WorldPop

Workshop on Advanced Sampling Methodologies

Introduction to R Programming

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Agenda

- Introduction to R and RStudio
- Data types and data structures
- Working with scripts and the console
- Importing data
- Saving and closing sessions

What is R?

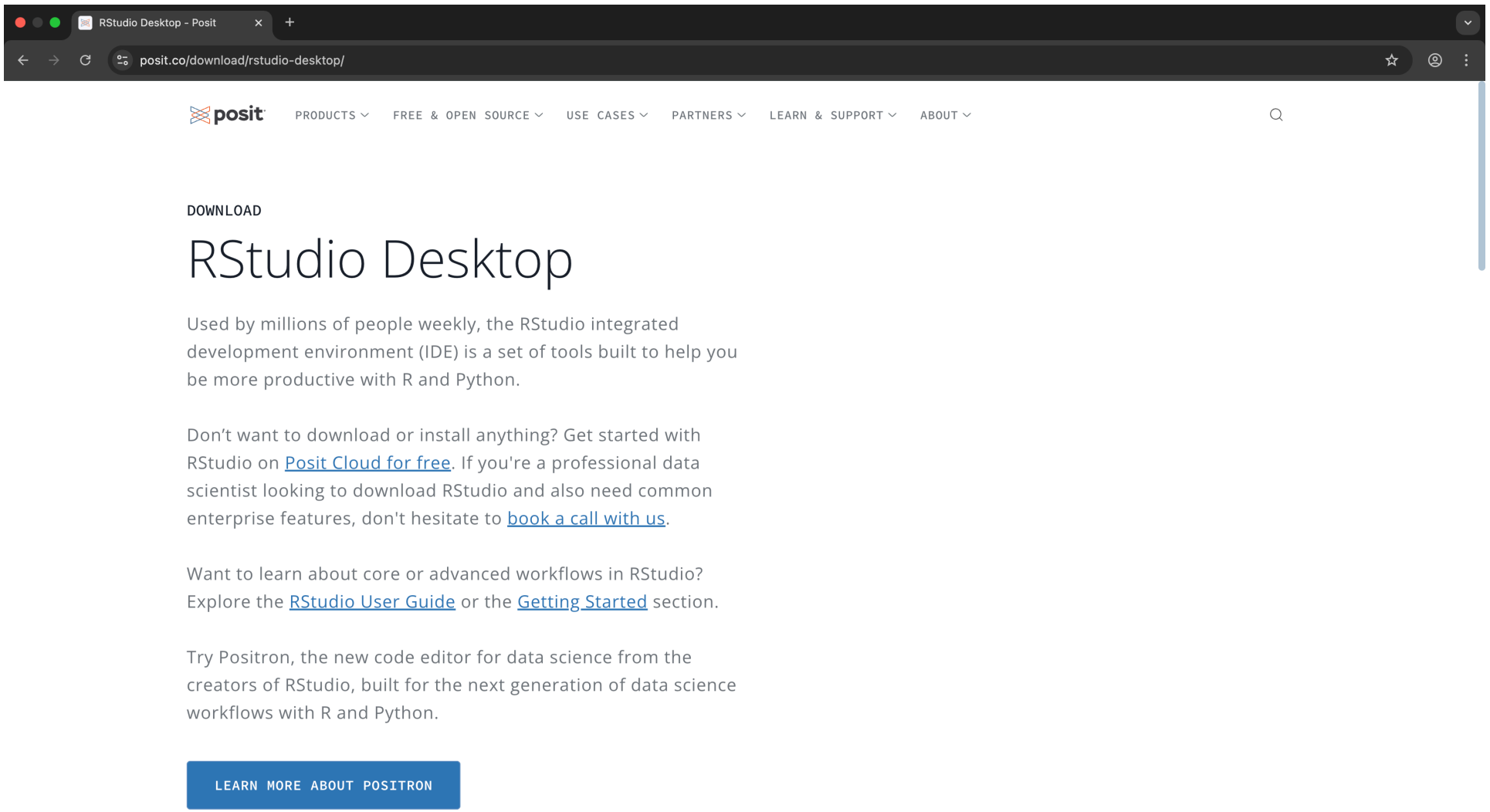
- R is a free, open-source programming language for statistical computing and graphics
- It evolved from the **S language** developed in the 1970s
- Most of R is written in **C** and **Fortran**
- The first stable version was **released in 2000**
- **RStudio** provides a user-friendly interface to R

Why R?

- Powerful tool for **data analysis and visualization**
- Encourages **reproducibility** and **sharing**
- Thousands of user-created **packages** extend its functionality
- Large and active **community** with extensive support

Installing R and RStudio

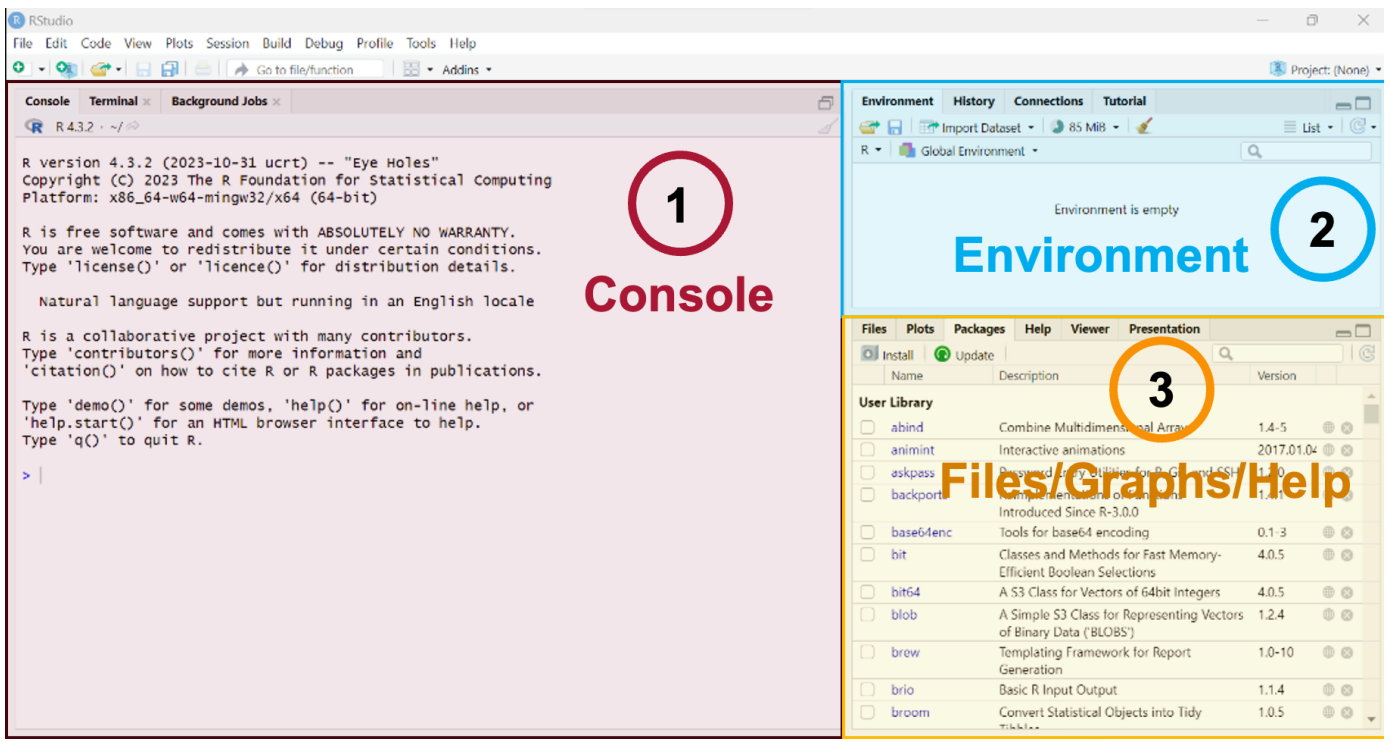
- Download and install **R and RStudio** from posit.co



RStudio Interface

RStudio has four main panes:

- **Source Editor** – write and save code
- **Console** – run commands interactively
- **Environment/History** – see and manage objects
- **Files/Plots/Packages/Help/Viewer** – tools and outputs



Script Editor vs Console

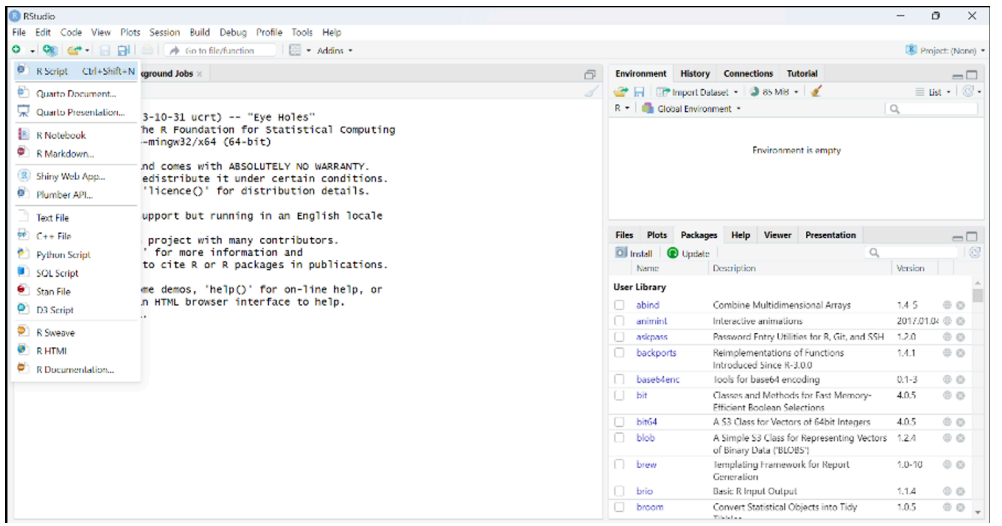
Script Editor

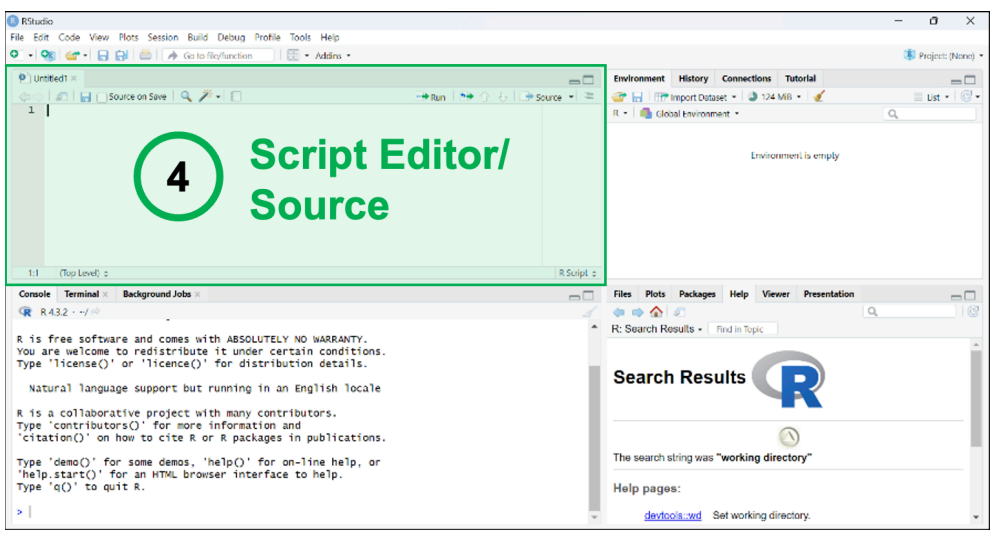
- Write, edit, and save code
- Organize analysis in reproducible scripts
- Prevent accidental execution before editing

Console

- Executes code immediately
- Use for quick checks and interactive testing
- Output and errors appear here

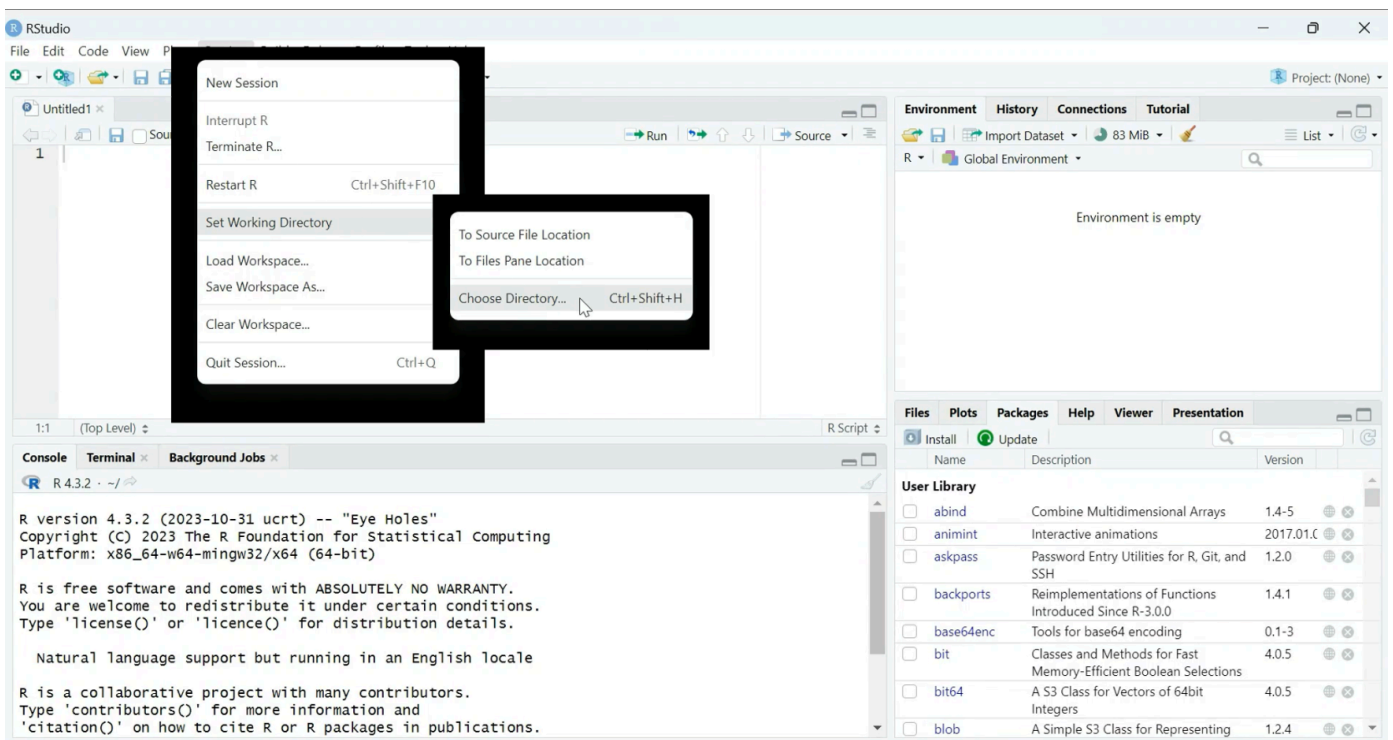
ℹ Best practice: write in the Script Editor, run via Console.





Working Directory

- Your working directory is the folder where R looks for and saves files.
- Set with: `setwd("path")`
- Check with: `getwd()`
- Good practice: create a dedicated folder for each project.



Try to run the code in your R Console and in the Script Editor.

R as a Calculator

- R can perform arithmetic directly

```
1 + 2 * 8
a <- log(10)
b <- 5
b + b
```

- Results in Console are prefixed with `[1]` (index of first element).
- `[2], [3], ...` appear if output spans multiple lines.

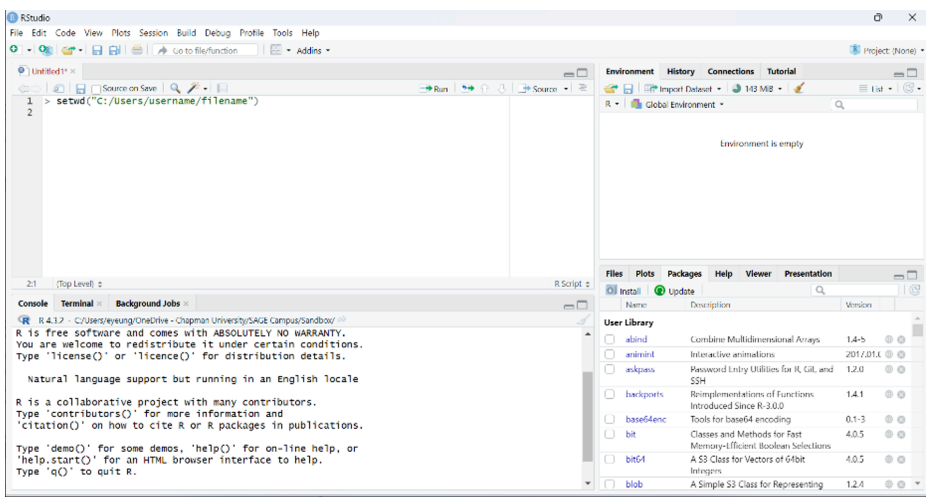
ℹ️ Try to run the code in your R Console and in the Script Editor.

R Packages

- Collections of functions, datasets, and documentation.
- Expand R beyond base functions.
- Install from CRAN, GitHub, or other repositories.

In RStudio

- Use the *Packages* tab to install, update, or remove.

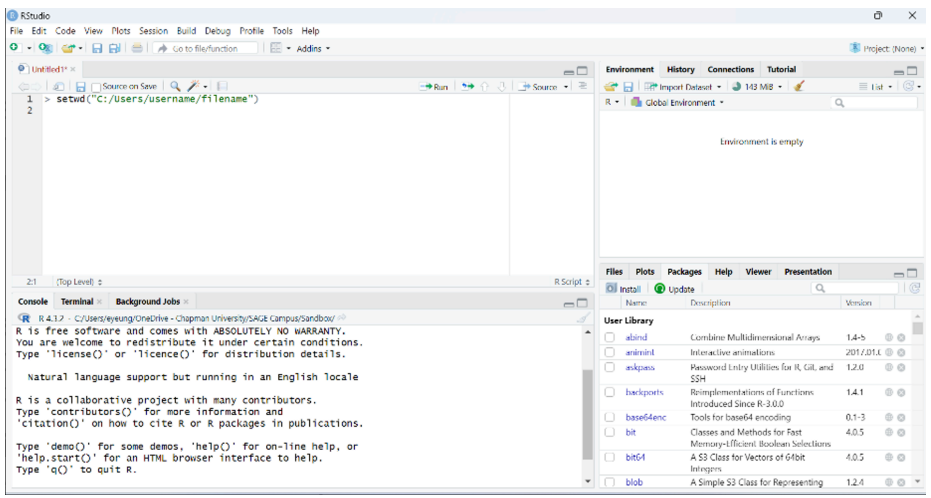


- Or install in the Script Editor

```
1  install.packages("dplyr")
```

Loading Packages

- Load packages into a session via checkbox in the *Packages* pane.



- Or load packages into a session with:

```
1  library(dplyr)
```

ℹ️ Best practice: only load what you need.

R Objects

- Everything in R is an **object** (vectors, lists, functions, data frames, etc.).
- Assign values using `<-`.

```r
x <- 5
x + x   # returns 10
```

Naming tips

- ✅ Descriptive and concise
- ✅ Use underscores `_` or periods `.`
- ❌ Avoid very long names
- ❌ Avoid existing function names
- ❌ No blank spaces

ℹ️ Try to run the code in your Script Editor.

Data Types

- **Numeric**: numbers, may include decimals.

```
w <- c(1.7, 3)
x <- c(1, 2, 3)   # integers are numeric without decimals
```

- **Character**: text strings.

```
y <- c("male", "female")
```

- **Logical**: TRUE/FALSE values.

```
y <- c(TRUE, FALSE)
```

- **Factor**: categorical variables.

```
gender <- factor(c("boy", "girl", "girl", "boy"))
```

Check type:

```
class(object)
typeof(object)
```

Data Structures

- **Vectors**: one-dimensional, homogeneous elements
- **Matrices**: two-dimensional, homogeneous elements
- **Lists**: flexible, heterogeneous elements
- **Arrays**: multi-dimensional, homogeneous elements
- **Data frames**: tabular, columns may differ in type

Vectors

- The most basic structure in R
- One-dimensional, elements must be the **same type**

```r
numbers <- c(1, 2, 3, 4, 5)
colors <- c("red", "green", "blue")
logical_values <- c(TRUE, FALSE, TRUE)
```

Indexing with brackets:

```r
numbers[1]      # first element
colors[2:3]     # second and third elements
```

Vectorized operations apply to all elements:

```r
numbers * 2     # multiplies each element by 2
```

ℹ️ Try to run the code in your Script Editor.

Matrices

- Two-dimensional, **homogeneous elements**
- Create with `matrix()`

```
rownames <- c("math", "science", "history", "English", "law")
colnames <- c("male", "female")
subject_matrix <- matrix(
  c(10,9,11,13,12,18,17,13,6,5),
  nrow = 5, ncol = 2, byrow = TRUE,
  dimnames = list(rownames, colnames)
)
```

- Add row: `rbind()`
- Add column: `cbind()`

ℹ️ Try to add a row to `subject_matrix` for `geography <- c(4,2)` using `rbind` in your Script Editor.

Matrices to Data Frames

- Convert a matrix into a data frame to **mix numeric and non-numeric types**.

```r
matrix_stats <- matrix(
  c(4015,3980,3756,3333,4000,3000,2000,1000),
  nrow = 4, ncol = 2, byrow = TRUE,
  dimnames = list(
    c("freshmen", "sophomores", "juniors", "seniors"),
    c("enrollment", "living on campus")
  )
)

df_stats <- as.data.frame(matrix_stats)
avg.grades <- c("A-","B+","B-","A+")
school_stats <- cbind(df_stats, avg.grades)
```

ℹ️ Try to run the code in your Script Editor.

Data Frames

- Tabular structure with columns of different types
- Similar to spreadsheets

```r
cats <- data.frame(
  coat = c("Persian", "black", "tabby"),
  weight = c(2.1, 5.0, 3.2),
  likes_string = c(TRUE, FALSE, TRUE)
)

animal_sleep <- data.frame(
  ranking = c(4, 1, 2, 3),
  animal = c("koala", "capybara", "camel", "panda"),
  country = c("Australia", "Brazil", "Egypt", "China"),
  avg_sleep_hr = c(20, 3, 6, 12)
)
```

ℹ️ Try to run the code in your Script Editor.

Lists

- Flexible data structure with elements of **different types**
- Can include vectors, data frames, matrices, or other lists

```r
my_list <- list(
  name = "Alice",
  age = 25,
  scores = c(90, 85, 92),
  passed = TRUE
)

my_list$name
my_list[[2]]
```

ℹ️ Try to run the code in your Script Editor.

Arrays

- Extend vectors to two or more dimensions
- All elements must be the same type

```r
arr <- array(1:12, dim = c(2, 3, 2))
arr
arr[1, 2, 1]   # element at row 1, col 2, slice 1
```

Useful for structured multi-dimensional data. However, this is hardly used in most cases.

ℹ️ Try to run the code in your Script Editor.

Importing Data

- Create data manually, but usually import from files

Common formats
- **Text**: `.txt` (`readLines()` function)
- **Tabular data**: `.csv`, `.tsv` (`read.table()` function or `read_csv()` function from the `readr` package)
- **Excel**: `.xlsx` (`xlsx` package)
- **Google sheets**: (`googlesheets` package)
- **Statistics program**: SPSS, SAS (`haven` package)
- **Databases**: MySQL (`RMySQL` package)

Example:

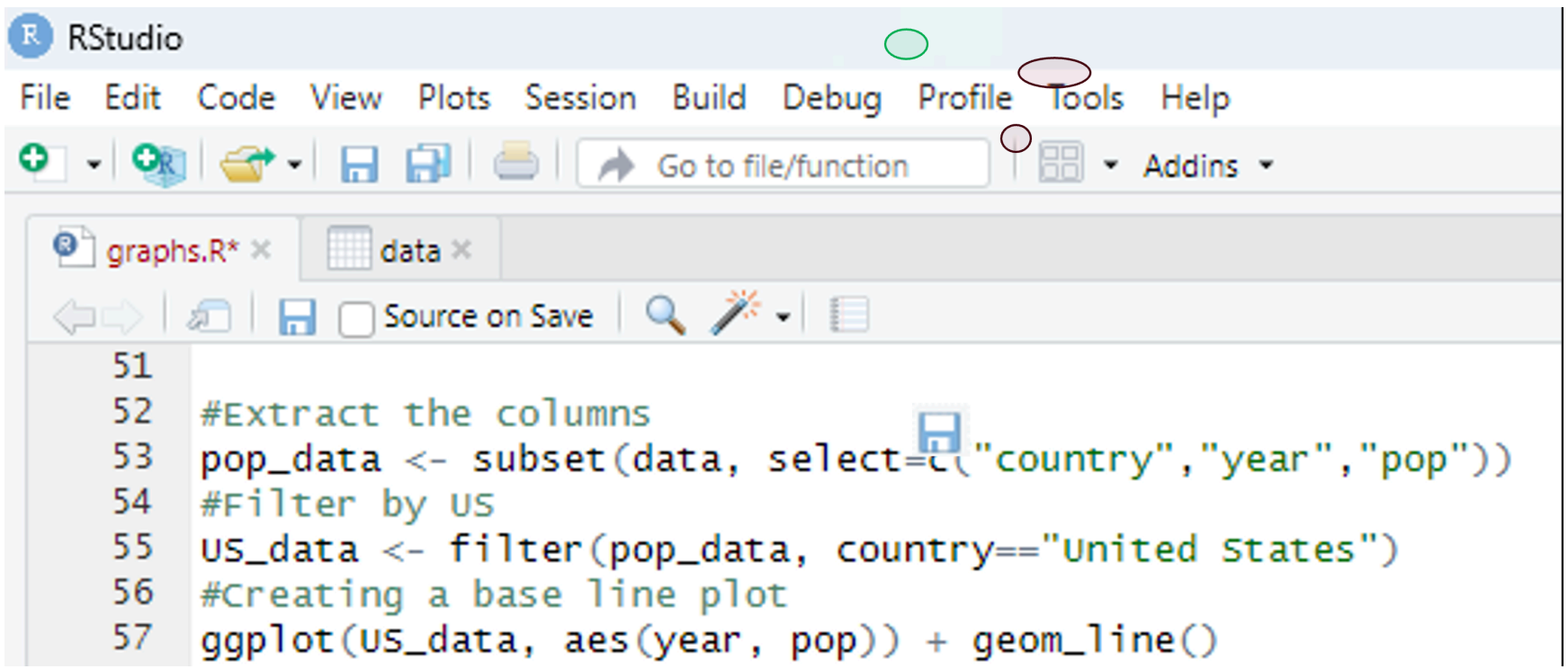
```
1  csv_data <- read.csv("data/world_data.csv")
```

➡️ Always use forward slashes `/` in file paths.

ℹ️ Try to run the code in your Script Editor.

Saving Your Script

- Save all steps of analysis in `.R` scripts
- Add comments with `#`
- Save with **File → Save** or `Ctrl+S` / `Cmd+S`
- Unsaved scripts show in red with an asterisk `*`

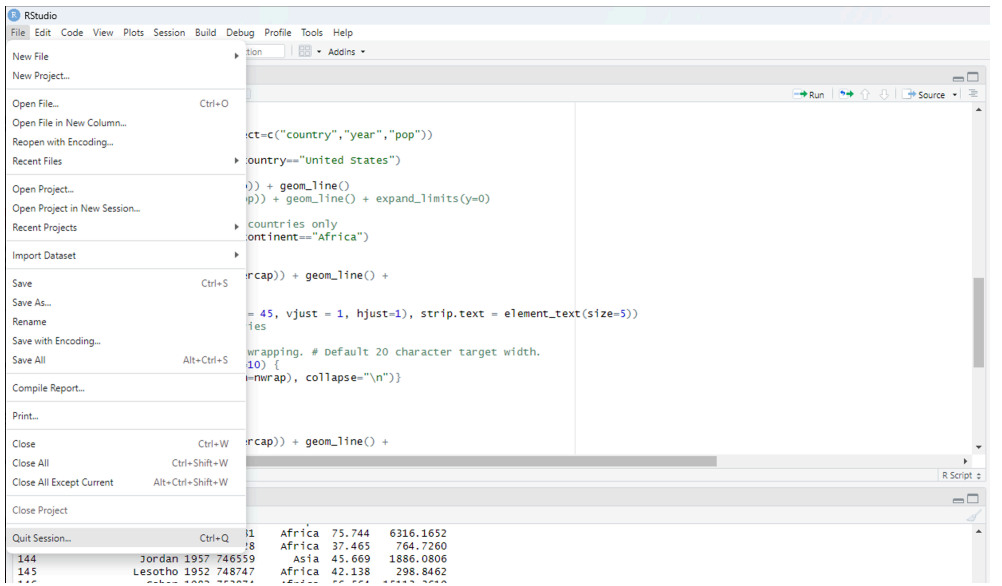


Try to save your script.

Closing an R Session

Options:

- **File → Quit Session**
- `q()` in Console



➡️ Do **not** save the workspace image. Always start fresh for reproducibility.

ℹ️ Try to close and reopen your R Session.

Take home

- R is a **versatile tool for data analysis and visualization** – free, open-source, and supported by a vast community with thousands of packages.
- RStudio **enhances productivity** – organize, edit, and execute code efficiently using the Script Editor, Console, and built-in panes.
- Understand **R objects, data types, and structures** – Vectors, matrices, lists, data frames, and arrays form the building blocks of R programming.
- **Reproducibility** matters – save scripts, comment your code, and avoid saving workspace images to ensure analyses can be repeated.
- Packages **expand functionality** – install, load, and use packages to extend R's capabilities for importing, manipulating, and visualizing data.

References

R Core Team. (2025). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org

The official reference for R itself, including installation, base functions, and documentation.

RStudio Team. (2025). RStudio: Integrated Development Environment for R. https://posit.co

Wickham, H., & Grolemund, G. (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. O'Reilly Media. https://r4ds.had.co.nz

Venables, W. N., Smith, D. M., & the R Core Team. (2023). An Introduction to R. CRAN. https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An Introduction to Statistical Learning with Applications in R (2nd edition). Springer.

Exercise

Please download the R script with exercises from GitHub and try to complete it.