Introduction to

BIST Biostatistics course

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Outline

- R: what, when, why?
- Getting started
- Data structures
- Libraries / Packages
- Basic commands
- Functions
- R Studio

R: what, when, why?

What is R?

- Integrated suite of software facilities for **data manipulation**, **calculation** and **graphical display.**

- Simple and effective programming language which includes conditionals, loops etc.

- Implementation of the **S** programming language (Bell laboratories)

What is R?

- Created by Ross Ihaka and Robert Gentleman at the University of Auckland, New Zealand
- Now developed by the "**R development core team**"
- GNU project (free software, pass collaboration)

→ **Open source !**

R: what, when, why?

[Home]

Download

CRAN

R Project

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Links

Bioconductor
Related Projects

The R Project for Statistical Computing

Getting Started

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To **download R**, please choose your preferred CRAN mirror.

If you have questions about R like how to download and install the software, or what the license terms are, please read our answers to frequently asked questions before you send an email.

News

- Beta test period for version 3.3.0 has been extended to accommodate new Windows toolchain for CRAN. Final release rescheduled for Tuesday 2016-05-03.
- **Notice XQuartz users (Mac OS X)** A security issue has been detected with the Sparkle update mechanism used by XQuartz. Avoid updating over insecure channels.
- **R version 3.2.4 (Very Secure Dishes)** has been released on Thursday 2016-03-10.
- **R version 3.3.0 (Supposedly Educational) prerelease versions** will appear starting Monday 2016-03-14. Final release is scheduled for Thursday 2016-04-14.
- The **R Logo** is available for download in high-resolution PNG or SVG formats.
- **useR! 2016**, will take place at Stanford University, CA, USA, June 27 - June 30, 2016.
- **The R Journal Volume 7/2** is available.
- **R version 3.2.3 (Wooden Christmas-Tree)** has been released on 2015-12-10.
- **R version 3.1.3 (Smooth Sidewalk)** has been released on 2015-03-09.

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

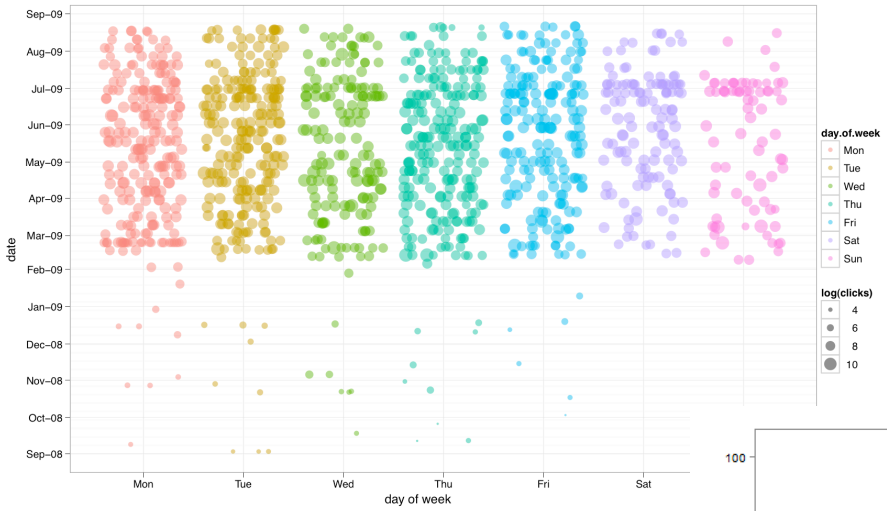
When to use R?

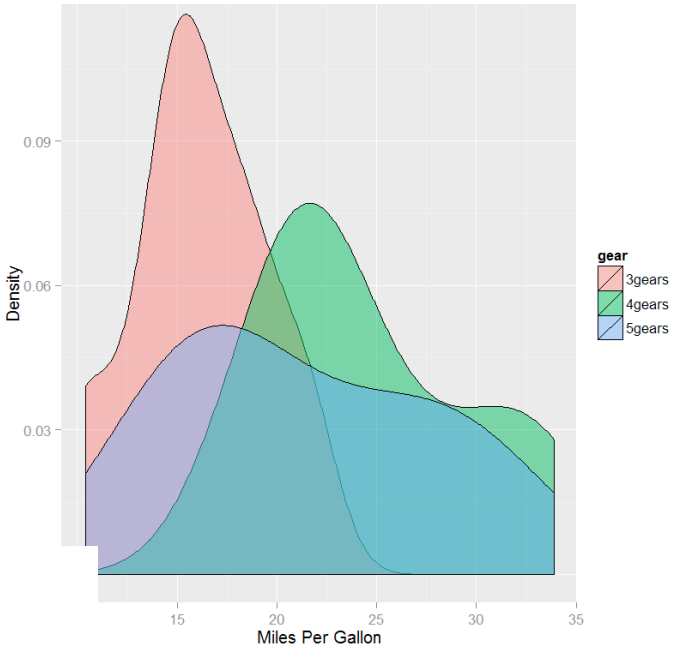
- Data analysis
- Statistical modeling
- Simulation
- Graphics

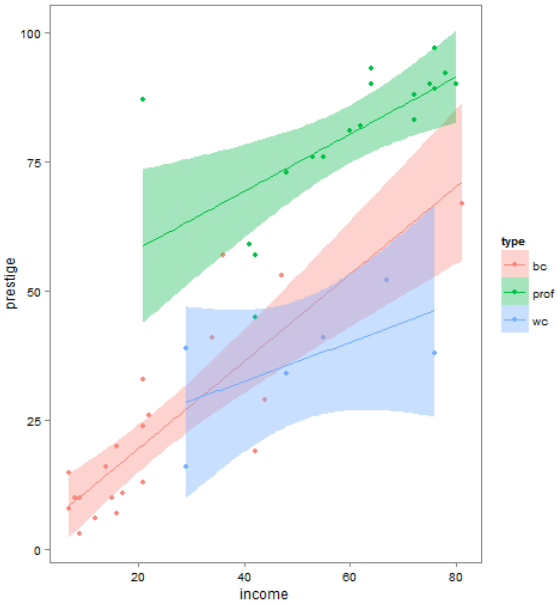
Why to use R?

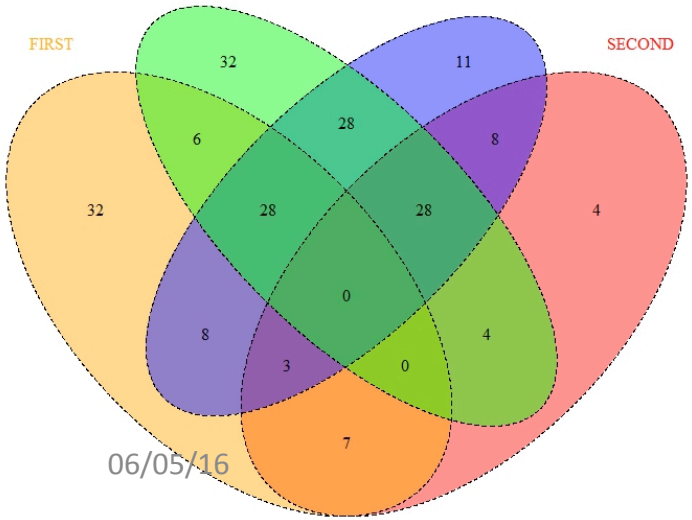
- Flexible
- Powerful
- Interactive
- **Very active community of developers and users!**

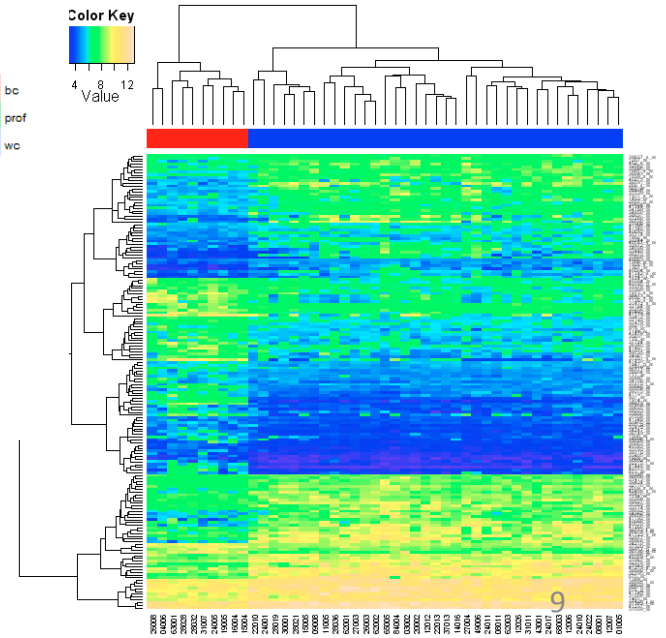
R: what, when, why?









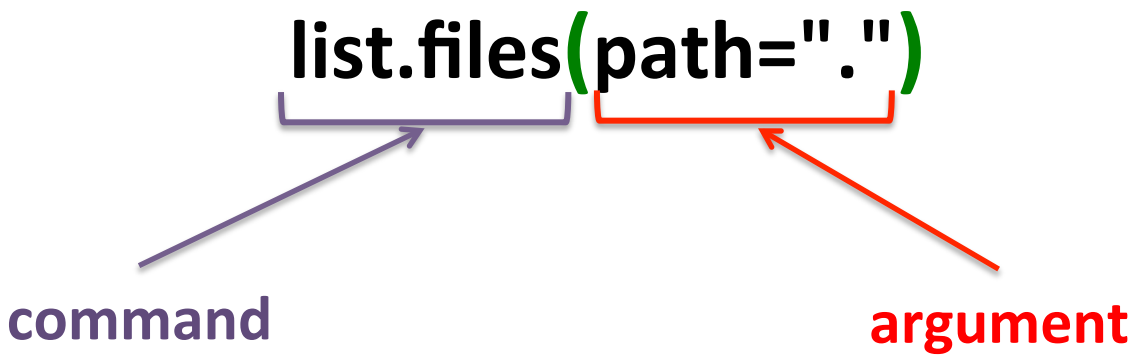


Getting started

R syntax

function(arguments)

example:

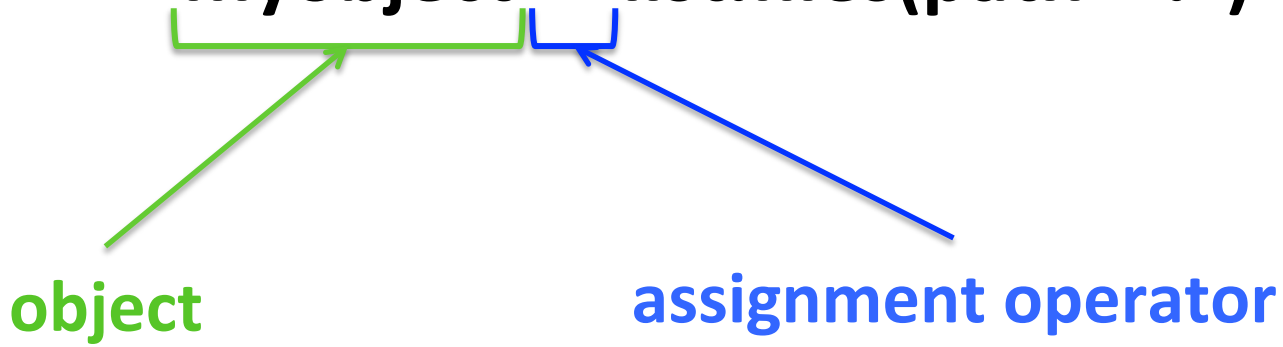


R syntax

a <- function(arguments)

example:

myobject <- list.files(path=".")



R syntax

- Case sensitive:

  List.files ≠ list.files

- Comment lines start with **#**

- Commands separated by **;** or a new line

- Arguments in a function separated by **,**

Getting help

- **help(function)**
- **?function**

- Google!

Starting R interactively from a terminal

- Starting session:

R

- Ending session:

q()

Data Structures

Vectors

Factors

Matrices

Data frames

List

Data Types

- Every value has a **data type** that tells what sort of value it is.

- Most common data types:
  - Numeric (Numbers)
  - Character (Text)
  - Logical (True / False)

- Checking object type with mode():
  - mode("a") / [1] "character”
  - mode(10) / [1] "numeric”
  - mode(FALSE) / [1] "logical"

Vectors

- Sequence of data elements of the same type

- Elements of an atomic vector are of **one type only**, either:
  - Numeric (1, 2, 5.3, 6, -2, 4)
  - Character ("one", "two", "three")
  - Logical (TRUE, TRUE, TRUE, FALSE, TRUE, FALSE)

Vectors

- Assignment of values to vector using the **c** command (combining elements)

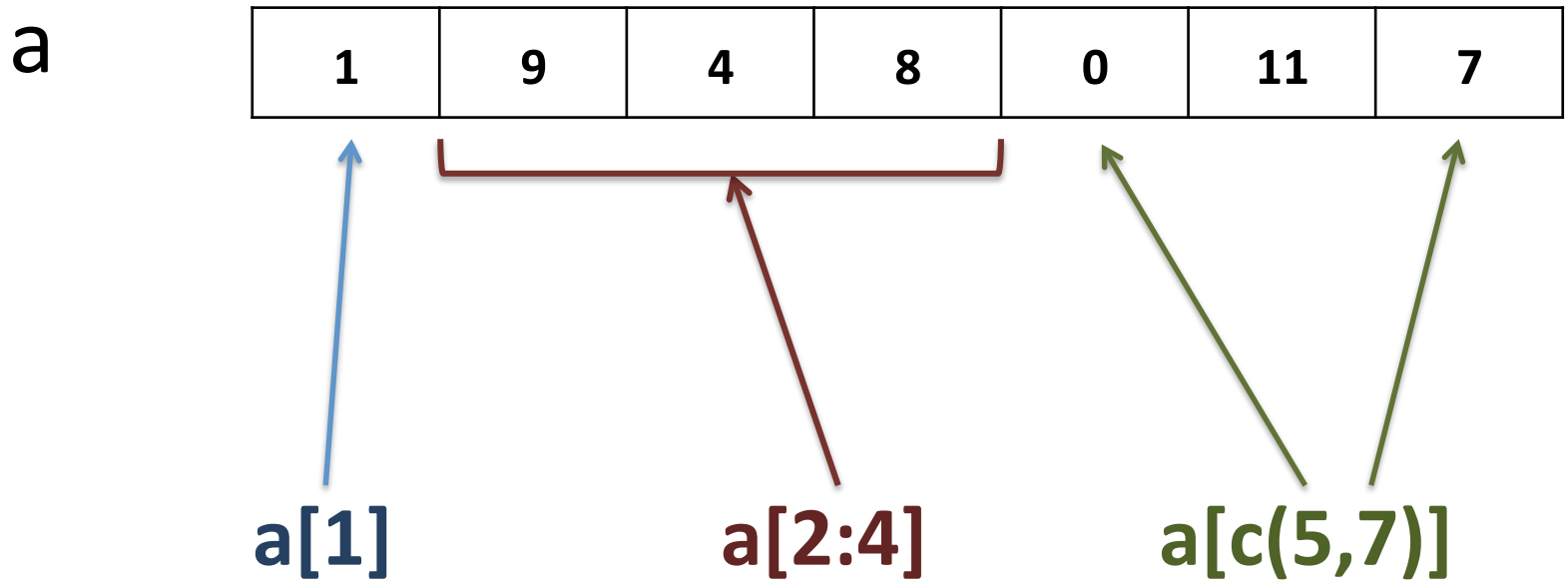
myvector <- **c**(0.5, 2, 10, 3, 8)

myvector <- 1:5 ← **same as c(1, 2, 3, 4, 5)**

- Checking if an object is a vector with **is.vector**(myvector)

Vectors

- Fetch elements of a vector: subscripts



Factors

- Vector **object used to specify a discrete classification** of the components in a data set:

  → **Categorical variables**

- Used mainly in **statistical modeling**, but also in some graphical functions.

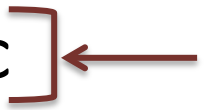
- Similar to vectors, but their values are limited to a **fixed set of possible values.**

Factors

- Both numeric and character variables can be made into factors.

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

myfactor
[1] a a b c 1 2
Levels: 1 2 a b c
```



Levels are character vectors

Factors

- Checking if an object is a factor:
  - **is.factor**(myfactor)

- Transforming a vector into a factor:
  - **as.factor**(myvector)

Matrices

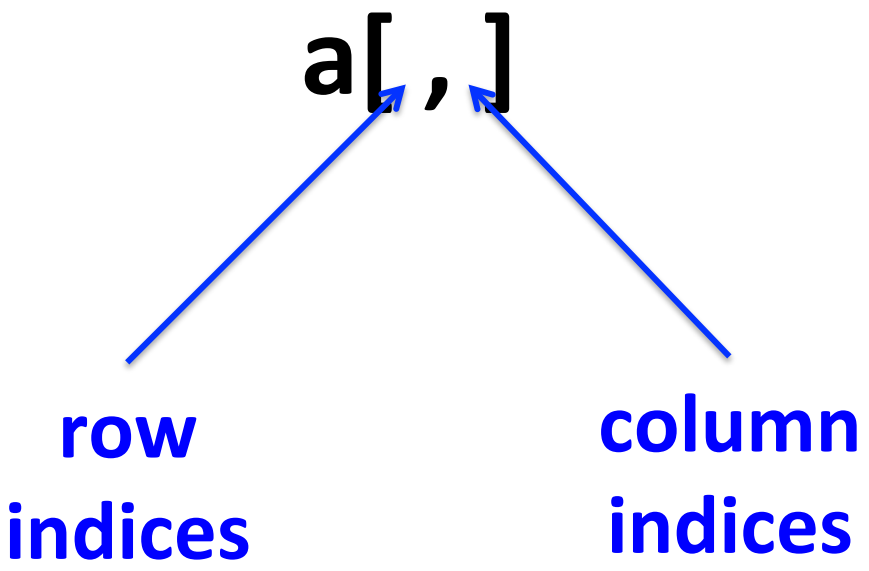
- A matrix is a vector of **2 dimensions**

- All columns in a matrix must have :
  - the same **type** (numeric, character, logical)
  - the same **length**

```
a <- matrix(c(1, 0, 34, 5, 13, 44, 12, 4, 3, 8, 6, 9, 22, 7, 76),
            nrow=5,
            ncol=3)
```

Matrices

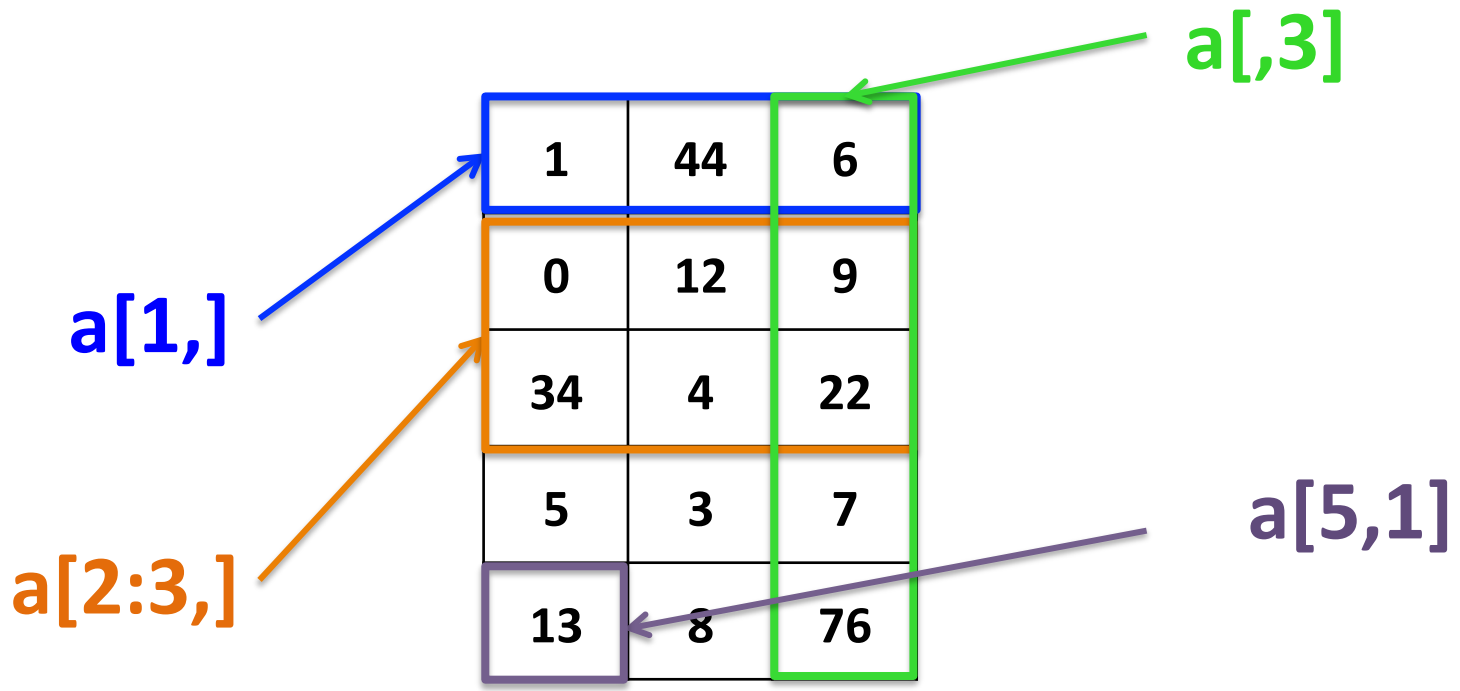
- Fetch rows, columns or single elements of a matrix using subscript:



Matrices

- Fetch rows, columns or single elements of a matrix using subscript:

a



Data frames

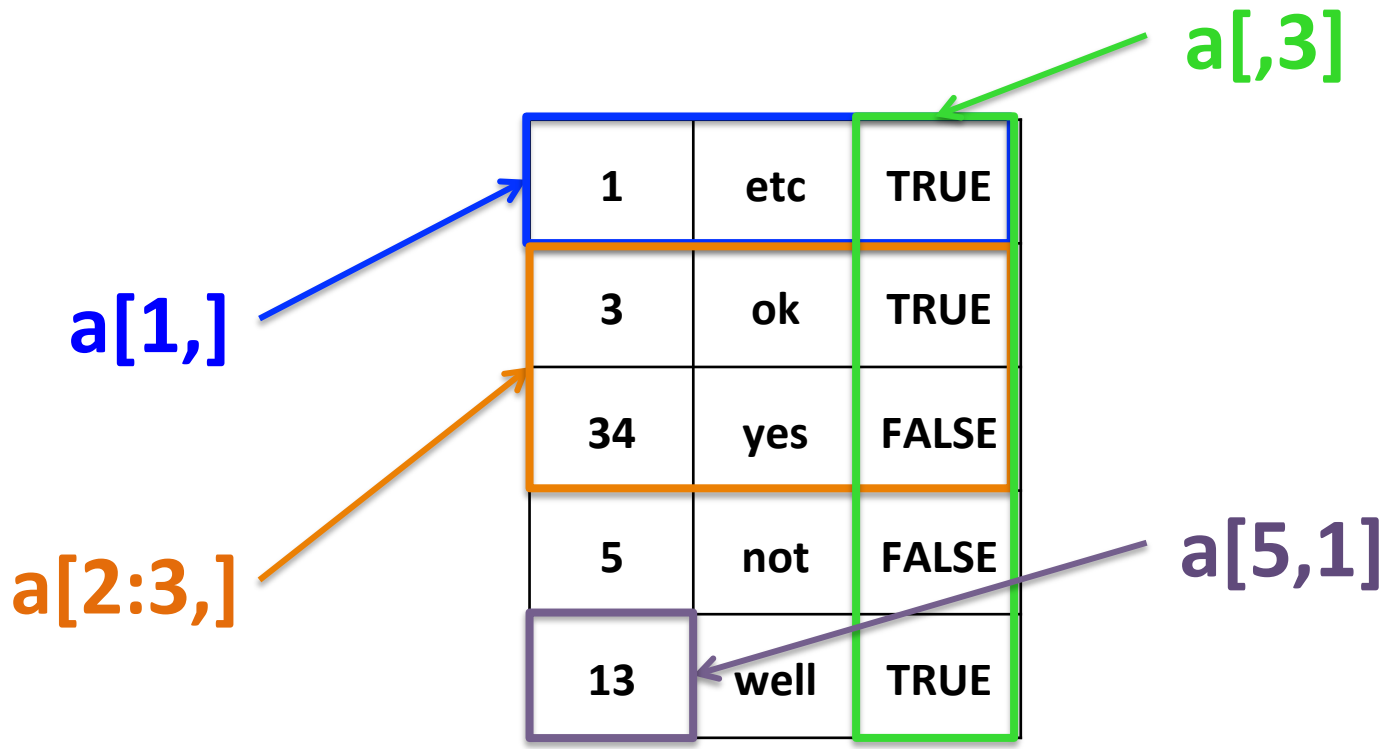
- Structures of 2 dimensions.
- More general than matrices.
- Different columns can have **different types** but must have the **same length.**

```
a <- data.frame(c(1, 3, 34, 5, 13),
                c("etc", "ok", "yes", "no", "well"),
                c(TRUE, TRUE, FALSE, FALSE, TRUE))
```

Data frames

- Fetch rows, columns or single elements of a data frame using subscript:

a



Matrices and data frames dimension names

```
a <- matrix(c(1, 0, 34, 5, 13, 44),
            nrow=3,
            ncol=2,
            dimnames=list(c(”row1”, ”row2”, ”row3”), c(”col1”, ”col2”)))

b <- data.frame(c(1, 0, 34),
            c(5, 13),
            row.names=c("row1", "row2", "row3"),
            col.names=, c(”col1”, ”col2”))
```

Matrices and data frames dimension names

- Changing column and / or row names:

  colnames(x) <- c(“a”, “b”, “c”)

  rownames(x) <- 1:5

- Changing column and row names at once:

  dimnames(x) <- list(c(“a”, “b”, “c”), 1:5)

Matrices and data frames dimension names

Matrix

a[,"col1”] ✓

a["col1”] ✗

a$col1 ✗

a["row1",] ✓

a["row1”] ✗

a["row1","col1"] ✓

	col1	col2
row1	1	5
row2	0	13
row3	34	44

Data frame

b[,"col1”] ✓

b["col1”] ✓

b$col1 ✓

b["row1",] ✓

b["row1”] ✗

b["row1","col1"] ✓

Matrices and data frames
Checks and conversions

- Checking if the object is a matrix…

  is.matrix(mymatrix)

… or a data frame:

  is.data.frame(mydataframe)

- Converting a matrix into a data frame…

  as.matrix(mydataframe)

… or vice versa:

  as.data.frame(mymatrix)

Lists

- Linear structures.

- A component of a list can be **any data structure**

  (matrix, vector, data frame, another list)

Lists

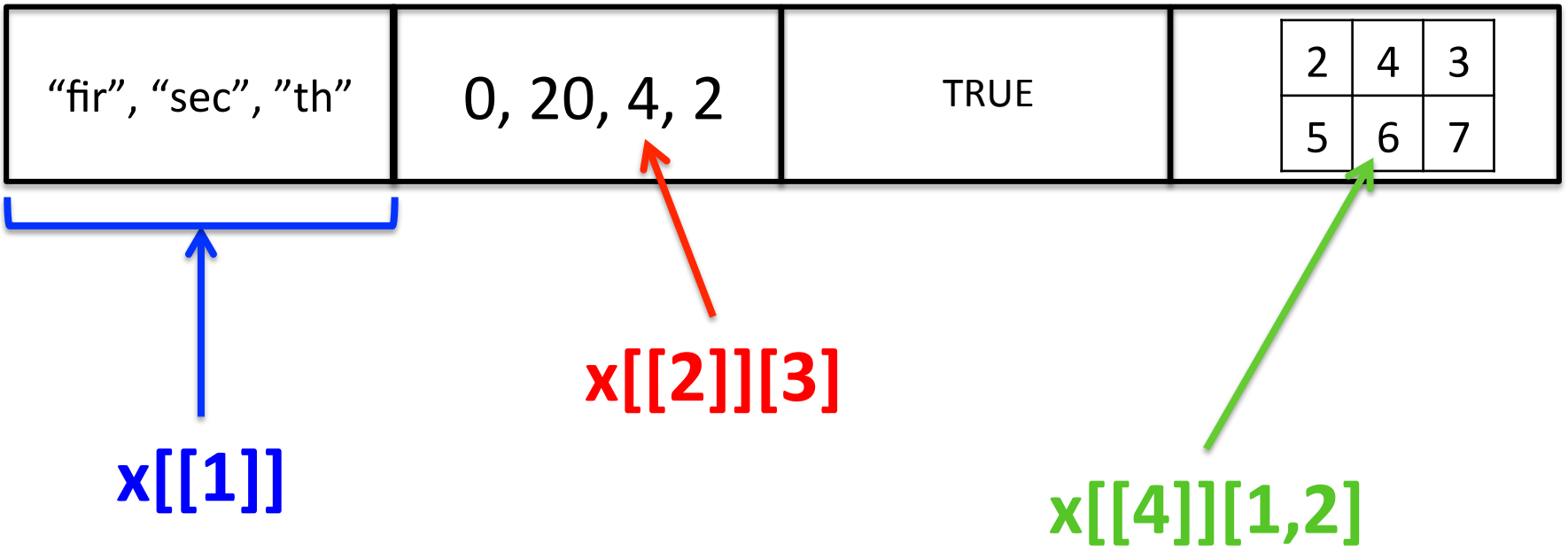
- Create a list:

```
x<- list()      # Empty list that can be filled later on

x<- list(c("fir", "sec", "th"),      # 1st element of the list
                    c(0, 20, 4, 2),      # 2d element of the list
                    TRUE,      # 3d element of the list
                    matrix(c(2, 5, 4, 6, 3, 7),  # 4th element of the list
                    nrow=2, ncol=3))
```

Lists

- Accessing elements of a list x:



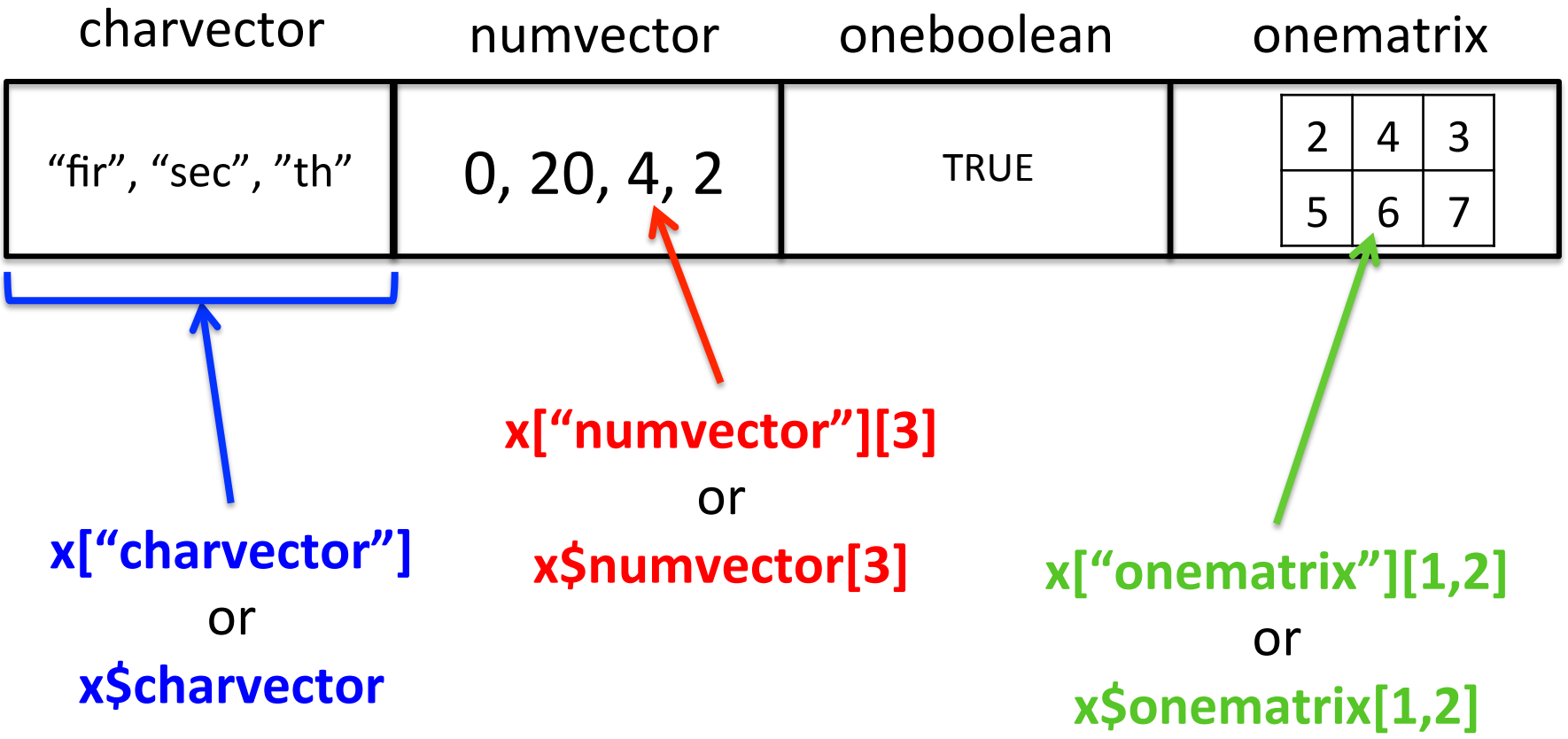
Naming elements of a list

```
x <- list(charvector=c("fir", "sec", "th"),
                numvector=c(0, 20, 4, 2),
                oneboolean=TRUE,
                onematrix=matrix(c(2, 5, 4, 6, 3, 7),
                nrow=2, ncol=3))
```

or

```
names(x) <- c("charvector", "numvector",
"oneboolean", "onematrix")
```

Accessing elements of list x per name



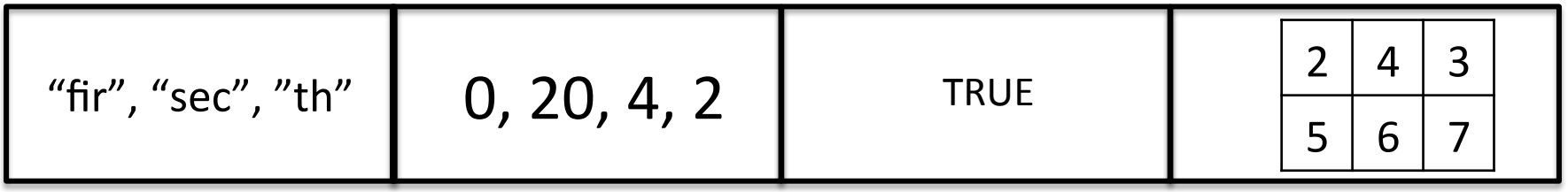
Length and dimension of lists

- Lists have a length but only **one dimension**

length(x)

4

- Elements within a list can have lengths and dimensions, depending on their data structure.



length(x[[2]])

4

dim(x[[4]])

2 3

Checking and converting data types and structures

Checking	Converting
is.matrix(x)	as.matrix()
is.data.frame(x)	as.data.frame()
is.vector()	as.vector()
is.list()	as.list()
is.factor()	as.factor()
is.character()	as.character()
is.numeric()	as.numeric()

Library / packages

Library/packages

- **Packages** are collections of R functions, data, and compiled code in a well-defined format.

- The directory where packages are stored is called the **library**.

Definitions from http://www.statmethods.net/interface/packages.html

Standard packages

- About 25 standard packages are supplied with R by default (example: base, stats, graphics).
- On May 4th 2016, **8340 packages** were available!
- Anyone can contribute to the R package repository

Installing and loading packages

- Packages can be installed from:
  - the interactive session:

    install.packages("ggplot2")

    install.packages("ggplot2", repos= http://cran.r-project.org/web/packages/)
  - the terminal:

    R CMD INSTALL ggplot2_version.tar.gz

- And loaded:

  library("ggplot2")

Listing packages

- Installed packages: **library()**

```
acepack            ace() and avas() for selecting regression transformations
affy               Methods for Affymetrix Oligonucleotide Arrays
affyio             Tools for parsing Affymetrix data files
AnnotationDbi      Annotation Database Interface
Biobase            Biobase: Base functions for Bioconductor
BiocGenerics       S4 generic functions for Bioconductor
...
```

- Loaded packages: **search()**

```
[1] ".GlobalEnv"        "package:stats"     "package:graphics"
[4] "package:grDevices" "package:utils"     "package:datasets"
[7] "package:methods"   "Autoloads"         "package:base"
```

Listing functions from packages

- **ls("package:yourpackage")**

- **ls("package:VennDiagram")**

```
 [1] "add.title"              "adjust.venn"
 [3] "calculate.overlap"      "decide.special.case"
 [5] "draw.pairwise.venn"     "draw.quad.venn"
 [7] "draw.quintuple.venn"    "draw.single.venn"
 …."
```

Accessing package's functions

- Usually, calling the function by its name is enough:

  add.title()

- If 2 packages have a function with the same name, make sure you are using the right one:

  VennDiagram::add.title ()

Basic commands

Getting and changing working directory

- **getwd()**
  - Returns current working directory

- **setwd("/home/mydir/")**
  - Changes current working directory to "/home/mydir"

Information about objects

- **summary(x)**
  - → for numerical data: min, max, median etc.
  - → for character data: count of items occurrences

col1	col2	col3
1	ok	TRUE
3	yes	FALSE
5	no	FALSE
6	maybe	FALSE

```
      col1            col2          col3
 Min.   :1.00     maybe:1     Mode :logical
 1st Qu.:2.50     no   :1     FALSE:3
 Median :4.00     ok   :1     TRUE :1
 Mean   :3.75     yes  :1     NA's :0
 3rd Qu.:5.25
 Max.   :6.00
```

Information about objects

- **str(x):**

  → Internal structure of an R object

col1	col2	col3
1	ok	TRUE
3	yes	FALSE
5	no	FALSE
6	maybe	FALSE

'data.frame': 4 obs. of 3 variables:
$ col1: num 1 3 5 6
$ col2: Factor w/ 4 levels "maybe","no","ok",..: 3 4 2 1
$ col3: logi TRUE FALSE FALSE FALSE

Size/dimensions of objects

number of elements in vector, factor or list	**length(x)**
dimensions of matrix or data frame	**dim(x)**
number of rows of matrix or data frame	**nrow(x)**
number of columns of matrix or data frame	**ncol(x)**

Elementary arithmetic operators

addition	**+**
subtraction	**-**
division	**/**
multiplication	*****
exponentiation	**^** or **

Logical operators

inferior	**<**
inferior or equal	**<=**
superior	**>**
superior or equal	**>=**
equality	**==**
inequality	**!=**
intersection (“and”)	**&**
union (“or”)	**|**

Obtaining summary statistics

average/mean	**mean(x)**
median	**median(x)**
minimum	**min(x)**
maximum	**max(x)**
variance	**var(x)**
correlation	**cor(x)**

Some common arithmetic functions

natural logarithm	**log(x)**
exponential function e^x	**exp(x)**
sine	**sin(x)**
cosine	**cos(x)**
tangent	**tan(x)**
absolute value	**abs(x)**
square root	**sqrt(x)**

Objects stored in the global environment

- Listing:

ls() or **objects()**

- Removing one object from environment:

rm(x)

- Removing several objects:

rm(x, y)

- Removing all object from environment:

rm(list=ls())

Reading and writing files

Reading file into object

a <- read.table(“file.txt”)

Writing object to file

write.table(a, “file.txt”)

Saving objects or session

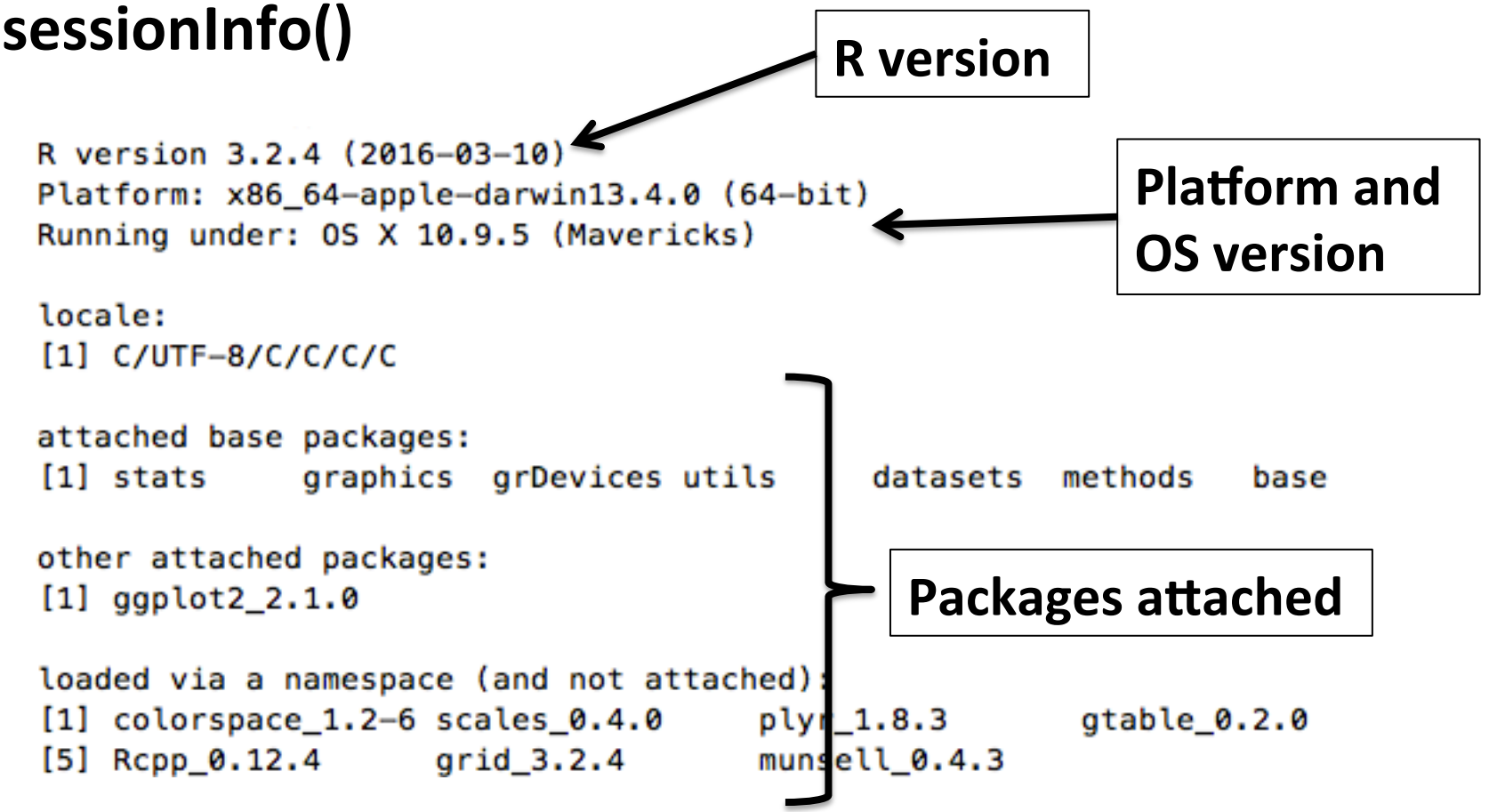
- Save objects x and y into “myobjects.RData” file
  - **save(x, y, file=“myobjects.RData”)**
- Load objects x and y into current directory:
  - **load(“myobjects.RData”)**
- Save the current workspace (all objects):
  - **save.image(file=“.RData”)**

Command history

- Last 25 commands:
  - **history()**
- All previous commands
  - **history(max.show=Inf)**
- Save command history:
  - **savehistory()**
- Load command history:
  - **loadhistory()**

Information about the current session

sessionInfo()



Functions in R

Knowing the source code of a function

- Name of the function without **()**

For example:

sort

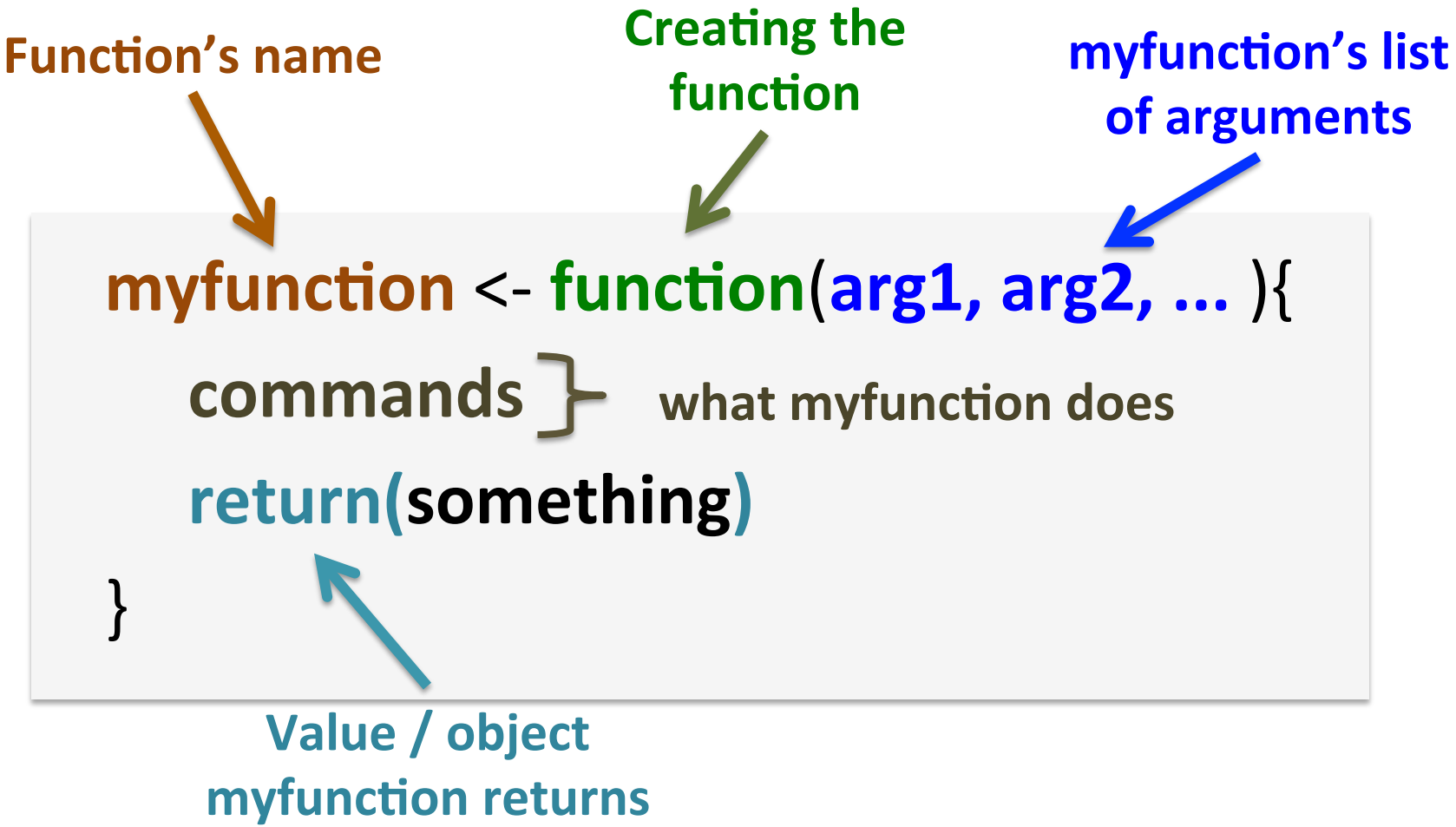
```
function (x, decreasing = FALSE, ...)
{
    if (!is.logical(decreasing) || length(decreasing) != 1L)
        stop("'decreasing' must be a length-1 logical vector.\nDid
you intend to set 'partial'?")
    UseMethod("sort")
}
```

User-written functions

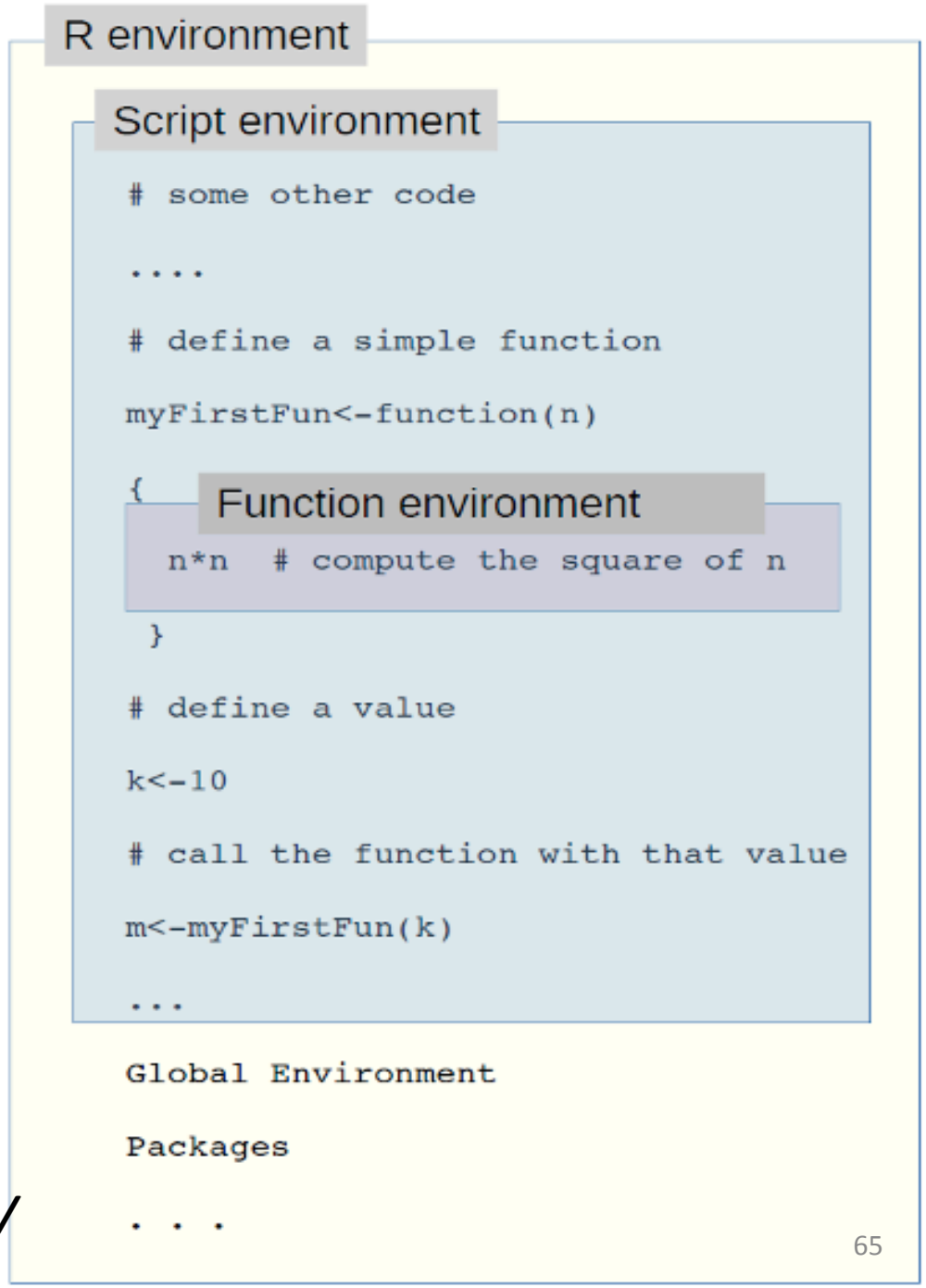
- Functions are pieces of code written **to carry out (a) specified task(s)** and be able to repeat it(them) easily.

- R allows you to create your own functions.

Functions' structure



Objects in a function are local to that function!



from https://www.datacamp.com/community/tutorials/functions-in-r-a-tutorial

Objects in functions

```
myfunction <- function(arg1){
    a <- arg1
    return(a+1)
}
```

```
> myfunction(10)
[1] 11
> a
Error: object 'a' not found
```

```
> a <- 12
> myfunction(10)
[1] 11
> a
[1] 12
```

Example of a function

Function "somestats":

takes as an argument: one numeric vector.

computes: median and mean of that vector.

returns: a vector containing these 2 values.

Example of a function

```
somestats <- function(vector_input){
    my_mean <- mean(vector_input)
    my_median <- median(vector_input)
    return(c(my_mean, my_median))
}

x <- c(0, 2, 1, 6.3, 2.2, 10, 8, 5.4)
```

somestats(x)

4.3625 3.8000

Saving and sourcing functions

myfunctions.R

```
somestats <- function(vector_input){
        my_mean <- mean(vector_input)
        my_median <- median(vector_input)
        vector_output <- c(my_mean, my_median)
        return(c(vector_output))
}
```

source("myfunctions.R")

→ Content of **myfunctions.R** loaded in the user workspace (global environment)

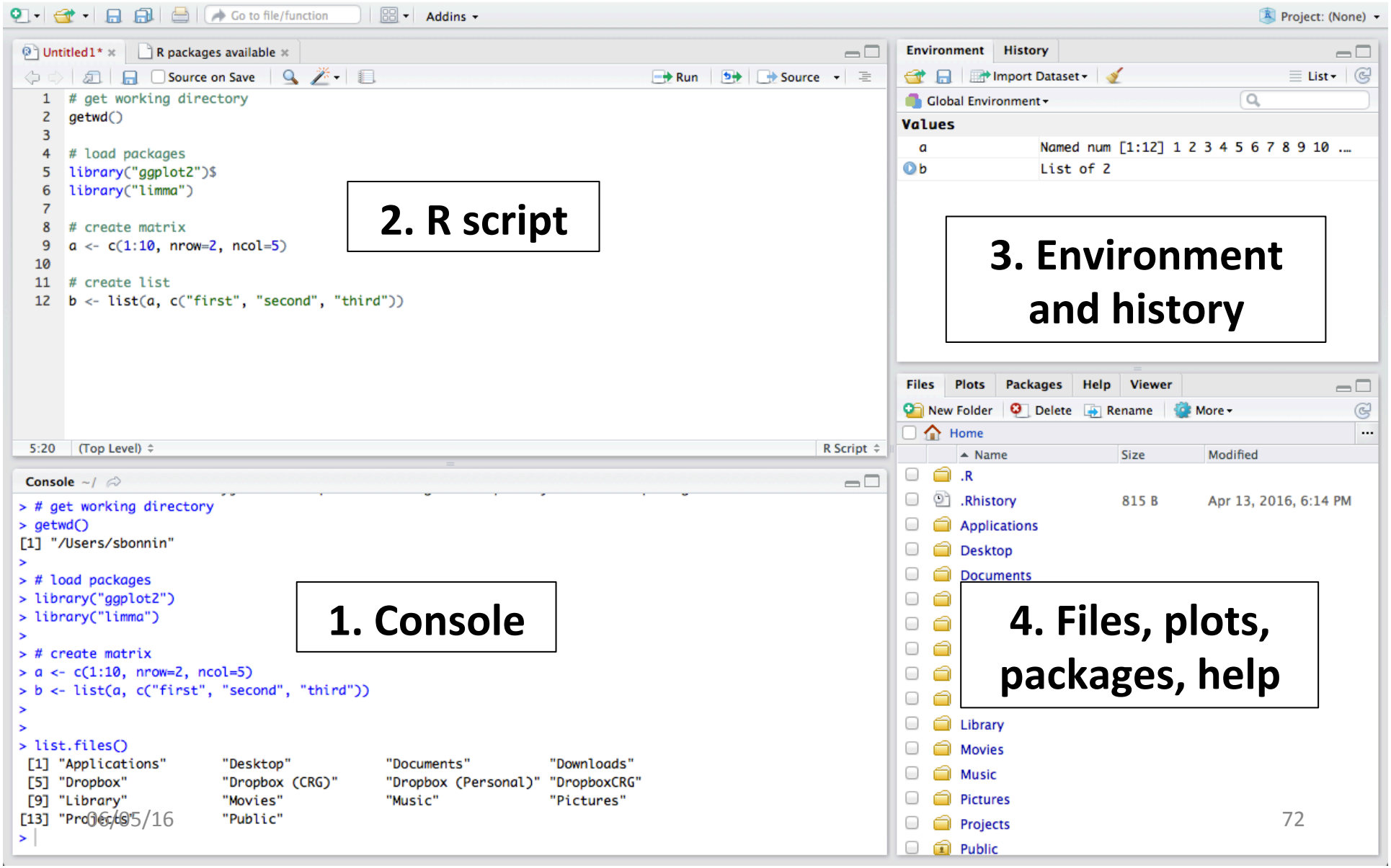
R Studio

What is R studio?

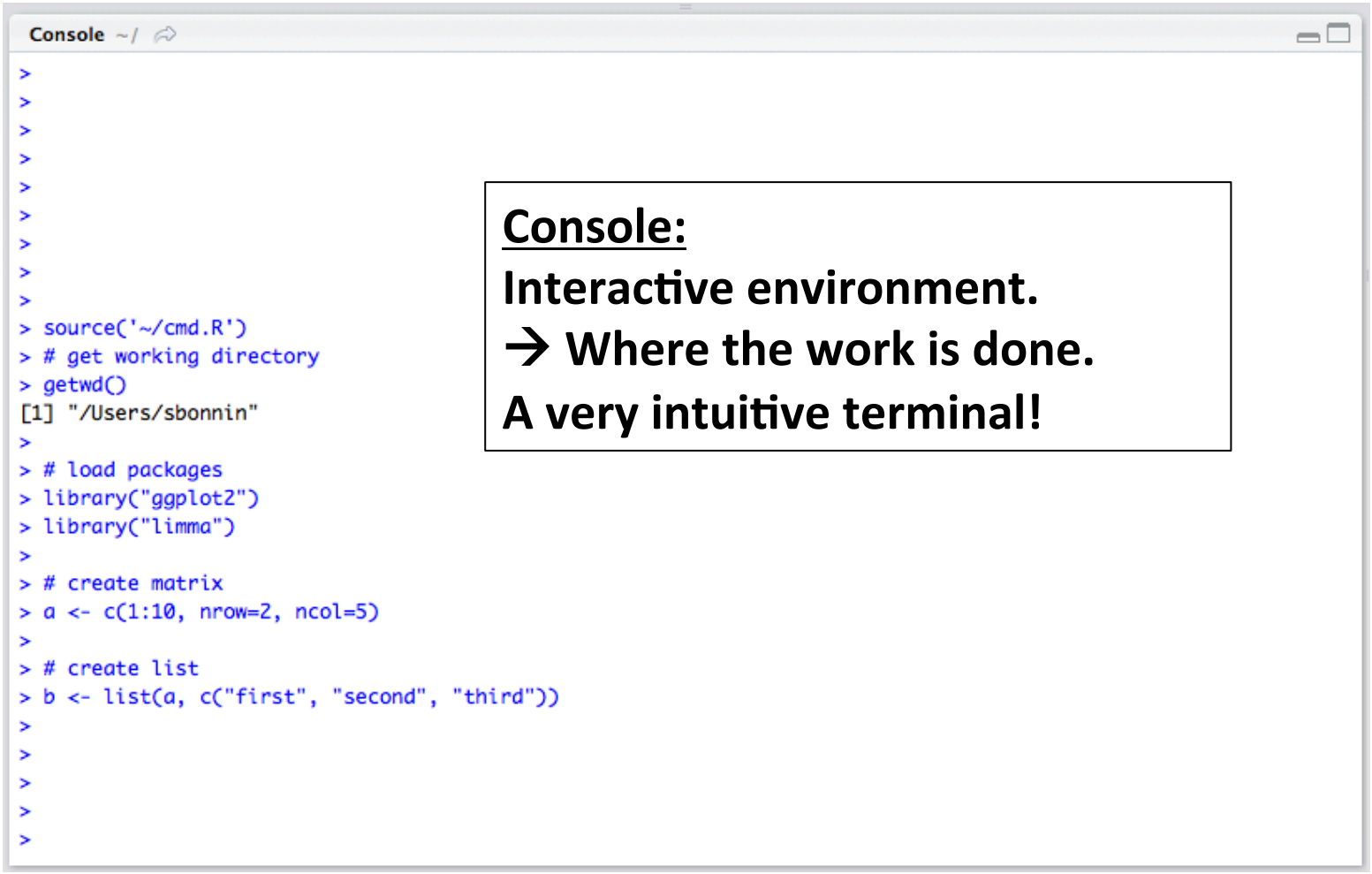
- **Free and open source** IDE (Integrated Development Environment) for R
- Available for Windows, Mac OS and Linux
- Written in C++
- First beta version available in 2009
- User friendly environment

R Studio

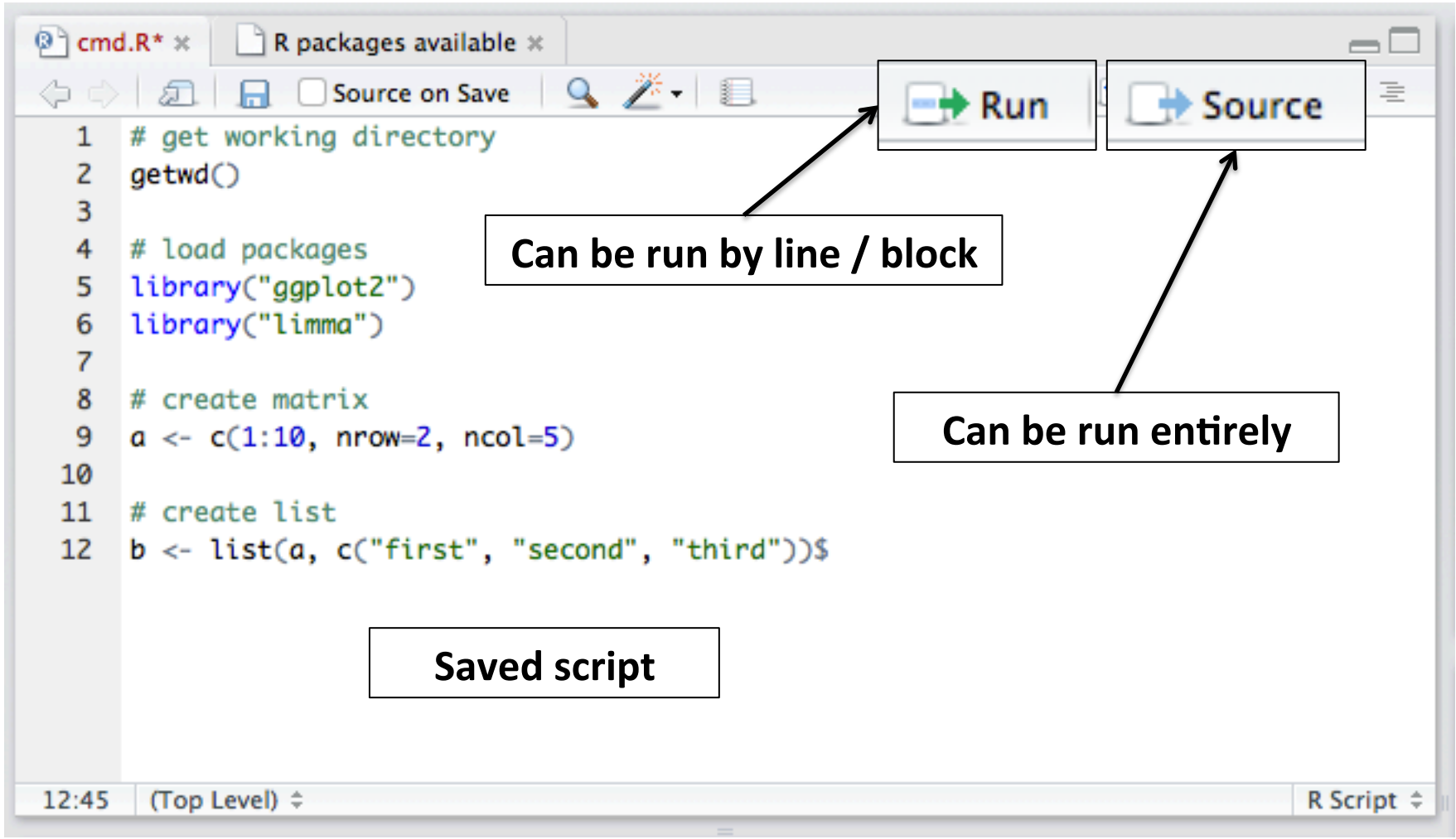
Screen: 4 windows



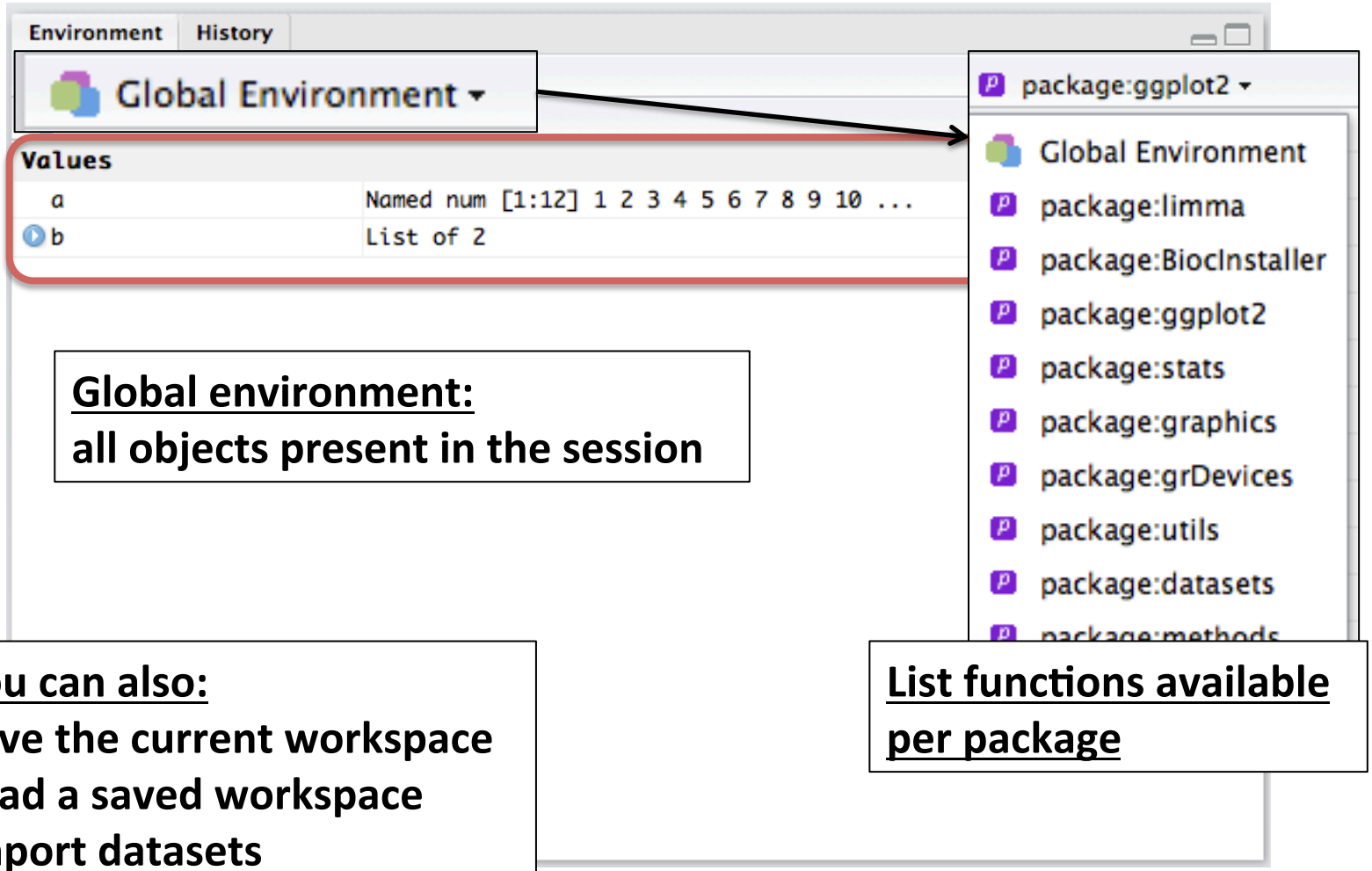
1. Console


Console ~/
>
>
>
>
>
>
>
>
>
>
> source('~/cmd.R')
> # get working directory
> getwd()
[1] "/Users/sbonnin"
>
> # load packages
> library("ggplot2")
> library("limma")
>
> # create matrix
> a <- c(1:10, nrow=2, ncol=5)
>
> # create list
> b <- list(a, c("first", "second", "third"))
>
>
>
>
>
Console:
Interactive environment.
→ Where the work is done.
A very intuitive terminal!

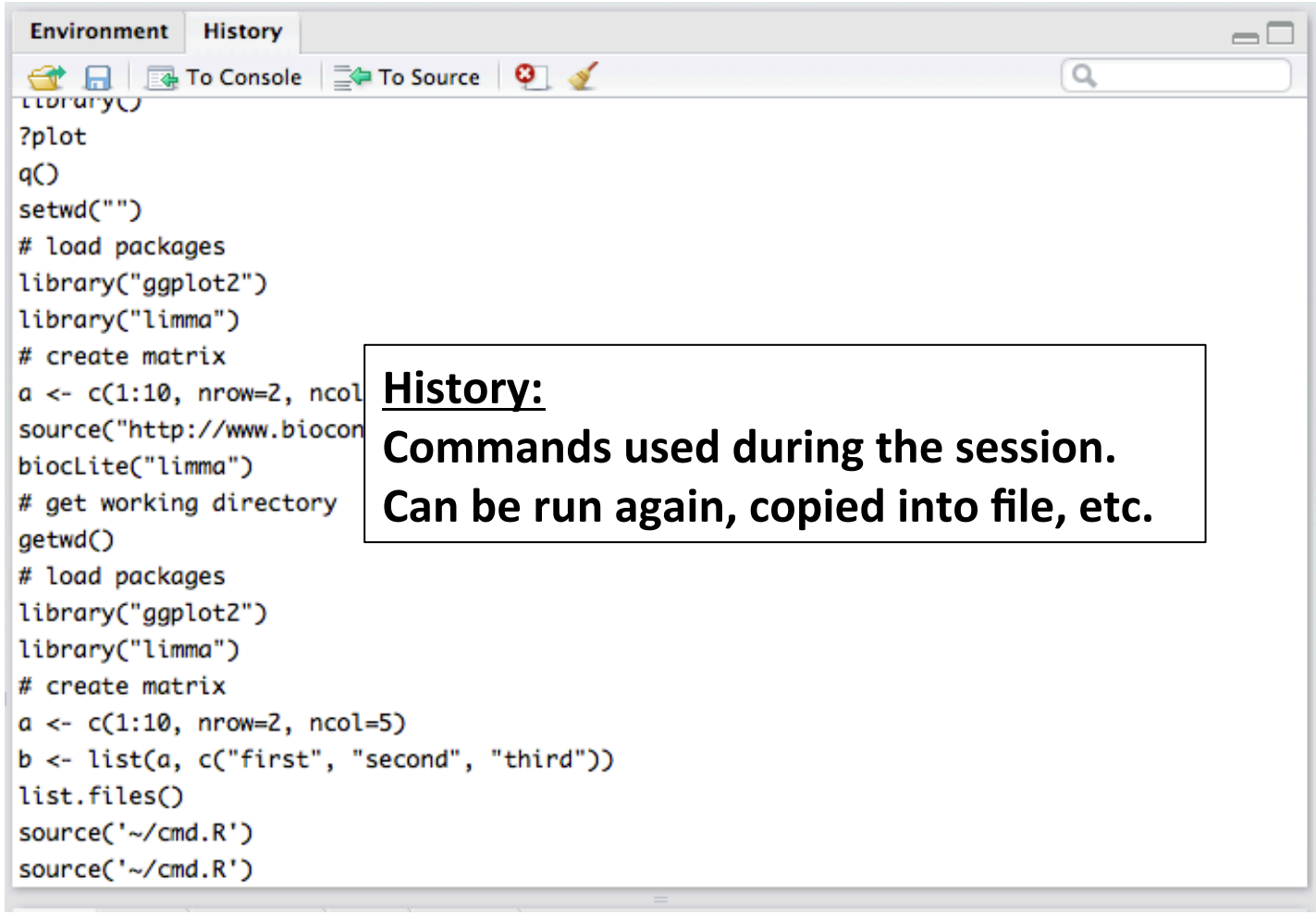
2. R script


cmd.R*
R packages available
Source on Save
Run
Source
1 # get working directory
2 getwd()
3
4 # load packages
5 library("ggplot2")
6 library("limma")
7
8 # create matrix
9 a <- c(1:10, nrow=2, ncol=5)
10
11 # create list
12 b <- list(a, c("first", "second", "third"))$
Can be run by line / block
Can be run entirely
Saved script
12:45
(Top Level)
R Script

3. Environment and history

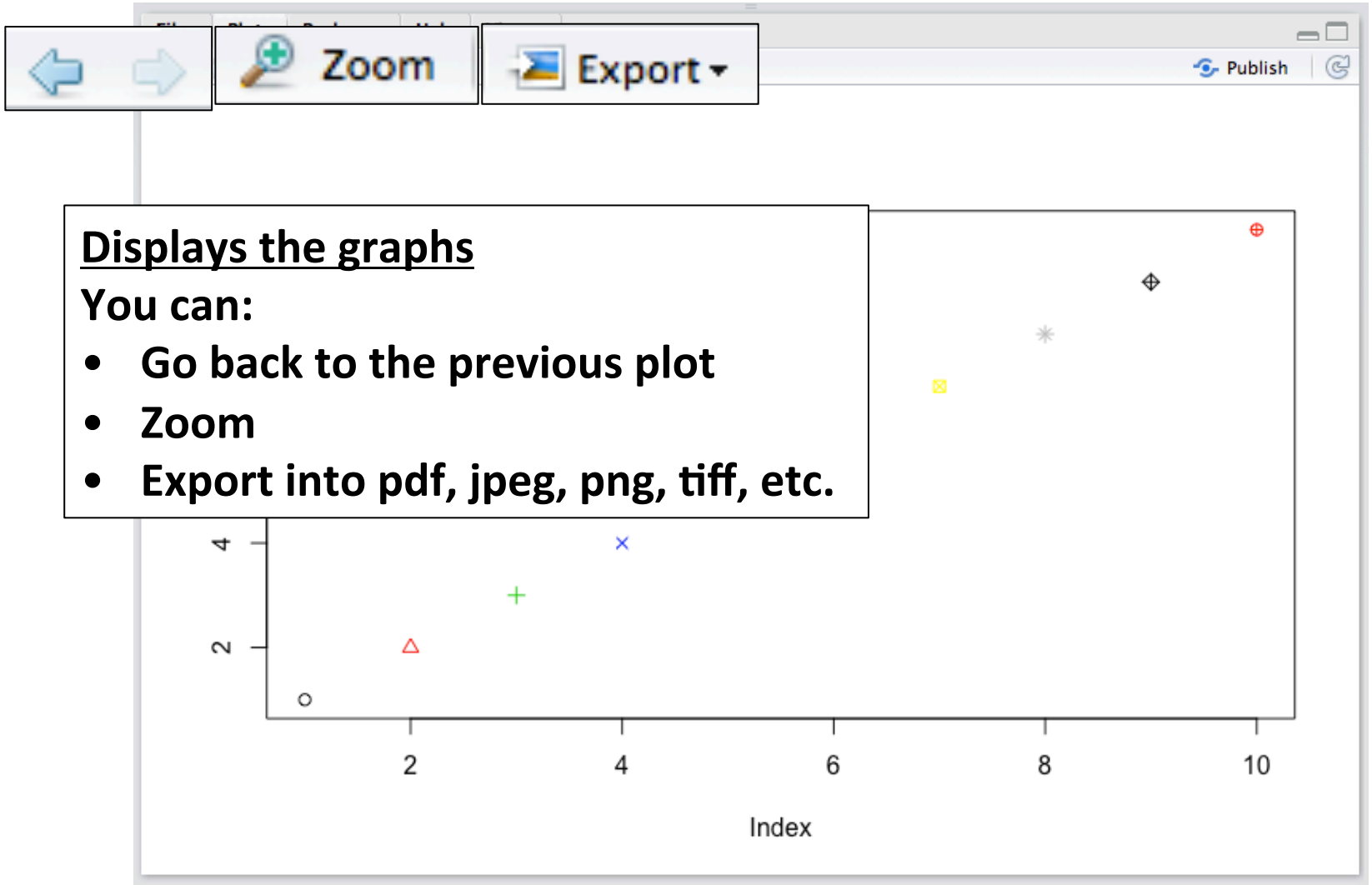


3. Environment and history

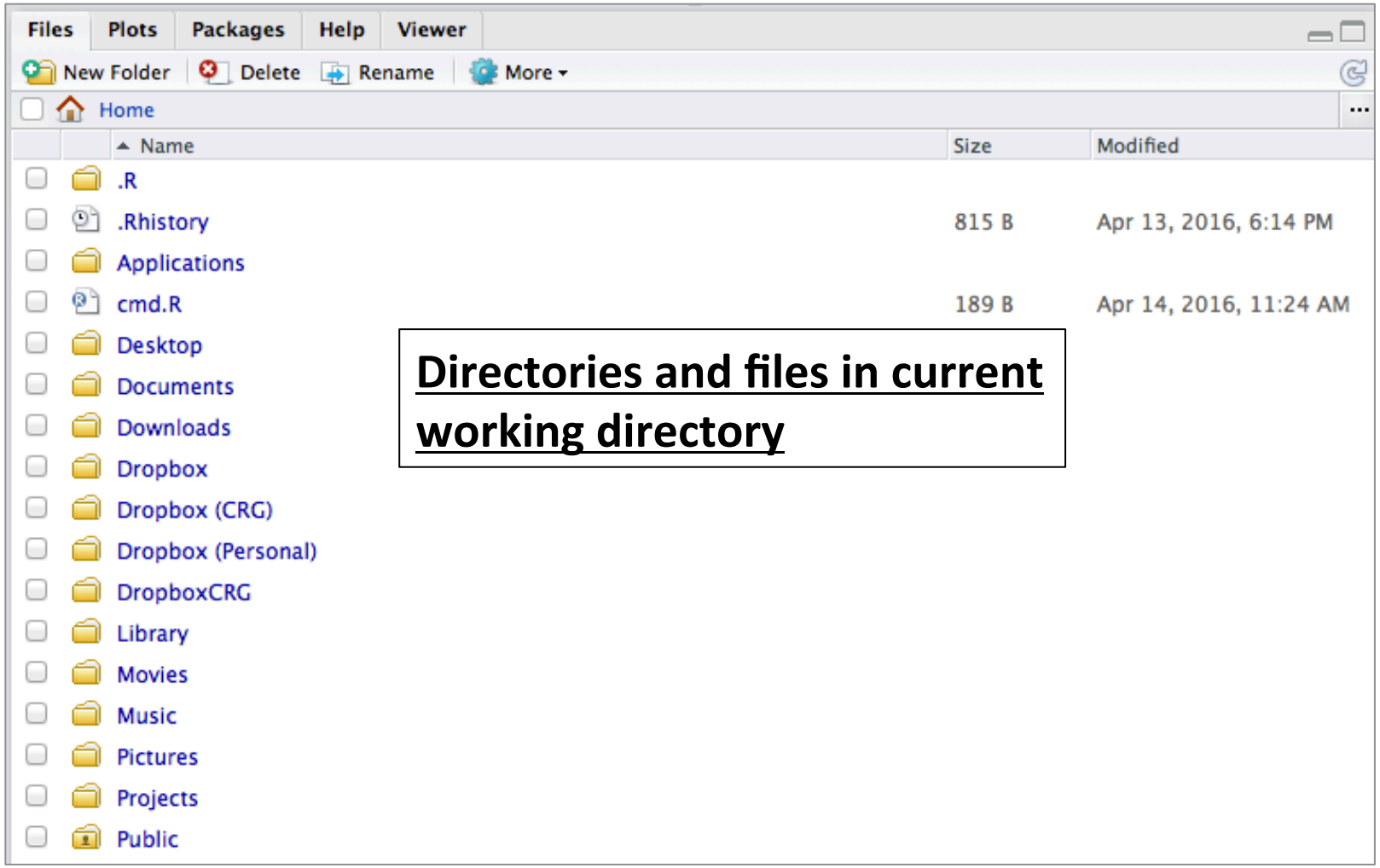


History:
Commands used during the session.
Can be run again, copied into file, etc.

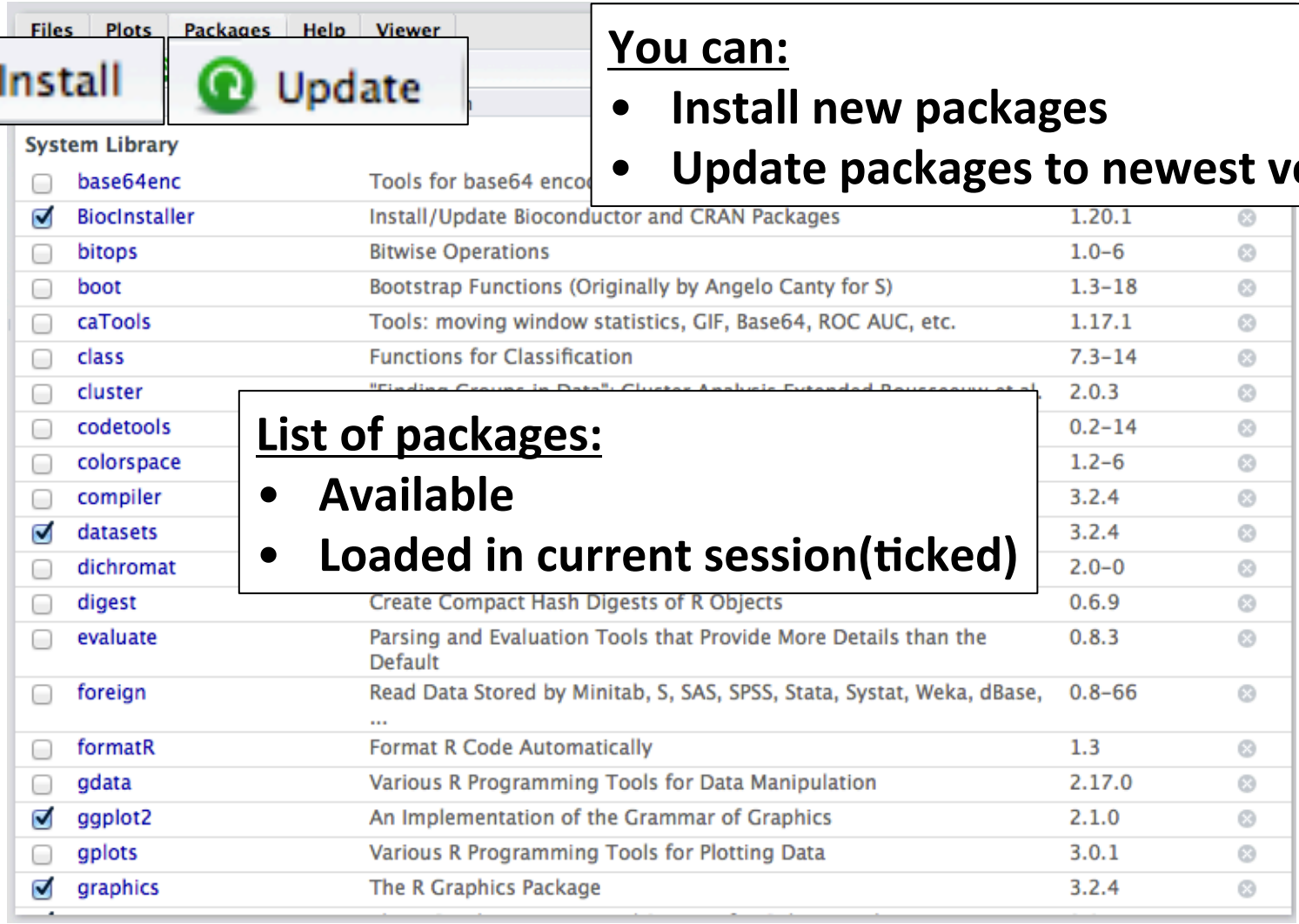
4. Plot area


Zoom
Export
Publish
Displays the graphs
You can:
• Go back to the previous plot
• Zoom
• Export into pdf, jpeg, png, tiff, etc.
2
4
2
4
6
8
10
Index

4. Files


Files
Plots
Packages
Help
Viewer
New Folder
Delete
Rename
More
Home
Name
Size
Modified
.R
.Rhistory
815 B
Apr 13, 2016, 6:14 PM
Applications
cmd.R
189 B
Apr 14, 2016, 11:24 AM
Desktop
Documents
Downloads
Dropbox
Dropbox (CRG)
Dropbox (Personal)
DropboxCRG
Library
Movies
Music
Pictures
Projects
Public
Directories and files in current working directory

4. Packages



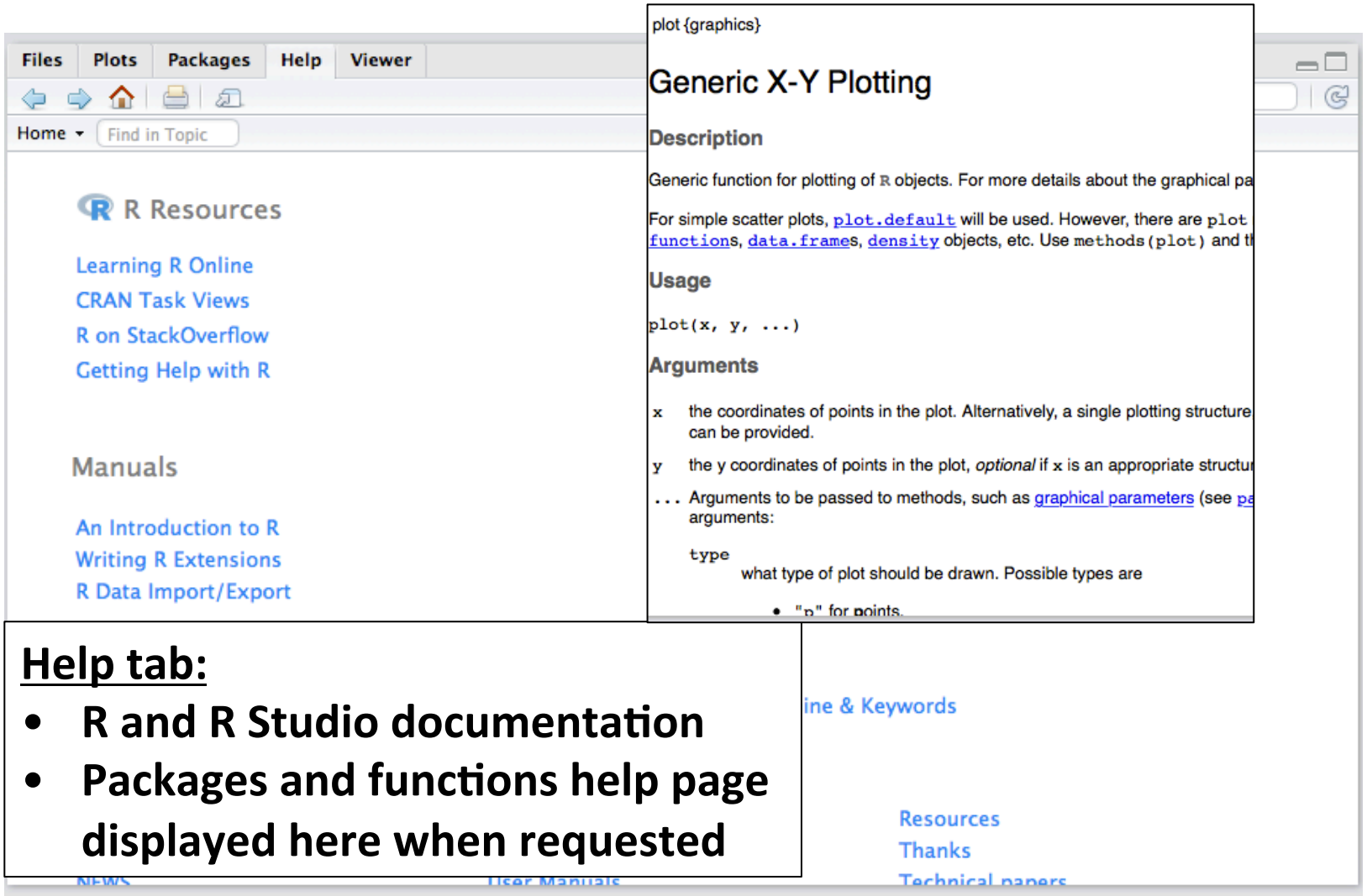
You can:

- **Install new packages**
- **Update packages to newest versions**

List of packages:

- **Available**
- **Loaded in current session(ticked)**

4. Help



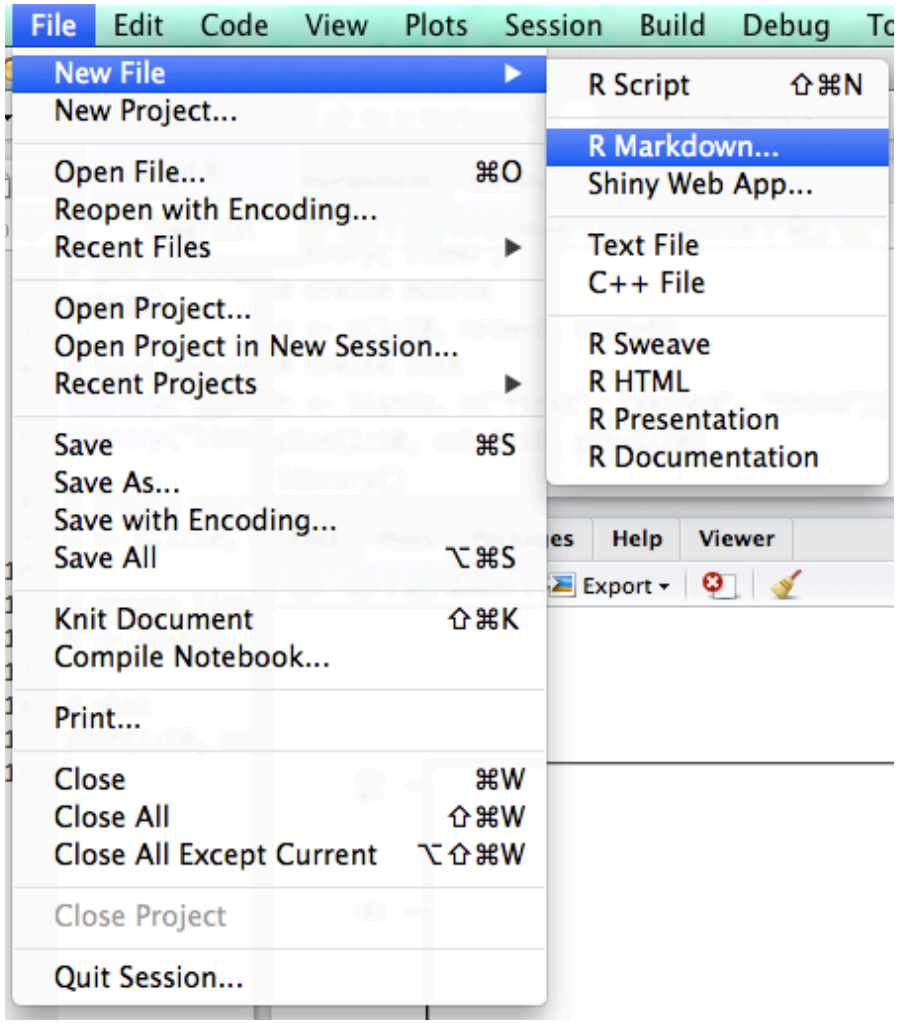
Help tab:

- **R and R Studio documentation**
- **Packages and functions help page displayed here when requested**

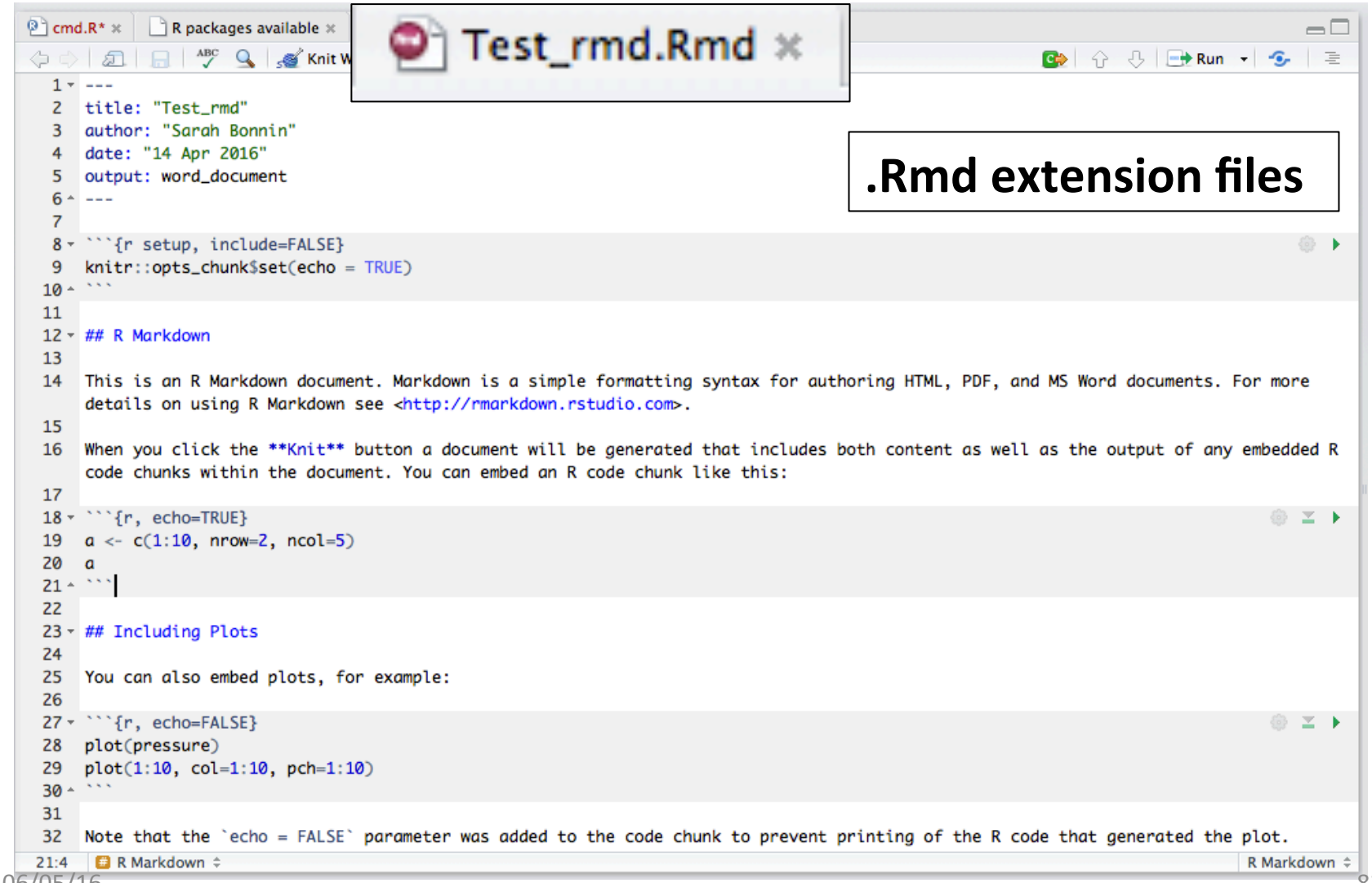
RMD: R Markdown

- Format for writing **reproducible, dynamic reports** with R.
- Work directly inserted into formatted documents (HTML, PDF and Word)
- Easy to use!

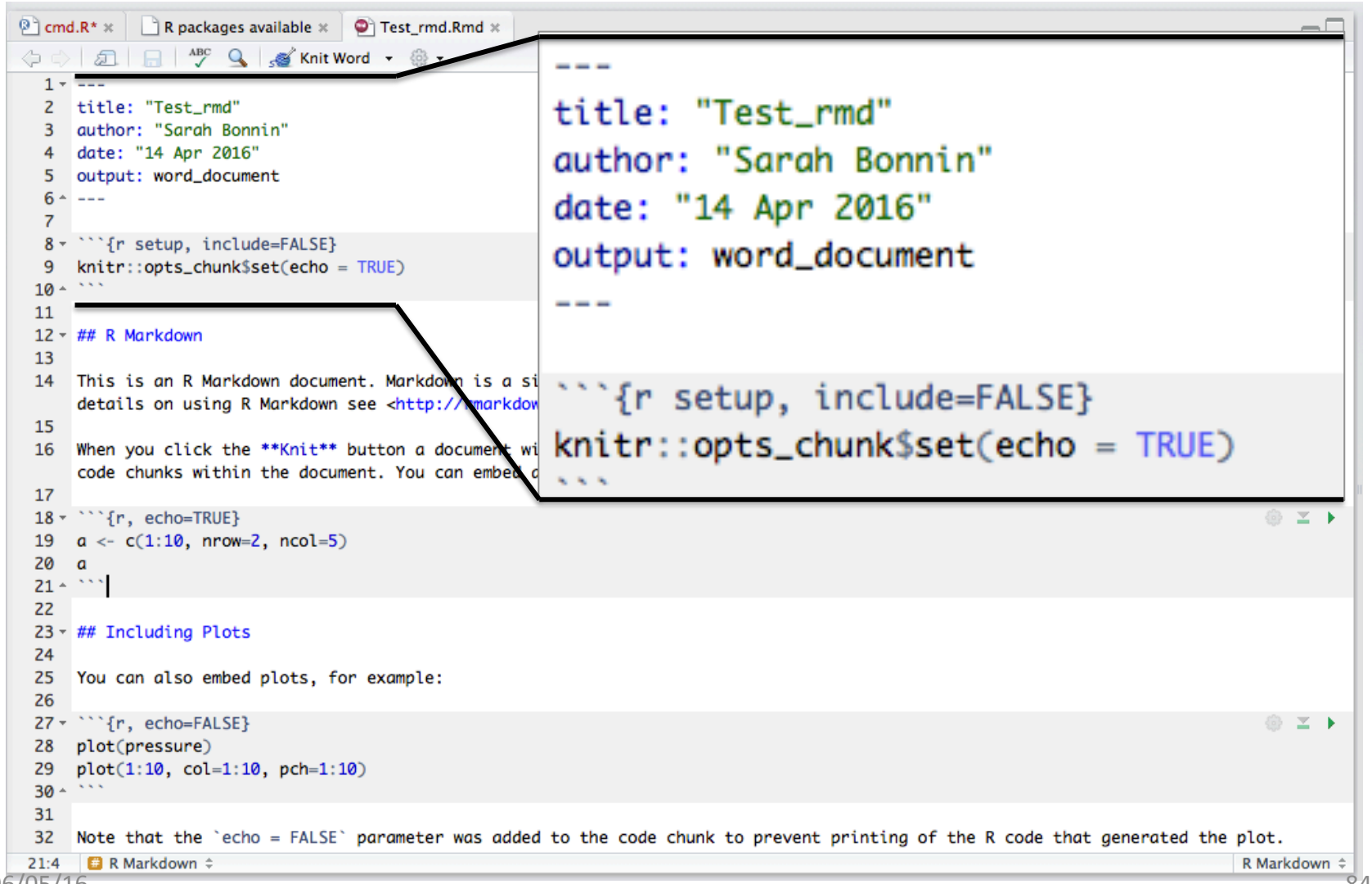
RMD: R Markdown



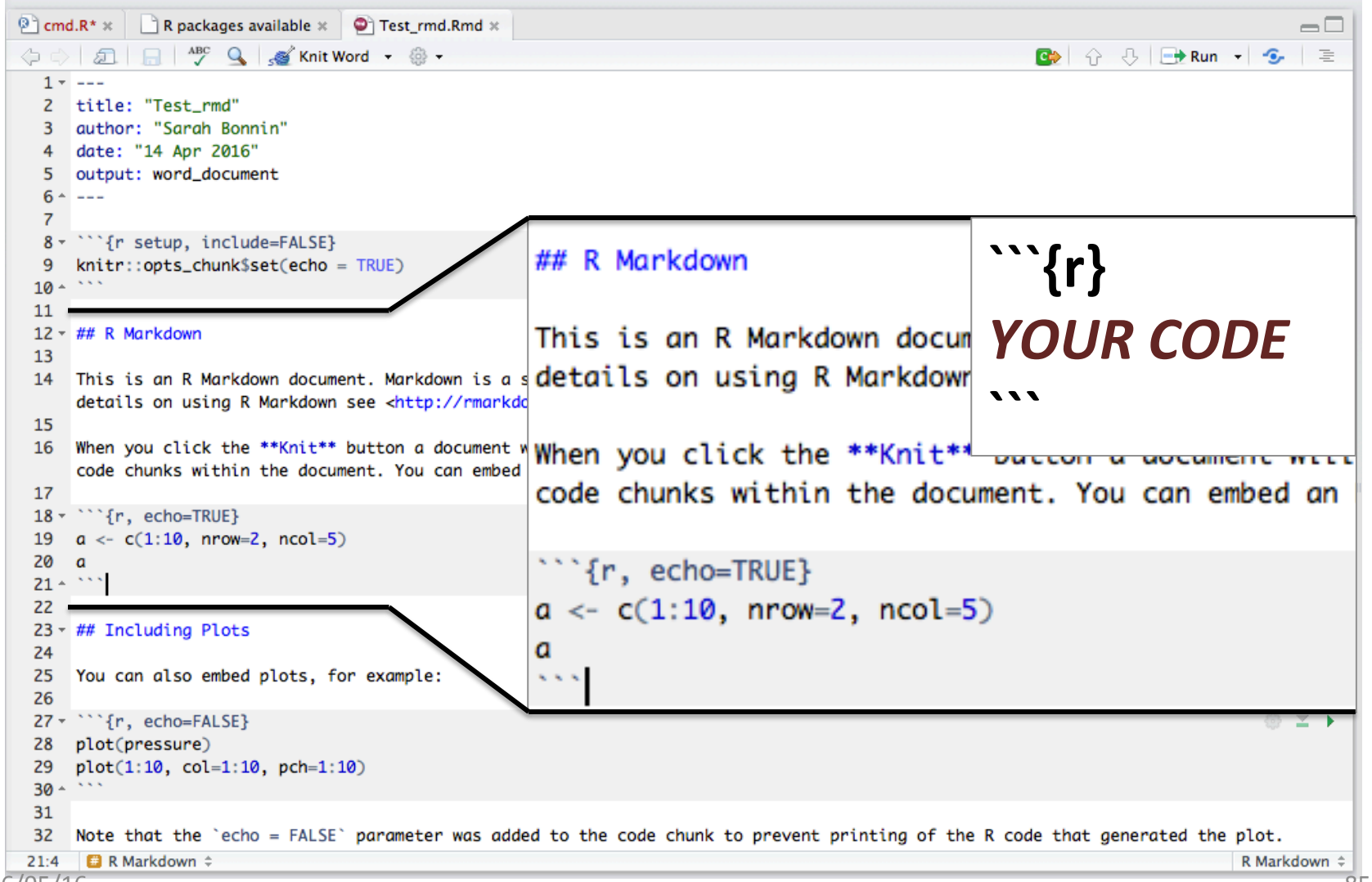
RMD: R Markdown



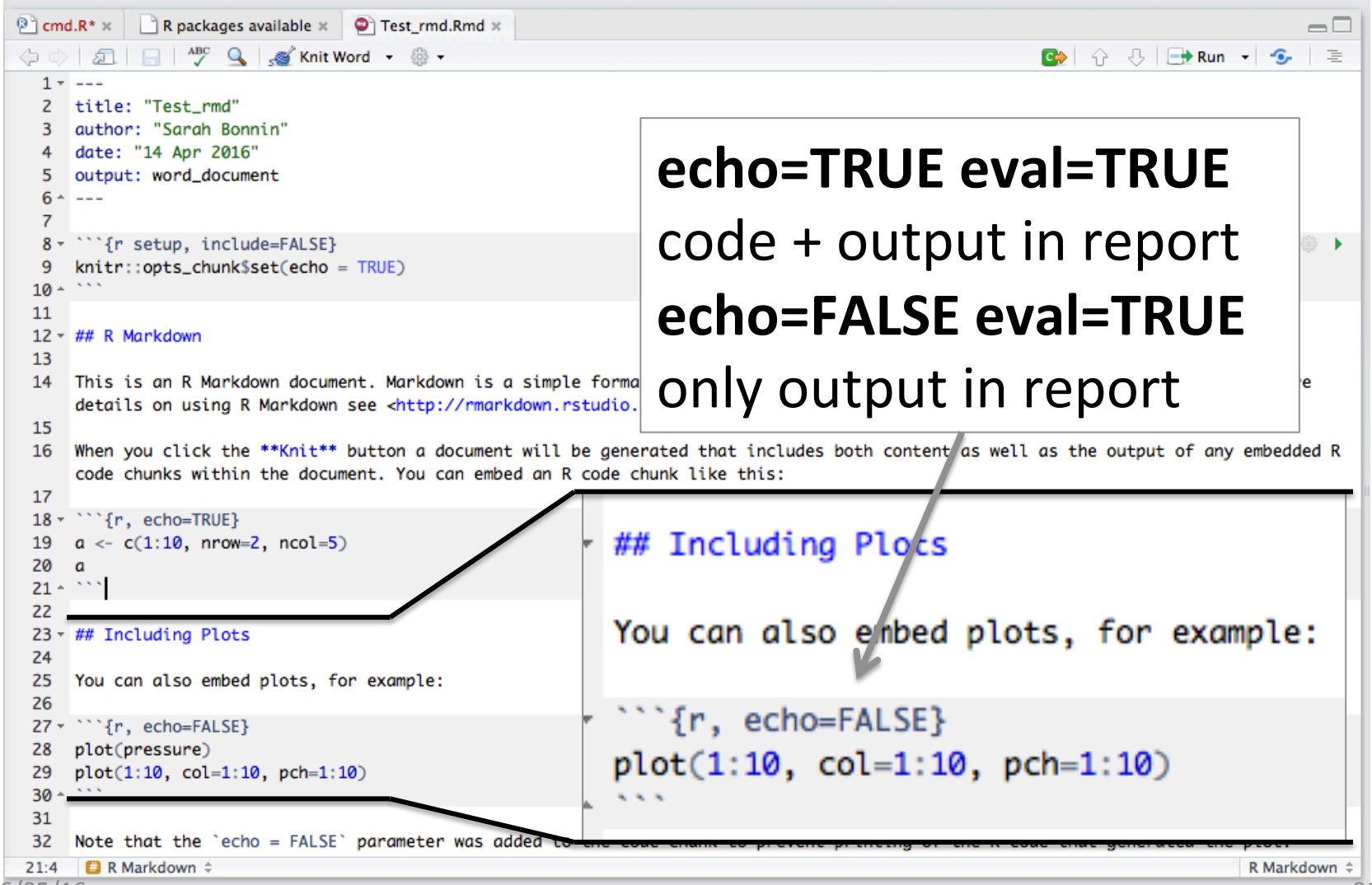
RMD: R Markdown



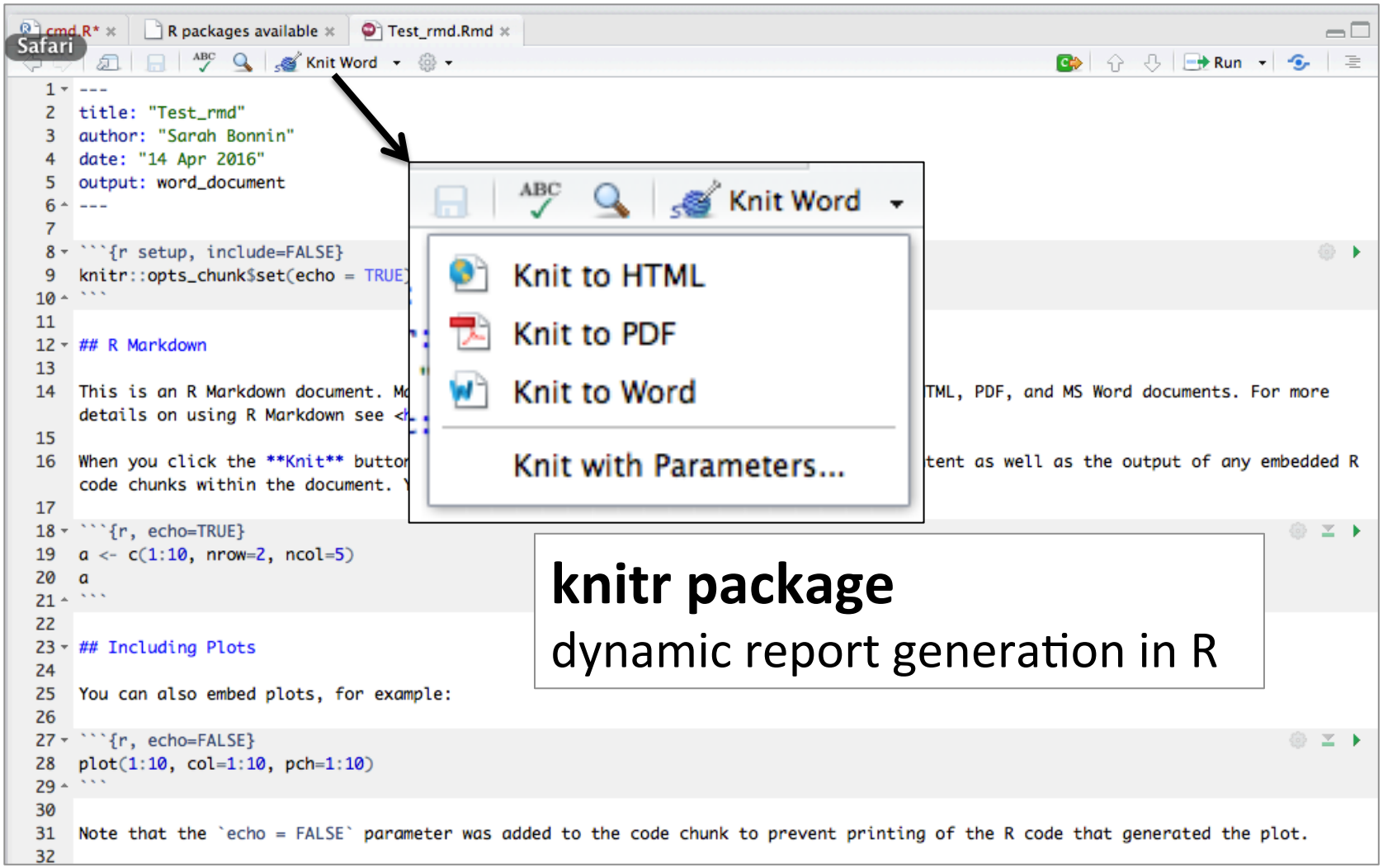
RMD: R Markdown



RMD: R Markdown



RMD: R Markdown



knitr package

dynamic report generation in R

RMD: R Markdown

Knit to HTML
→ Creates a .html file

Useful resources

- Quick R: http://www.statmethods.net/
- R bloggers: http://www.r-bloggers.com/
- Cookbook for R: http://www.cookbook-r.com/
- R forge forum: https://r-forge.r-project.org/forum/forum.php?forum_id=78
- R help: http://r.789695.n4.nabble.com/R-help-f789696.html