

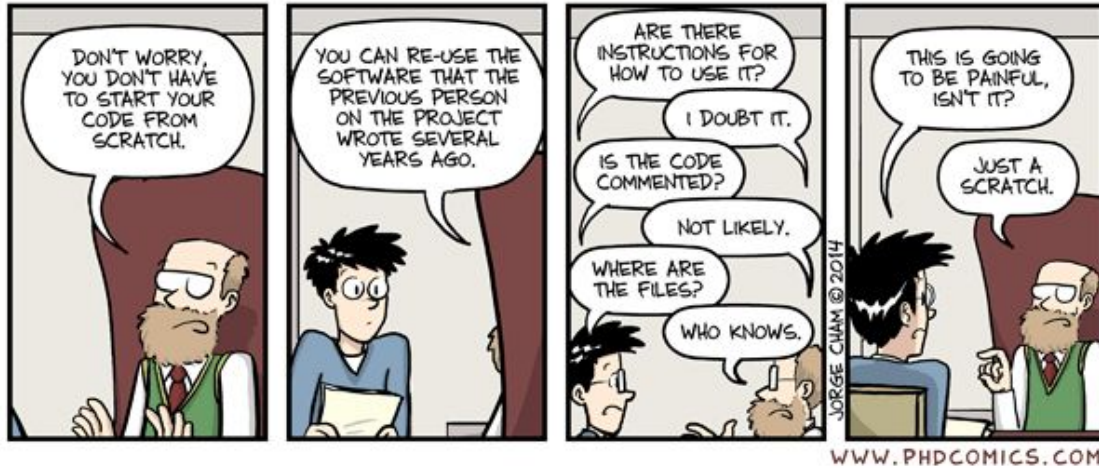


Introduction to R, RStudio, and RStudio Server

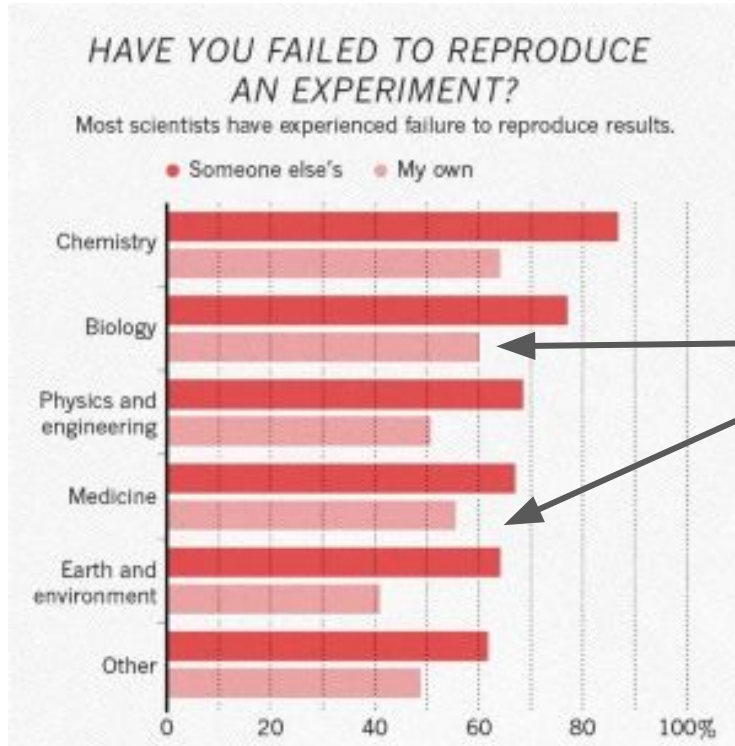
The Data Lab

Powered by Alex's Lemonade Stand Foundation

Who's been here before?



Reproducibility in 2016



55% and 60% of biologists and clinicians, respectively, could not reproduce their own results.

Baker, M. 1,500 scientists lift the lid on reproducibility. *Nature* 533, 452–454 (2016).
<https://doi.org/10.1038/533452a>

Command line vs GUI (graphics user interface)

- An interface is how you interact with a program
- GUI's have buttons you can *click* to do things, but...
- Command-line interfaces (CLI) have you *type* out things to do them

One in five genetics papers contains errors thanks to Microsoft Excel

By [Jessica Boddy](#) | Aug. 29, 2016, 1:45 PM

What you type	What you see	How Excel stores it
MARCH1	1-MAR	42430
SEPT2	2-SEP	42615

<https://www.sciencemag.org/news/2016/08/one-five-genetics-papers-contains-errors-thanks-microsoft-excel>
Ziemann et al. Genome Biology (2016) 17:177 DOI 10.1186/s13059-016-1044-7

The problem continues...

NEWS | 13 August 2021 | Correction [25 August 2021](#)

Autocorrect errors in Excel still creating genomics headache

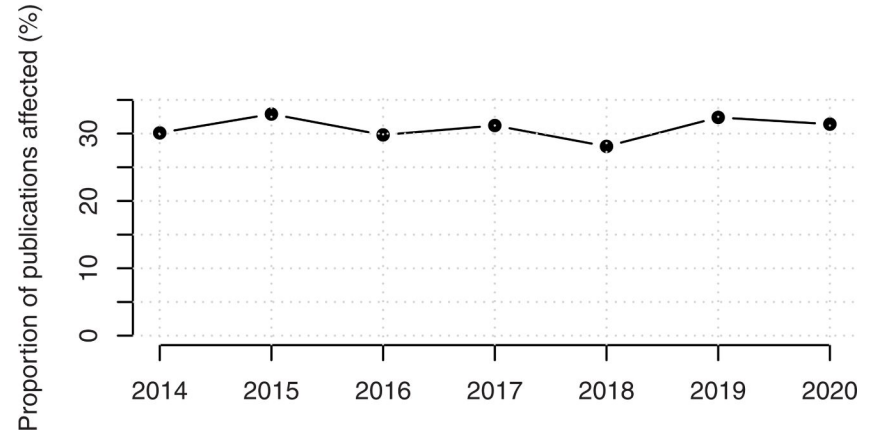
Despite geneticists being warned about spreadsheet problems, 30% of published papers contain mangled gene names in supplementary data.

[Dyani Lewis](#)



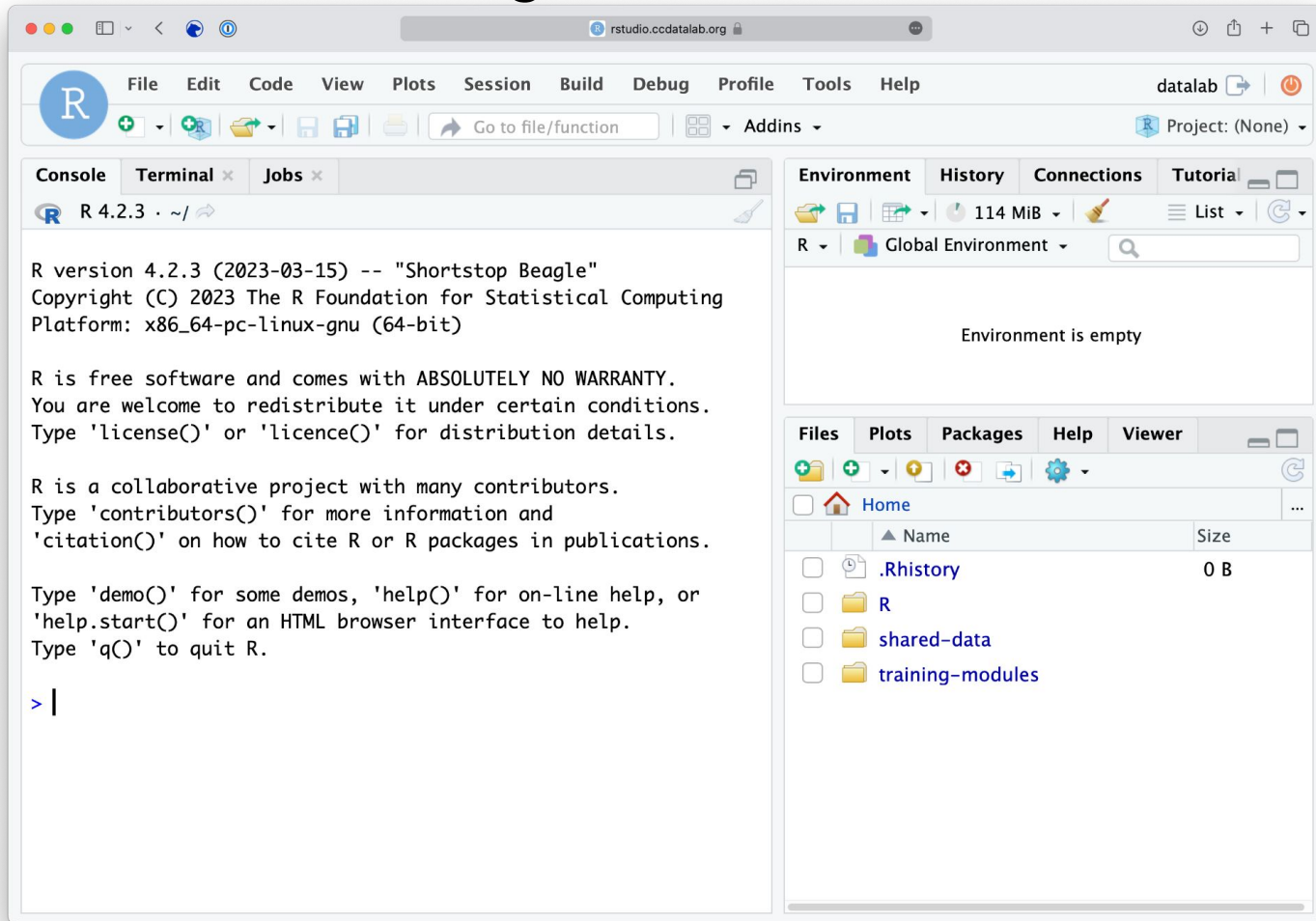
Embarrassing autocorrect mistakes are common fodder for Internet listicles and Twitter threads. But they are also the bane of geneticists using spreadsheet programs such as Microsoft Excel. Five years after a study showed that [autocorrect problems](#) were widespread, the academic literature is still littered with error-riddled spreadsheets, according to an

<https://www.nature.com/articles/d41586-021-02211-4>



<https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1008984>

RStudio Server: A basic guide



The screenshot displays the RStudio Server web interface. The top navigation bar includes the R logo, menu items (File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help), a 'datalab' link, and a power button. Below the navigation bar is a toolbar with icons for file operations and a search bar labeled 'Go to file/function'. The main interface is divided into several panes:

- Console:** Shows the R version (4.2.3) and the standard startup message, including the license information and instructions on how to use R.
- Environment:** Displays the current environment as 'Global Environment' and indicates that the environment is empty.
- Files:** Shows a file browser view of the current directory, listing files and folders such as `.Rhistory`, `R`, `shared-data`, and `training-modules`.

```
R 4.2.3 · ~/
```

R version 4.2.3 (2023-03-15) -- "Shortstop Beagle"
Copyright (C) 2023 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> |

Environment: 114 MiB, Global Environment

Environment is empty

Name	Size
<code>.Rhistory</code>	0 B
<code>R</code>	
<code>shared-data</code>	
<code>training-modules</code>	

The screenshot shows the RStudio interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The top right shows 'datalab' and 'Project: (None)'. The main area is divided into several panes: Console, Terminal, Jobs, Environment, History, Connections, Tutorial, Files, Plots, Packages, Help, and Viewer. The Console pane is highlighted with a red border and contains the following text:

```
R 4.2.3 . ~/ ↵
```

R version 4.2.3 (2023-03-15) -- "Shortstop Beagle"
Copyright (C) 2023 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
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R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

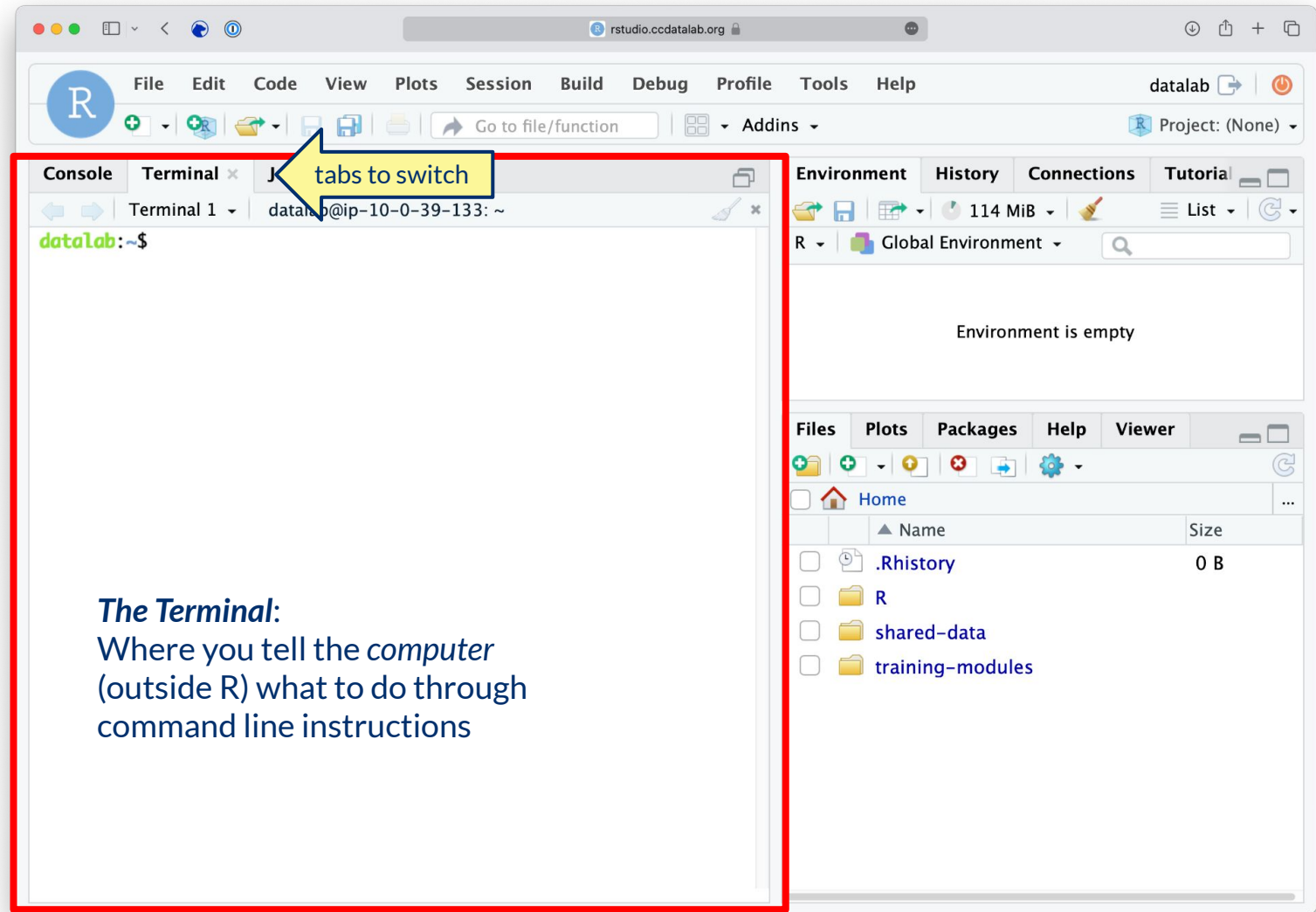
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

```
> |
```

The Console:
where you tell R what to do through
command line instructions

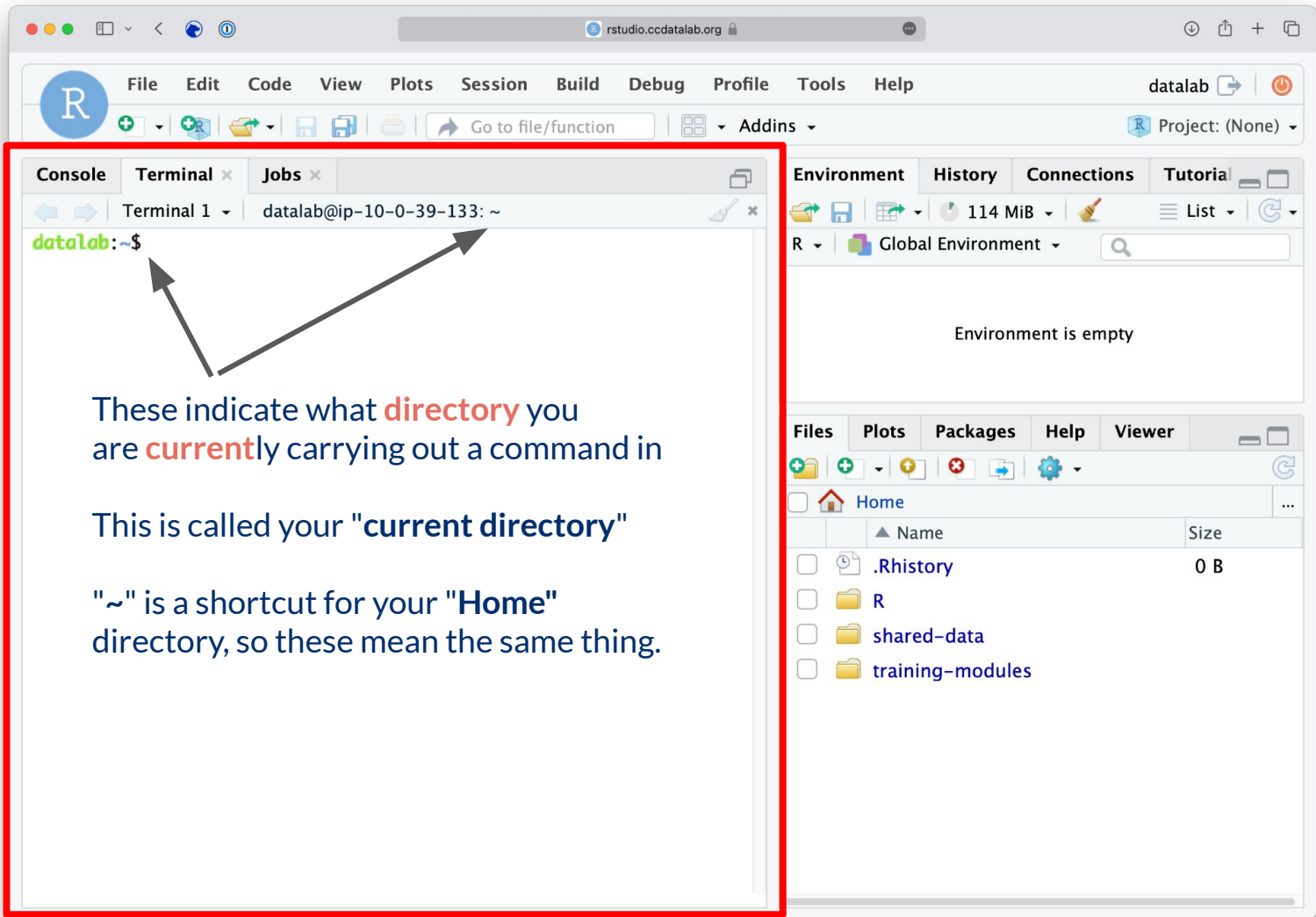
The Environment pane shows 'Global Environment' and 'Environment is empty'. The Files pane shows a file browser with a table of files:

	Name	Size
<input type="checkbox"/>	.Rhistory	0 B
<input type="checkbox"/>	R	
<input type="checkbox"/>	shared-data	
<input type="checkbox"/>	training-modules	

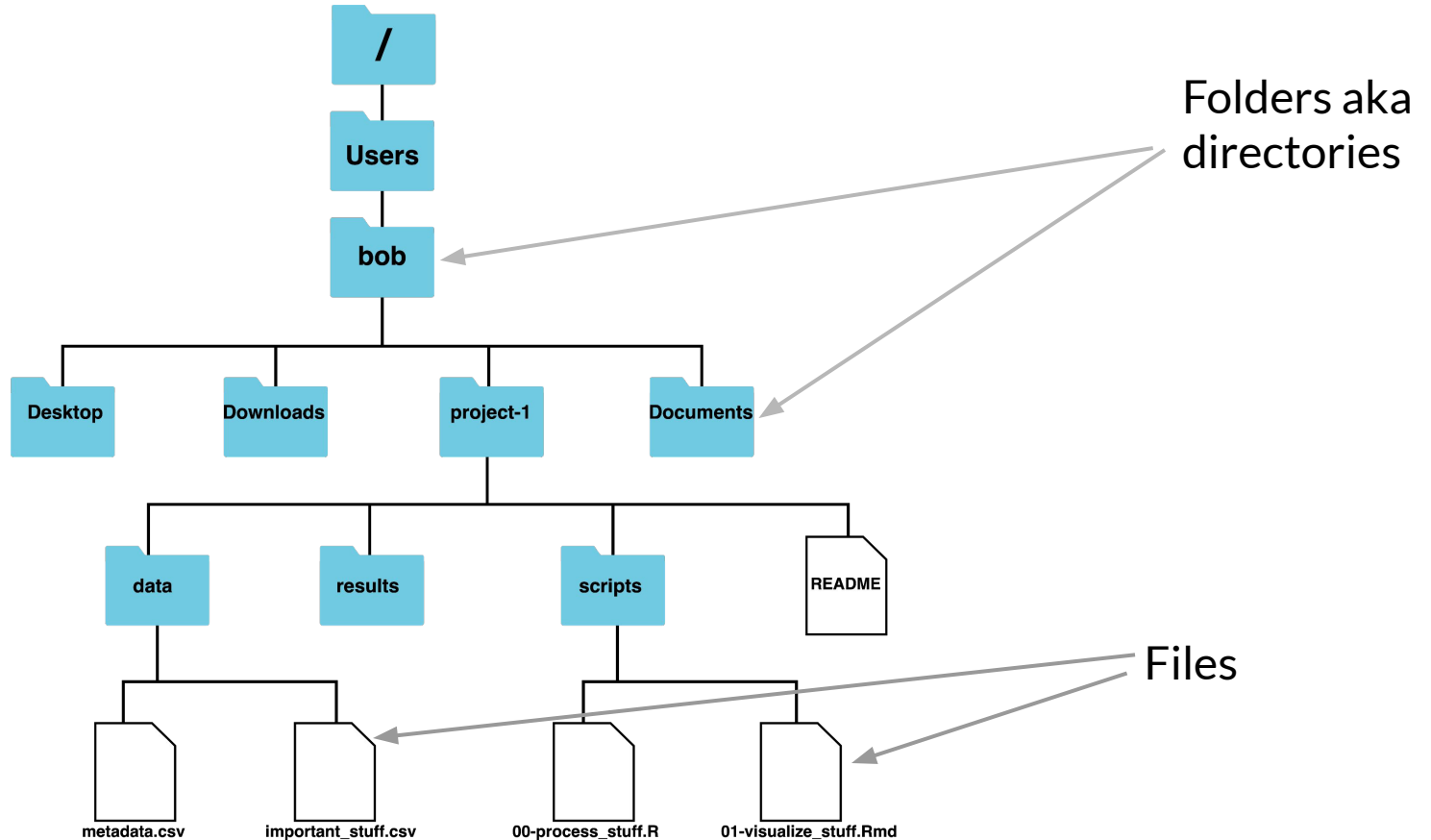


The Terminal:

Where you tell the *computer* (outside R) what to do through command line instructions

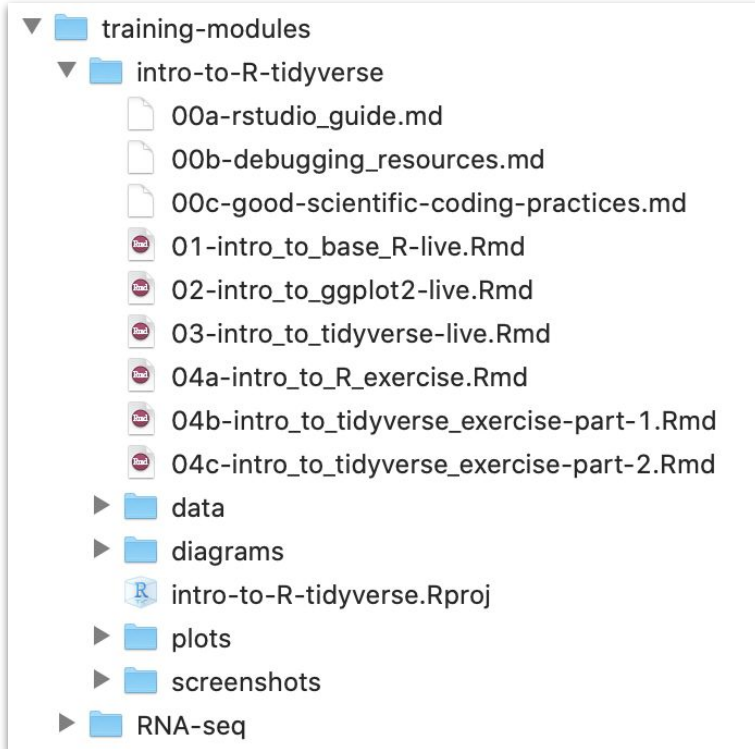


Example of a filesystem hierarchy



Our "current directory" for today's *Intro to R* module

When we are working on the command line, we have to keep track of where the files we are using are being kept.



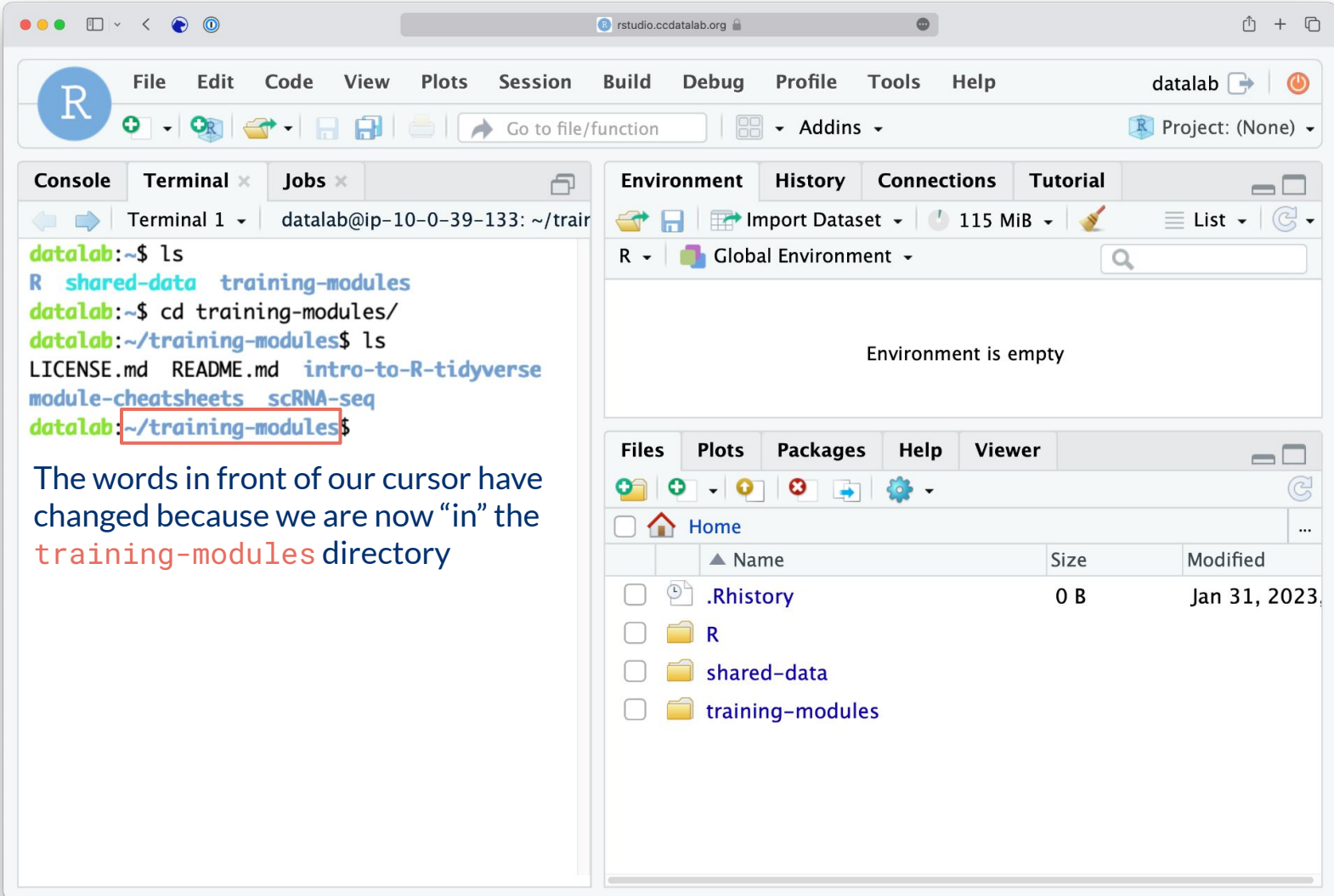
The screenshot shows the RStudio interface with the following components:

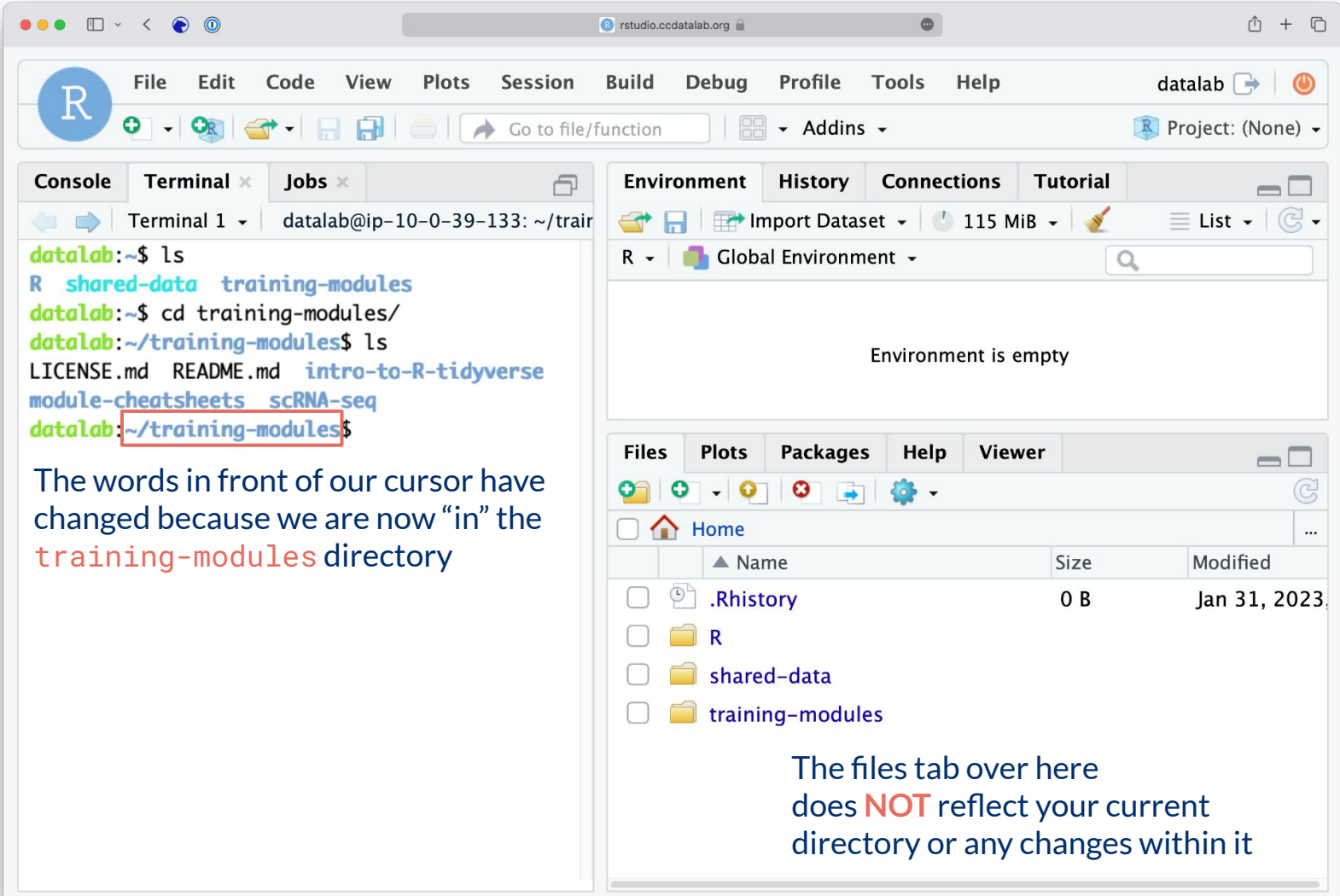
- Terminal:** Shows the execution of `ls` and `cd training-modules/` commands.
- Environment:** Shows the Global Environment is empty.
- Files:** Shows a file browser view of the Home directory with the following table:

	Name	Size	Modified
<input type="checkbox"/>	.Rhistory	0 B	Jan 31, 2023,
<input type="checkbox"/>	R		
<input type="checkbox"/>	shared-data		
<input type="checkbox"/>	training-modules		

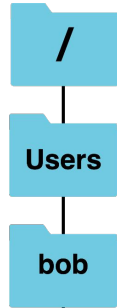
Some common **Terminal** commands:

- ls** - list the files and folders in a directory (files that start with a '.' are not shown by default)
- cd** - change directories

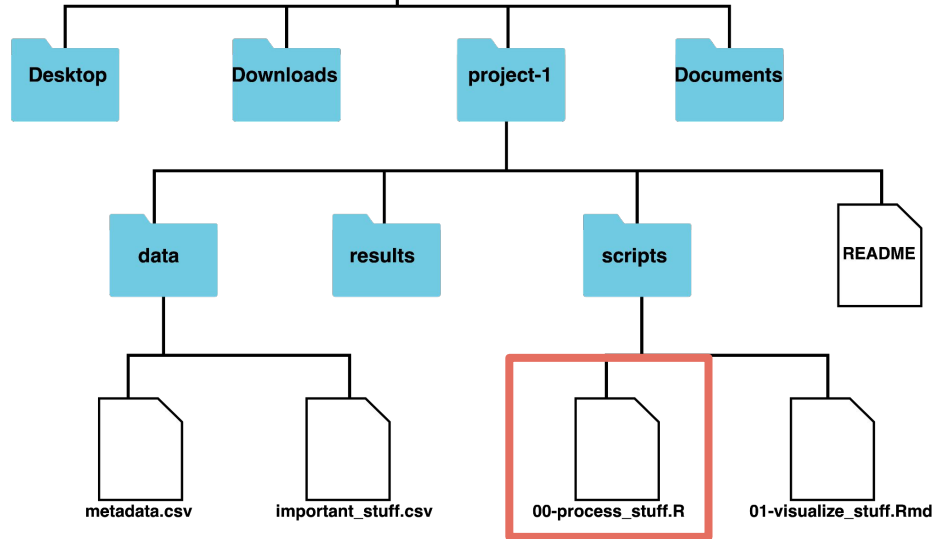




We are always working somewhere!



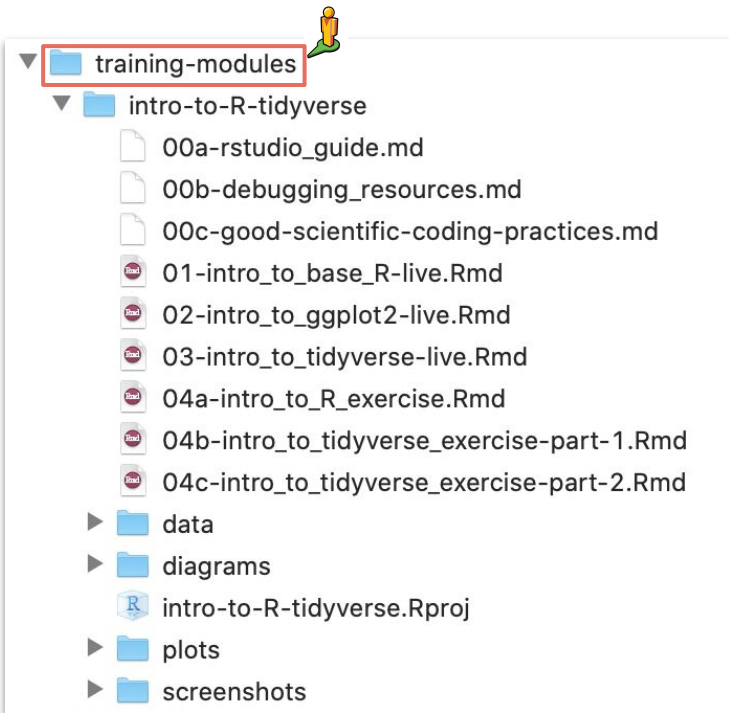
Assume we are working “from” the **bob** directory.
This means **bob** is the *current (working) directory*




The file we are working on
Relative path: **project-1/scripts/00-process_stuff.R**

File paths: Directions to a file or folder

Let's say we want access to `01-intro_to_base_R-live.Rmd`

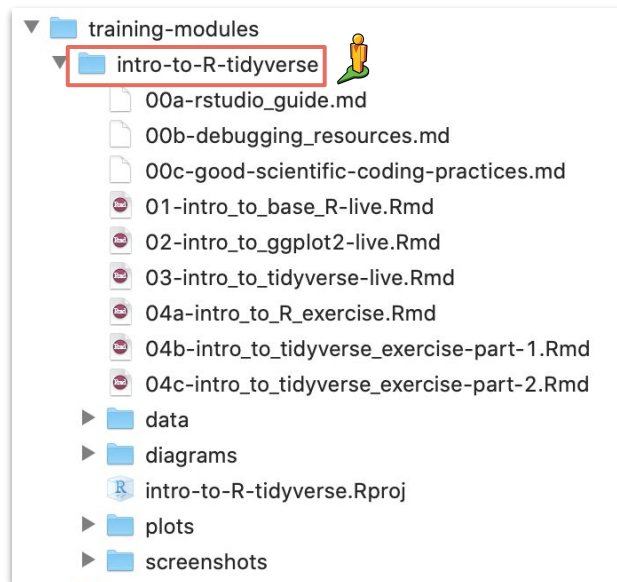
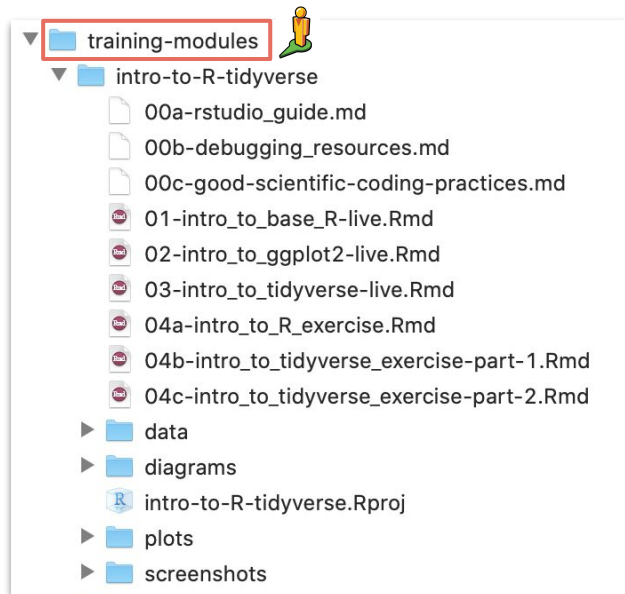



Current directory = `training-modules` 

File path = `intro-to-R-tidyverse/01-intro_to_base_R-live.Rmd`

Relative file paths

Let's say we want to work with **01-intro_to_base_R-live.Rmd**



 training-modules

 training-modules/intro-to-R-tidyverse

Relative file path =
intro-to-R-tidyverse/01-intro_to_base_R-live.Rmd

Relative file path = **01-intro_to_base_R-live.Rmd**



Introduction to R


The Data Lab

R programming

Programming: making executable scripts for accomplishing a task
(in this case, data analysis is our task)

Scripts allow others to see, step-by-step, what you did.

Why we use R:

- It's free and open-source
 - People make cool packages that do stuff for us
 - Many researchers in genomics use it (as well as Python)
- 

R, RStudio, and RStudio Server

R is a statistical programming language.



RStudio is an IDE for working in R

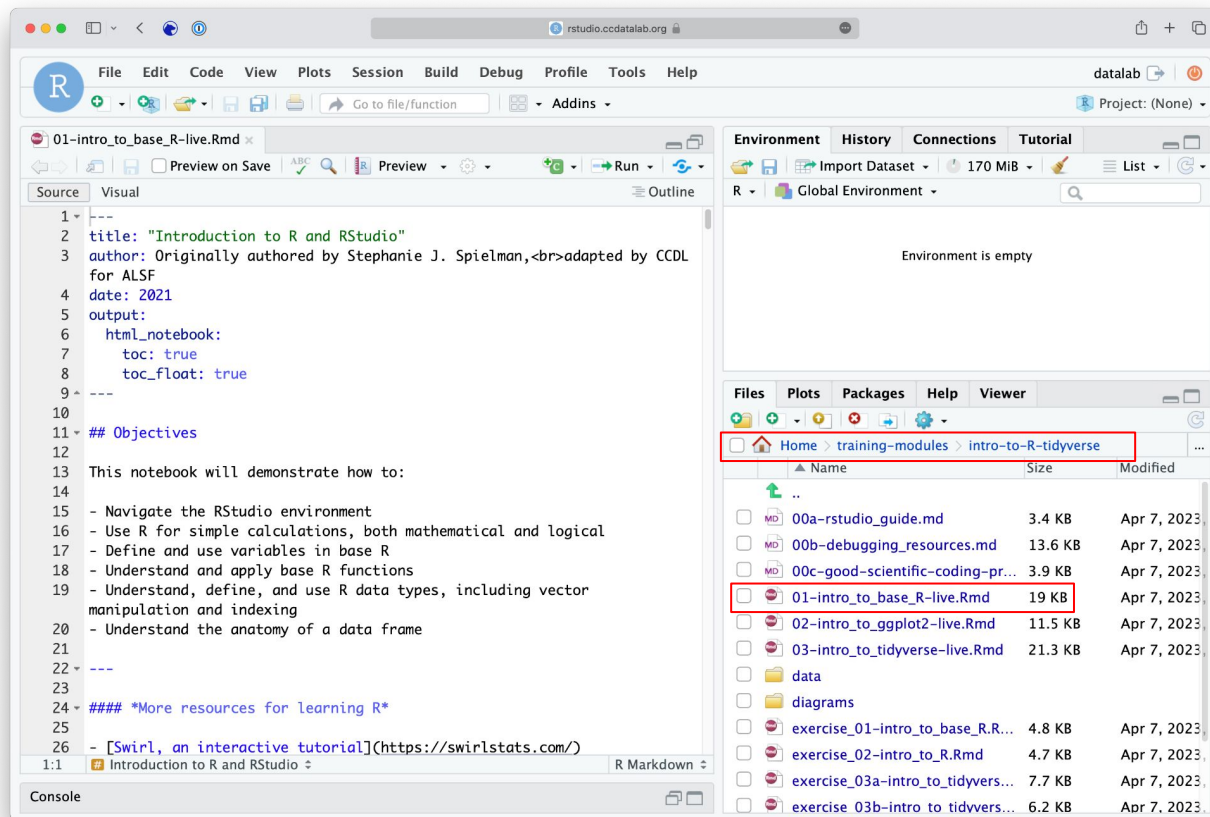
- IDE: Integrated Development Environment
- We write R code using the (free!) RStudio IDE



RStudio Server allows us to run the RStudio IDE from a browser

R Notebooks

Use the "Files" tab to open: `training-modules/intro-to-R-tidyverse/01-intro_to_base_R-live.Rmd`



The screenshot shows the RStudio interface with the following components:

- Source Editor:** Displays the R Notebook content, including a title, author information, and a list of objectives.
- Environment Panel:** Shows the current environment is empty.
- Files Panel:** Shows the file browser with the path `Home > training-modules > intro-to-R-tidyverse` and a list of files.

Source Editor Content:

```
1 ---
2 title: "Introduction to R and RStudio"
3 author: Originally authored by Stephanie J. Spielman, <br> adapted by CC DL
4   for ALSF
5 date: 2021
6 output:
7   html_notebook:
8     toc: true
9     toc_float: true
10 ---
11 ## Objectives
12
13 This notebook will demonstrate how to:
14
15 - Navigate the RStudio environment
16 - Use R for simple calculations, both mathematical and logical
17 - Define and use variables in base R
18 - Understand and apply base R functions
19 - Understand, define, and use R data types, including vector
20   manipulation and indexing
21 - Understand the anatomy of a data frame
22 ---
23
24 #### *More resources for learning R*
25
26 - [Swirl, an interactive tutorial](https://swirlstats.com/)
```

Files Panel Content:

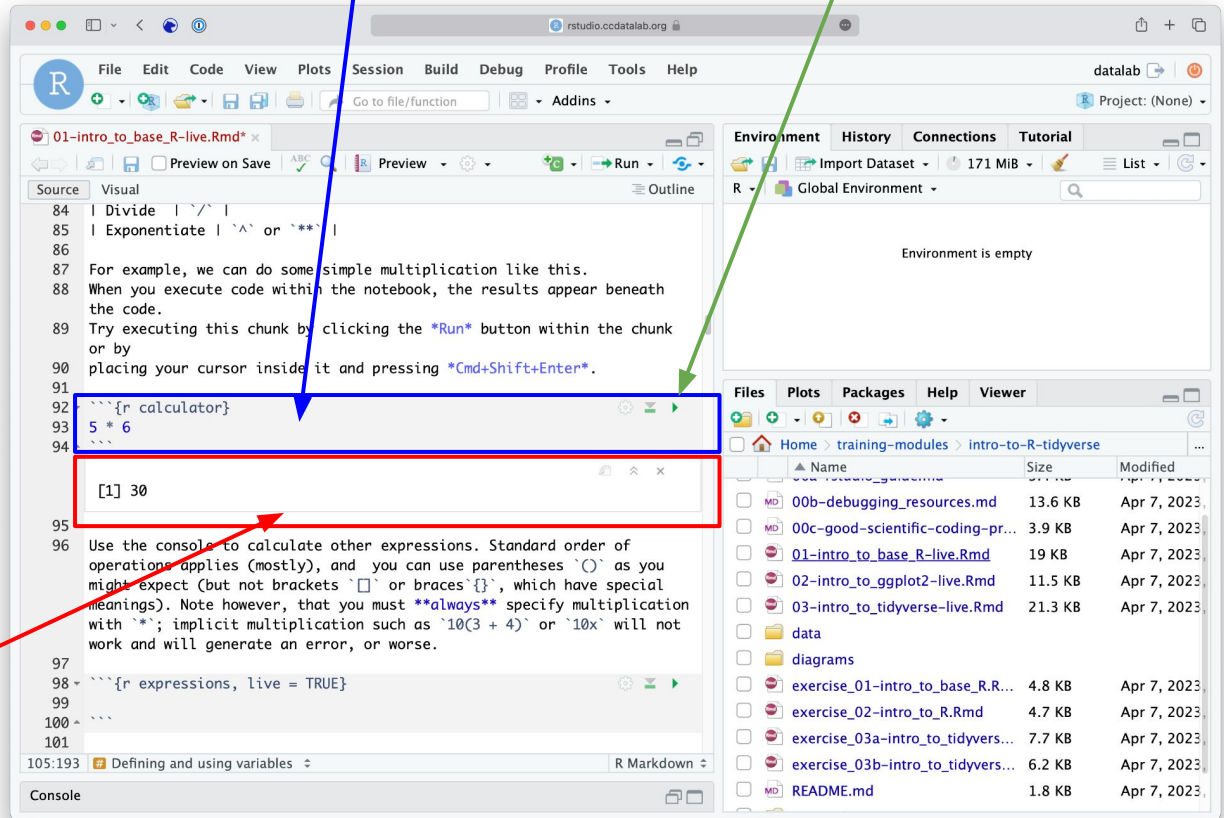
Name	Size	Modified
..		
00a-rstudio_guide.md	3.4 KB	Apr 7, 2023
00b-debugging_resources.md	13.6 KB	Apr 7, 2023
00c-good-scientific-coding-pr...	3.9 KB	Apr 7, 2023
01-intro_to_base_R-live.Rmd	19 KB	Apr 7, 2023
02-intro_to_ggplot2-live.Rmd	11.5 KB	Apr 7, 2023
03-intro_to_tidyverse-live.Rmd	21.3 KB	Apr 7, 2023
data		
diagrams		
exercise_01-intro_to_base_R.R...	4.8 KB	Apr 7, 2023
exercise_02-intro_to_R.Rmd	4.7 KB	Apr 7, 2023
exercise_03a-intro_to_tidvers...	7.7 KB	Apr 7, 2023
exercise_03b-intro_to tidvers...	6.2 KB	Apr 7, 2023

R Notebooks

R Notebooks allow you to have files that show both your code and results

Executable code chunk

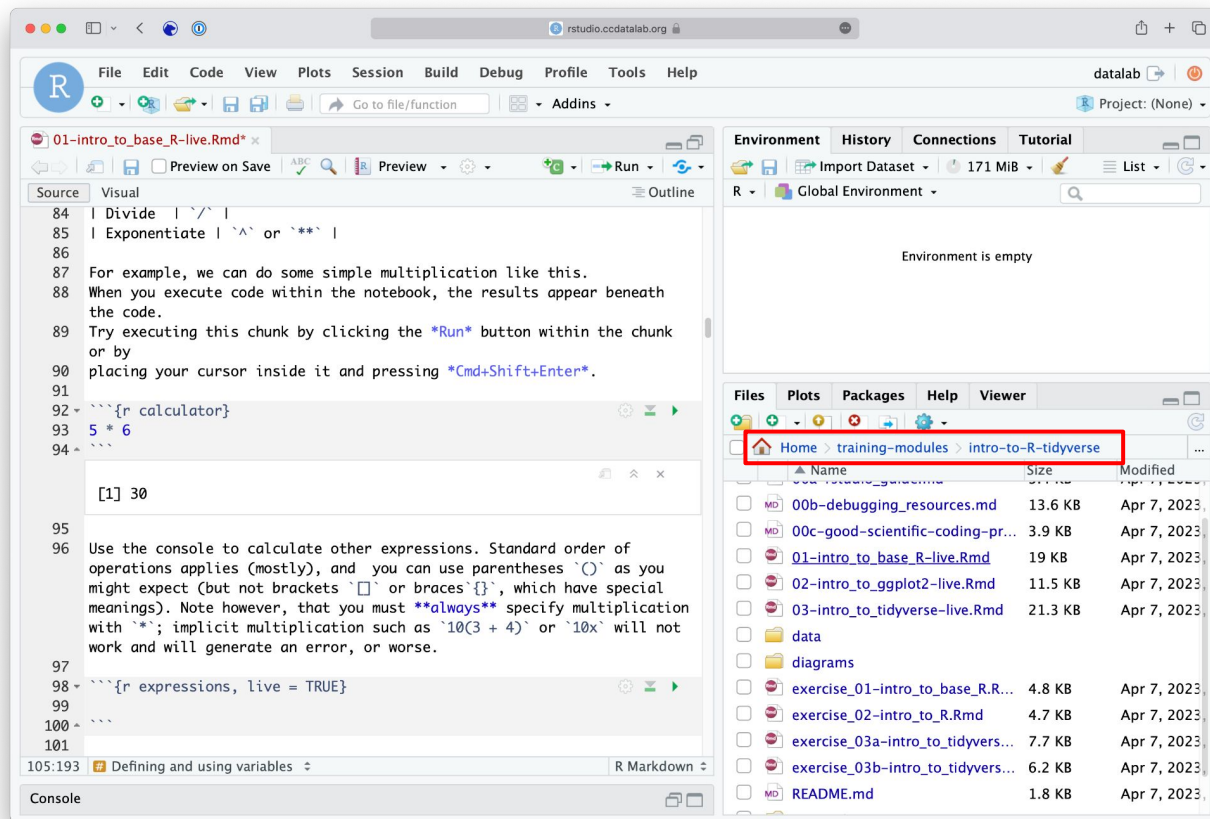
Can click here to run a code chunk



Output from above code chunk

R Notebooks

- Code that runs in R Notebooks uses wherever the file is saved as its current directory
- **Warning!** That may not be the directory shown in the files pane or the console!



The screenshot shows the RStudio interface with a notebook titled "01-intro_to_base_R-live.Rmd". The code in the notebook includes instructions on how to run code chunks and a live R chunk that calculates 5 * 6. The console output shows the result [1] 30. The Environment pane is empty, and the Files pane shows a directory listing of files in the "intro-to-R-tidyverse" folder. A red box highlights the "Console" icon in the bottom right corner of the RStudio interface, with a red arrow pointing to it and a text box that says "Click here to show the Console".

Environment is empty

```
84 | Divide | ` / ` |
85 | Exponentiate | ` ^ ` or ` ** ` |
86
87 For example, we can do some simple multiplication like this.
88 When you execute code within the notebook, the results appear beneath
89 the code.
90 Try executing this chunk by clicking the *Run* button within the chunk
91 or by
92 placing your cursor inside it and pressing *Cmd+Shift+Enter*.
93
94 ```{r calculator}
95 5 * 6
96 ```
```

[1] 30

```
97
98 Use the console to calculate other expressions. Standard order of
99 operations applies (mostly), and you can use parentheses `(`) as you
100 might expect (but not brackets `[` or braces `{}`, which have special
101 meanings). Note however, that you must **always** specify multiplication
102 with `*`; implicit multiplication such as `10(3 + 4)` or `10x` will not
103 work and will generate an error, or worse.
104
105 ```{r expressions, live = TRUE}
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```

105:193 # Defining and using variables R Markdown

Name	Size	Modified
00a-intro_to_tidyverse.md	13.6 KB	Apr 7, 2023
00b-debugging_resources.md	3.9 KB	Apr 7, 2023
00c-good-scientific-coding-pr...	19 KB	Apr 7, 2023
01-intro_to_base_R-live.Rmd	11.5 KB	Apr 7, 2023
02-intro_to_ggplot2-live.Rmd	21.3 KB	Apr 7, 2023
03-intro_to_tidyverse-live.Rmd		
exercise_01a-intro_to_tidyvers...	6.2 KB	Apr 7, 2023
exercise_02a-intro_to_tidyvers...	1.8 KB	Apr 7, 2023
exercise_03b-intro_to_tidyvers...		
README.md		

Click here to show the Console

The screenshot displays the RStudio interface. The main editor window shows a script titled "01-intro_to_base_R-live.Rmd" with the following code:

```
95  
96 Use the console to calculate other expressions. Standard order of  
operations applies (mostly), and you can use parentheses `()` as you  
might expect (but not brackets `[]` or braces `{}`, which have special  
meanings). Note however, that you must **always** specify multiplication  
with `*`; implicit multiplication such as `10(3 + 4)` or `10x` will not  
work and will generate an error, or worse.  
97  
98 ```{r expressions, live = TRUE}  
99 x <- 5.5  
100  
101 x  
102 ```
```

The Environment pane on the right shows the Global Environment with a variable `x` having a value of `5.5`.

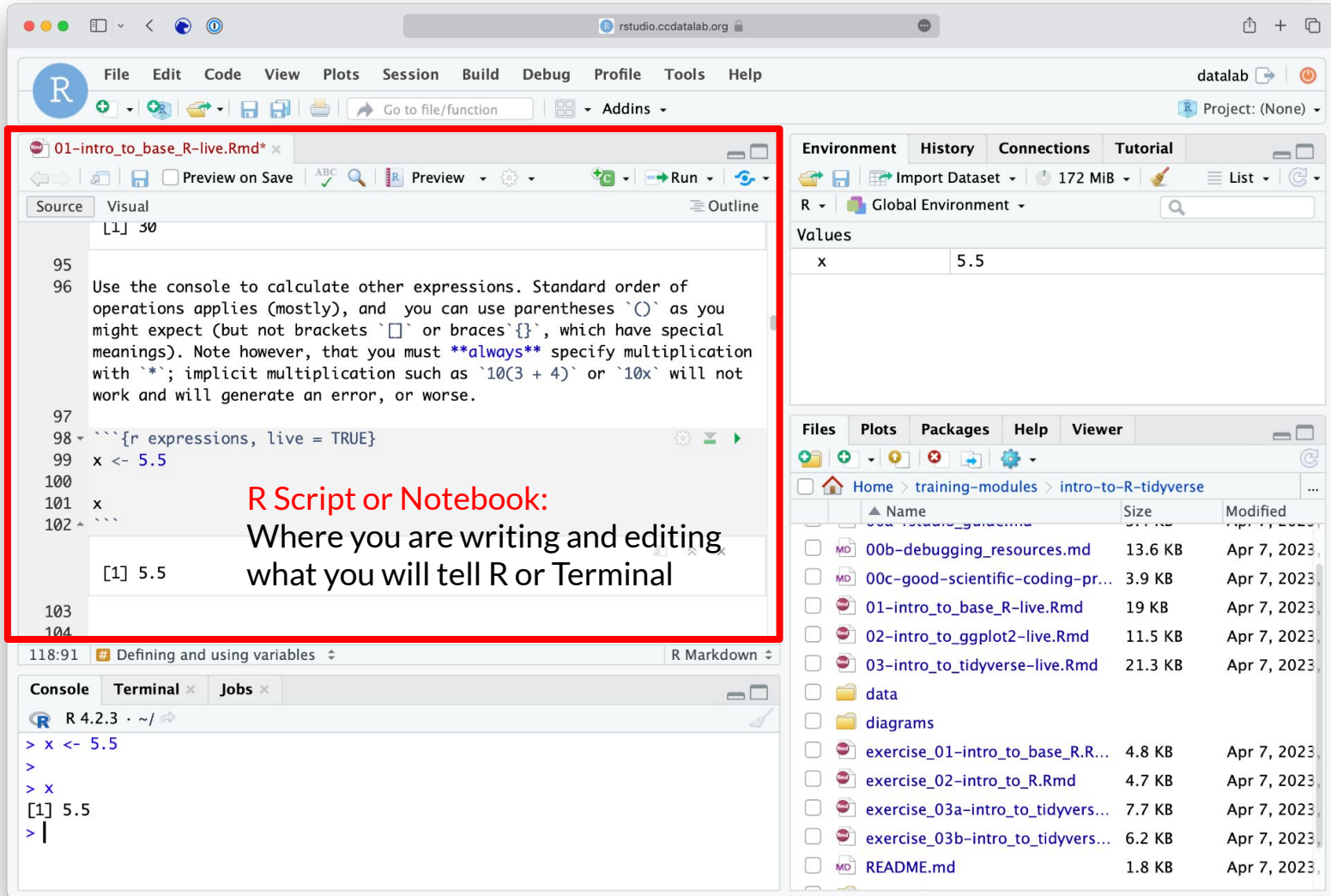
The Files pane on the right shows a directory listing for `training-modules > intro-to-R-tidyverse`:

Name	Size	Modified
00a-creating_variables.md	13.6 KB	Apr 7, 2023
00b-debugging_resources.md	3.9 KB	Apr 7, 2023
00c-good-scientific-coding-pr...	19 KB	Apr 7, 2023
01-intro_to_base_R-live.Rmd	11.5 KB	Apr 7, 2023
02-intro_to_ggplot2-live.Rmd	21.3 KB	Apr 7, 2023
03-intro_to_tidyverse-live.Rmd		
data		
diagrams		
exercise_01-intro_to_base_R.R...	4.8 KB	Apr 7, 2023
exercise_02-intro_to_R.Rmd	4.7 KB	Apr 7, 2023
exercise_03a-intro_to_tidyvers...	7.7 KB	Apr 7, 2023
exercise_03b-intro_to_tidyvers...	6.2 KB	Apr 7, 2023
README.md	1.8 KB	Apr 7, 2023

The Console pane at the bottom shows the R session output:

```
R 4.2.3 · ~/ /  
> x <- 5.5  
>  
> x  
[1] 5.5  
> |
```

R Console:
What you are actually telling R to do



R Script or Notebook:
Where you are writing and editing
what you will tell R or Terminal

```
01-intro_to_base_R-live.Rmd* x
[1] 30

95
96 Use the console to calculate other expressions. Standard order of
operations applies (mostly), and you can use parentheses `()` as you
might expect (but not brackets `[]` or braces `{}`, which have special
meanings). Note however, that you must **always** specify multiplication
with `*`; implicit multiplication such as `10(3 + 4)` or `10x` will not
work and will generate an error, or worse.
97
98 ```{r expressions, live = TRUE}
99 x <- 5.5
100
101 x
102 - ```

[1] 5.5

103
104
```

Environment History Connections Tutorial

Import Dataset 172 MiB

R Global Environment

Values

x	5.5
---	-----

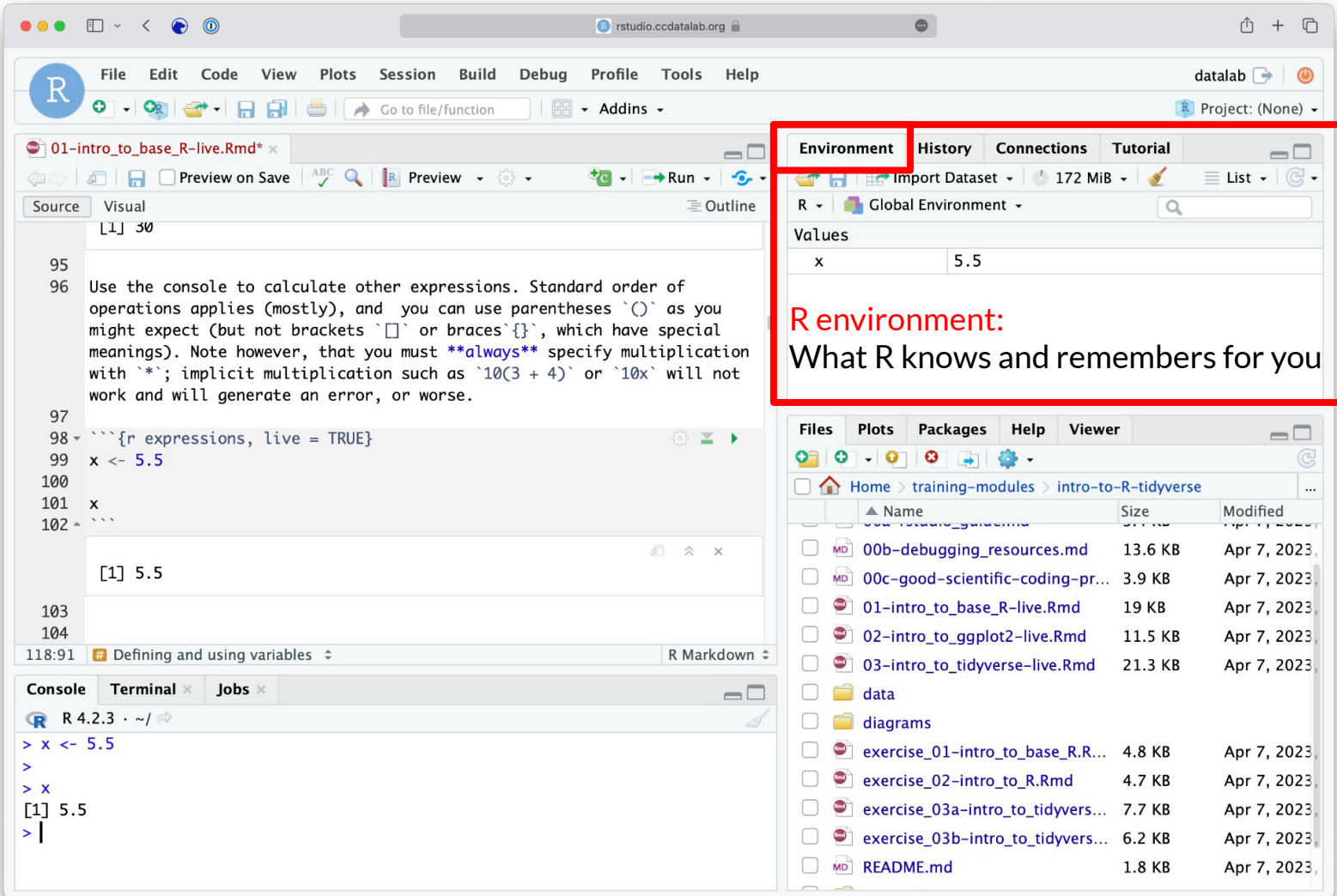
Files Plots Packages Help Viewer

Home > training-modules > intro-to-R-tidyverse

Name	Size	Modified
00a-tidyverse_guidance		
00b-debugging_resources.md	13.6 KB	Apr 7, 2023
00c-good-scientific-coding-pr...	3.9 KB	Apr 7, 2023
01-intro_to_base_R-live.Rmd	19 KB	Apr 7, 2023
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data		
diagrams		
exercise_01-intro_to_base_R.R...	4.8 KB	Apr 7, 2023
exercise_02-intro_to_R.Rmd	4.7 KB	Apr 7, 2023
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exercise_03b-intro_to_tidyvers...	6.2 KB	Apr 7, 2023
README.md	1.8 KB	Apr 7, 2023

```
118:91 # Defining and using variables
R Markdown

Console Terminal Jobs
R 4.2.3 ~ /
> x <- 5.5
>
> x
[1] 5.5
> |
```



Environment History Connections Tutorial

R - Global Environment

Values

x	5.5
---	-----

R environment:
What R knows and remembers for you

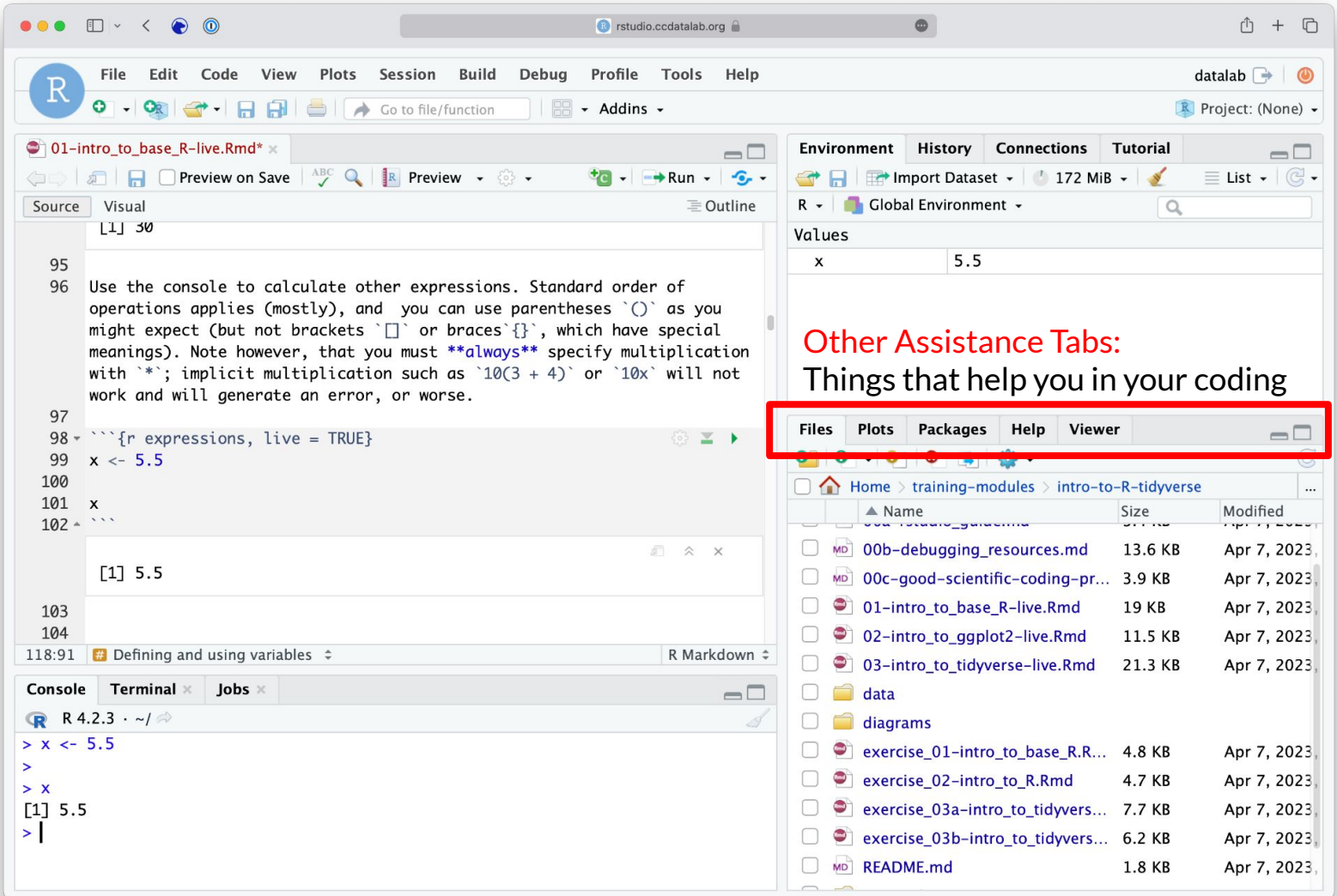
```
01-intro_to_base_R-live.Rmd* x
Source Visual
[1] 30
95
96 Use the console to calculate other expressions. Standard order of
operations applies (mostly), and you can use parentheses `()` as you
might expect (but not brackets `[]` or braces `{}`, which have special
meanings). Note however, that you must **always** specify multiplication
with `*`; implicit multiplication such as `10(3 + 4)` or `10x` will not
work and will generate an error, or worse.
97
98 ```{r expressions, live = TRUE}
99 x <- 5.5
100
101 x
102 -```
[1] 5.5
103
104
```

```
118:91 # Defining and using variables
R Markdown
Console Terminal Jobs
R 4.2.3 ~ /
> x <- 5.5
>
> x
[1] 5.5
> |
```

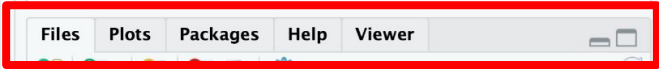
Files Plots Packages Help Viewer

Home > training-modules > intro-to-R-tidyverse

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00a-creating_a_garden.md	13.6 KB	Apr 7, 2023
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exercise_03b-intro_to_tidyvers...	6.2 KB	Apr 7, 2023
README.md	1.8 KB	Apr 7, 2023



Other Assistance Tabs:
Things that help you in your coding



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00a-intro_to_base_R-live.Rmd	19 KB	Apr 7, 2023
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exercise_03b-intro_to_tidyvers...	6.2 KB	Apr 7, 2023
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RStudio Sessions

- On the server, R is running many times at once
 - Each user has their own “**Session**” running, with its own memory and processes
- We will usually want to start new sessions between notebooks to keep the environment clean

Log out of website



End the current session and start new session