

# Introduction to R programming for data science – day 1

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## R programming

R is:

- One of the leading programming languages for statistics and data science
- Useful for basic and advanced data analyses
- Prerequisite for job positions in the life sciences

Why?

- Its is free
- It supports reproducible analysis
- It provides packages for data analysis

# In this course

We will learn the **basics of R programming** through lectures and hands-on computer exercises using Rstudio:

- variables, data types, and data structures
- data manipulation and visualization
- operations
- reading and writing files
- running and repeating tasks using functions and control statements.

Disclaimer: this is **not** a course in statistics or bioinformatics.

3/36

## Course info

Course material and info: <https://github.com/FFinotello/Rcourse>

**Note:** to download a text file, right-click on “Raw” and select “Save link as”.

**Evaluation:** based on a data analysis project to be described in a short report and sent by e-mail.

### How to ask questions

- Chat
- [Collaborative Google Doc](#)
- E-mail

4/36

# Installation

Install first R and then Rstudio

To install R (version  $\geq 4$ ):

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

See “[To download R, please choose your preferred CRAN mirror](#)”.

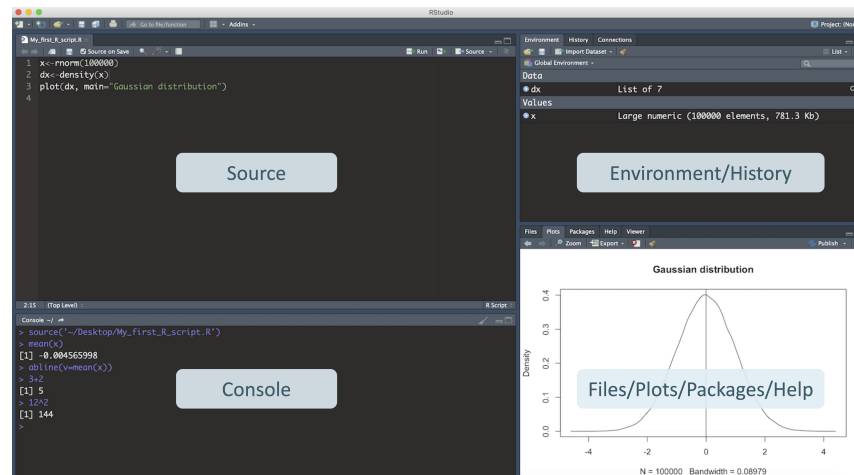
To install RStudio Desktop:

<https://www.rstudio.com/products/rstudio/download/#download>

RStudio

# RStudio console

RStudio is an integrated development environment (IDE) for R. It has four main panels with adjustable sizes:



From the toolbar: [View > Panes > Show All Panes](#)

7/36

## The RStudio console

In the console you can type commands and see outputs.

```
( 12^2 - 20 * 2 + 1 ) / 5
```

```
## [1] 21
```

```
log10(100) - sqrt(9) / 3
```

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

```
# Any text preceded by a hashtag is not evaluated (= comment!)
```

8/36

# Variables and data types

## Variables

**Variables:** symbolic names used to store data that can be manipulated in a computer program

In R, variables are assigned with `<-`

```
height <- 1.90
```

```
weight <- 80
```

# Variable names

- *Should* be short but descriptive
- *Must* start with a letter
- *Must not* contain special characters
- *Cannot* be reserved words

**Reserved words:** words with special meaning in R that cannot be used as identifiers. Examples: **if**, **break**, **Inf**, **TRUE**

👍 *cellFrac*, *cell\_frac*, *cell.frac*, *cellfrac\_1*

👎 *cell-frac*, *1cellfrac*, *TRUE*

```
(T <- 5 * 2 )
```

```
## [1] 10
```

11/36

## Case-sensitive programming

R is case-sensitive

```
# Body mass index (BMI)
# defined as: weight/height^2
BMI <- 80/1.90^2
```

```
BMI
```

```
## [1] 22.16066
```

```
bmi
```

```
## Error in eval(expr, envir, enclos): object 'bmi' not found
```

12/36

# Operations

Once variables are assigned, they can be used to perform operations

```
height <- 1.90
weight <- 80
( BMI <- weight/height^2 )
```

```
## [1] 22.16066
```

```
x <- 6
y <- 2
x <- 4
x + y
```

```
## [1] 6
```

13/36

## Arithmetic operators

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Exponent
%%	Modulus (remainder from division)
/%	Integer Division

14/36

# Relational operators

Operator	Description
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to
==	Equal to
!=	Not equal to

15/36

# Logical operators

Operator	Description
!	Logical NOT
&	Element-wise logical AND
&&	Logical AND
	Element-wise logical OR
	Logical OR

16/36



# Atomic vector types

In R, there are several types of atomic vectors (also called *classes*):

- Numeric
- Character
- Logical
- Complex
- Integer

17/36

## Data type examples

```
Name <- "Maria"  
class(Name)
```

```
## [1] "character"
```

```
PhD <- TRUE  
class(PhD)
```

```
## [1] "logical"
```

```
yearsSincePhD <- 5  
class(yearsSincePhD)
```

```
## [1] "numeric"
```

18/36

# Missing values

In R, missing values are usually coded with **NA**

```
Name <- "Michael"  
PhD <- FALSE  
yearsSincePhD <- NA  
  
is.na(Name)
```

```
## [1] FALSE
```

```
is.na(yearsSincePhD)
```

```
## [1] TRUE
```

Note: **NA** are not strings (no quotation marks)

19/36

## Other indefinite values

Not a number: **NaN**

```
var1 <- 0/0  
var1
```

```
## [1] NaN
```

Infinite: **Inf**

```
( var2 <- 9/0 )
```

```
## [1] Inf
```

```
( var3 <- -10/0 )
```

```
## [1] -Inf
```

20/36

# Data conversion/coercion

Class conversion is possible, but it must be handled with care

```
var1 <- 1  
( var2 <- as.character(var1) )
```

```
## [1] "1"
```

```
class(var2)
```

```
## [1] "character"
```

```
( var3 <- as.logical(var1) )
```

```
## [1] TRUE
```

21/36

## Data type conversion

Conversion to	Function	Rules
numeric	as.numeric	FALSE → 0
		TRUE → 1
		"1", "2", ... → 1, 2, ...
		"A", ... → NA
logical	as.logical	0 → FALSE
		other numbers → TRUE
		"FALSE", "F" → FALSE
		"TRUE", "T" → TRUE
		other characters → NA
character	as.character	1, 2, ... → "1", "2", ...
		FALSE → "FALSE"
		TRUE → "TRUE"

Source: [https://cran.r-project.org/doc/contrib/Paradis-rdebuts\\_en.pdf](https://cran.r-project.org/doc/contrib/Paradis-rdebuts_en.pdf)

22/36

# Data structures

## Data structures

In R, there are different **data structures**, including:

Data structure	Can contain different data types?
Vector	No
Matrix	No
Factor	No
List	Yes
Data.frame	Yes

# Data structure: vector

Vectors can be build with the `c` function and their length can be assessed with the `length` function

```
( x <- c(1, 2, 3, 4) )
```

```
## [1] 1 2 3 4
```

```
( y <- c("a", "b", "c") )
```

```
## [1] "a" "b" "c"
```

```
length(y)
```

```
## [1] 3
```

25/36

## Vectors and data types

Vectors can contain a single data type only, so beware of conversions

```
( z <- c("a", "b", 1, 2) )
```

```
## [1] "a" "b" "1" "2"
```

```
( v <- c(x, y) )
```

```
## [1] "1" "2" "3" "4" "a" "b" "c"
```

What are the classes of `z` and `v`?

26/36

# Creating numeric vectors

```
j <- 1:4 # Seq. of integers  
j
```

```
## [1] 1 2 3 4
```

```
x <- seq(0, 1, 0.1) # Seq. of numbers (from, to, step)  
x
```

```
## [1] 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
```

27/36

# Creating vectors with *rep*

```
y <- rep("A", 5) # Seq. of repeated numbers or characters  
y
```

```
## [1] "A" "A" "A" "A" "A"
```

```
z <- c( rep("A", 3), rep("B", 5) ) # Vector combination  
z
```

```
## [1] "A" "A" "A" "B" "B" "B" "B" "B"
```

28/36

# Vector names

```
( age <- c(19, 30, 20) )
```

```
## [1] 19 30 20
```

```
names(age) <- c("Mary", "John", "Lisa") # Assign
```

```
age
```

```
## Mary John Lisa
```

```
##    19    30    20
```

```
names(age) # Query
```

```
## [1] "Mary" "John" "Lisa"
```

29/36

## Accessing vectors

You can access the elements of a vector by using indexes between **square** brackets. **Note:** Round brackets are for functions.

```
age <- c(11, 12, 18, 20, 45, 2, 33)
```

```
age[1]
```

```
## [1] 11
```

```
age(1)
```

```
## Error in age(1): could not find function "age"
```

```
mean(age)
```

```
## [1] 20.14286
```

30/36

# Accessing vectors

You can access the elements of a vector by using *logical* or *numeric* indexes (positive and negative)

```
days <- c("Mon", "Tue", "Wed", "Thu", "Fri", "Sat", "Sun")
```

```
days[c(6,7)] # Format: days[ INDEX ]
```

```
## [1] "Sat" "Sun"
```

```
weekend <- days[c(FALSE, FALSE, FALSE, FALSE, FALSE, TRUE, TRUE)]
```

```
weekend <- days[-seq(1,5)] # Negative ind. of elements to be removed
```

31/36

# Accessing vectors

Vector elements can be also accessed using their names, when initialized

```
age <- c(11, 12, 18, 20)
```

```
names(age) <- c("John", "Lisa", "Maria", "Markus")
```

```
age
```

```
##   John   Lisa  Maria Markus
```

```
##    11    12    18    20
```

```
age[c("John", "Maria")]
```

```
##   John Maria
```

```
##    11    18
```

32/36



# Subsetting vectors

You can extract the elements of a vector that satisfy a certain condition:

```
age <- c(11, 12, 18, 20, 45, 2, 33)
```

```
age[age>=18] # Logical index
```

```
## [1] 18 20 45 33
```

```
age[which(age>=18)] # Numerical index
```

```
## [1] 18 20 45 33
```

33/36

# Manipulating vectors

You can change the elements of a vector:

```
x <- c(11, 12, -18, 20, -45, -2, 33)
```

```
x[1] <- 35 # Subsitute the first element
```

```
x
```

```
## [1] 35 12 -18 20 -45 -2 33
```

```
x[x<0] <- 0 # Set to 0 all negative elements
```

```
x
```

```
## [1] 35 12 0 20 0 0 33
```

34/36

# Data structure: factor

A **factor** is categorical variable that can be built with the function *factor*

```
strain <- factor(c("WildType", "WildType", "Mutant", "Mutant"))
strain
```

```
## [1] WildType WildType Mutant    Mutant
## Levels: Mutant WildType
```

```
length(strain)
```

```
## [1] 4
```

```
levels(strain)
```

```
## [1] "Mutant"    "WildType"
```

35/36

## Factor conversion

```
( x <- factor(c(10, 2, 2, 3)) )
```

```
## [1] 10 2  2  3
## Levels: 2 3 10
```

```
( y <- as.numeric(x) ) # This does NOT work
```

```
## [1] 3 1 1 2
```

```
( z <- as.numeric(as.character(x)) ) # This works
```

```
## [1] 10  2  2  3
```

36/36