You Ready? An Introduction to R for Researchers

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Hopefully by the end of this workshop, you will:

- Become familiar with the main features of RStudio
- Know how to upload your dataset
- Know how to install and use R packages and functions
- Learn basic data manipulation and operations in R
- Learn to generate basic figures using ggplot2
- Learn how to save your results

Why use R?

- Designed specifically for statistics and data analysis and visualization
  - Thousands of freely available functions and packages for data analysis and visualization
- Can avoid manual errors by automating repetitive tasks with code
- Create customized, professional figures for presentations and publications

R Programming Language

- R is an object-oriented language
  - Everything in R is an object
- An object is something that contain data
  - Different types of data: numbers, characters, functions, symbols, plots, and mathematical and logical expressions
- All R code manipulates objects
- Objects may have attributes, such as names, dimensions, and class

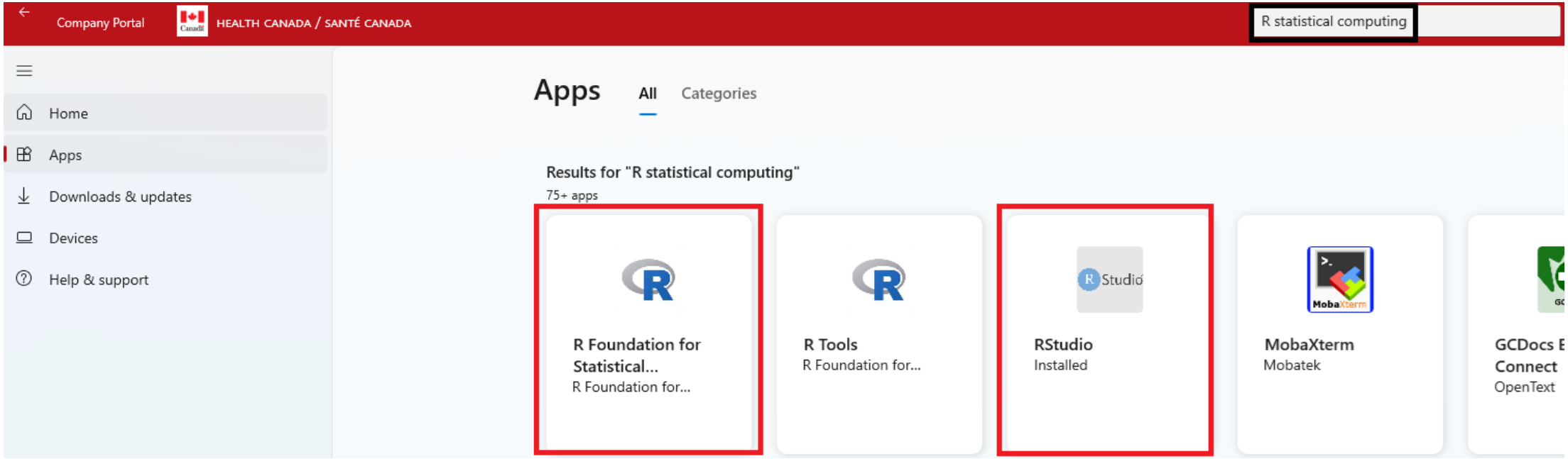
RStudio

- An Integrated Development Environment (IDE)
  - A platform for programming in R
  - Write, edit, and run your R code
  - Install and use packages and functions

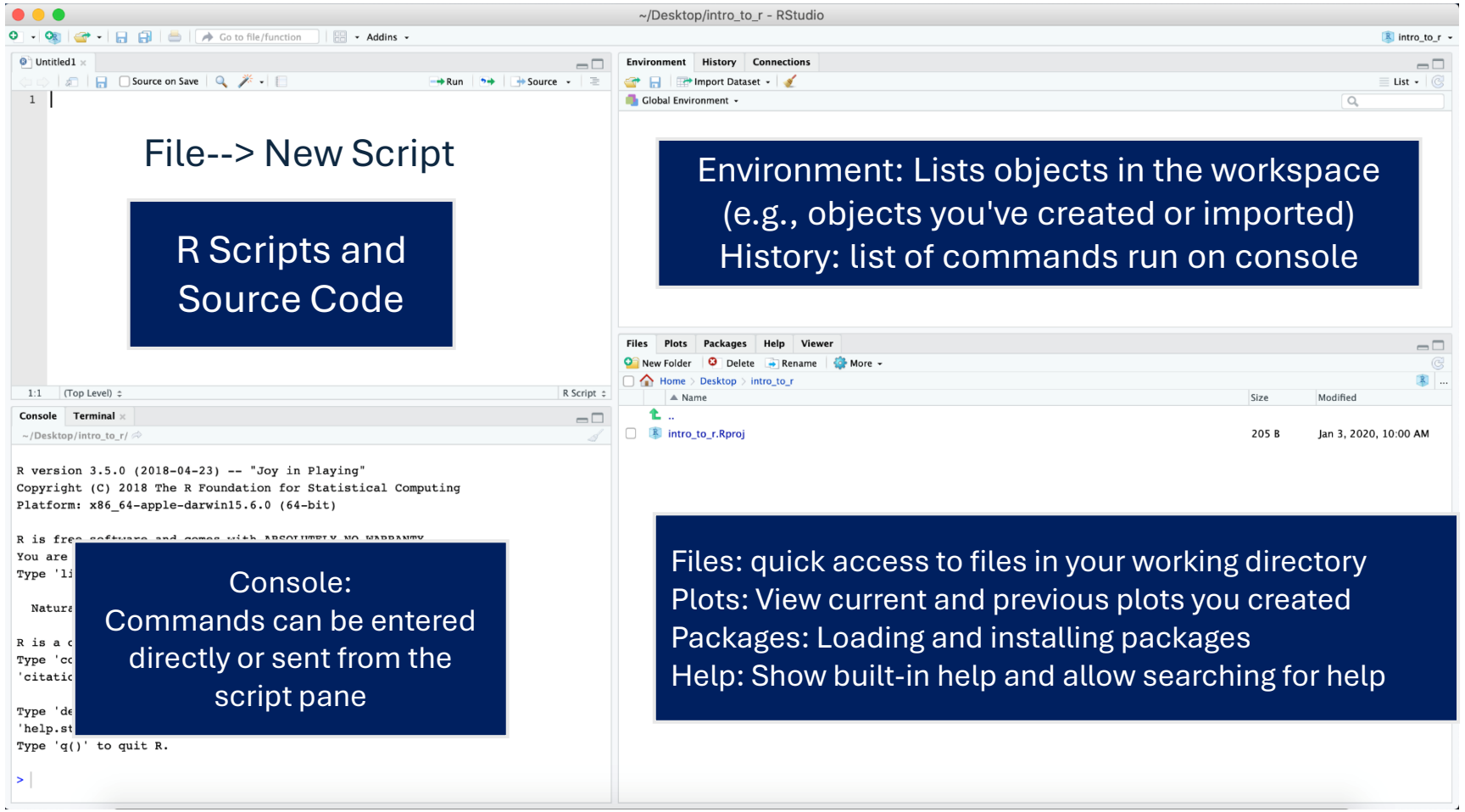
- In RStudio, you can load, manipulate (data wrangling), analyze, and visualize your data

Getting started – Download R and RStudio

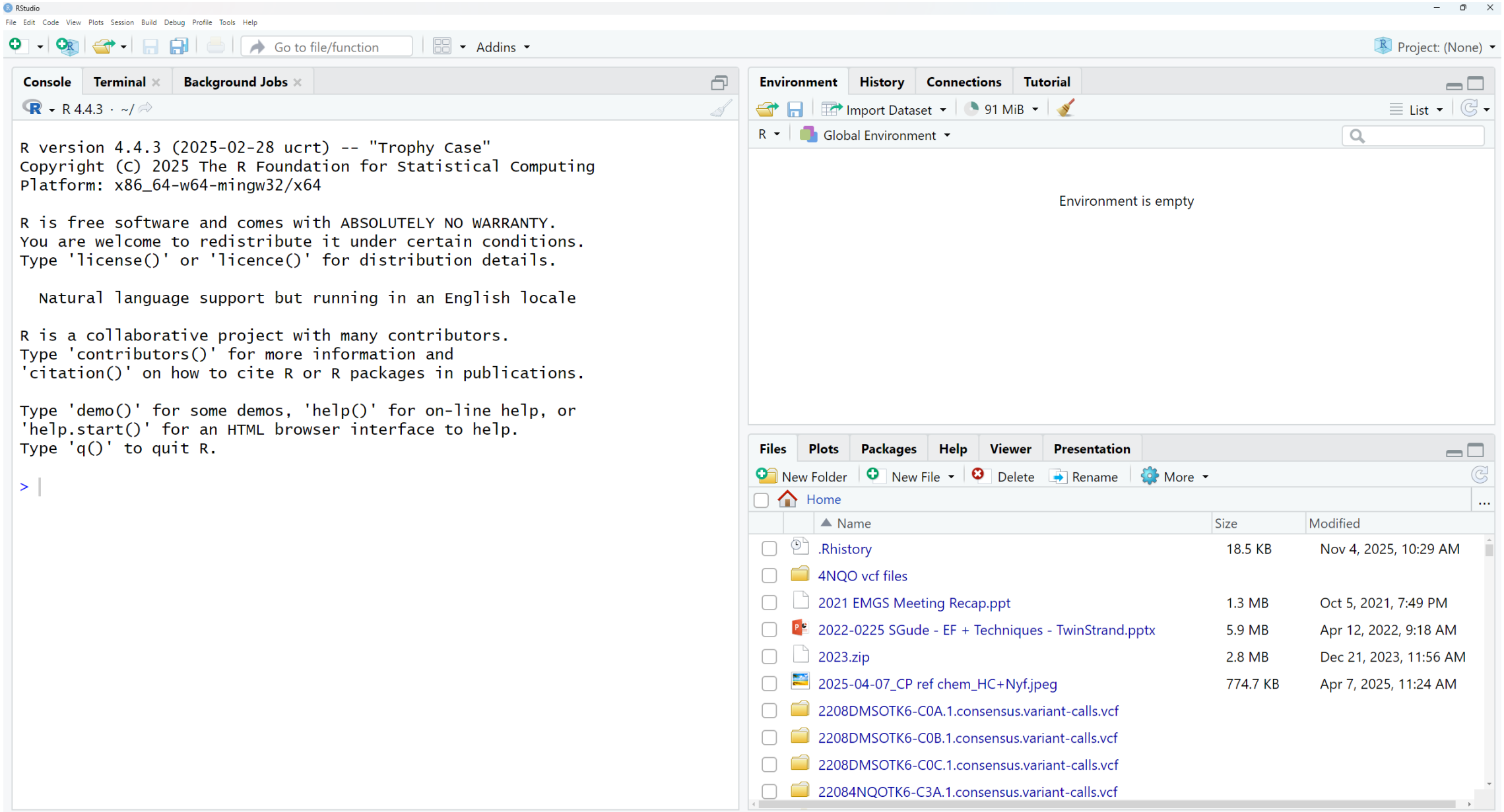
- Search “R statistical computing” on the Company Portal
- Install “R Foundation for Statical Computing” and “RStudio”



A Guided Tour of RStudio

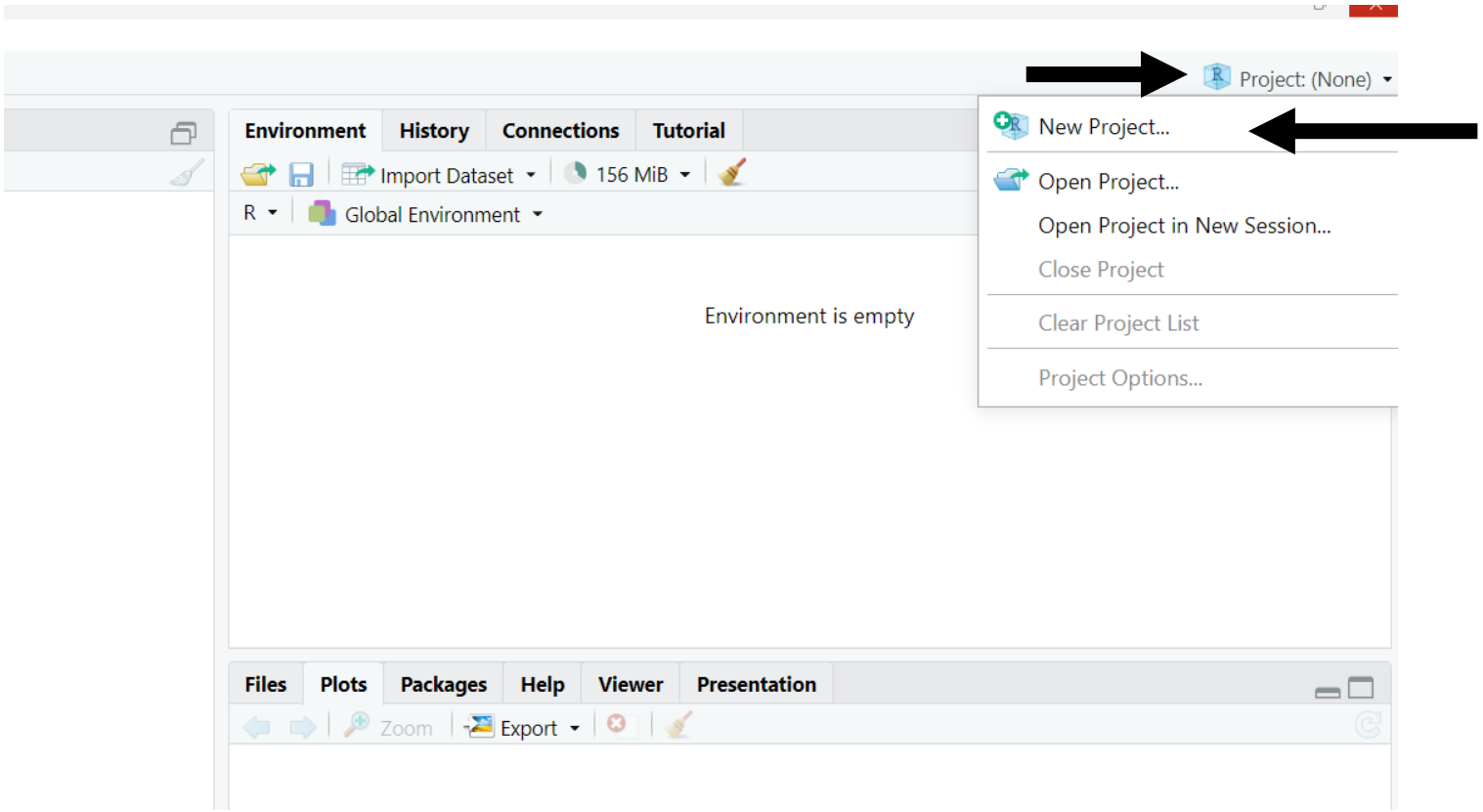


RStudio Interface



Before you start, create a new project in RStudio

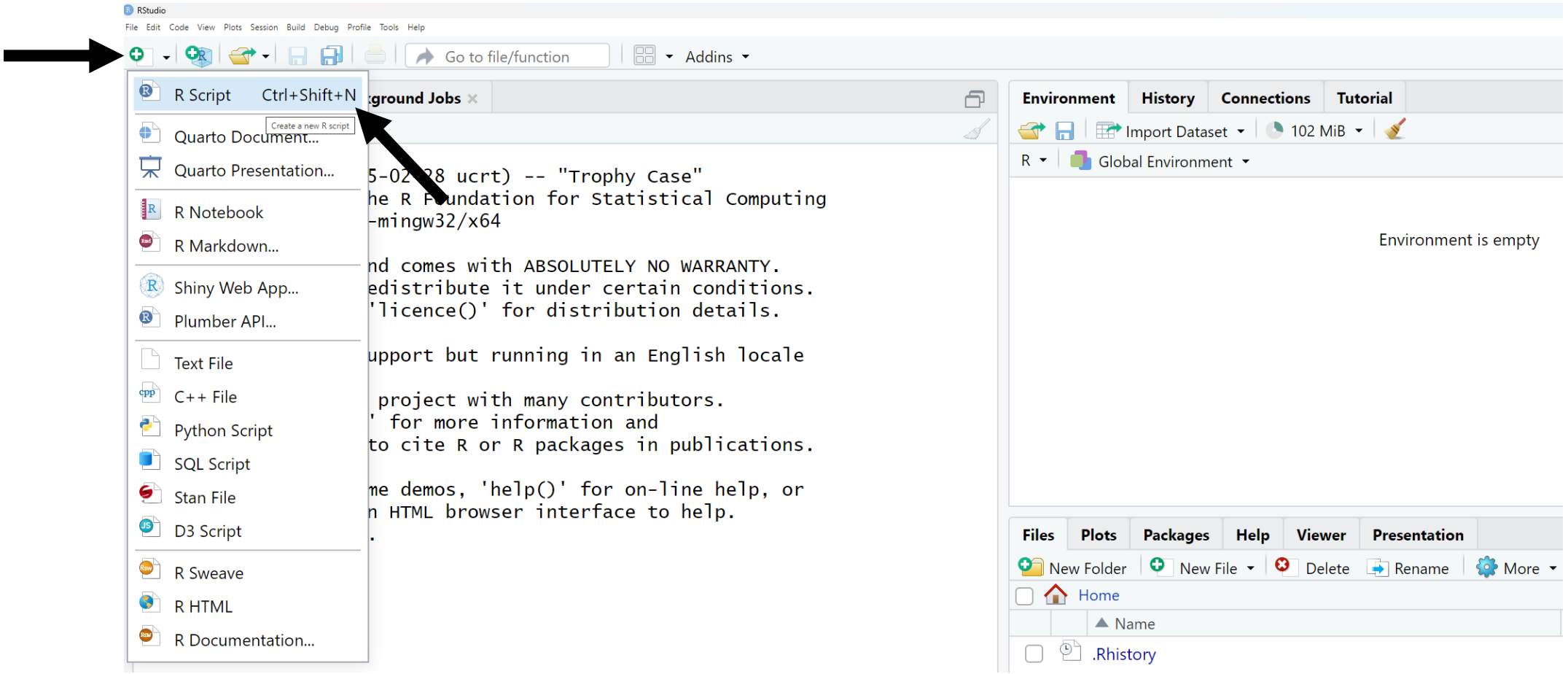
Under the “Project” tab at the top right corner of RStudio



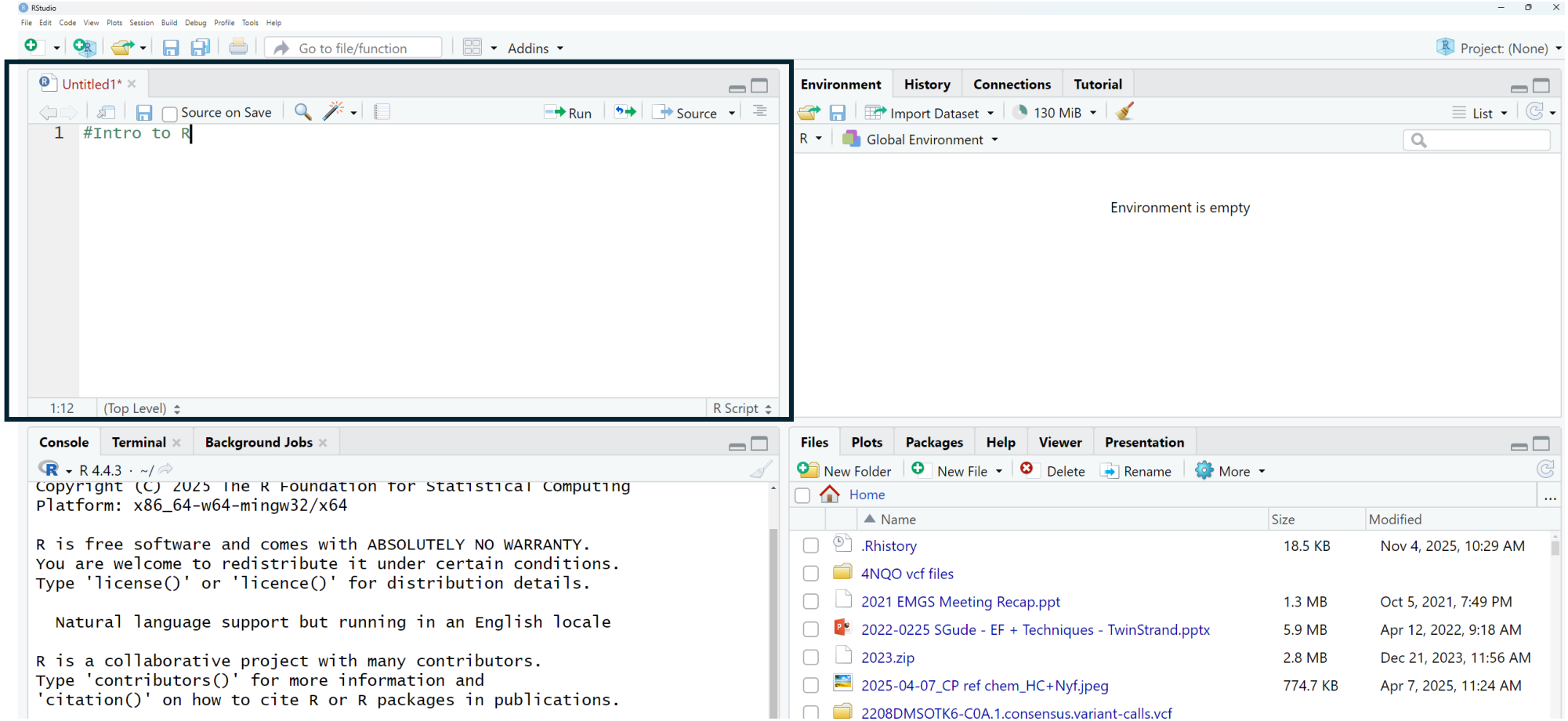
- A project is a self-contained workspace/folder that keeps all your scripts, data, and output
  - Your working directory

Create a new R Script

At the top left corner of RStudio



Create a new R Script



Introducing R Commands

- R is an interpreted language
  - Code are executed line by line
- Accessed through a command-line interpreter
  - This requires the user knowledge of commands and their parameters, and the syntax of the language
- Upon starting, there is a “>” in the console
  - R is prompting you to type something, so this is called a prompt
- The commands that you type into the console are called expressions

Creating and naming an object

- To create an object, the assignment operator (**<-**) is used

- <- assigns value to a name:
  - object_name <- 125
  - object.name <- 357
  - ObjectName <- “Object”

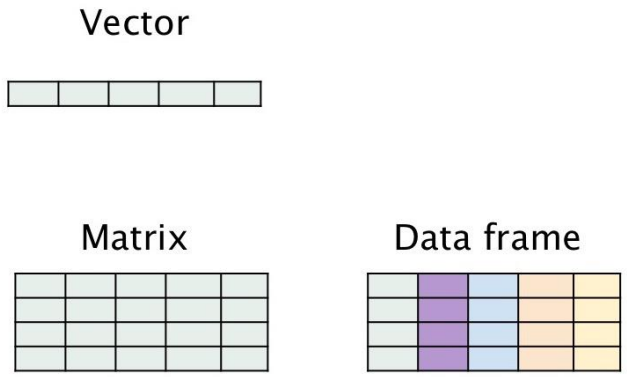
- Names are case sensitive

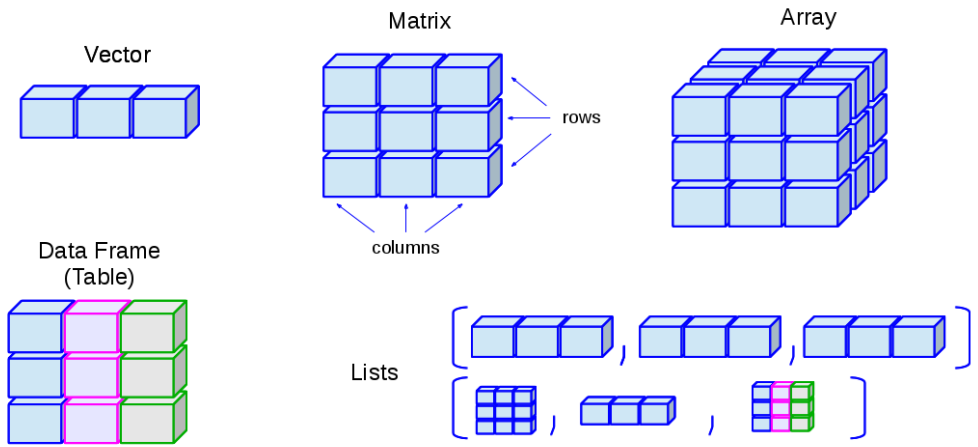
- Never use space or special characters in object names
  - Including mathematical operators
- Names should not start with a number

Objects in R

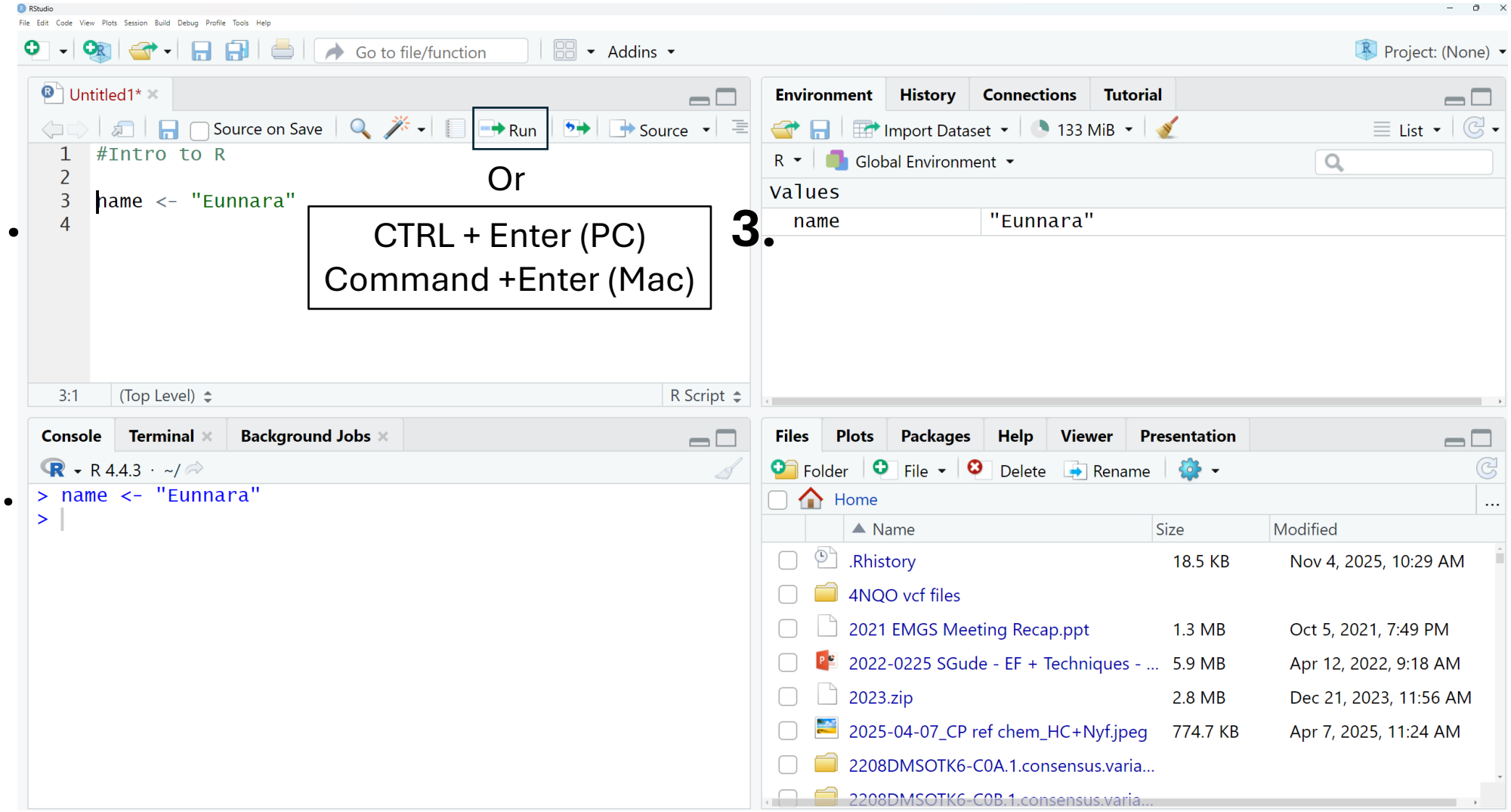
- Numeric
  - my_number <- 5
- Character
  - my_name <- “Eunnara”
- Vector (simple list of values)
  - even_numbers <- c(2, 4, 6, 8)
  - my_vowels <- c(“a”, “e”, “i”, “o”)
- Data frame (data tables)
- Plots (images)
- Functions

Variables	Example
integer	100
numeric	0.05
character	“hello”
logical	TRUE
factor	“Green”





Write and execute your commands



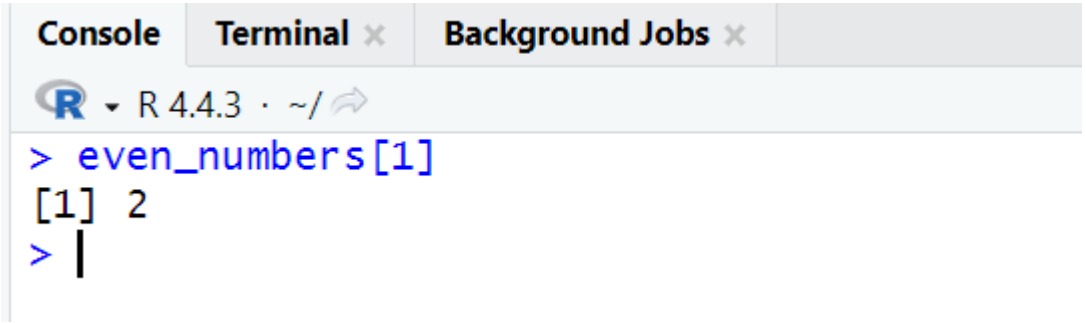
Indexing data in R

- **Numbering starts from 1**
  - Some programming languages start from 0

- Consider the vector:

  even_numbers <- c(2, 4, 6, 8)

  - To access the first number in the vector (2),

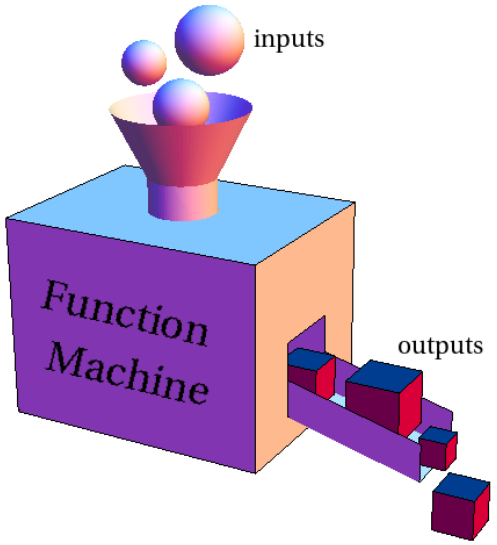


- Similarly, for a table/data frame:

  dataframe[row, column]

Functions in R

- Set of R statements that are executed in a specific order to process input arguments to produce an output
  - Output can be made into an object
  - Output can be numeric, character, vector, data table, plot

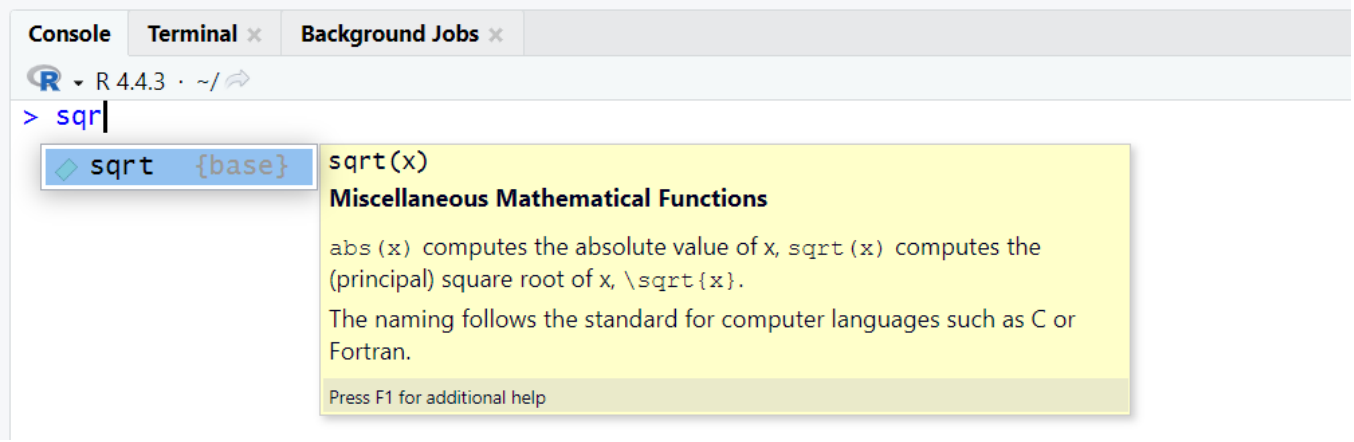


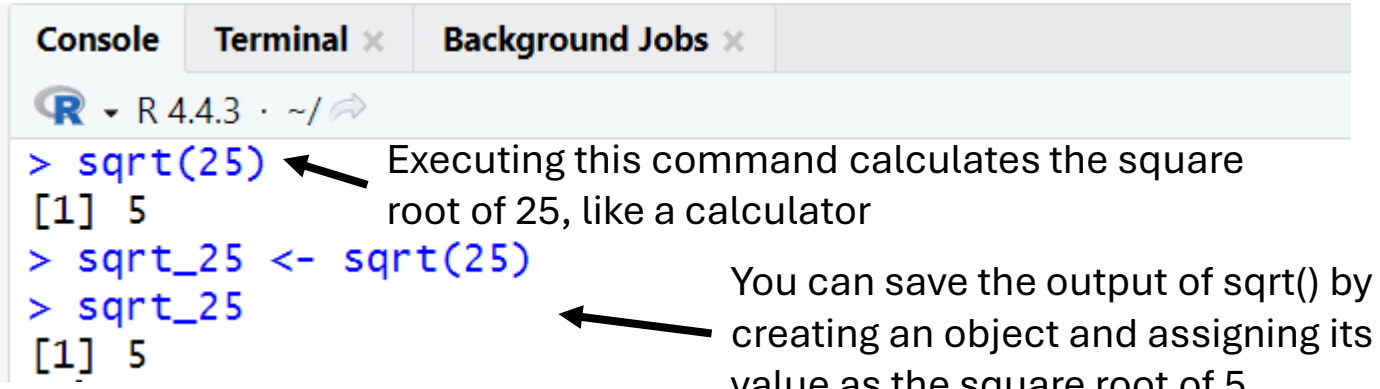
- Reusable for different input
- Hundreds of thousands of premade functions available in R
- Users can write their own functions too
- function_name(input1, input2,….)
  - Different functions require a different number of input arguments

Examples of functions

Category	Function
Mathematical Functions	`abs()`, `sqrt()`, `round()`, `exp()`, `log()`, `cos()`, `sin()`, `tan()`
Statistical Functions	`mean()`, `median()`, `cor()`, `var()`, `aov()`
Data Manipulation Functions	`unique()`, `subset()`, `aggregate()`, `order()`
File Input/Output Functions	`read.csv()`, `write.csv()`, `read.table()`, `write.table()`

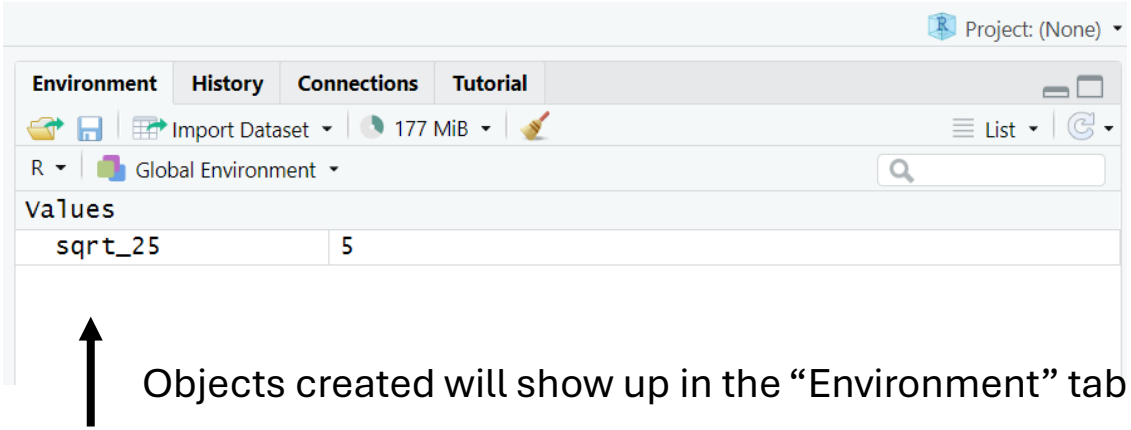
https://www.geeksforgeeks.org/r-language/functions-in-r-programming/





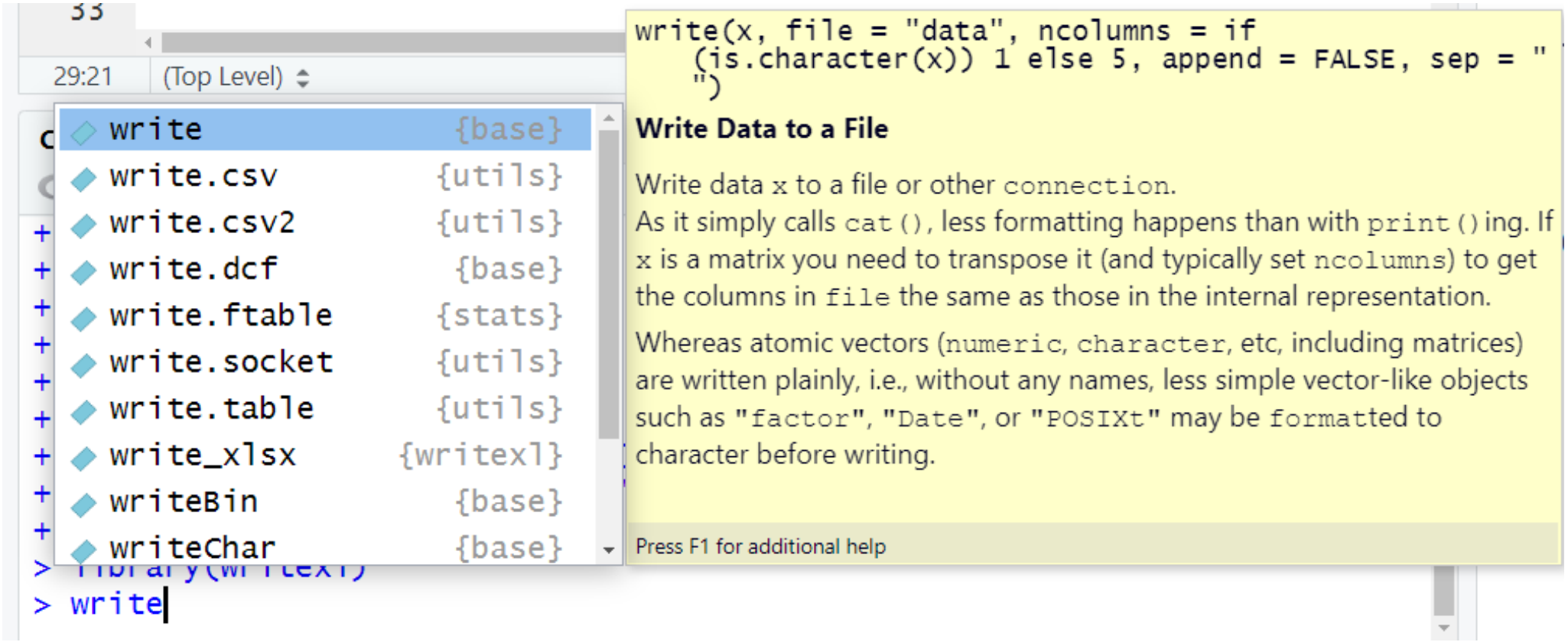
Executing this command calculates the square root of 25, like a calculator

You can save the output of sqrt() by creating an object and assigning its value as the square root of 5

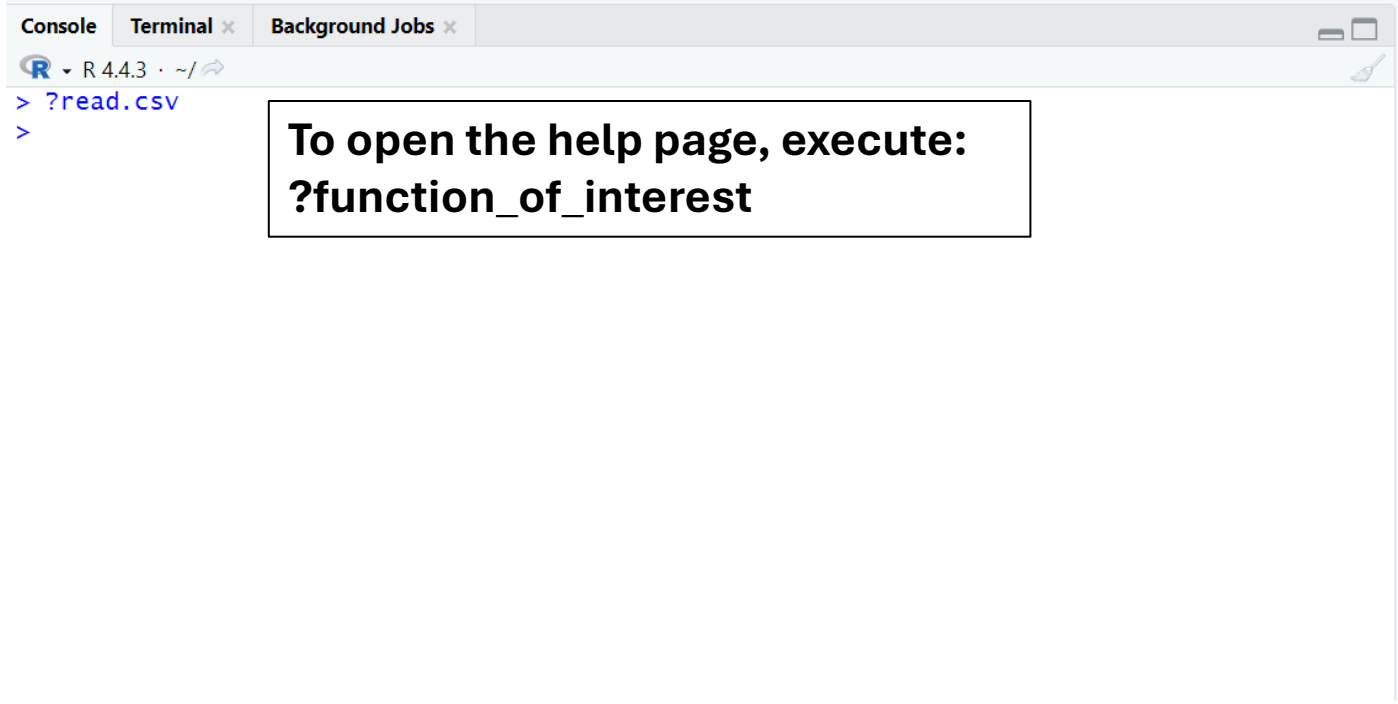


Objects created will show up in the “Environment” tab

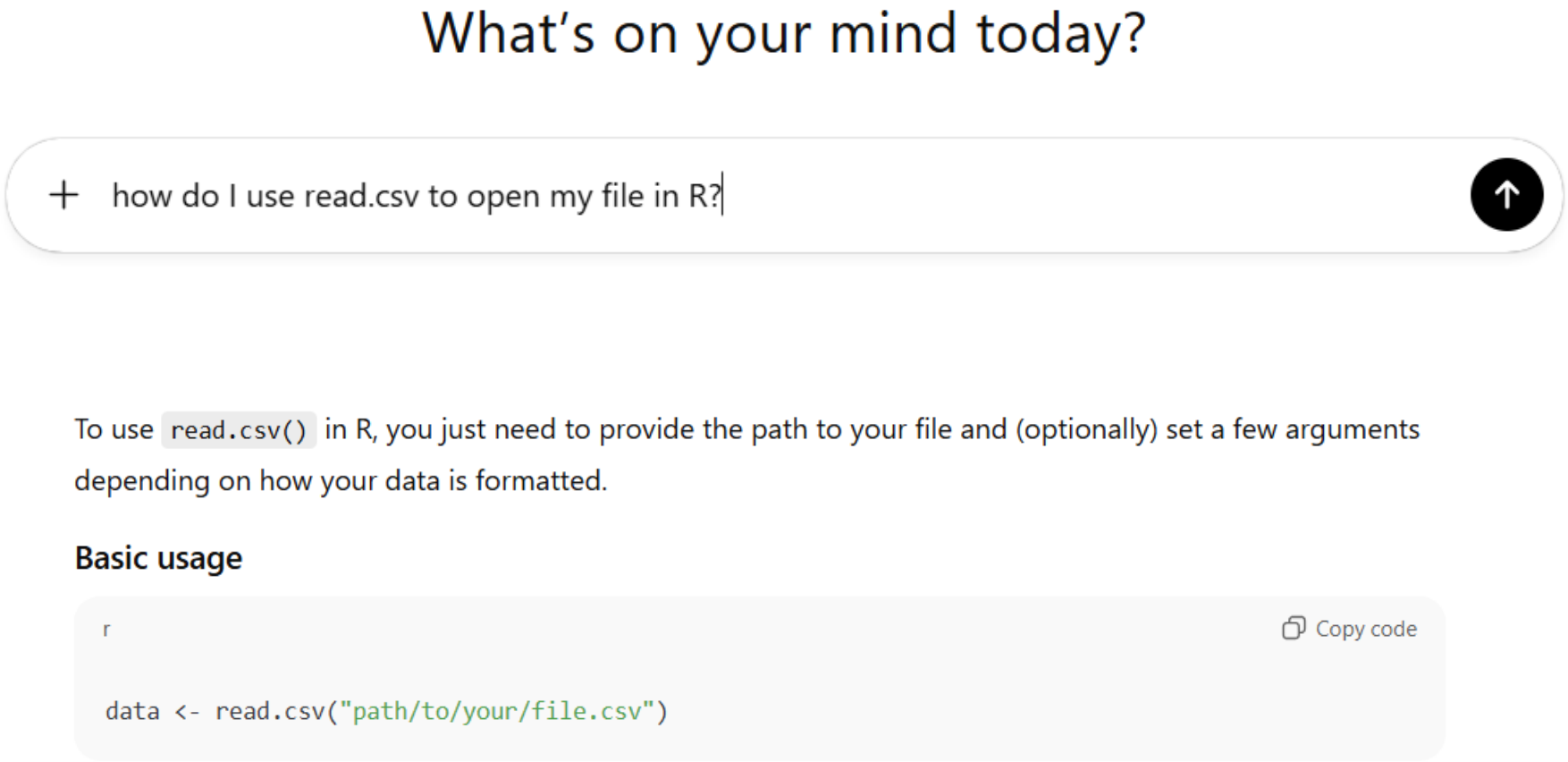
Required input arguments



The Help tab shows you how to use a function



AI is also a great resource



What's on the agenda today?

+ Which R function can I use to merge two dataframes together?

To merge two data frames in **R**, the most common built-in function is:

✅ `merge()`

r

Copy code

```r
merged_df <- merge(df1, df2, by = "id")
```

You can also specify:

- `by.x` / `by.y` (if the key columns have different names)
- `all = TRUE` (full join)
- `all.x = TRUE` (left join)
- `all.y = TRUE` (right join)

[No Title]

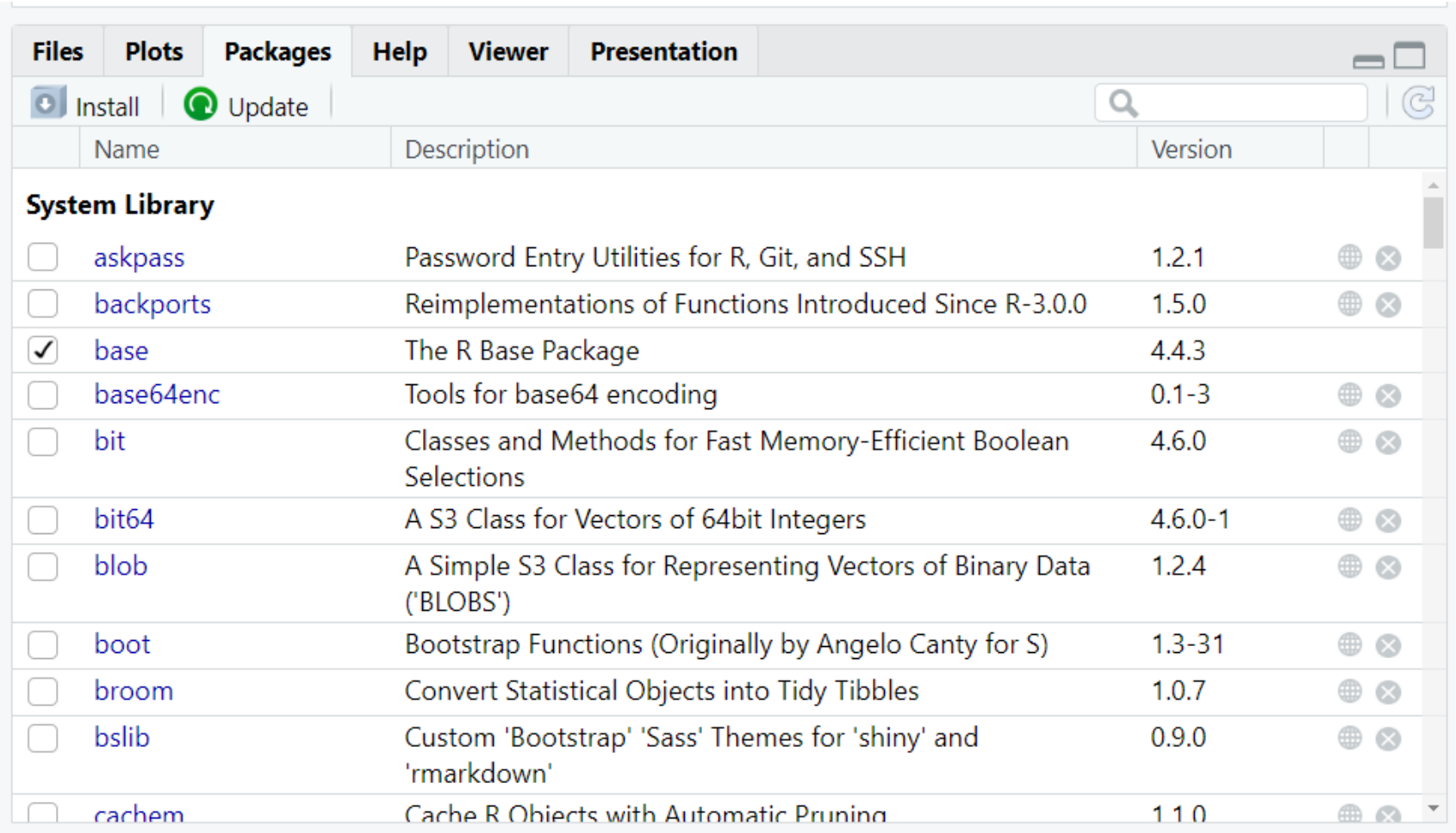
👍 **Tidyverse alternatives (from dplyr):**

- `left_join(df1, df2, by = "id")`
- `right_join(df1, df2, by = "id")`

Packages

- Sets of functions that are related to each other
- Some packages are included with R and loaded by default
- Some need to be installed and loaded to use the functions:
  - Function to install packages: **install.packages("package_name")**
  - Function to load packages: **library(package_name)**
- Some packages rely on functions from other packages
  - These other packages are called "dependencies"

The Packages tab shows pre-installed base packages



Useful packages

- Tidyverse
  - Collection of R packages for data manipulation and visualization

  - dplyr – manipulate data in tables
  - tidyr – reshaping data
  - readr – import datasets (csv, tsv)
  - stringr – manipulate text in data
  - ggplot2 – data visualization

- readxl and writexl
  - For importing and exporting .xls and .xlsx files

Load your data on RStudio

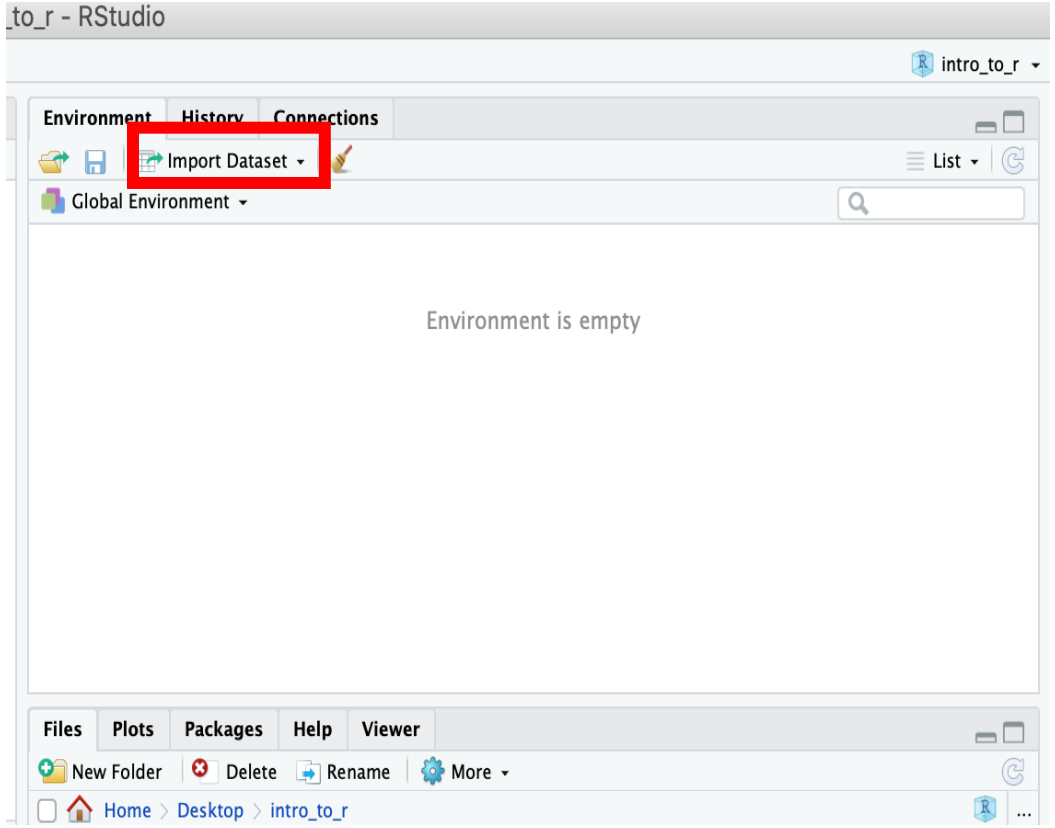
- You can import common file formats like .xlsx, .txt, .csv, and .tsv

- However, **plain text files (.csv, .tsv) are recommended**
  - Can be opened on any computer
  - Transferable across programming languages
  - No special software required
  - Less chance of corrupted files

- .xls or .xlsx files require Excel, a proprietary software

How to load your data on RStudio

1) Manually import your data into your R environment using the “Import Dataset” button



2) Use functions to import your data

- **your_data <- read.csv(path_to_file)**
- **your_data <- read.table(path_to_file)**
- your_data <- read_xlsx(path_to_file)

Example:

your_data <- read.csv("C:/Users/EUCHO/OneDrive - HC-SC PHAC-ASPC/Documents/sample_data.csv")

  - Backslashes (\) in the pathway need to be replaced with forward slashes (/)

Data frames

- Similar to data tables in Excel spreadsheets
  - Very commonly used data structure in R
- Columns contain variables
  - Different columns can have different types of data (e.g. numeric, character, logical)
- Rows contain observations for each variable
- All columns must have the same length

Animal	Chemical	Dose	Weight	Vehicle
Mouse	ChemA	0	28	SolventA
Mouse	ChemA	10	27	SolventA
Mouse	ChemA	20	25	SolventA
Mouse	ChemA	40	23	SolventA
Mouse	ChemB	0	28	SolventB
Mouse	ChemB	10	26	SolventB
Mouse	ChemB	20	24	SolventB
Mouse	ChemB	40	22	SolventB
Mouse	ChemC	0	28	SolventA
Mouse	ChemC	10	25	SolventA
Mouse	ChemC	20	22	SolventA
Mouse	ChemC	40	17	SolventA

Data visualization: ggplot2 package

- Package for developing graphics
- Plots are built by combining layers of data, aesthetics, and geometry:
  - Data – your dataset (data frame)
  - Aesthetics – define x- and y- axis, other properties like colour
  - Geometry – type of plot (point, line, bar)
- Additional layers can be added to customize your plots
  - Labels
  - Legends
  - Trend lines etc.

Example ggplot2 code

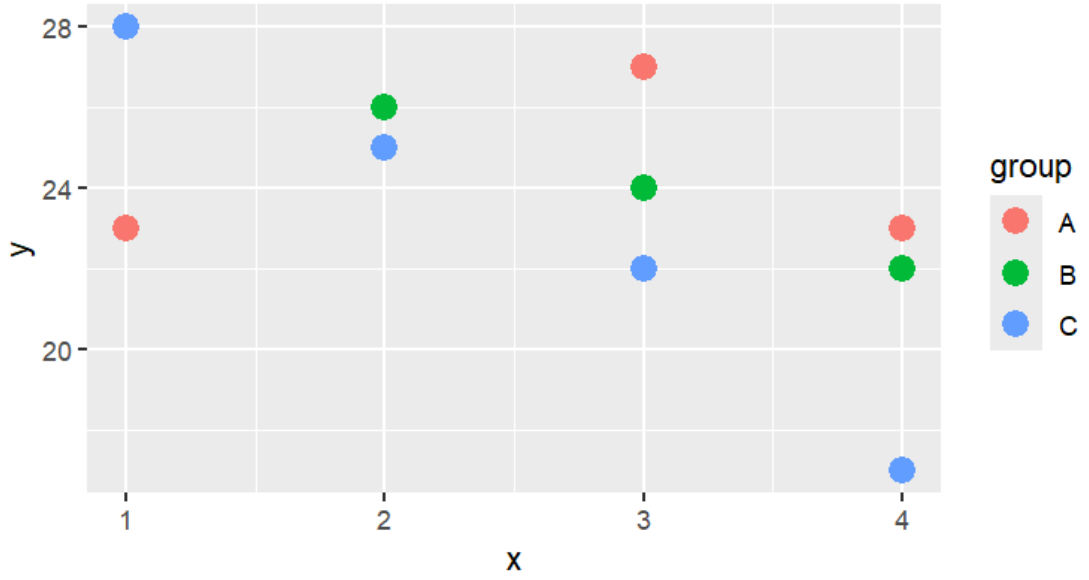
```
ggplot(your_data, aes(x = x, y = y, color = group)) +

 geom_point(size = 4)
```

your_data

group	x	y
A	1	23
A	2	25
A	3	27
A	4	23
B	1	28
B	2	26
B	3	24
B	4	22
C	1	28
C	2	25
C	3	22
C	4	17

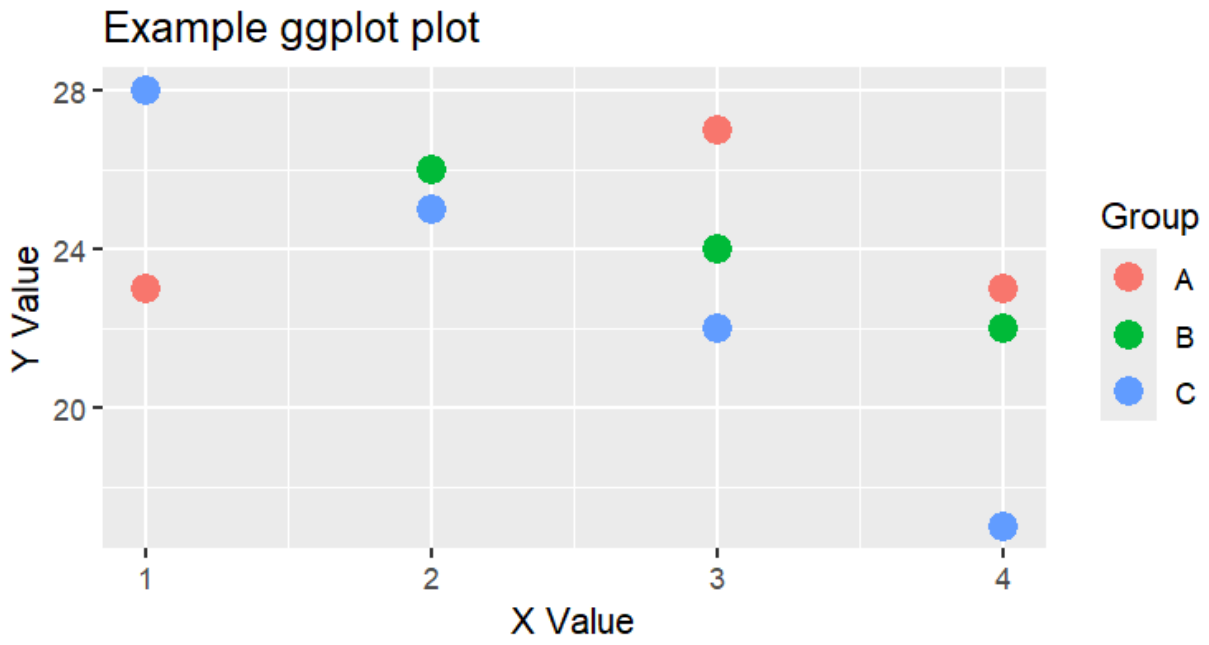
ggplot output



```
ggplot(your_data, aes(x = x, y = y, color = group)) +

 geom_point(size = 4) +

labs(
   title = “Example ggplot plot",
   x = "X Value",
   y = "Y Value",
   color = "Group"
 )
```

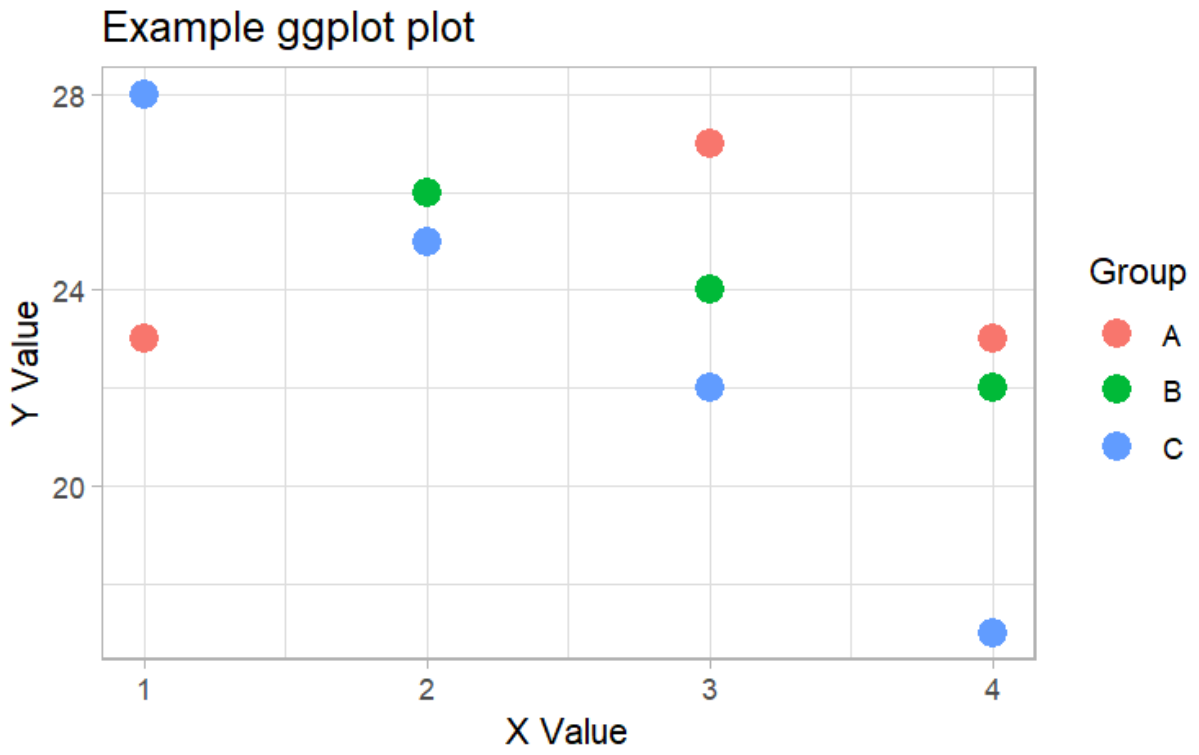


```
ggplot(your_data, aes(x = x, y = y, color = group)) +

 geom_point(size = 4) +

labs(
   title = “Example ggplot plot",
   x = "X Value",
   y = "Y Value",
   color = "Group"
 ) +

 theme_light( )
```



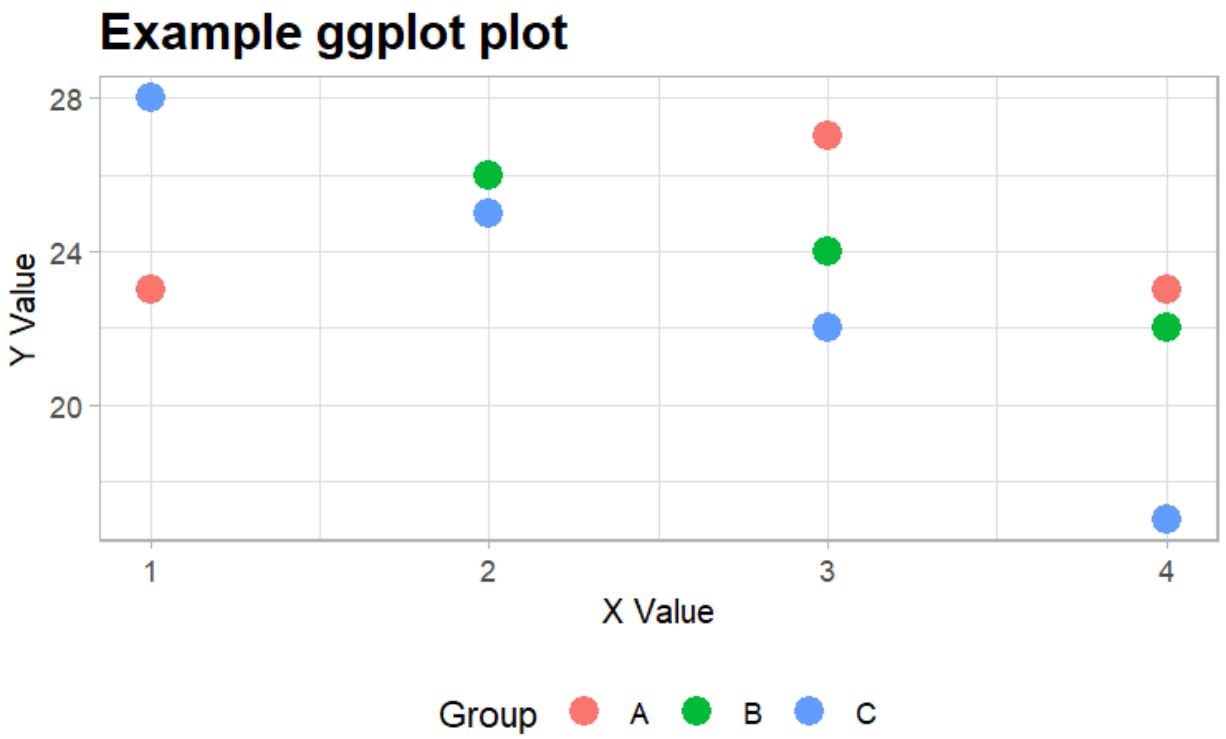
```
ggplot(your_data, aes(x = x, y = y, color = group)) +

 geom_point(size = 4) +

labs(
   title = “Example ggplot plot",
   x = "X Value",
   y = "Y Value",
   color = "Group"
 ) +

 theme_light( ) +

theme(plot.title = element_text(face = “bold”,
                                size = 15),
          axis.title.x = element_text(size = 10),
          axis.title.y = element_text(size = 10),
          legend.position = “bottom”
            )
```



Functions for data reshaping and manipulation

Functions in the tidyverse package can perform similar operations as the Sort & Filter option in Excel:

- select()
- filter()
- group_by()
- arrange()
- and many more

Selecting columns: select(data_frame, columns)

```
data_2 <- select(your_data, group, x)
```

your_data

group	x	y
A	1	23
A	2	25
A	3	27
A	4	23
B	1	28
B	2	26
B	3	24
B	4	22
C	1	28
C	2	25
C	3	22
C	4	17

data_2

group	x
A	1
A	2
A	3
A	4
B	1
B	2
B	3
B	4
C	1
C	2
C	3
C	4

Selecting columns: select(data_frame, columns)

```
data_2 <- select(your_data, Chemical:Weight)
```

your_data

Animal	Chemical	Dose	Weight	Vehicle
Mouse	ChemA	0	28	SolventA
Mouse	ChemA	10	27	SolventA
Mouse	ChemA	20	25	SolventA
Mouse	ChemA	40	23	SolventA
Mouse	ChemB	0	28	SolventB
Mouse	ChemB	10	26	SolventB
Mouse	ChemB	20	24	SolventB
Mouse	ChemB	40	22	SolventB
Mouse	ChemC	0	28	SolventA
Mouse	ChemC	10	25	SolventA
Mouse	ChemC	20	22	SolventA
Mouse	ChemC	40	17	SolventA

data_2

Chemical	Dose	Weight
ChemA	0	28
ChemA	10	27
ChemA	20	25
ChemA	40	23
ChemB	0	28
ChemB	10	26
ChemB	20	24
ChemB	40	22
ChemC	0	28
ChemC	10	25
ChemC	20	22
ChemC	40	17

Columns can also be specified by numbers

```
data_2 <- select(your_data, 2:4)
```

your_data

Animal	Chemical	Dose	Weight	Vehicle
Mouse	ChemA	0	28	SolventA
Mouse	ChemA	10	27	SolventA
Mouse	ChemA	20	25	SolventA
Mouse	ChemA	40	23	SolventA
Mouse	ChemB	0	28	SolventB
Mouse	ChemB	10	26	SolventB
Mouse	ChemB	20	24	SolventB
Mouse	ChemB	40	22	SolventB
Mouse	ChemC	0	28	SolventA
Mouse	ChemC	10	25	SolventA
Mouse	ChemC	20	22	SolventA
Mouse	ChemC	40	17	SolventA

data_2

Chemical	Dose	Weight
ChemA	0	28
ChemA	10	27
ChemA	20	25
ChemA	40	23
ChemB	0	28
ChemB	10	26
ChemB	20	24
ChemB	40	22
ChemC	0	28
ChemC	10	25
ChemC	20	22
ChemC	40	17

Filtering rows: filter(data_frame, filtering criteria)

- To set the filtering criteria, **operators** can be used:

For comparing two values:

Operator	Meaning	Example
==	equal to	5 == 5 → TRUE
!=	not equal to	5 != 3 → TRUE
<	less than	2 < 3 → TRUE
>	greater than	5 > 8 → FALSE
<=	less than or equal	3 <= 3 → TRUE
>=	greater than or equal	4 >= 5 → FALSE

For combining logical values:

Operator	Meaning	Example
&	AND	TRUE & FALSE → FALSE
|	OR	
!	NOT	!TRUE → FALSE

- Other than operators, functions that return TRUE/FALSE may be used to filter:
  - is.na(column)
  - grepl(“word”, column)
  - starts_with(“word”)

Filtering rows: filter(data_frame, filtering criteria)

```
data_2 <- filter(your_data, group == "A")
```

Values in the Group column are characters and, thus, need to be specified using "" in the filtering criteria

your_data

group	x	y
A	1	23
A	2	25
A	3	27
A	4	23
B	1	28
B	2	26
B	3	24
B	4	22
C	1	28
C	2	25
C	3	22
C	4	17

data_2

group	x	y
A	1	23
A	2	25
A	3	27
A	4	23

More than one filtering criteria

your_data

group	x	y
A	1	23
A	2	25
A	3	27
A	4	23
B	1	28
B	2	26
B	3	24
B	4	22
C	1	28
C	2	25
C	3	22
C	4	17

group == “A” & y < 25

data_2

group	x	y
A	1	23
A	4	23

x == 1 | y >25

group	x	y
A	1	23
A	3	27
B	1	28
B	2	26
C	1	28

group == "B" &
(y < 25 | x == 1)

group	x	y
B	1	28
B	3	24
B	4	22

group != "B" &
(y > 25 | x == 1)

group	x	y
A	1	23
A	3	27
C	1	28

Combining multiple functions with pipes (%>%)

- To chain a series of dplyr functions together, use the pipe operator **%>%**
- The pipe operator will pass the result of a function on to the next function
- Instead of:

```
data_2 <- filter(data_1, x > 15)
data_3 <- select(data_2, group, y)
```

- Below will result in the same dataframe data_3:

```
data_ 3 <- data_1 %>%
            filter(x > 15) %>%
            select(group, y)
```

Grouping and summarizing

- You can perform an operation on a group of rows at once using **group_by(column with the grouping variable)** and **summarise()**:

```
data_2 <- your_data %>%
            group_by(Dose) %>%
            summarise(mean_weight = mean(Weight))
```

Animal	Chemical	Dose	Weight
1	ChemA	0	28
2	ChemA	10	27
3	ChemA	20	25
4	ChemA	40	23
5	ChemA	0	28
6	ChemA	10	26
7	ChemA	20	24
8	ChemA	40	22
9	ChemA	0	28
10	ChemA	10	25
11	ChemA	20	22
12	ChemA	40	17

Dose	mean_weight
0	28.0000
10	26.0000
20	23.6667
40	20.6667

Sorting data: arrange(column to sort by)

- Ascending order:

```
your_data %>%
    arrange(group)
```

- Descending order:

```
your_data %>%
    arrange(desc(group))
```

- If you want to sort by the grouping variable first, use **.by_group=TRUE**:

```
your_data %>%
        group_by(Chemical) %>%
        arrange(Dose, .by_group=TRUE)
```

Saving your output in your working directory

- write.csv(data_2, file = “file_name.csv”)
- write.table(data_2, file = “file_name.txt”)
- write_xlsx(data_2, file = “file_name.xlsx”)

- ggsave(filename = “plot_name.jpeg”, plot = your_plot, height = x, width = y)

- You can also enter the complete file path in the file name if you want to save your file somewhere else other the working directory

Resources

- Dr. Kristin Eccles' Introduction to R Github repository:
  - https://github.com/kristineccles/Introduction_to_R
- ggplot2 Cheatsheet
  - https://rstudio.github.io/cheatsheets/html/data-visualization.html
- dplyr Cheatsheet
  - https://rstudio.github.io/cheatsheets/html/data-transformation.html
- ChatGPT