MAP 2112 – Introdução à Lógica de Programação e Modelagem Computacional

1º Semestre - 2020

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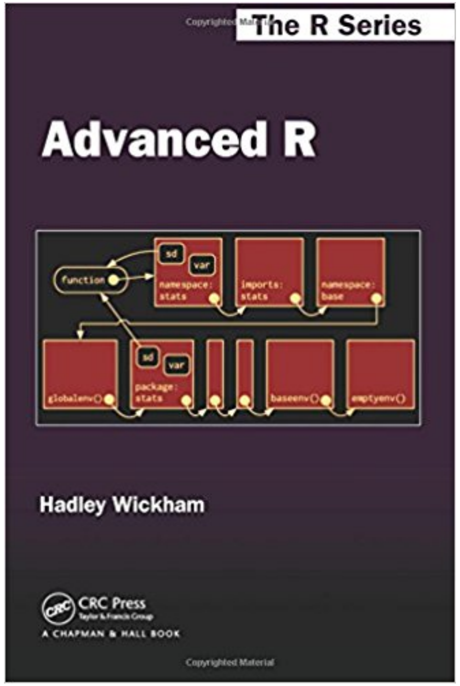
ROTEIRO

Esse material é fortemente baseado no livro

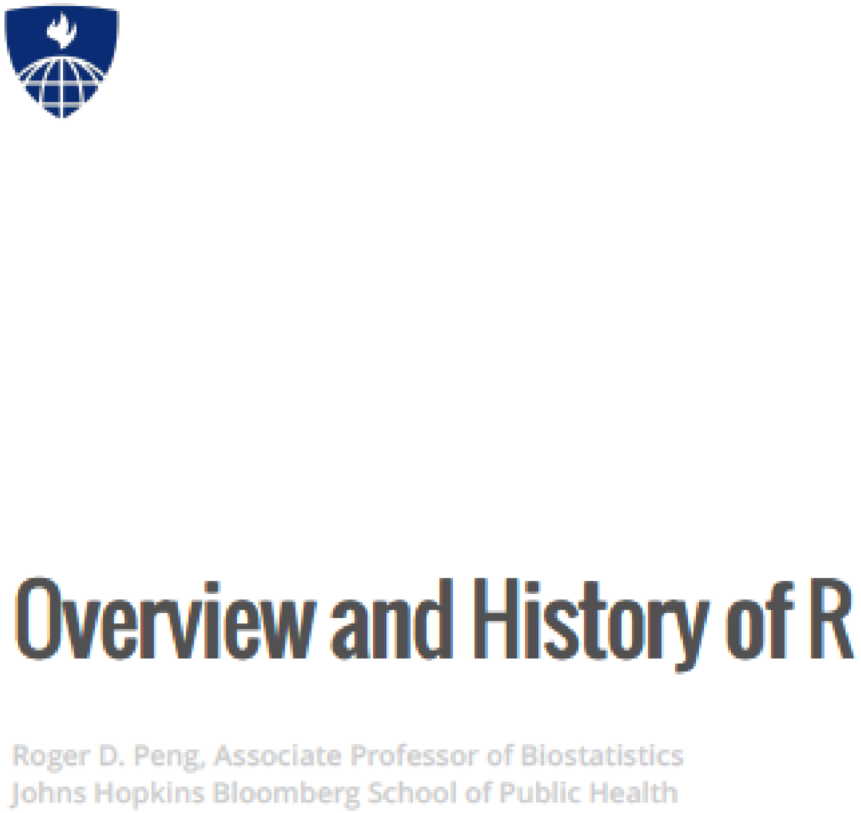
Advanced R (Chapman & Hall/CRC The R Series)

de Hadley Wickham (http://hadley.nz/) o Cientista-chefe do Rstudio



Seguindo o roteiro do Prof. Roger Peng
http://www.biostat.jhsph.edu/~rpeng/

Quando chegarmos nos tópicos de modelagem e Data Science novas referências serão selecionadas.



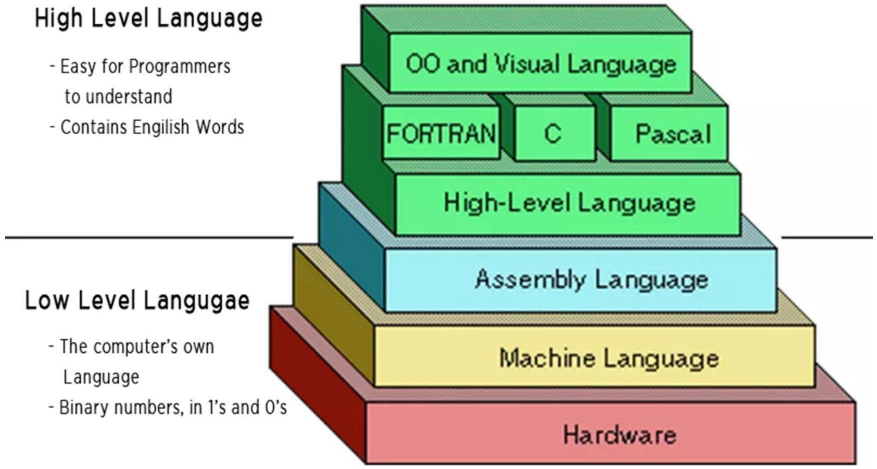
Overview and History of R

Roger D. Peng, Associate Professor of Biostatistics
Johns Hopkins Bloomberg School of Public Health

What is R?

What is R?

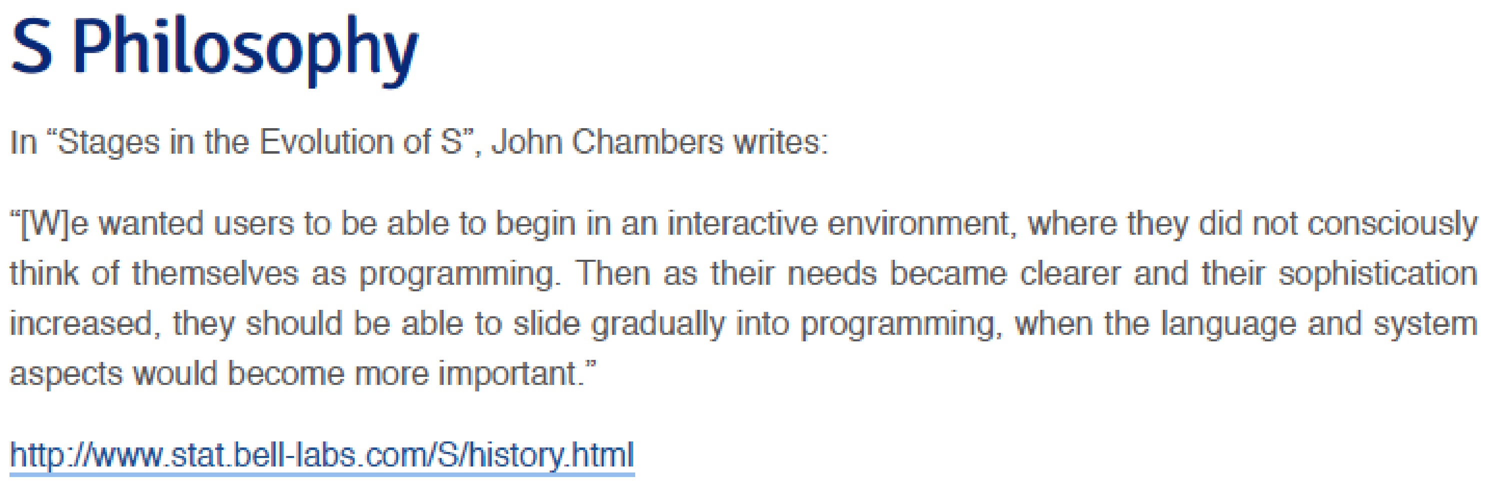
R is a dialect of the S language.



justcode.me

What is S?

- S is a language that was developed by John Chambers and others at Bell Labs.
- S was initiated in 1976 as an internal statistical analysis environment—originally implemented as Fortran libraries.
- Early versions of the language did not contain functions for statistical modeling.
- In 1988 the system was rewritten in C and began to resemble the system that we have today (this was Version 3 of the language). The book *Statistical Models in S* by Chambers and Hastie (the white book) documents the statistical analysis functionality.
- Version 4 of the S language was released in 1998 and is the version we use today. The book *Programming with Data* by John Chambers (the green book) documents this version of the language.

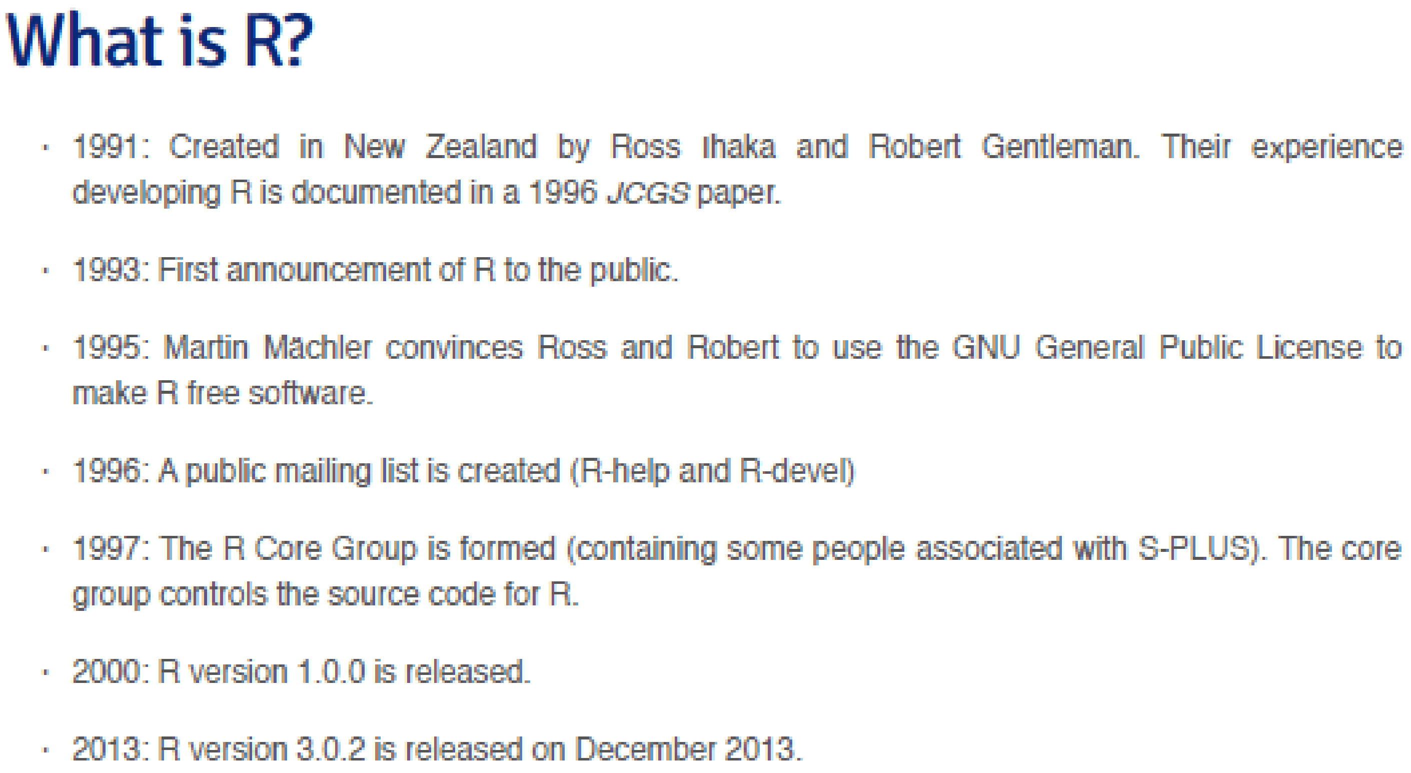


S Philosophy

In “Stages in the Evolution of S”, John Chambers writes:

“[W]e wanted users to be able to begin in an interactive environment, where they did not consciously think of themselves as programming. Then as their needs became clearer and their sophistication increased, they should be able to slide gradually into programming, when the language and system aspects would become more important.”

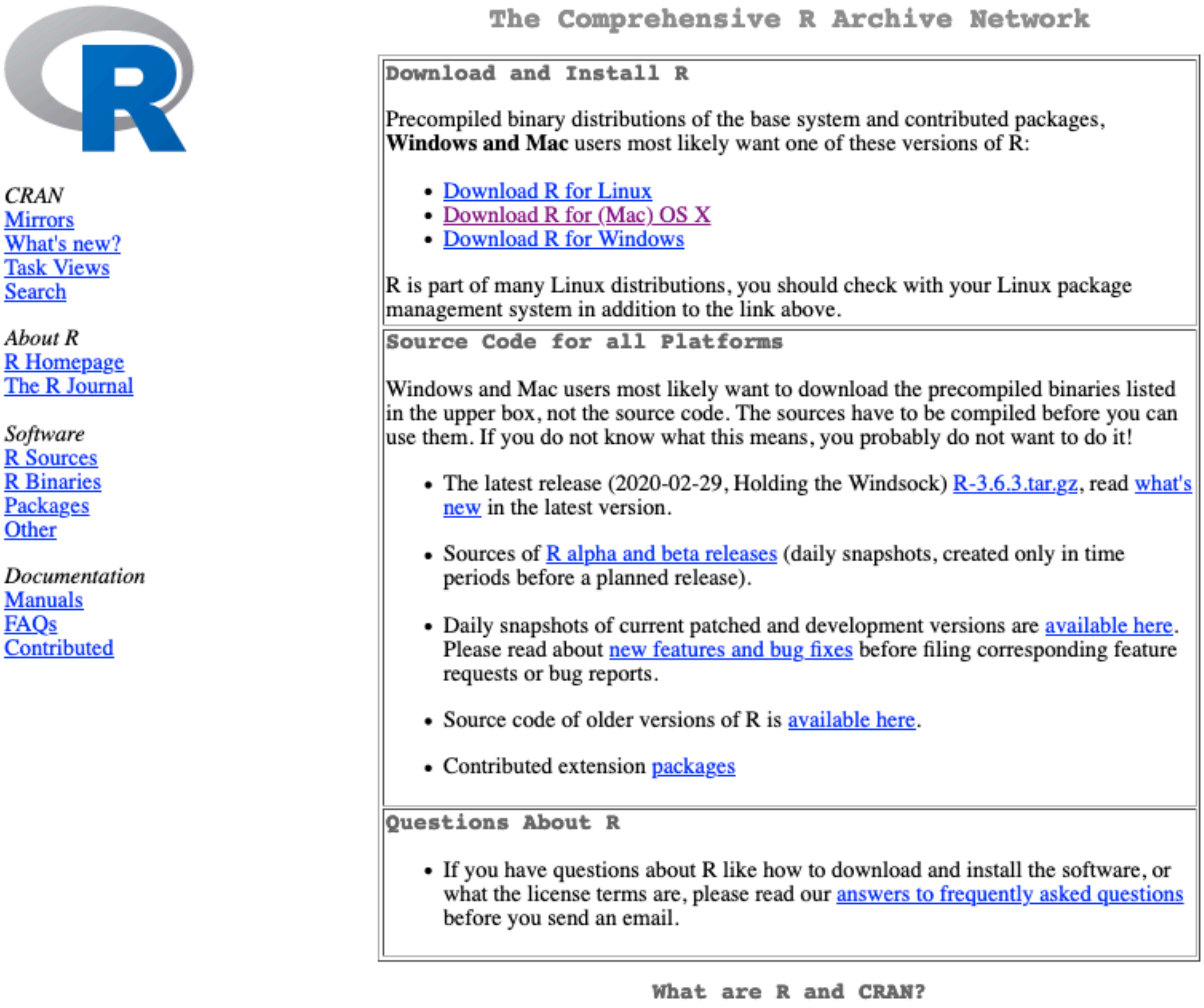
http://www.stat.bell-labs.com/S/history.html



What is R?

- 1991: Created in New Zealand by Ross Ihaka and Robert Gentleman. Their experience developing R is documented in a 1996 *JCGS* paper.
- 1993: First announcement of R to the public.
- 1995: Martin Mächler convinces Ross and Robert to use the GNU General Public License to make R free software.
- 1996: A public mailing list is created (R-help and R-devel)
- 1997: The R Core Group is formed (containing some people associated with S-PLUS). The core group controls the source code for R.
- 2000: R version 1.0.0 is released.
- 2013: R version 3.0.2 is released on December 2013.

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



The Comprehensive R Archive Network

CRAN
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About R
R Homepage
The R Journal

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Documentation
Manuals
FAQs
Contributed

Download and Install R

Precompiled binary distributions of the base system and contributed packages, **Windows and Mac** users most likely want one of these versions of R:

- Download R for Linux
- Download R for (Mac) OS X
- Download R for Windows

R is part of many Linux distributions, you should check with your Linux package management system in addition to the link above.

Source Code for all Platforms

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

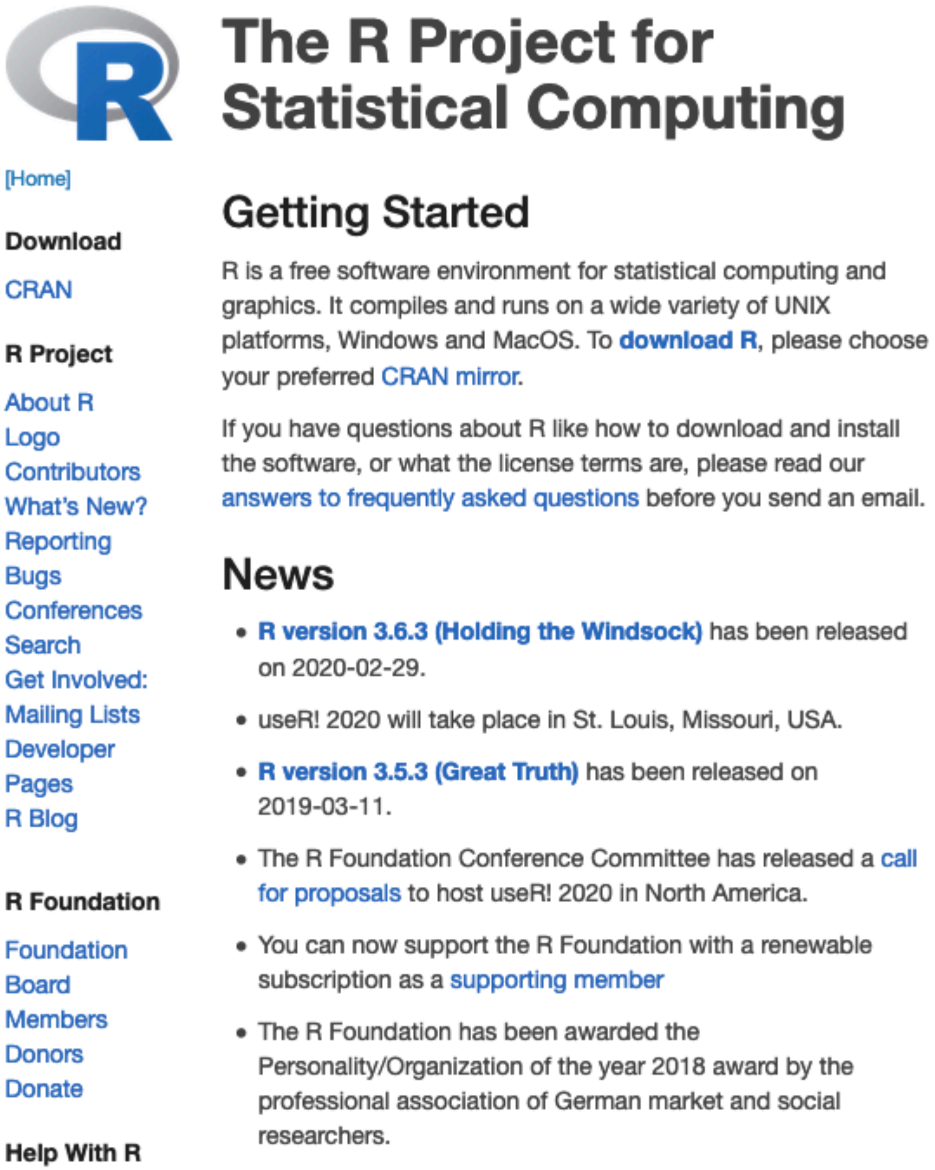
- The latest release (2020-02-29, Holding the Windsock) R-3.6.3.tar.gz, read what's new in the latest version.
- Sources of R alpha and beta releases (daily snapshots, created only in time periods before a planned release).
- Daily snapshots of current patched and development versions are available here. Please read about new features and bug fixes before filing corresponding feature requests or bug reports.
- Source code of older versions of R is available here.
- Contributed extension packages

Questions About R

- 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.

What are R and CRAN?

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



The R Project for Statistical Computing

[Home]

Download

CRAN

R Project

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Reporting Bugs
Conferences
Search
Get Involved: Mailing Lists
Developer Pages
R Blog

R Foundation

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Help With R

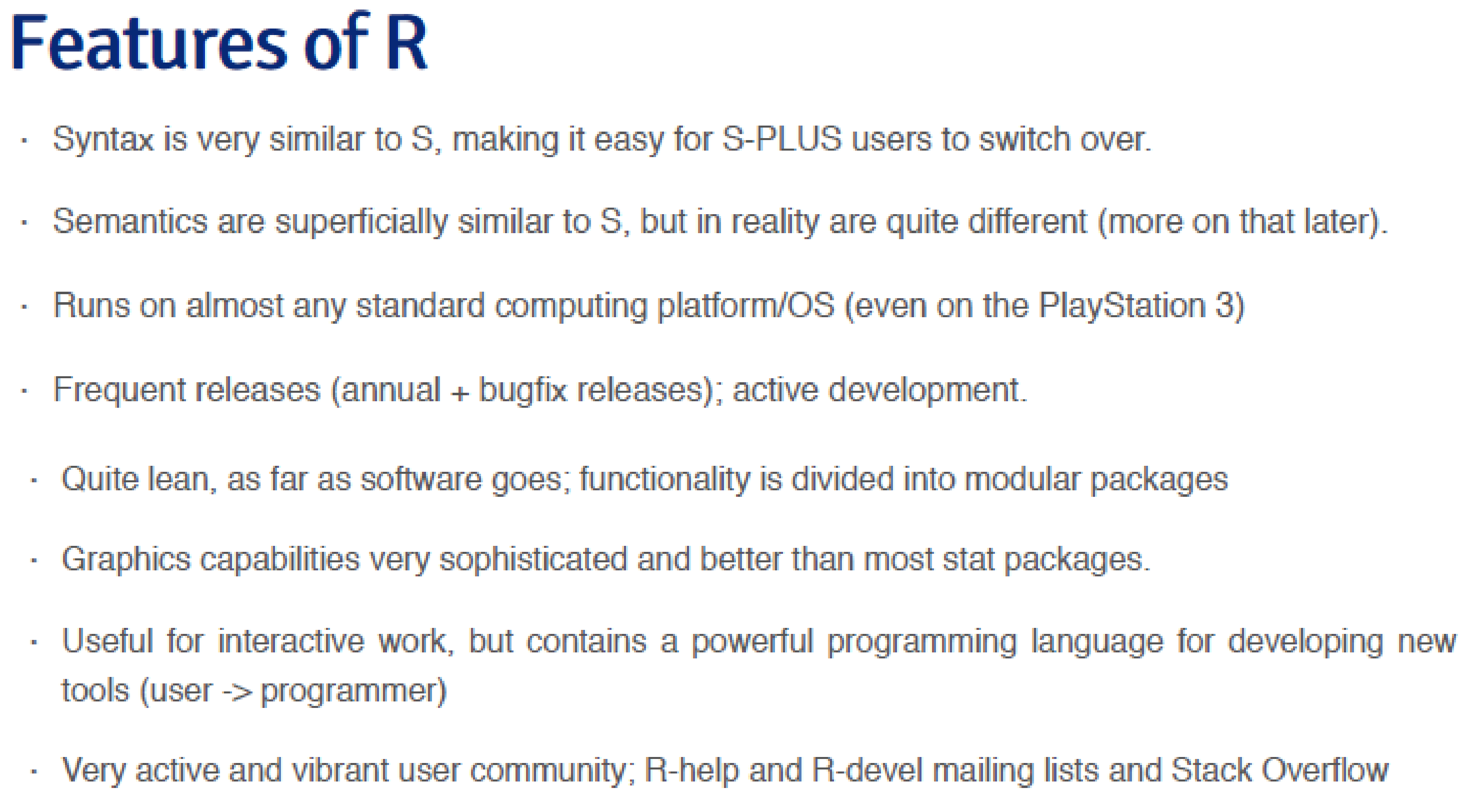
Getting Started

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.

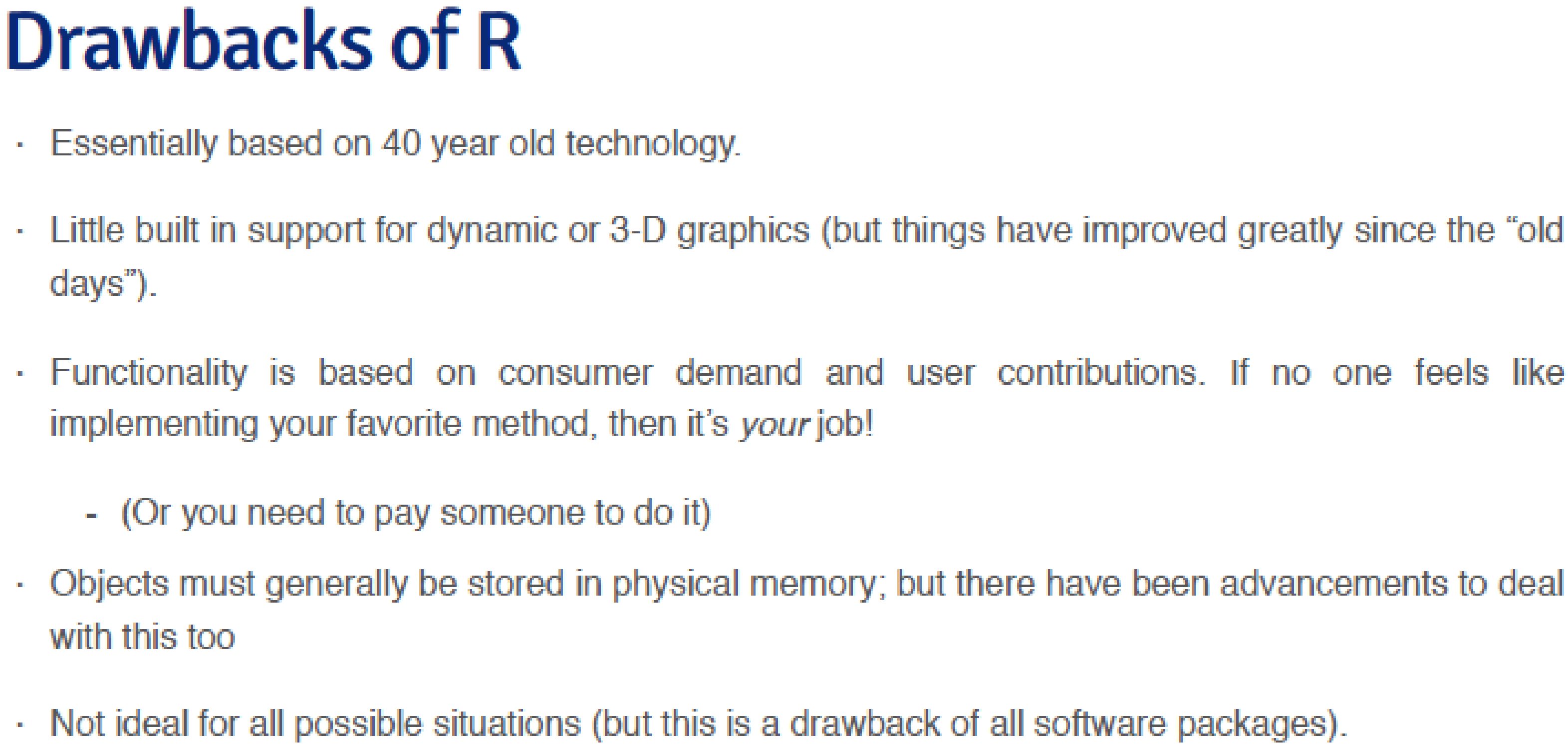
News

- **R version 3.6.3 (Holding the Windsock)** has been released on 2020-02-29.
- useR! 2020 will take place in St. Louis, Missouri, USA.
- **R version 3.5.3 (Great Truth)** has been released on 2019-03-11.
- The R Foundation Conference Committee has released a call for proposals to host useR! 2020 in North America.
- You can now support the R Foundation with a renewable subscription as a supporting member
- The R Foundation has been awarded the Personality/Organization of the year 2018 award by the professional association of German market and social researchers.



Features of R

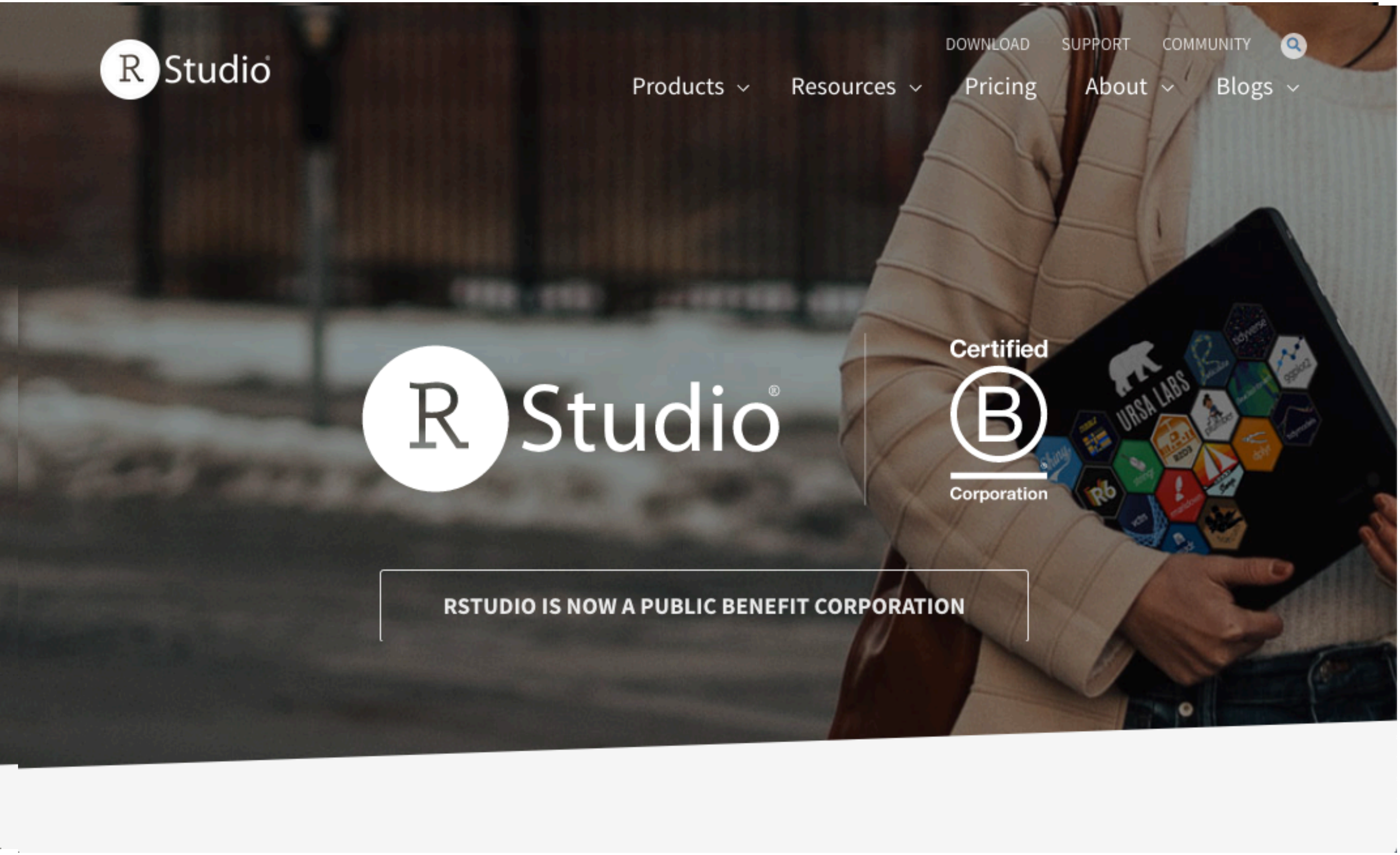
- Syntax is very similar to S, making it easy for S-PLUS users to switch over.
- Semantics are superficially similar to S, but in reality are quite different (more on that later).
- Runs on almost any standard computing platform/OS (even on the PlayStation 3)
- Frequent releases (annual + bugfix releases); active development.
- Quite lean, as far as software goes; functionality is divided into modular packages
- Graphics capabilities very sophisticated and better than most stat packages.
- Useful for interactive work, but contains a powerful programming language for developing new tools (user -> programmer)
- Very active and vibrant user community; R-help and R-devel mailing lists and Stack Overflow



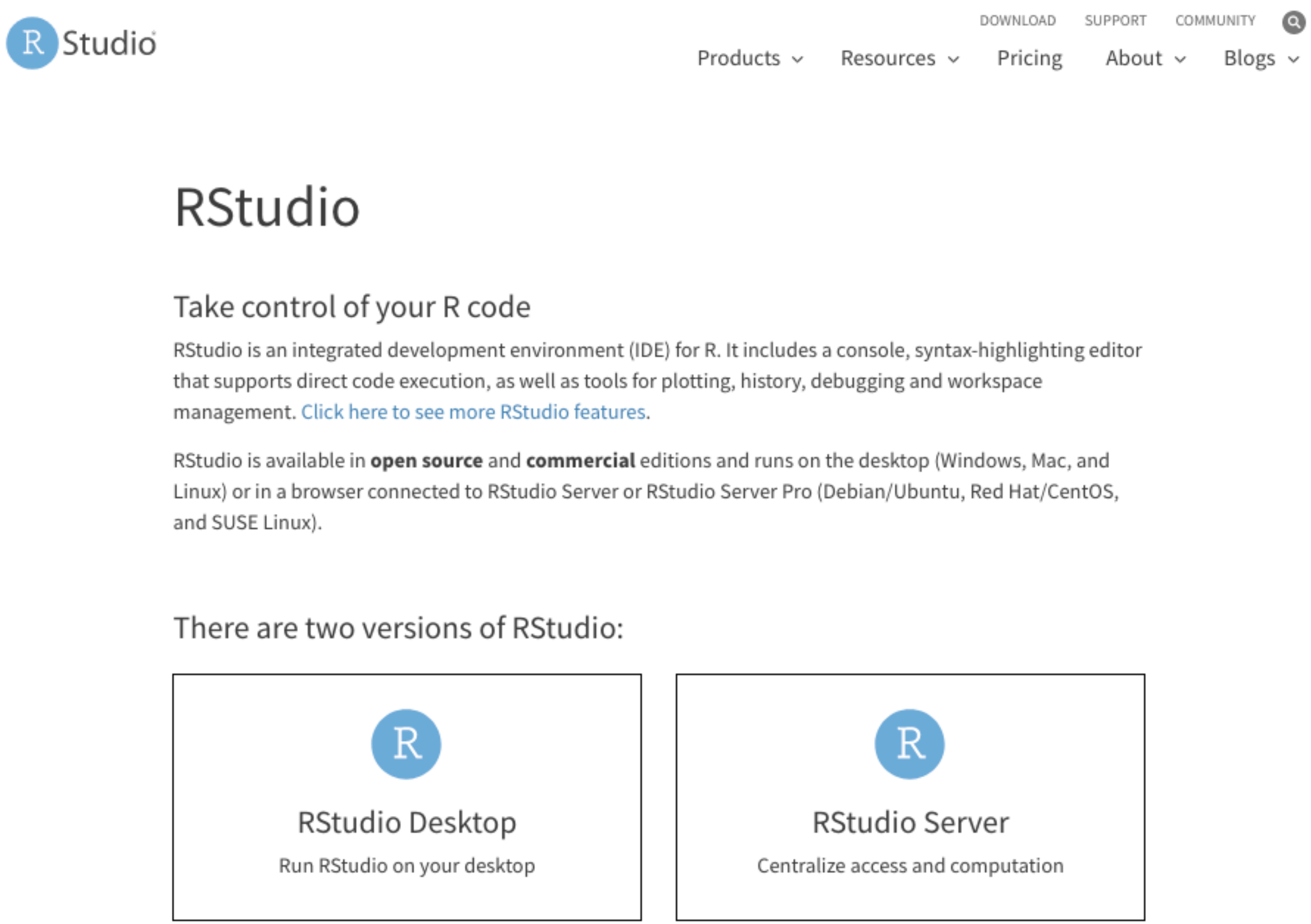
Drawbacks of R

- Essentially based on 40 year old technology.
- Little built in support for dynamic or 3-D graphics (but things have improved greatly since the "old days").
- Functionality is based on consumer demand and user contributions. If no one feels like implementing your favorite method, then it's *your* job!
  - (Or you need to pay someone to do it)
- Objects must generally be stored in physical memory; but there have been advancements to deal with this too
- Not ideal for all possible situations (but this is a drawback of all software packages).

https://www.rstudio.com/



https://www.rstudio.com/



RStudio

Take control of your R code

RStudio is an integrated development environment (IDE) for R. It includes a console, syntax-highlighting editor that supports direct code execution, as well as tools for plotting, history, debugging and workspace management. Click here to see more RStudio features.

RStudio is available in **open source** and **commercial** editions and runs on the desktop (Windows, Mac, and Linux) or in a browser connected to RStudio Server or RStudio Server Pro (Debian/Ubuntu, Red Hat/CentOS, and SUSE Linux).

There are two versions of RStudio:

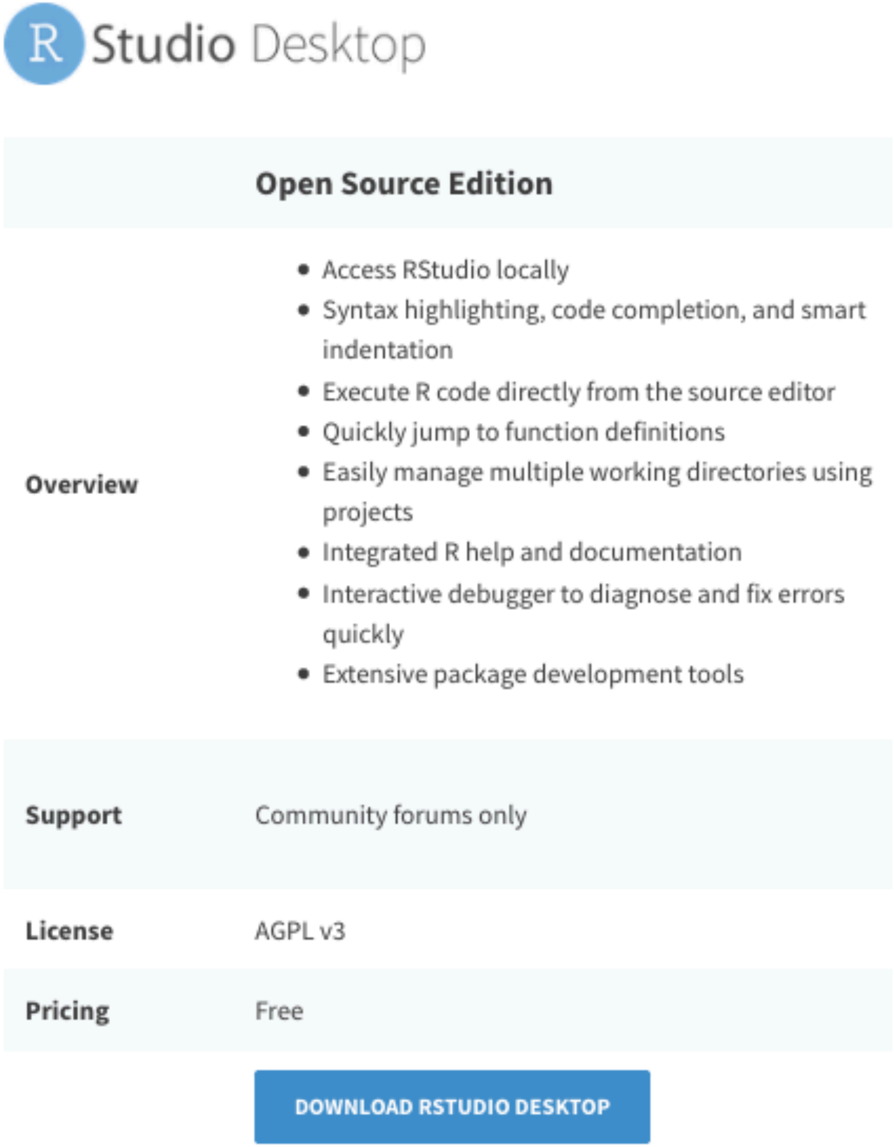
RStudio Desktop

Run RStudio on your desktop

RStudio Server

Centralize access and computation

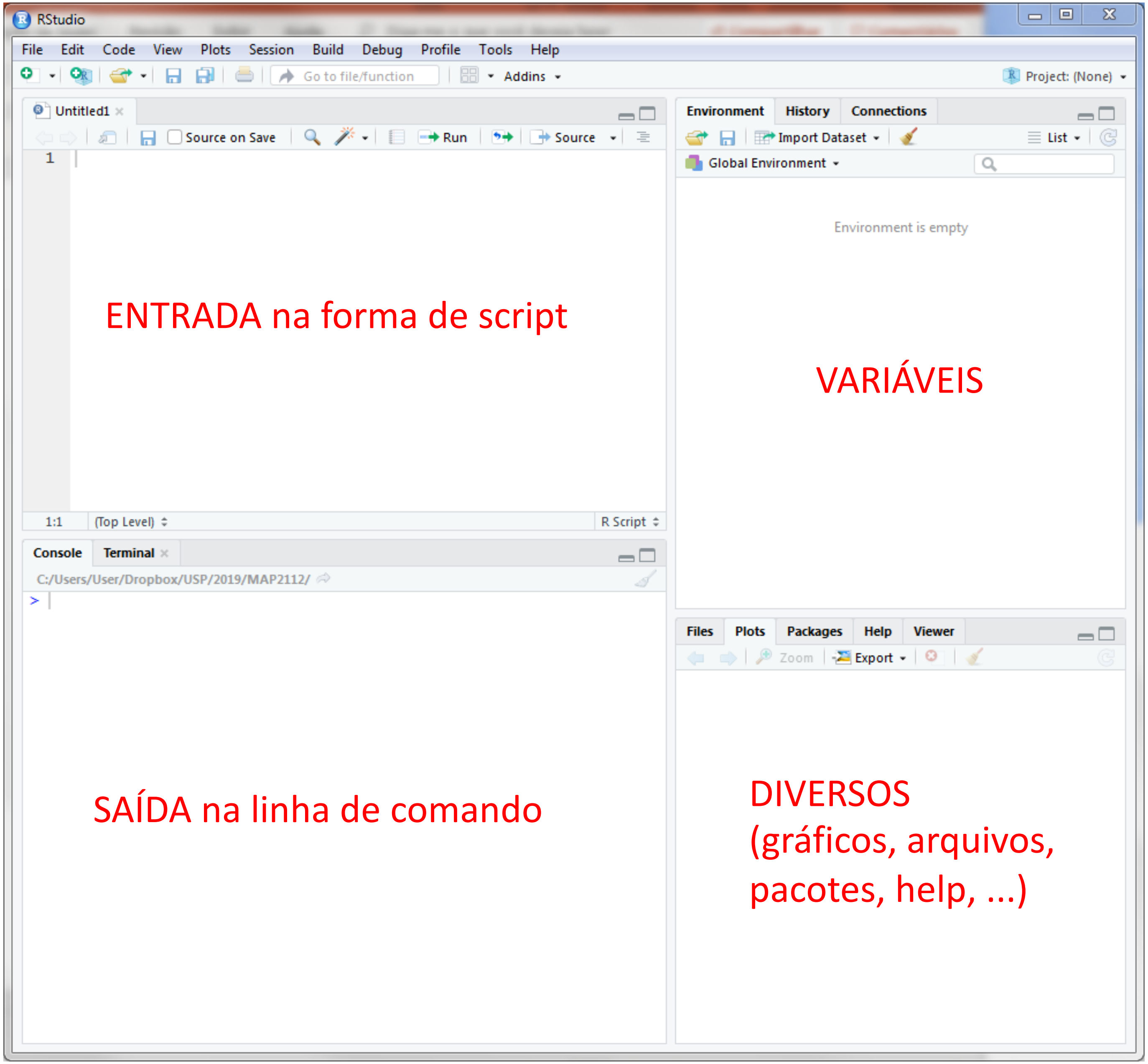
https://www.rstudio.com/



RStudio Desktop

Open Source Edition

Overview	• Access RStudio locally • Syntax highlighting, code completion, and smart indentation • Execute R code directly from the source editor • Quickly jump to function definitions • Easily manage multiple working directories using projects • Integrated R help and documentation • Interactive debugger to diagnose and fix errors quickly • Extensive package development tools
Support	Community forums only
License	AGPL v3
Pricing	Free



```
C:/Users/User/Dropbox/USP/2019/MAP2112/
>
```

Environment is empty

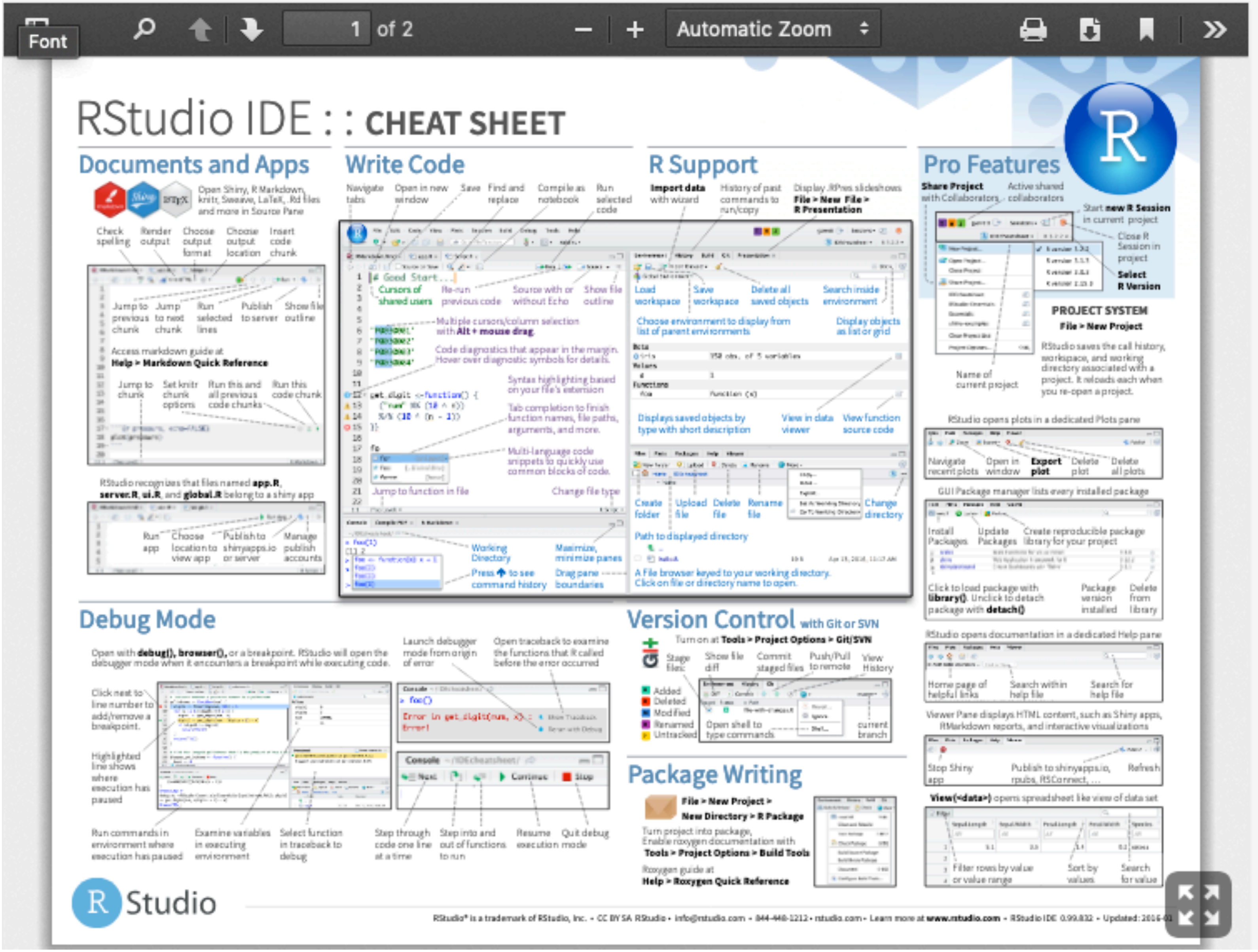
ENTRADA na forma de script

VARIÁVEIS

SAÍDA na linha de comando

DIVERSOS (gráficos, arquivos, pacotes, help, ...)

https://resources.rstudio.com/rstudio-developed/rstudio-ide



RStudio IDE : : CHEAT SHEET

Documents and Apps

Open Shiny, R Markdown, knitr, Sweave, LaTeX, .Rd files and more in Source Pane

Check spelling · Render output · Choose output format · Choose output location · Insert code chunk

Jump to previous chunk · Jump to next chunk · Run selected lines · Publish to server · Show file outline

Access markdown guide at **Help > Markdown Quick Reference**

Jump to chunk · Set knitr chunk options · Run this and all previous code chunks · Run this code chunk

RStudio recognizes that files named **app.R**, **server.R**, **ui.R**, and **global.R** belong to a shiny app

Run app · Choose location to view app · Publish to shinyapps.io or server · Manage publish accounts

Write Code

Navigate tabs · Open in new window · Save · Find and replace · Compile as notebook · Run selected code

Cursors of shared users · Re-run previous code · Source with or without Echo · Show file outline

Multiple cursors/column selection with **Alt + mouse drag**.

Code diagnostics that appear in the margin. Hover over diagnostic symbols for details.

Syntax highlighting based on your file's extension

Tab completion to finish function names, file paths, arguments, and more.

Multi-language code snippets to quickly use common blocks of code.

Jump to function in file · Change file type

Working Directory · Maximize, minimize panes · Press ↑ to see command history · Drag pane boundaries

R Support

Import data with wizard · History of past commands to run/copy · Display .RPres slideshows **File > New File > R Presentation**

Load workspace · Save workspace · Delete all saved objects · Search inside environment

Choose environment to display from list of parent environments · Display objects as list or grid

Displays saved objects by type with short description · View in data viewer · View function source code

Create folder · Upload file · Delete file · Rename file · Change directory

Path to displayed directory

A File browser keyed to your working directory. Click on file or directory name to open.

Pro Features

Share Project with Collaborators · Active shared collaborators · Start **new R Session** in current project · Close R Session in project · **Select R Version**

Name of current project

PROJECT SYSTEM

File > New Project

RStudio saves the call history, workspace, and working directory associated with a project. It reloads each when you re-open a project.

RStudio opens plots in a dedicated Plots pane

Navigate recent plots · Open in window · **Export plot** · Delete plot · Delete all plots

GUI Package manager lists every installed package

Install Packages · Update Packages · Create reproducible package library for your project

Click to load package with **library()**. Unclick to detach package with **detach()** · Package version installed · Delete from library

RStudio opens documentation in a dedicated Help pane

Home page of helpful links · Search within help file · Search for help file

Viewer Pane displays HTML content, such as Shiny apps, RMarkdown reports, and interactive visualizations

Stop Shiny app · Publish to shinyapps.io, rpubs, RSConnect, ... · Refresh

View(<data>) opens spreadsheet like view of data set

Filter rows by value or value range · Sort by values · Search for value

Debug Mode

Open with **debug()**, **browser()**, or a breakpoint. RStudio will open the debugger mode when it encounters a breakpoint while executing code.

Launch debugger mode from origin of error · Open traceback to examine the functions that R called before the error occurred

Click next to line number to add/remove a breakpoint.

Highlighted line shows where execution has paused

Run commands in environment where execution has paused · Examine variables in executing environment · Select function in traceback to debug

Step through code one line at a time · Step into and out of functions to run · Resume execution mode · Quit debug

Version Control with Git or SVN

Turn on at **Tools > Project Options > Git/SVN**

Stage files · Show file diff · Commit staged files · Push/Pull to remote · View History

Added · Deleted · Modified · Renamed · Untracked

Open shell to type commands · current branch

Package Writing

File > New Project > New Directory > R Package

Turn project into package, Enable roxygen documentation with **Tools > Project Options > Build Tools**

Roxygen guide at **Help > Roxygen Quick Reference**

RStudio

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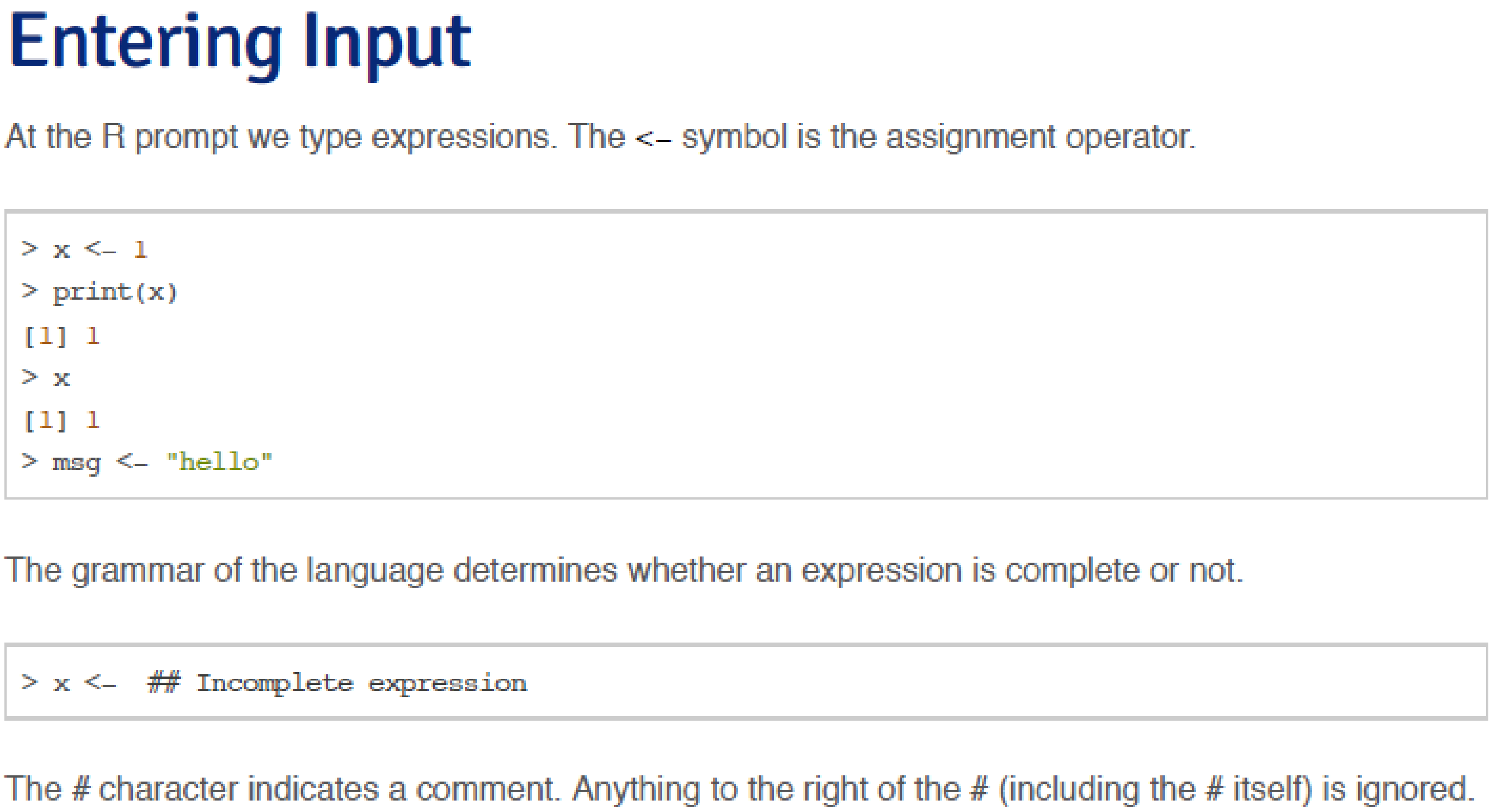


Entering Input

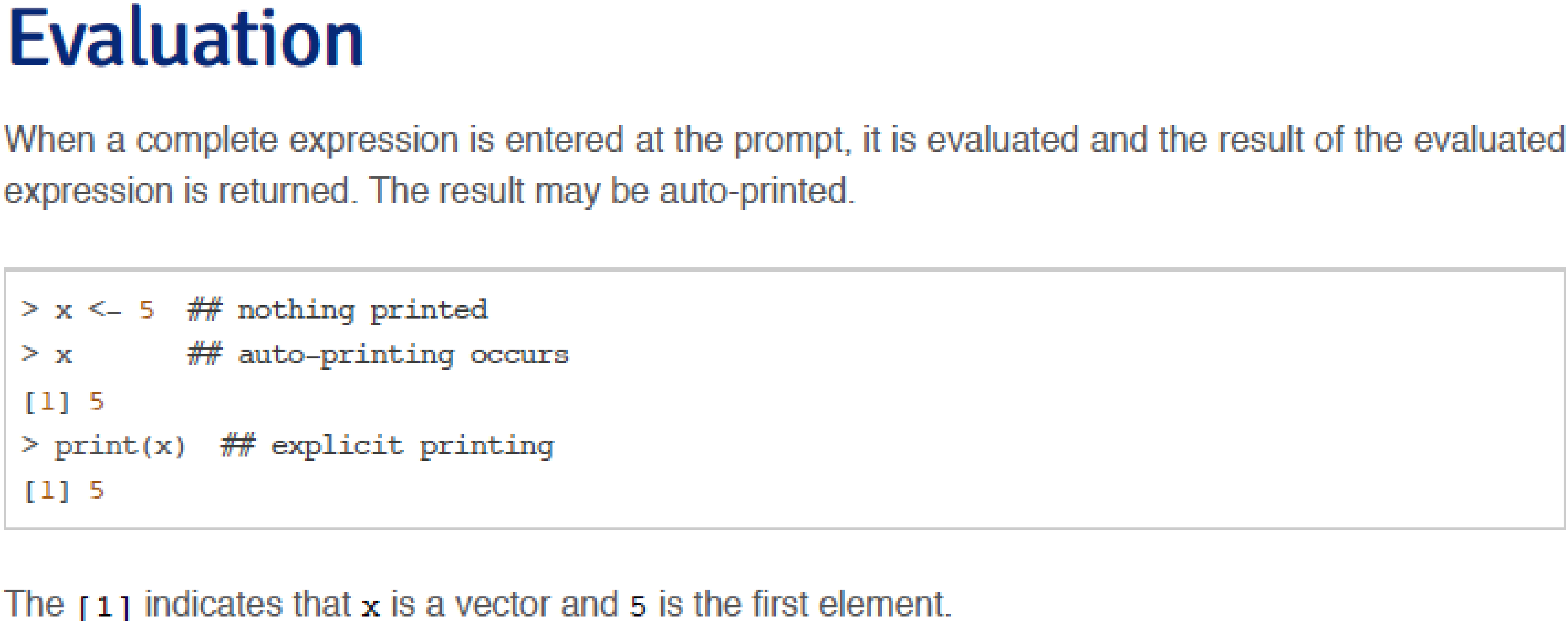
At the R prompt we type expressions. The <- symbol is the assignment operator.

```
> x <- 1
> print(x)
[1] 1
> x
[1] 1
> msg <- "hello"
```

The grammar of the language determines whether an expression is complete or not.

```
> x <-  ## Incomplete expression
```

The # character indicates a comment. Anything to the right of the # (including the # itself) is ignored.

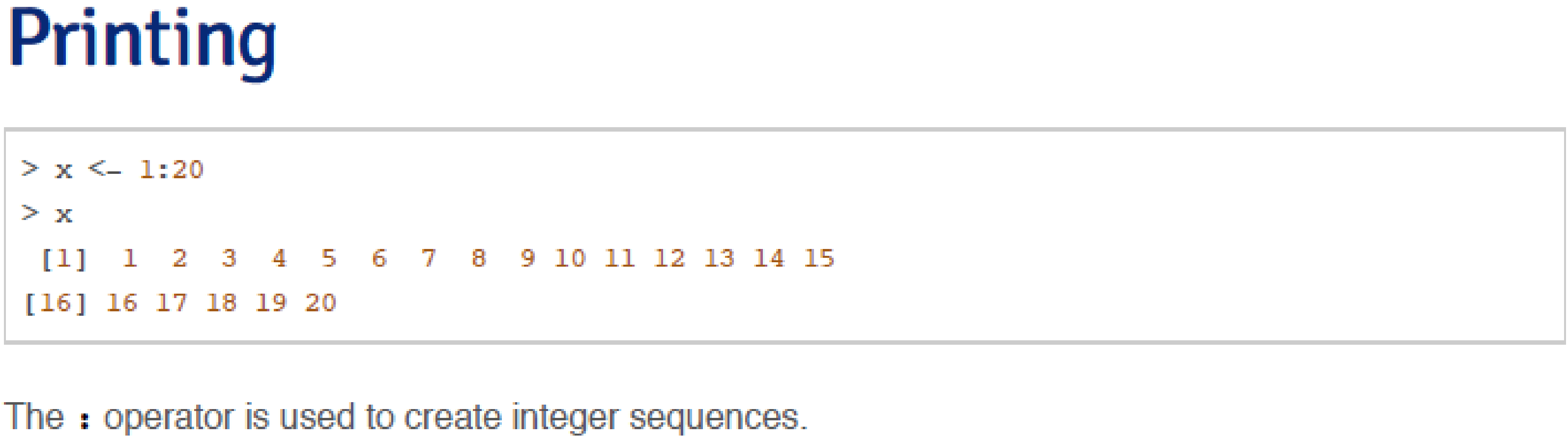


Evaluation

When a complete expression is entered at the prompt, it is evaluated and the result of the evaluated expression is returned. The result may be auto-printed.

```
> x <- 5  ## nothing printed
> x       ## auto-printing occurs
[1] 5
> print(x)  ## explicit printing
[1] 5
```

The `[1]` indicates that `x` is a vector and `5` is the first element.



Printing

```
> x <- 1:20
> x
 [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
[16] 16 17 18 19 20
```

The `:` operator is used to create integer sequences.

Objects

R has five basic or "atomic" classes of objects:

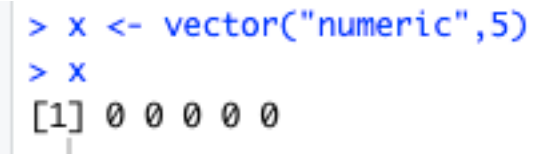
- character
- numeric (real numbers)
- integer
- complex
- logical (True/False)

The most basic object is a vector

- A vector can only contain objects of the same class
- BUT: The one exception is a *list*, which is represented as a vector but can contain objects of different classes (indeed, that's usually why we use them)

Empty vectors can be created with the `vector()` function.

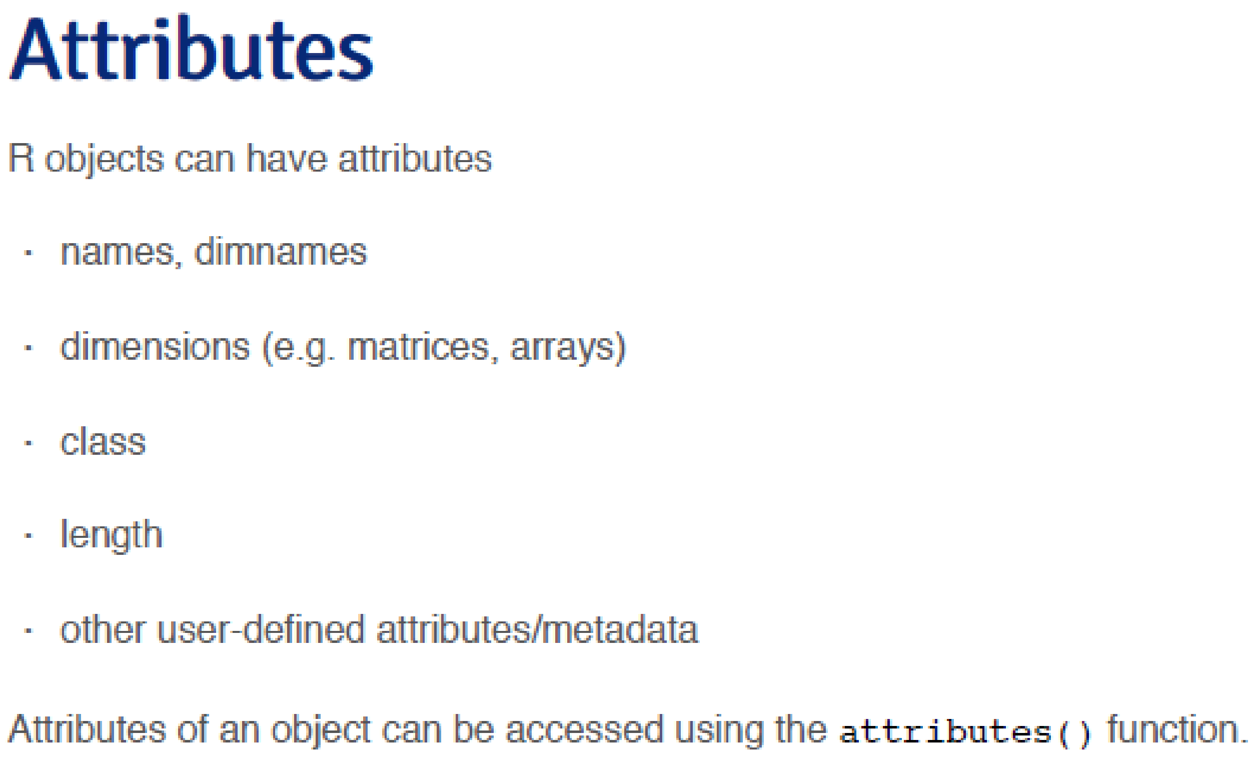
Empty vectors can be created with the `vector()` function.



```
> x <- vector("numeric",5)
> x
[1] 0 0 0 0 0
```

Numbers

- Numbers in R a generally treated as numeric objects (i.e. double precision real numbers)
- If you explicitly want an integer, you need to specify the `L` suffix
- Ex: Entering `1` gives you a numeric object; entering `1L` explicitly gives you an integer.
- There is also a special number `Inf` which represents infinity; e.g. `1 / 0`; `Inf` can be used in ordinary calculations; e.g. `1 / Inf` is 0
- The value `NaN` represents an undefined value ("not a number"); e.g. 0 / 0; `NaN` can also be thought of as a missing value (more on that later)

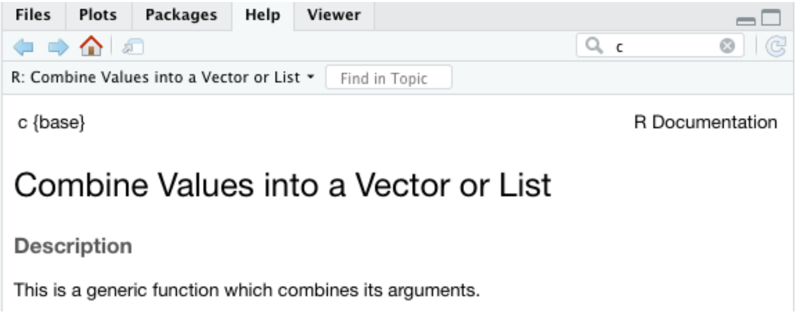


Attributes

R objects can have attributes

- names, dimnames
- dimensions (e.g. matrices, arrays)
- class
- length
- other user-defined attributes/metadata

Attributes of an object can be accessed using the `attributes()` function.



c {base} R Documentation

Combine Values into a Vector or List

Description

This is a generic function which combines its arguments.

Creating Vectors

The `c()` function can be used to create vectors of objects.

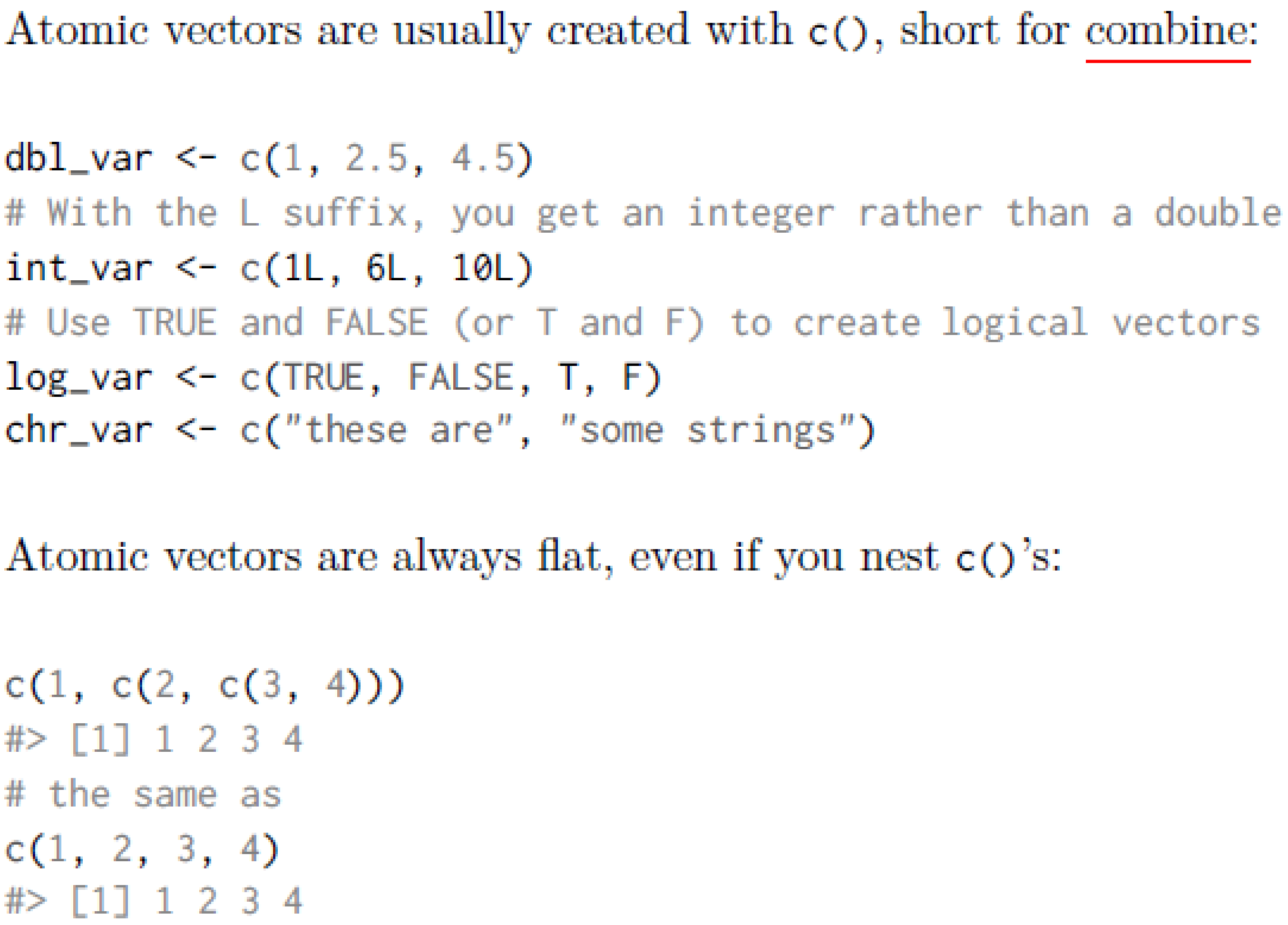
```
> x <- c(0.5, 0.6)       ## numeric
> x <- c(TRUE, FALSE)    ## logical
> x <- c(T, F)           ## logical
> x <- c("a", "b", "c")  ## character
> x <- 9:29              ## integer
> x <- c(1+0i, 2+4i)     ## complex
```

Using the `vector()` function

```
> x <- vector("numeric", length = 10)
> x
 [1] 0 0 0 0 0 0 0 0 0 0
```

> x <- vector("logical",length = 10)

O que seria o “default” ?

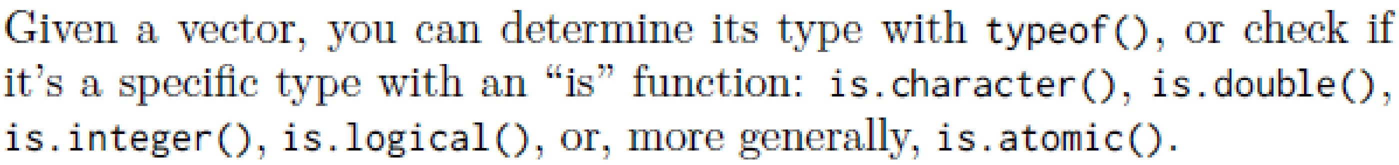


Atomic vectors are usually created with `c()`, short for combine:

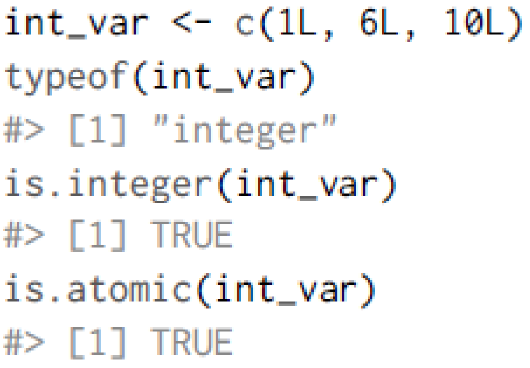
```
dbl_var <- c(1, 2.5, 4.5)
# With the L suffix, you get an integer rather than a double
int_var <- c(1L, 6L, 10L)
# Use TRUE and FALSE (or T and F) to create logical vectors
log_var <- c(TRUE, FALSE, T, F)
chr_var <- c("these are", "some strings")
```

Atomic vectors are always flat, even if you nest `c()`'s:

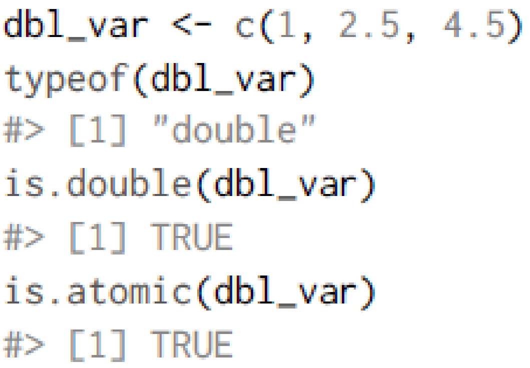
```
c(1, c(2, c(3, 4)))
#> [1] 1 2 3 4
# the same as
c(1, 2, 3, 4)
#> [1] 1 2 3 4
```



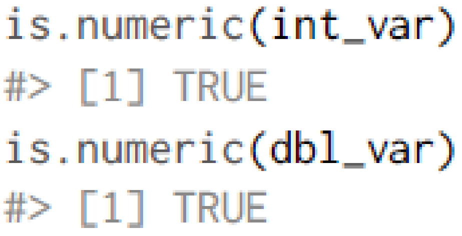
Given a vector, you can determine its type with `typeof()`, or check if it's a specific type with an "is" function: `is.character()`, `is.double()`, `is.integer()`, `is.logical()`, or, more generally, `is.atomic()`.



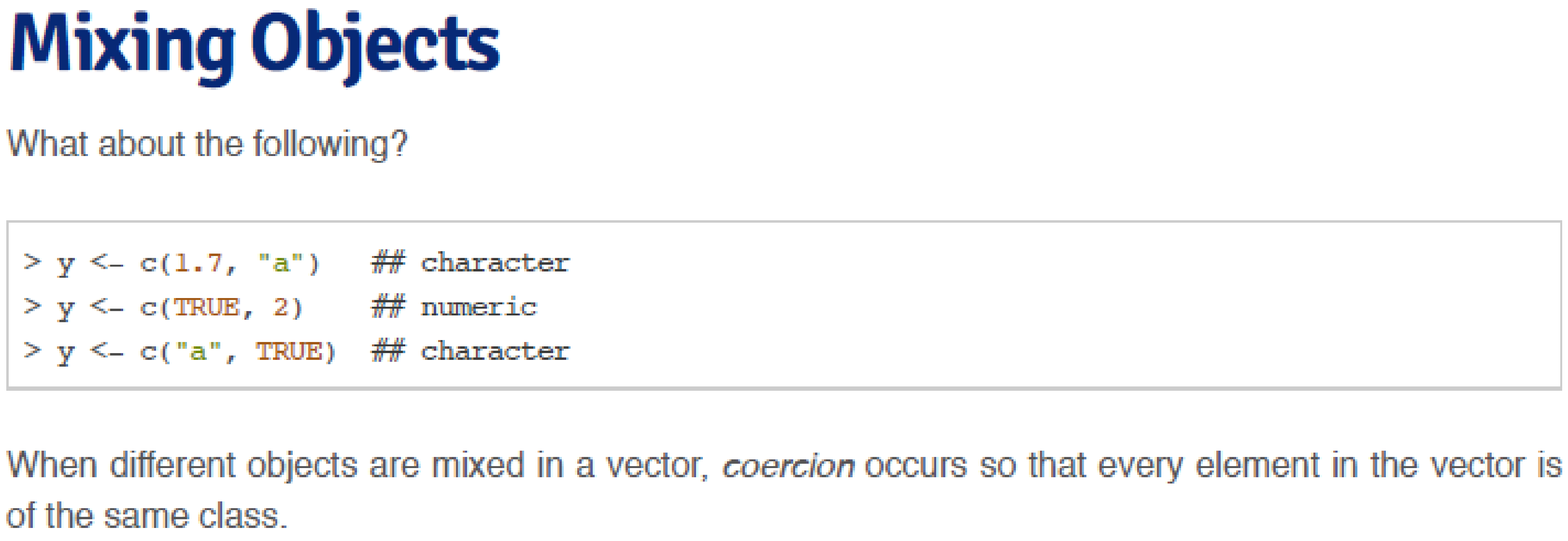
```
int_var <- c(1L, 6L, 10L)
typeof(int_var)
#> [1] "integer"
is.integer(int_var)
#> [1] TRUE
is.atomic(int_var)
#> [1] TRUE
```



```
dbl_var <- c(1, 2.5, 4.5)
typeof(dbl_var)
#> [1] "double"
is.double(dbl_var)
#> [1] TRUE
is.atomic(dbl_var)
#> [1] TRUE
```



```
is.numeric(int_var)
#> [1] TRUE
is.numeric(dbl_var)
#> [1] TRUE
```



Mixing Objects

What about the following?

```
> y <- c(1.7, "a")   ## character
> y <- c(TRUE, 2)    ## numeric
> y <- c("a", TRUE)  ## character
```

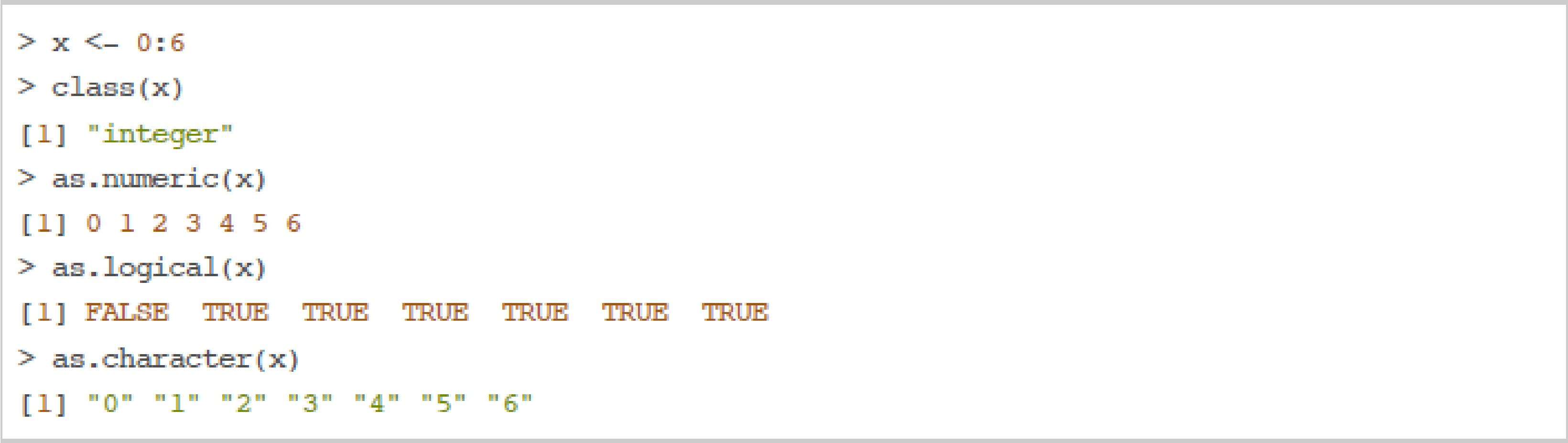
When different objects are mixed in a vector, *coercion* occurs so that every element in the vector is of the same class.

```
> x <- c(1.7,"a")
> x
[1] "1.7" "a"
```

```
> x <- c(TRUE,2)
> x
[1] 1 2
```

Explicit Coercion

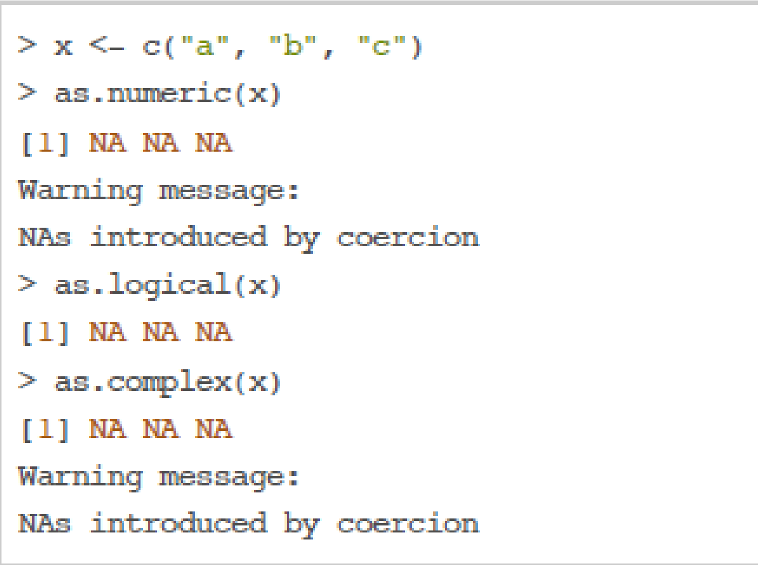
Objects can be explicitly coerced from one class to another using the `as.*` functions, if available.



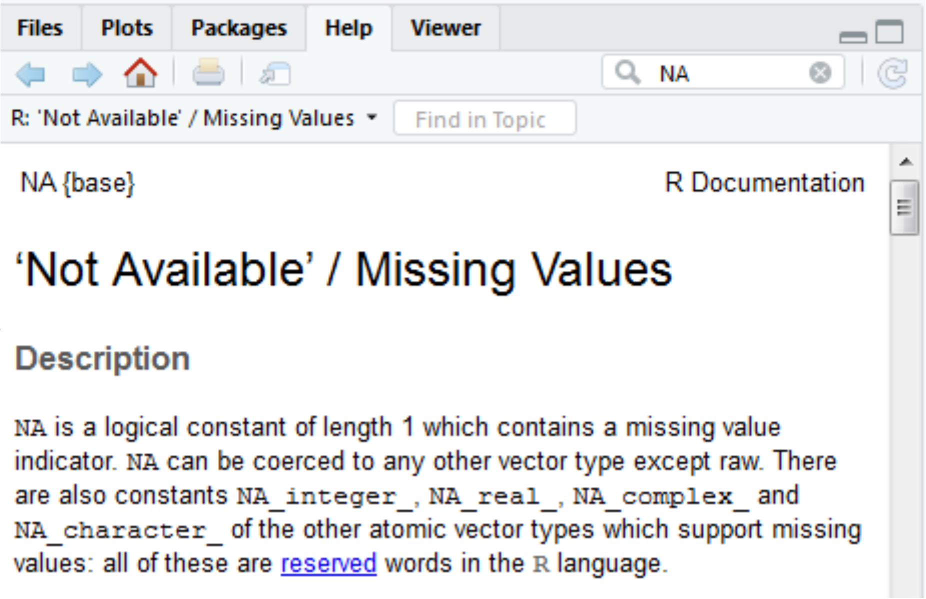
```
> x <- 0:6
> class(x)
[1] "integer"
> as.numeric(x)
[1] 0 1 2 3 4 5 6
> as.logical(x)
[1] FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
> as.character(x)
[1] "0" "1" "2" "3" "4" "5" "6"
```

Explicit Coercion

Nonsensical coercion results in `NA`s.



```
> x <- c("a", "b", "c")
> as.numeric(x)
[1] NA NA NA
Warning message:
NAs introduced by coercion
> as.logical(x)
[1] NA NA NA
> as.complex(x)
[1] NA NA NA
Warning message:
NAs introduced by coercion
```



NA {base} R Documentation

'Not Available' / Missing Values

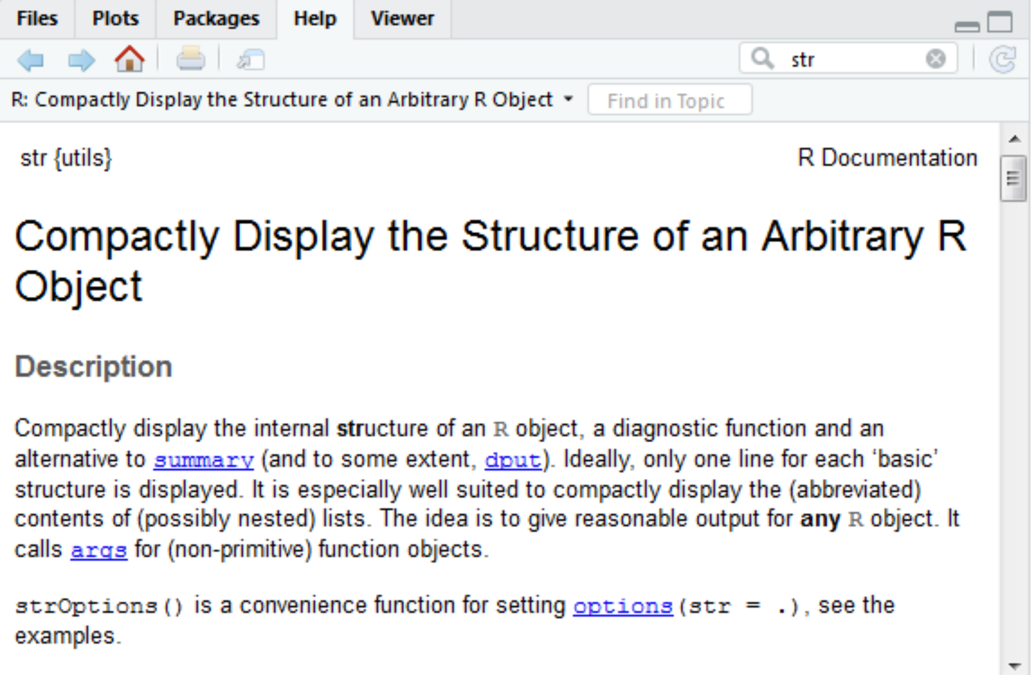
Description

`NA` is a logical constant of length 1 which contains a missing value indicator. `NA` can be coerced to any other vector type except raw. There are also constants `NA_integer_`, `NA_real_`, `NA_complex_` and `NA_character_` of the other atomic vector types which support missing values: all of these are reserved words in the `R` language.

All elements of an atomic vector must be the same type, so when you attempt to combine different types they will be **coerced** to the most flexible type. Types from least to most flexible are: logical, integer, double, and character.

For example, combining a character and an integer yields a character:

```
str(c("a", 1))
#>  chr [1:2] "a" "1"
```



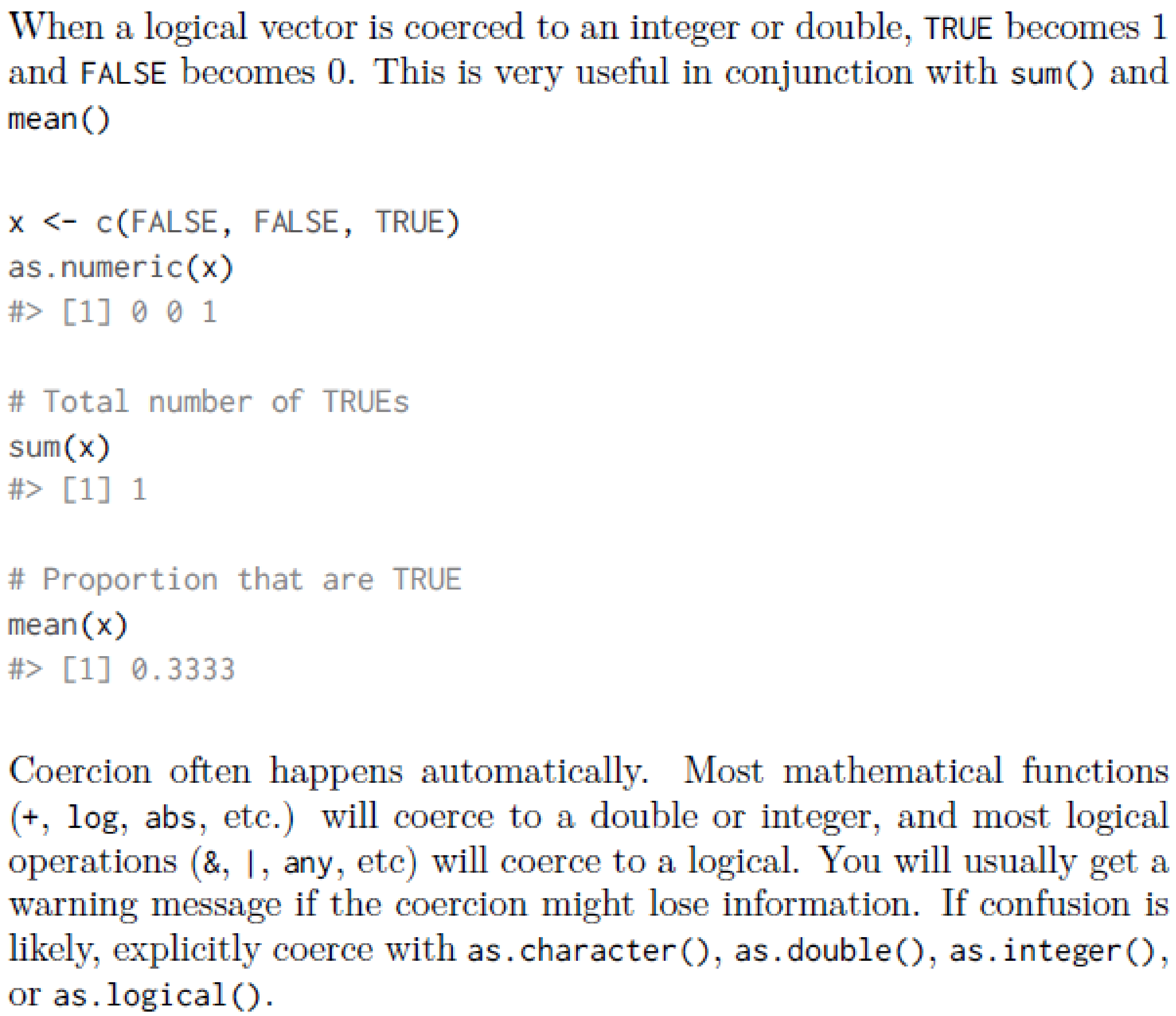
str {utils}　R Documentation

Compactly Display the Structure of an Arbitrary R Object

Description

Compactly display the internal **structure** of an R object, a diagnostic function and an alternative to summary (and to some extent, dput). Ideally, only one line for each 'basic' structure is displayed. It is especially well suited to compactly display the (abbreviated) contents of (possibly nested) lists. The idea is to give reasonable output for **any** R object. It calls args for (non-primitive) function objects.

`strOptions()` is a convenience function for setting `options(str = .)`, see the examples.



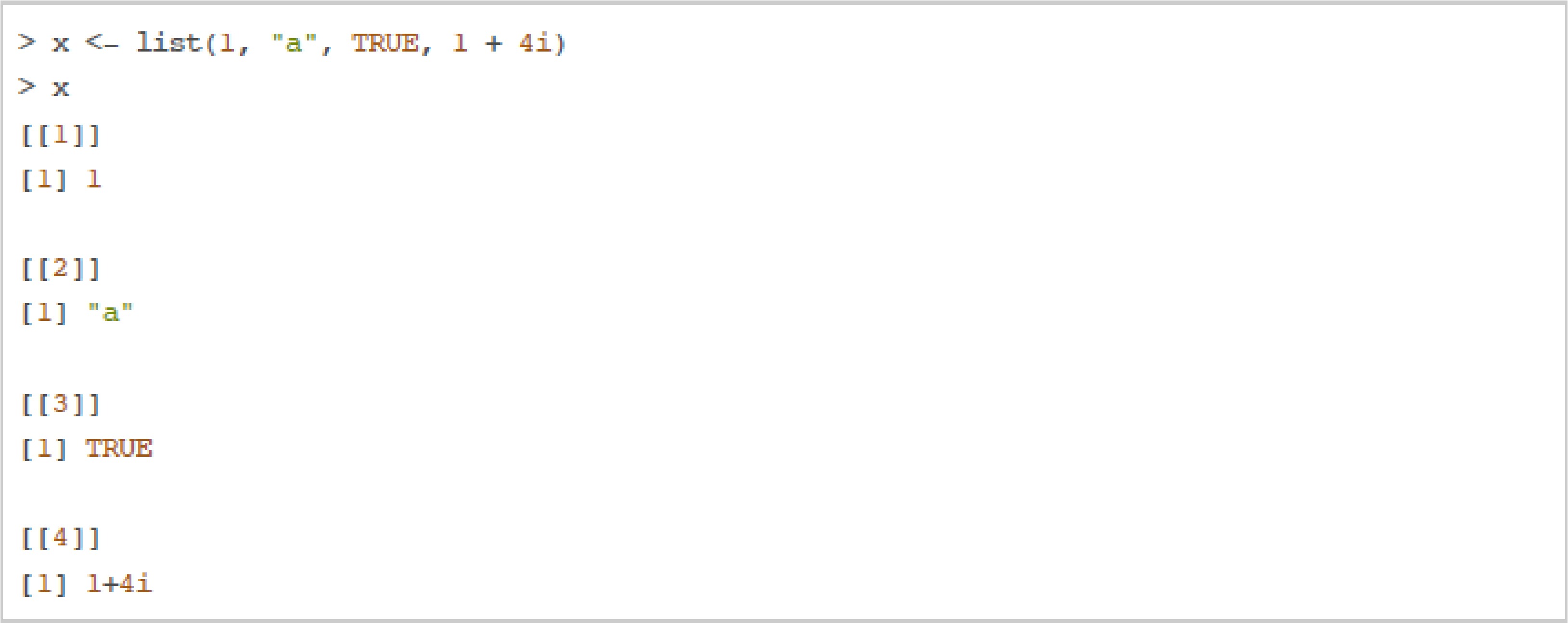
When a logical vector is coerced to an integer or double, `TRUE` becomes 1 and `FALSE` becomes 0. This is very useful in conjunction with `sum()` and `mean()`

```
x <- c(FALSE, FALSE, TRUE)
as.numeric(x)
#> [1] 0 0 1

# Total number of TRUEs
sum(x)
#> [1] 1

# Proportion that are TRUE
mean(x)
#> [1] 0.3333
```

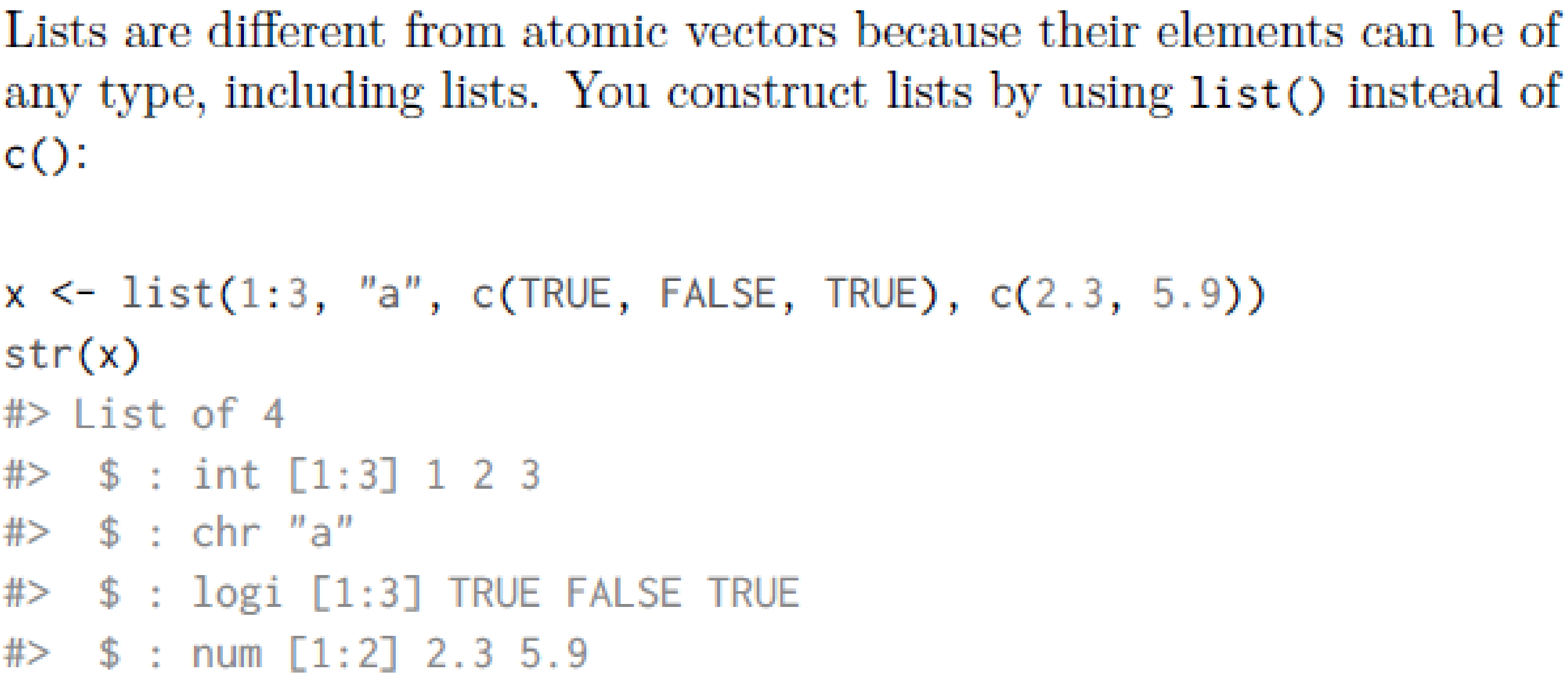
Coercion often happens automatically. Most mathematical functions (`+`, `log`, `abs`, etc.) will coerce to a double or integer, and most logical operations (`&`, `|`, `any`, etc) will coerce to a logical. You will usually get a warning message if the coercion might lose information. If confusion is likely, explicitly coerce with `as.character()`, `as.double()`, `as.integer()`, or `as.logical()`.

Lists

Lists are a special type of vector that can contain elements of different classes. Lists are a very important data type in R and you should get to know them well.

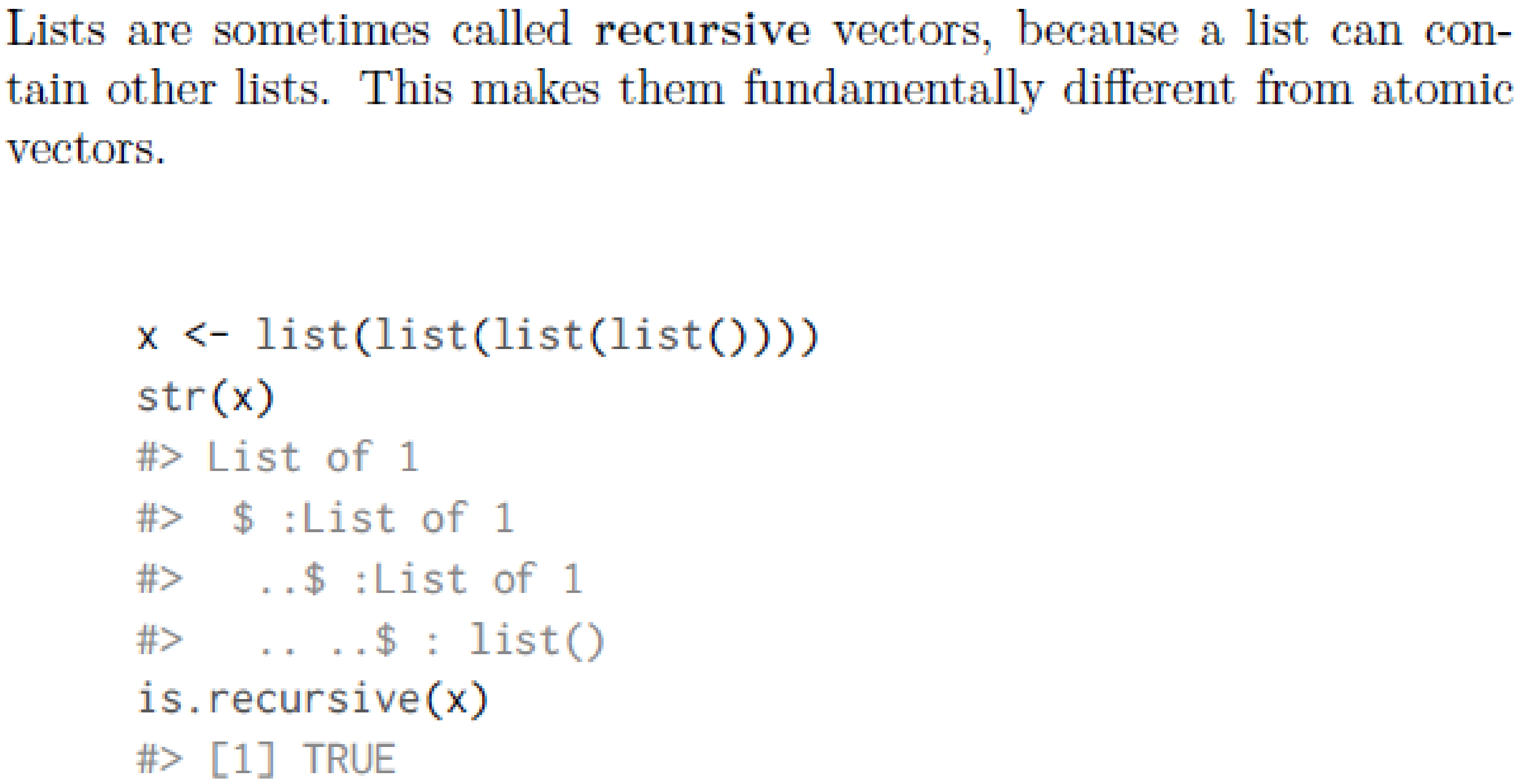


```
> x <- list(1, "a", TRUE, 1 + 4i)
> x
[[1]]
[1] 1

[[2]]
[1] "a"

[[3]]
[1] TRUE

[[4]]
[1] 1+4i
```



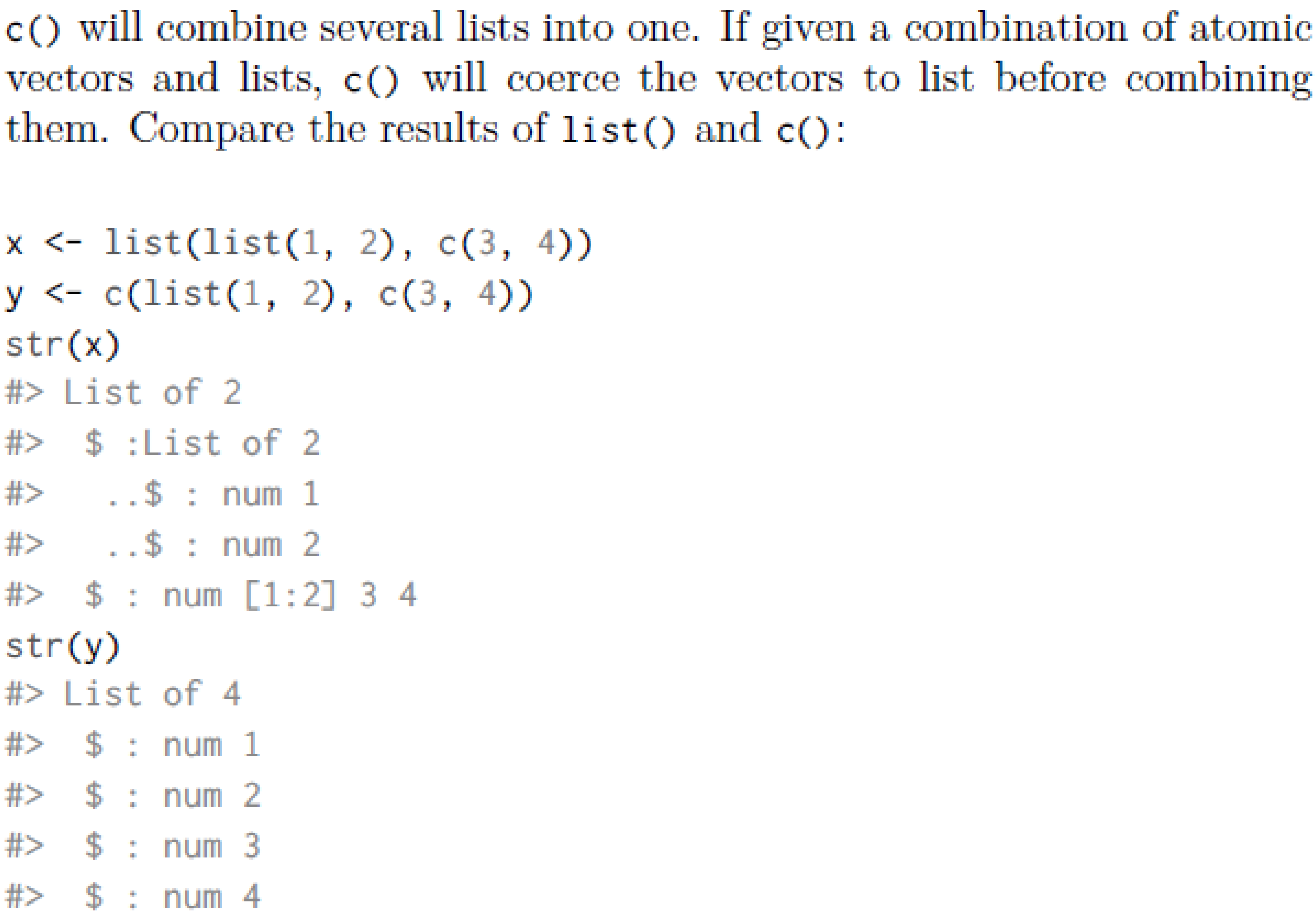
Lists are different from atomic vectors because their elements can be of any type, including lists. You construct lists by using `list()` instead of `c()`:

```
x <- list(1:3, "a", c(TRUE, FALSE, TRUE), c(2.3, 5.9))
str(x)
#> List of 4
#>  $ : int [1:3] 1 2 3
#>  $ : chr "a"
#>  $ : logi [1:3] TRUE FALSE TRUE
#>  $ : num [1:2] 2.3 5.9
```



Lists are sometimes called **recursive** vectors, because a list can contain other lists. This makes them fundamentally different from atomic vectors.

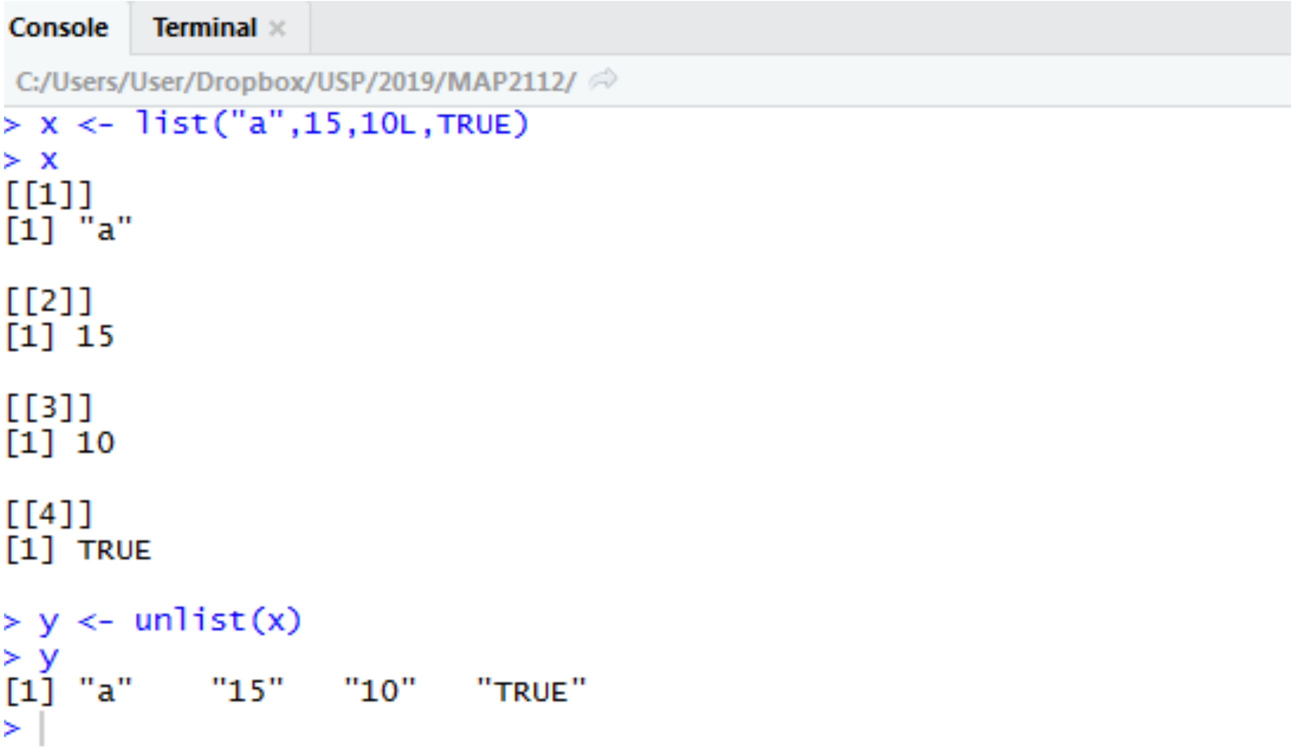
```
x <- list(list(list(list())))
str(x)
#> List of 1
#>  $ :List of 1
#>   ..$ :List of 1
#>   .. ..$ : list()
is.recursive(x)
#> [1] TRUE
```



c() will combine several lists into one. If given a combination of atomic vectors and lists, c() will coerce the vectors to list before combining them. Compare the results of list() and c():

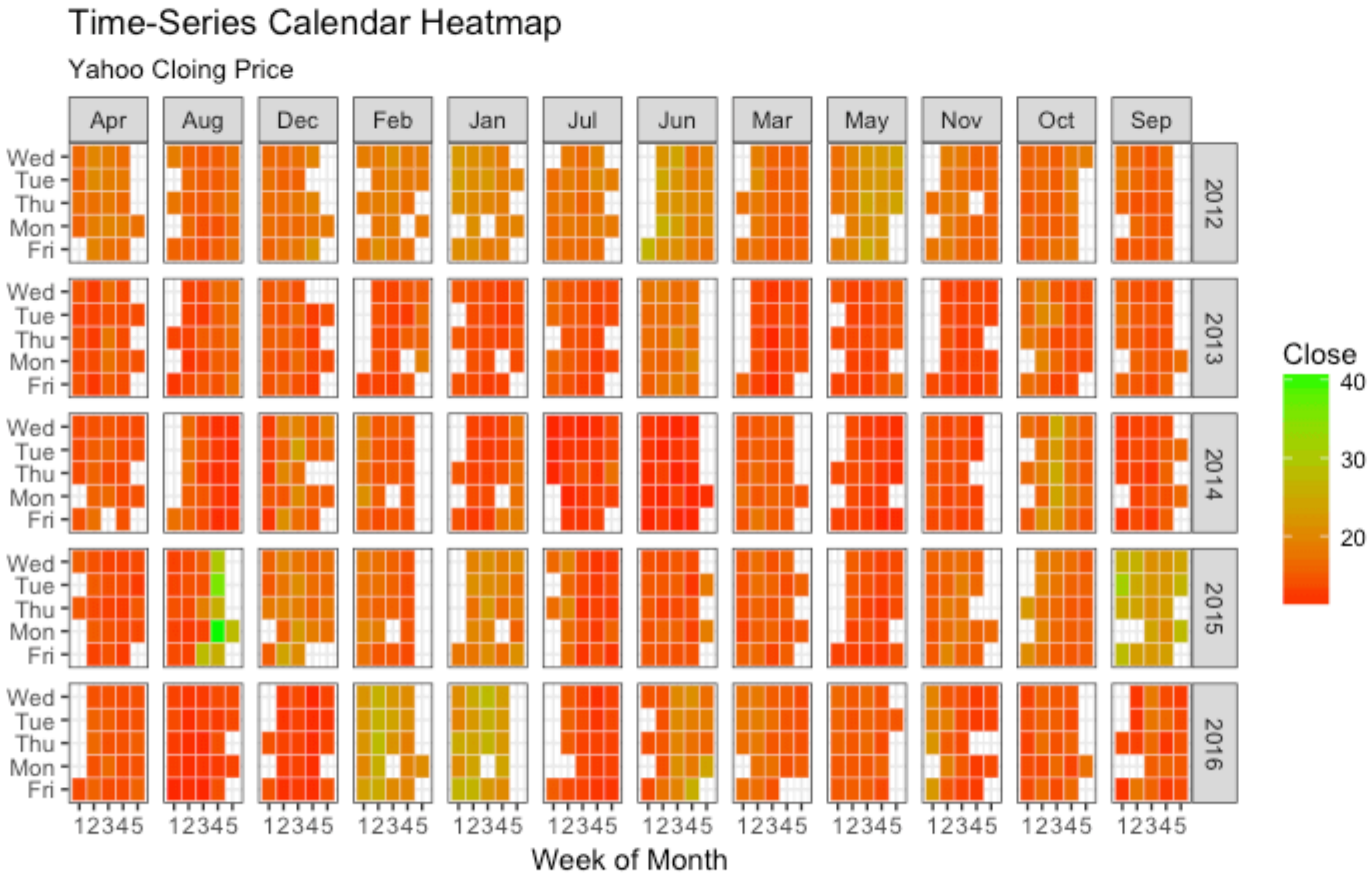
```
x <- list(list(1, 2), c(3, 4))
y <- c(list(1, 2), c(3, 4))
str(x)
#> List of 2
#>  $ :List of 2
#>   ..$ : num 1
#>   ..$ : num 2
#>  $ : num [1:2] 3 4
str(y)
#> List of 4
#>  $ : num 1
#>  $ : num 2
#>  $ : num 3
#>  $ : num 4
```

The typeof() a list is list. You can test for a list with is.list() and coerce to a list with as.list(). You can turn a list into an atomic vector with unlist(). If the elements of a list have different types, unlist() uses the same coercion rules as c().



```
> x <- list("a",15,10L,TRUE)
> x
[[1]]
[1] "a"

[[2]]
[1] 15

[[3]]
[1] 10

[[4]]
[1] TRUE

> y <- unlist(x)
> y
[1] "a"    "15"   "10"   "TRUE"
> 
```

# http://margintale.blogspot.in/2012/04/ggplot2-time-series-heatmaps.html


Time-Series Calendar Heatmap
Yahoo Cloing Price
Apr
Aug
Dec
Feb
Jan
Jul
Jun
Mar
May
Nov
Oct
Sep
Wed
Tue
Thu
Mon
Fri
Week of Month
Close