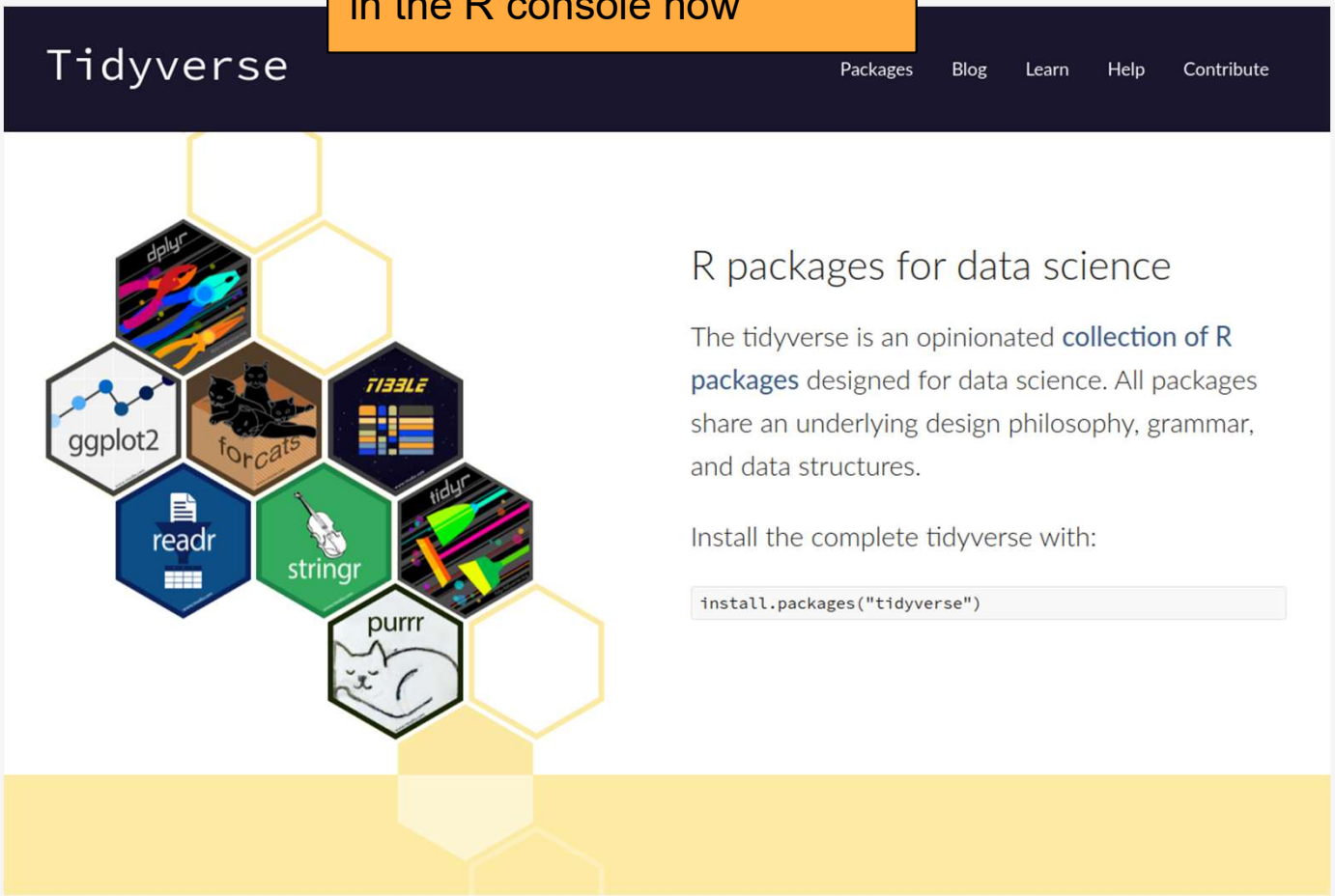
*"A system of packages for **data manipulation**, **exploration** and **visualization** that share a common design philosophy."*

Centered around "Rectangular data structures" (e.g. data frames, matrices..)

tidyverse.org

```
install.packages("tidyverse")
```

Everyone should try to run install.packages("tidyverse") in the R console now



Free online book for learning R and the tidyverse: [R for Data Science (2e)]

The rectangular data type

A lot of the work you will do in R is centered around “rectangular data”, or data frames. Data frames are like tables with each row is a record and the columns are the different variables.

Columns

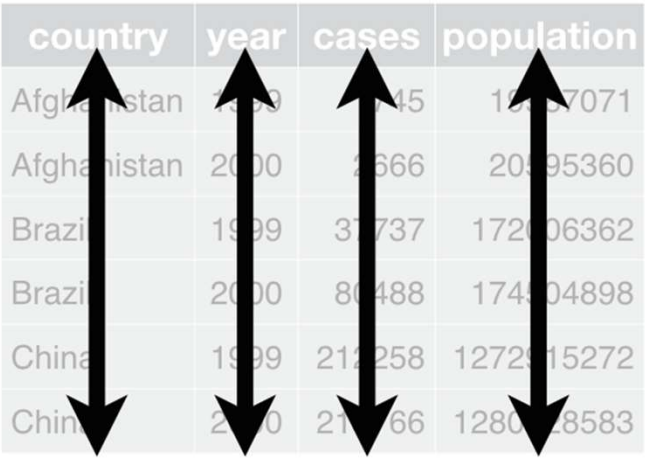
Header

Rows

```
        state abb region population total
1     Alabama  AL  South    4779736   135
2      Alaska  AK   West     710231    19
3     Arizona  AZ   West    6392017   232
4    Arkansas  AR  South    2915918    93
5  California  CA   West   37253956  1257
6    Colorado  CO   West    5029196    65
```

Tidy data

1. Each variable is a column; each column is a variable.



variables

2. Each observation is a row; each row is an observation.

observations

3. Each value is a cell; each cell is a single value.

values

Contain all *values* that measure the same underlying attribute (e.g., country, year…).

An *observation* contains all *values* measured on the same unit (e.g., country) across attributes (notice multiple observations on the same row).

Strings (text) or numbers. Belong to a *variable* and an *observation.*

"tidy datasets are all alike but every messy dataset is messy in its own way."
https://www.jstatsoft.org/article/view/v059i10

R for Data Science, Hadley Wickham

Tidy data

We say that a data table is in ***tidy format*** if each row represents *one observation* and columns represent the different *variables* available for each of these observations.

Each variable forms a column

One observation per row

```
      country year fertility
1     Germany 1960      2.41
2 South Korea 1960      6.16
3     Germany 1961      2.44
4 South Korea 1961      5.99
5     Germany 1962      2.47
6 South Korea 1962      5.79
```

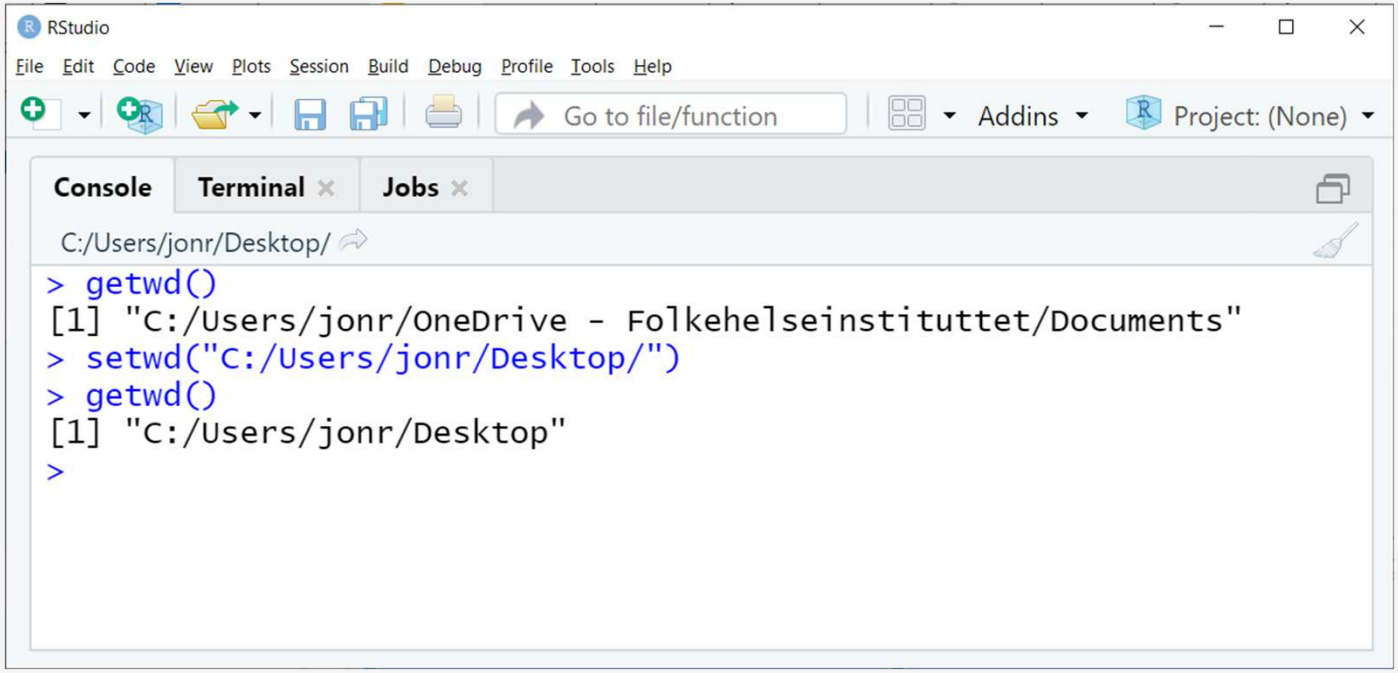
Multiple observations per row

```
      country 1960 1961 1962
1     Germany 2.41 2.44 2.47
2 South Korea 6.16 5.99 5.79
```

https://rafalab.github.io/dsbook/tidyverse.html

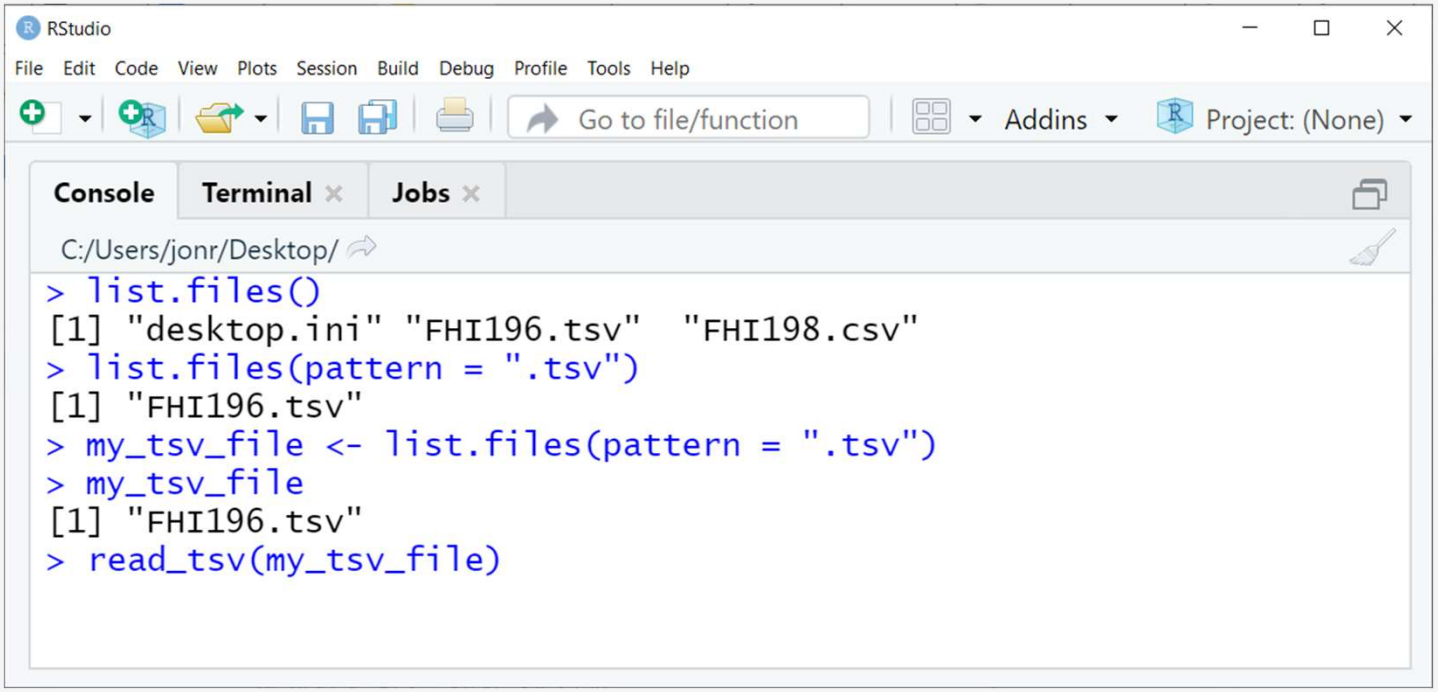
Working directory

The *getwd()* function let's you see where on your file system R is currently working. Change the working directory with *setwd()*.



File system - access files

lists.files() and *list.dirs()* will show the files and the directories in the working directory. Use the *pattern* argument to filter what kind of files or directories to be listed.



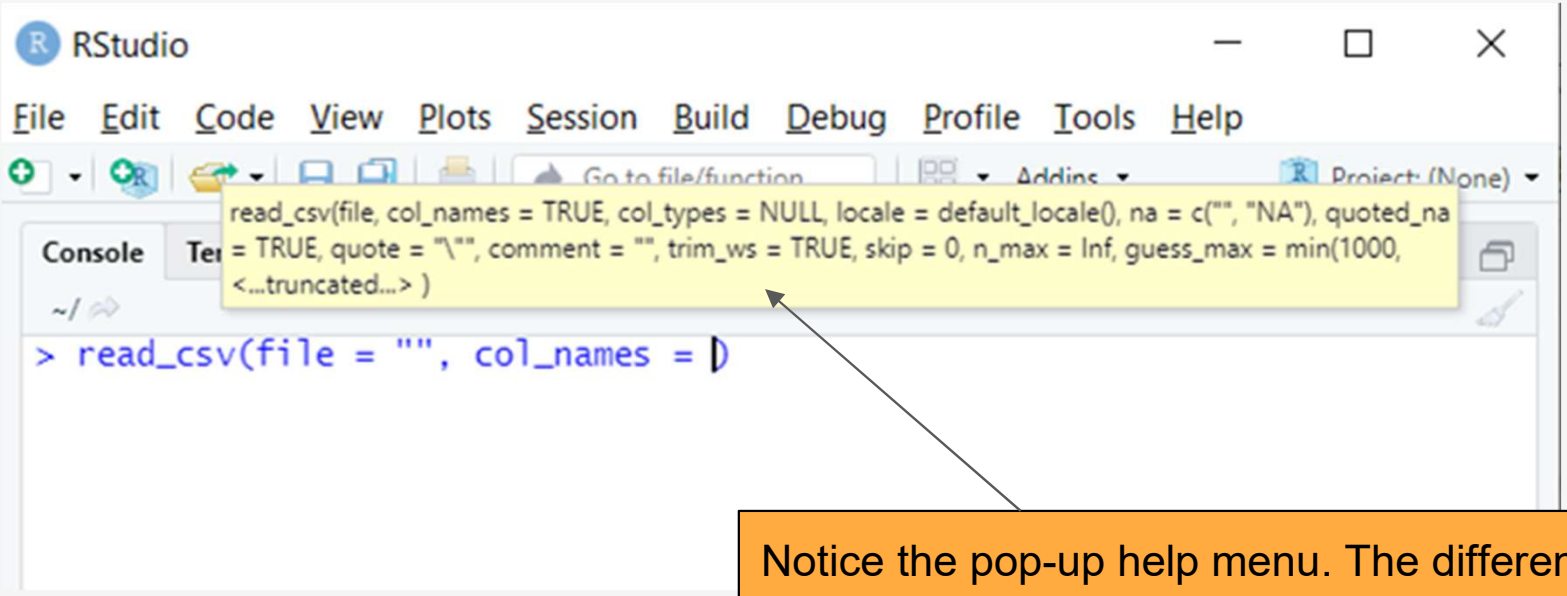
Getting data into R - the readr package

There are many ways of getting data from files into R. The readr package offers several functions for reading different data types.

```
read_csv(): comma separated (CSV) files
read_tsv(): tab separated files
read_delim(): general delimited files
read_fwf(): fixed width files
read_table(): tabular files where columns are
separated by white-space.
read_log(): web log files
```

Getting data into R - the readr package

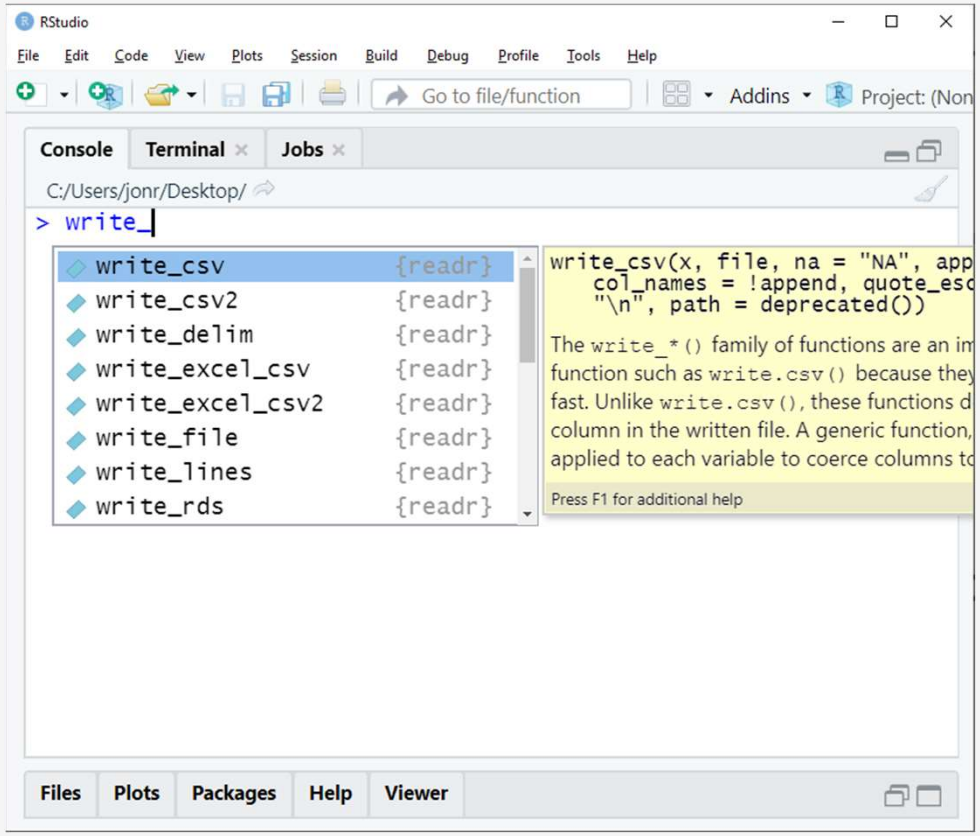
The functions have different arguments that can be used to further specify the structure of the file to be read. E.g., does the file have a header line? What type of symbol separates the columns? Are there any lines that should be skipped? Etc.



Notice the pop-up help menu. The different arguments are shown, with default values.

Getting data out of R

The readr package also comes with complementary write functions that can write files in different formats.



Tibbles

A tibble is a special kind of data frame. Tibbles are the preferred format in the tidyverse and most tidyverse operations result in a tibble. Tibbles also display better when printed in R.

```
Console   Terminal ×   Background Jobs ×
R 4.0.4 · C:/Users/jonr/Desktop/
> murders
                  state abb        region population total
1               Alabama  AL         South    4779736   135
2                Alaska  AK          West     710231    19
3               Arizona  AZ          West    6392017   232
4              Arkansas  AR         South    2915918    93
5            California  CA          West   37253956  1257
6              Colorado  CO          West    5029196    65
7           Connecticut  CT     Northeast    3574097    97
8              Delaware  DE         South     897934    38
9  District of Columbia  DC         South     601723    99
10              Florida  FL         South   19687653   669
11              Georgia  GA         South    9920000   376
12               Hawaii  HI          West    1360301     7
13                Idaho  ID          West    1567582    12
14             Illinois  IL North Central   12830632   364
```

```
RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function   Addins   Project: (None)
Console   Terminal ×   Jobs ×
C:/Users/jonr/Desktop/
> as_tibble(murders)
# A tibble: 51 x 5
   state                abb   region    population total
   <chr>                <chr> <fct>          <dbl> <dbl>
 1 Alabama              AL    South        4779736   135
 2 Alaska               AK    West          710231    19
 3 Arizona              AZ    West         6392017   232
 4 Arkansas             AR    South        2915918    93
 5 California           CA    West        37253956  1257
 6 Colorado             CO    West         5029196    65
 7 Connecticut          CT    Northeast    3574097    97
 8 Delaware             DE    South         897934    38
 9 District of Columbia DC    South         601723    99
10 Florida              FL    South       19687653   669
# ... with 41 more rows
>
```