Macquarie R Users Group - An Introduction to R (written in R Notebook (Markdown))

Prerequisite

Please install the latest versions of R and RStudio. See Installing R and R Studio below!

Installing R and R Studio

Instructions courtesy of Data carpentries, see here for full instruction and linux install.

Windows

If you already have R and RStudio installed: 1. Open RStudio 2. Click on "Help" > "Check for updates". 3. If a new version is available, quit RStudio, and download the latest version for RStudio. 4. To check which version of R you are using, start RStudio and the first thing that appears in the console indicates the version of R you are running. Alternatively, you can type `sessionInfo()`, which will also display which version of R you are running. 5. Go on the CRAN website and check whether a more recent version is available. If so, please download and install it. You can check here for more information on how to remove old versions from your system if you wish to do so.

If you don't have R and RStudio installed: 1. Download R from the CRAN website. 2. Run the `.exe` file that was just downloaded 3. Go to the RStudio download page 4. Under Installers select **RStudio x.yy.zzz - Windows Vista/7/8/10** (where x, y, and z represent version numbers) 5. Double click the file to install it 6. Once it's installed, open RStudio to make sure it works and you don't get any error messages.

macOS

If you already have R and RStudio installed: 1. Open RStudio 2. Click on "Help" > "Check for updates". 3. If a new version is available, quit RStudio, and download the latest version for RStudio. 4. To check which version of R you are using, start RStudio and the first thing that appears in the console indicates the version of R you are running. Alternatively, you can type `sessionInfo()`, which will also display which version of R you are running. 5. Go on the CRAN website and check whether a more recent version is available. If so, please download and install it. You can check here for more information on how to remove old versions from your system if you wish to do so.

If you don't have R and RStudio installed: 1. Download R from the CRAN website. 2. Select the `.pkg` file for the latest R version 3. Once downloaded double click on the file to install R. 4. To dowload Rstudio go to the RStudio download page 5. Under Installers select **RStudio x.yy.zzz - Mac OS X 10.6+ (64-bit)** (where x, y, and z represent version numbers) 6. Double click the file to install RStudio 7. Once it's installed, open RStudio to make sure it works and you don't get any error messages.

Section 1

- Sit together in pairs. Envision yourself as navigator and programmer. Swap tasks once in a while.

Goals

1. Getting comfortable with R Studio Interface and finding out what it is all about.
2. Using basic commands.
3. Loading and saving data.
4. Basic statistics.
5. Plotting.
6. Not being scared of coding!

What is R?

"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." (CRAN)

"In its broadest definition, R is a computer language that allows the user to program algorithms and use tools that have been programmed by others." (Zuur et al 2009 - A Beginner's Guide to R:14)

But what can it actually do?

- R as a calculator
- Manipulate data
- Conduct any statistical test
- Import software 'packages' with specialised functions (more on this later)
- Automate analyses
- Design simple or complicated graphs

Why you should use it?

- It is free and open-source
- R has been receiving contributions from many programmers around the globe
- Listed as 3rd most used languages in Data Science
- Massive community for online support
- Very specific problems are mostly addressed with a package
- It is widely used with many books published in the last years

Awesome! Why is not everyone using it?

- A bit of a learning curve
- Coding necessary (eh!)

** BUT **

- The most basic syntax (grammar) can be used for most of the things in R
- R studio makes it easier to code in R, providing a user friendly interface
- Once you get used to programming you can adopt new languages easier

There are a lot of online courses, videos and texts available for understanding R, its packages etc.

Let's have a look at R Studio

What's what:

- Console: your code is run here and you will see the results of your coding.
- R-Script: your code is written and saved here, just like in a normal text-document.
- Environment: all the loaded data and objects are listed here, you can even take a look at your data tables or the structure of your data.
- History: shows the history of your executed code.
- Files: what is in your source folder, i.e. is my data table in the folder?
- Plots: this is where your plots will be shown, you can also export them from here (but there are better ways).
- Packages: load and search for new packages and your installed packages are listed here.
- Help: look for help or specific vignettes (support documents) for each package. Also access via ¿function'
- Viewer: can be used to view local web content for web graphics generated using packages like googleVis, htmlwidgets, and rCharts, or even a local web application created using Shiny, Rook, or OpenCPU.

R-studio gives you a more intuitive interface and takes the scariness out of coding. It also provides functions that simplify the process of developing your code. 'Tab completion' is one of such function.

Some basic R syntax: objects and functions and arguments

```
# output<-function1(argument1, argument2, ...) + function2(argument)

# flat_white <- froth(milk, hot) + extract(coffee)
# flat_white = froth(milk, hot) + extract(coffee)

# verb(argument)
# argument can be a "noun" (being acted upon) or an "adverb" (modifying its behavior)

# Example1: boiling milk normally
# boiled_milk <- boil (milk)

# Example2: boiling milk for a long time
# boiled_milk <- boil (milk, long_time)
```

froth() and extract() are *functions*, milk, hot and coffee are *arguments*

functions are sets of instructions used to do something to arguments. They can be stored in an *object* (flat_white). Objects can be used as arguments.

arguments are used to tell functions what *objects* to act on, and any details of how to perform the action

Functions need arguments to fulfill the purpose they were designed for. e.g. froth() needs to know what kind of milk to froth and how hot to make it.

packages are precoded sets of instructions (functions) that were written by someone and are available for everyone to use

Now it's time to play around in R. We will create some dummy data and create a basic scatterplot.

1. We can assign (<-) a basic calculation to the object 'a' and call the content of 'a'. Execute your code using Ctrl+Enter

```
a <- 1+2 # here R works like a calculator
a        # print a to see what it contains
```

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

2. We use function c() to combine specific values into a vector. Assign this new vector to object 'x'.

```
x <- c(1,2,3,4) # 'c' is a function that combines values into the vector x (object), the numbers are ar
```

A vector is a sequence of data *components* of the same basic type (i.e. numbers or letters)

3. Using function mean (), we can extract the mean of our vector.

```
mean(x) # mean() is a function
```

```
## [1] 2.5
```

4. Create two vectors (they are going to be numeric in our case) using seq() and assign them the object seq_a and seq_b. object seq_a contains a vector with the components 1 to 10 and is increasing by 1. seq_b contains the components 1 to 25 and increases by 2. If you are not sure how to use a function, such as seq(), just call ?seq and have a look what arguments can be used.

```
seq_a <- seq(from=1,to=10,by=1)
seq_b <- seq(from=1,to=25,by=2)
```

5. Using cbind() you can bind two vectors to create a *matrix* (a kind of table). Use cbind() to bind seq_a and seq_b. Assign it to the object 'c'. For help, call ?cbind

```
# uncomment this next line and pay attention to what happens when this like is run

# c <- cbind(seq_a,seq_b)
```

6. Oops! Let's see what went wrong. Can you decipher the error message? Have a look at seq_a and seq_b. Just type seq_a and seq_b and execute both. No worries, debugging (resolving errors) is a major part of programming.

```
seq_a
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```
seq_b
```

```
##  [1]  1  3  5  7  9 11 13 15 17 19 21 23 25
```

7. To make the problem more obvious, let's check the length of each object. Use length().

```
length(seq_a)
```

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

```
length(seq_b)
```

```
## [1] 13
```

8. To cbind() two vectors they have to have the same length. Let's overwrite seq_a and create a vector of the same length as seq_b. Check if the length is matching the other vector and bind them using cbind(). Assign this object to a new object, 'c'. What class has 'c'? Check it!

```r
seq_a<- seq(1,13,by=1)

length(seq_a)
```

```
## [1] 13
```

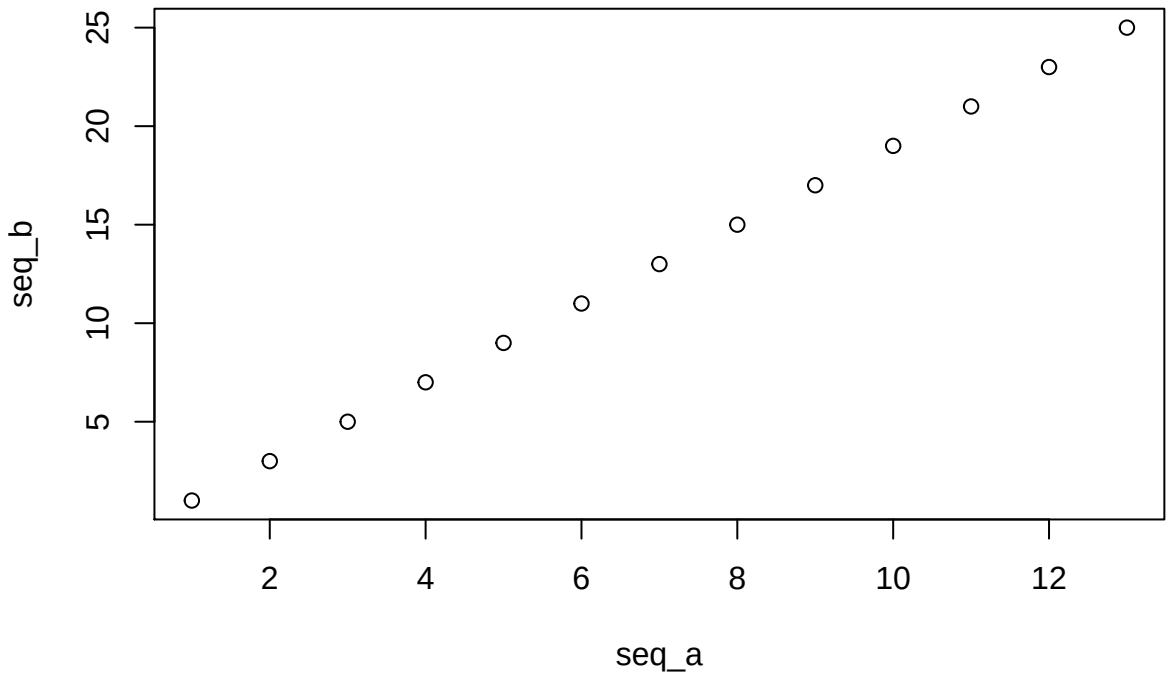
```r
c <- cbind(seq_a,seq_b)

class(c) #class() can figure out if you are working with vectors, matrices, dataframes, lists etc....it
```

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

**Note: The counterpart to cbind() is rbind() if you would like to connect rows instead of columns.

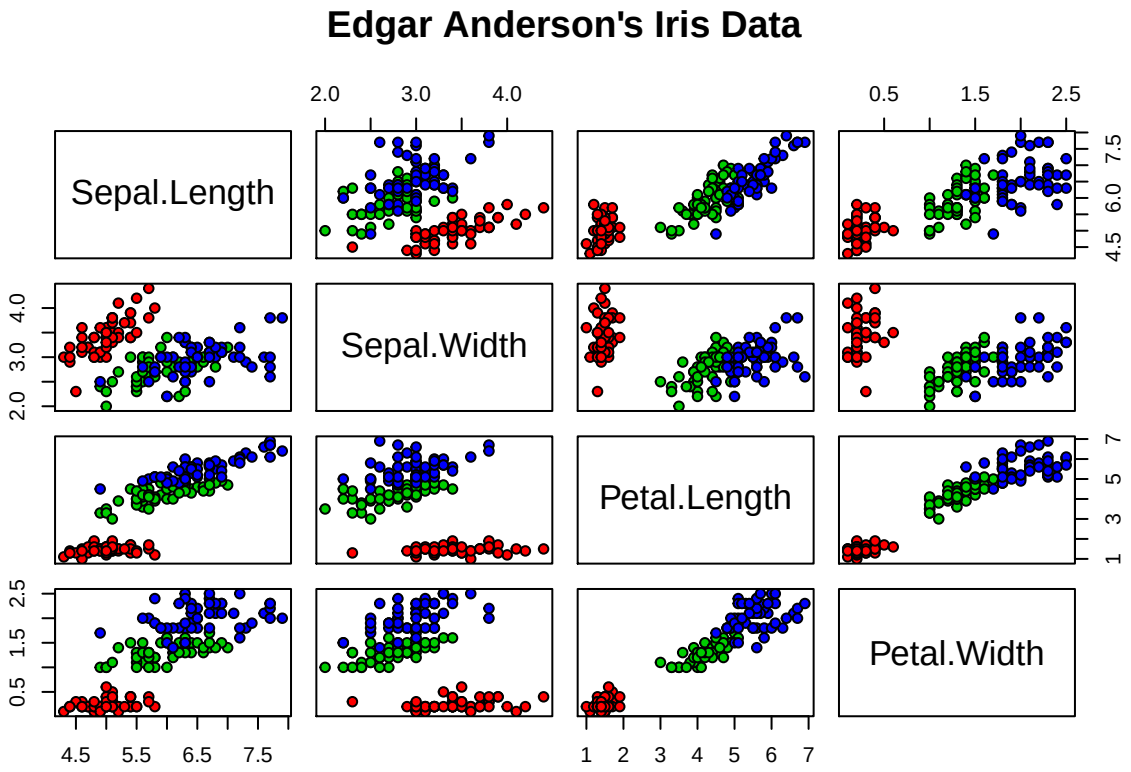
9. Plot 'c' by using plot()

```r
plot(c)
```



Note: If we wanted to, we could modify the appearance of this plot completely. Labelling axis, change tickmarks and intervals, add text or shapes...more than you can think of now. With just a few lines of code we can create beautiful plots. Once a plot is coded we can use it over and over again and also easily modify it. See here:

```
pairs(iris[1:4], main = "Edgar Anderson's Iris Data", pch = 21, bg = c("red","green3","blue")[unclass(ir
```



What we have learned:

- Get an idea of what R can possibly do
- Discover R Studio
- Become familiar with some basic expressions
- Encounter error messages
- Create some first data
- Have an idea that there are different classes that R can use (different packages want different classes)
- See what a basic plot looks like and how it could look like (Know that there are different ways/ packages of plotting something)

Section 2

Getting Data into R

How do we get started?

- Save your current script: File > Save
- Create a new project folder for our R users introduction course: File/R project > New project > New directory > New project > Browse and name it: 'My first R project'.
- Create 3 subfolders within the project and name them 'input', 'output' and 'scripts'
- Move both files datasets found within input folder from the original workshop folder to our new input folder we just created.

- Move our script RUsersGroup_BeginnerSession_2020.R to the newly created script folder and reopen it
- We can also create new scripts: File > New File > R script

1. Let's import our data and see what it looks like

```
# if the dataset is build in R, it is unnecessary to export it as csv and import it, you just need the
# it is the case with iris and PlantGrowth datasets, so they can be loaded using:
data(iris)
data(PlantGrowth)

# or

irisdata <- read.csv("input/irisdata.csv")
irisdata
```

```
##       X Sepal.Length Sepal.Width Petal.Length Petal.Width    Species
## 1     1          5.1         3.5          1.4         0.2     setosa
## 2     2          4.9         3.0          1.4         0.2     setosa
## 3     3          4.7         3.2          1.3         0.2     setosa
## 4     4          4.6         3.1          1.5         0.2     setosa
## 5     5          5.0         3.6          1.4         0.2     setosa
## 6     6          5.4         3.9          1.7         0.4     setosa
## 7     7          4.6         3.4          1.4         0.3     setosa
## 8     8          5.0         3.4          1.5         0.2     setosa
## 9     9          4.4         2.9          1.4         0.2     setosa
## 10   10          4.9         3.1          1.5         0.1     setosa
## 11   11          5.4         3.7          1.5         0.2     setosa
## 12   12          4.8         3.4          1.6         0.2     setosa
## 13   13          4.8         3.0          1.4         0.1     setosa
## 14   14          4.3         3.0          1.1         0.1     setosa
## 15   15          5.8         4.0          1.2         0.2     setosa
## 16   16          5.7         4.4          1.5         0.4     setosa
## 17   17          5.4         3.9          1.3         0.4     setosa
## 18   18          5.1         3.5          1.4         0.3     setosa
## 19   19          5.7         3.8          1.7         0.3     setosa
## 20   20          5.1         3.8          1.5         0.3     setosa
## 21   21          5.4         3.4          1.7         0.2     setosa
## 22   22          5.1         3.7          1.5         0.4     setosa
## 23   23          4.6         3.6          1.0         0.2     setosa
## 24   24          5.1         3.3          1.7         0.5     setosa
## 25   25          4.8         3.4          1.9         0.2     setosa
## 26   26          5.0         3.0          1.6         0.2     setosa
## 27   27          5.0         3.4          1.6         0.4     setosa
## 28   28          5.2         3.5          1.5         0.2     setosa
## 29   29          5.2         3.4          1.4         0.2     setosa
## 30   30          4.7         3.2          1.6         0.2     setosa
## 31   31          4.8         3.1          1.6         0.2     setosa
## 32   32          5.4         3.4          1.5         0.4     setosa
## 33   33          5.2         4.1          1.5         0.1     setosa
## 34   34          5.5         4.2          1.4         0.2     setosa
## 35   35          4.9         3.1          1.5         0.2     setosa
## 36   36          5.0         3.2          1.2         0.2     setosa
```

```
## 37   37          5.5         3.5          1.3         0.2     setosa
## 38   38          4.9         3.6          1.4         0.1     setosa
## 39   39          4.4         3.0          1.3         0.2     setosa
## 40   40          5.1         3.4          1.5         0.2     setosa
## 41   41          5.0         3.5          1.3         0.3     setosa
## 42   42          4.5         2.3          1.3         0.3     setosa
## 43   43          4.4         3.2          1.3         0.2     setosa
## 44   44          5.0         3.5          1.6         0.6     setosa
## 45   45          5.1         3.8          1.9         0.4     setosa
## 46   46          4.8         3.0          1.4         0.3     setosa
## 47   47          5.1         3.8          1.6         0.2     setosa
## 48   48          4.6         3.2          1.4         0.2     setosa
## 49   49          5.3         3.7          1.5         0.2     setosa
## 50   50          5.0         3.3          1.4         0.2     setosa
## 51   51          7.0         3.2          4.7         1.4 versicolor
## 52   52          6.4         3.2          4.5         1.5 versicolor
## 53   53          6.9         3.1          4.9         1.5 versicolor
## 54   54          5.5         2.3          4.0         1.3 versicolor
## 55   55          6.5         2.8          4.6         1.5 versicolor
## 56   56          5.7         2.8          4.5         1.3 versicolor
## 57   57          6.3         3.3          4.7         1.6 versicolor
## 58   58          4.9         2.4          3.3         1.0 versicolor
## 59   59          6.6         2.9          4.6         1.3 versicolor
## 60   60          5.2         2.7          3.9         1.4 versicolor
## 61   61          5.0         2.0          3.5         1.0 versicolor
## 62   62          5.9         3.0          4.2         1.5 versicolor
## 63   63          6.0         2.2          4.0         1.0 versicolor
## 64   64          6.1         2.9          4.7         1.4 versicolor
## 65   65          5.6         2.9          3.6         1.3 versicolor
## 66   66          6.7         3.1          4.4         1.4 versicolor
## 67   67          5.6         3.0          4.5         1.5 versicolor
## 68   68          5.8         2.7          4.1         1.0 versicolor
## 69   69          6.2         2.2          4.5         1.5 versicolor
## 70   70          5.6         2.5          3.9         1.1 versicolor
## 71   71          5.9         3.2          4.8         1.8 versicolor
## 72   72          6.1         2.8          4.0         1.3 versicolor
## 73   73          6.3         2.5          4.9         1.5 versicolor
## 74   74          6.1         2.8          4.7         1.2 versicolor
## 75   75          6.4         2.9          4.3         1.3 versicolor
## 76   76          6.6         3.0          4.4         1.4 versicolor
## 77   77          6.8         2.8          4.8         1.4 versicolor
## 78   78          6.7         3.0          5.0         1.7 versicolor
## 79   79          6.0         2.9          4.5         1.5 versicolor
## 80   80          5.7         2.6          3.5         1.0 versicolor
## 81   81          5.5         2.4          3.8         1.1 versicolor
## 82   82          5.5         2.4          3.7         1.0 versicolor
## 83   83          5.8         2.7          3.9         1.2 versicolor
## 84   84          6.0         2.7          5.1         1.6 versicolor
## 85   85          5.4         3.0          4.5         1.5 versicolor
## 86   86          6.0         3.4          4.5         1.6 versicolor
## 87   87          6.7         3.1          4.7         1.5 versicolor
## 88   88          6.3         2.3          4.4         1.3 versicolor
## 89   89          5.6         3.0          4.1         1.3 versicolor
## 90   90          5.5         2.5          4.0         1.3 versicolor
```

```
## 91   91          5.5         2.6          4.4         1.2 versicolor
## 92   92          6.1         3.0          4.6         1.4 versicolor
## 93   93          5.8         2.6          4.0         1.2 versicolor
## 94   94          5.0         2.3          3.3         1.0 versicolor
## 95   95          5.6         2.7          4.2         1.3 versicolor
## 96   96          5.7         3.0          4.2         1.2 versicolor
## 97   97          5.7         2.9          4.2         1.3 versicolor
## 98   98          6.2         2.9          4.3         1.3 versicolor
## 99   99          5.1         2.5          3.0         1.1 versicolor
## 100 100          5.7         2.8          4.1         1.3 versicolor
## 101 101          6.3         3.3          6.0         2.5  virginica
## 102 102          5.8         2.7          5.1         1.9  virginica
## 103 103          7.1         3.0          5.9         2.1  virginica
## 104 104          6.3         2.9          5.6         1.8  virginica
## 105 105          6.5         3.0          5.8         2.2  virginica
## 106 106          7.6         3.0          6.6         2.1  virginica
## 107 107          4.9         2.5          4.5         1.7  virginica
## 108 108          7.3         2.9          6.3         1.8  virginica
## 109 109          6.7         2.5          5.8         1.8  virginica
## 110 110          7.2         3.6          6.1         2.5  virginica
## 111 111          6.5         3.2          5.1         2.0  virginica
## 112 112          6.4         2.7          5.3         1.9  virginica
## 113 113          6.8         3.0          5.5         2.1  virginica
## 114 114          5.7         2.5          5.0         2.0  virginica
## 115 115          5.8         2.8          5.1         2.4  virginica
## 116 116          6.4         3.2          5.3         2.3  virginica
## 117 117          6.5         3.0          5.5         1.8  virginica
## 118 118          7.7         3.8          6.7         2.2  virginica
## 119 119          7.7         2.6          6.9         2.3  virginica
## 120 120          6.0         2.2          5.0         1.5  virginica
## 121 121          6.9         3.2          5.7         2.3  virginica
## 122 122          5.6         2.8          4.9         2.0  virginica
## 123 123          7.7         2.8          6.7         2.0  virginica
## 124 124          6.3         2.7          4.9         1.8  virginica
## 125 125          6.7         3.3          5.7         2.1  virginica
## 126 126          7.2         3.2          6.0         1.8  virginica
## 127 127          6.2         2.8          4.8         1.8  virginica
## 128 128          6.1         3.0          4.9         1.8  virginica
## 129 129          6.4         2.8          5.6         2.1  virginica
## 130 130          7.2         3.0          5.8         1.6  virginica
## 131 131          7.4         2.8          6.1         1.9  virginica
## 132 132          7.9         3.8          6.4         2.0  virginica
## 133 133          6.4         2.8          5.6         2.2  virginica
## 134 134          6.3         2.8          5.1         1.5  virginica
## 135 135          6.1         2.6          5.6         1.4  virginica
## 136 136          7.7         3.0          6.1         2.3  virginica
## 137 137          6.3         3.4          5.6         2.4  virginica
## 138 138          6.4         3.1          5.5         1.8  virginica
## 139 139          6.0         3.0          4.8         1.8  virginica
## 140 140          6.9         3.1          5.4         2.1  virginica
## 141 141          6.7         3.1          5.6         2.4  virginica
## 142 142          6.9         3.1          5.1         2.3  virginica
## 143 143          5.8         2.7          5.1         1.9  virginica
## 144 144          6.8         3.2          5.9         2.3  virginica
```

```
## 145 145          6.7         3.3          5.7         2.5  virginica
## 146 146          6.7         3.0          5.2         2.3  virginica
## 147 147          6.3         2.5          5.0         1.9  virginica
## 148 148          6.5         3.0          5.2         2.0  virginica
## 149 149          6.2         3.4          5.4         2.3  virginica
## 150 150          5.9         3.0          5.1         1.8  virginica
```

```
# We used class to see how our object was structured e.g. vectors, matrices, dataframes. When working w
```

```
str(irisdata)
```

```
## 'data.frame':    150 obs. of  6 variables:
##  $ X           : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Sepal.Length: num  5.1 4.9 4.7 4.6 5 5.4 4.6 5 4.4 4.9 ...
##  $ Sepal.Width : num  3.5 3 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1 ...
##  $ Petal.Length: num  1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 ...
##  $ Petal.Width : num  0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1 ...
##  $ Species     : Factor w/ 3 levels "setosa","versicolor",..: 1 1 1 1 1 1 1 1 1 1 ...
```

```
head(irisdata)
```

```
##   X Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1 1          5.1         3.5          1.4         0.2  setosa
## 2 2          4.9         3.0          1.4         0.2  setosa
## 3 3          4.7         3.2          1.3         0.2  setosa
## 4 4          4.6         3.1          1.5         0.2  setosa
## 5 5          5.0         3.6          1.4         0.2  setosa
## 6 6          5.4         3.9          1.7         0.4  setosa
```

```
tail(irisdata)
```

```
##       X Sepal.Length Sepal.Width Petal.Length Petal.Width   Species
## 145 145          6.7         3.3          5.7         2.5 virginica
## 146 146          6.7         3.0          5.2         2.3 virginica
## 147 147          6.3         2.5          5.0         1.9 virginica
## 148 148          6.5         3.0          5.2         2.0 virginica
## 149 149          6.2         3.4          5.4         2.3 virginica
## 150 150          5.9         3.0          5.1         1.8 virginica
```

Why using .csv instead of Excel sheets (.xls and .xlsx)?

2. We can easily call some summary stats now.

```
summary(irisdata)
```

```
##        X           Sepal.Length    Sepal.Width     Petal.Length
##  Min.   :  1.00   Min.   :4.300   Min.   :2.000   Min.   :1.000
##  1st Qu.: 38.25   1st Qu.:5.100   1st Qu.:2.800   1st Qu.:1.600
##  Median : 75.50   Median :5.800   Median :3.000   Median :4.350
```

```
##  Mean   : 75.50   Mean   :5.843   Mean   :3.057   Mean   :3.758
##  3rd Qu.:112.75   3rd Qu.:6.400   3rd Qu.:3.300   3rd Qu.:5.100
##  Max.   :150.00   Max.   :7.900   Max.   :4.400   Max.   :6.900
##   Petal.Width          Species
##  Min.   :0.100   setosa    :50
##  1st Qu.:0.300   versicolor:50
##  Median :1.300   virginica :50
##  Mean   :1.199
##  3rd Qu.:1.800
##  Max.   :2.500
```

3. We can also access specific values in this dataset. For vectors, matrices and dataframes we can use "[]", and the "$" is useful only for dataframes. If we use "[]" then we must think of it like this: [rows,columns]

```
irisdata[,1] # all values in column 1
```

```
##   [1]   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17
##  [18]  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34
##  [35]  35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51
##  [52]  52  53  54  55  56  57  58  59  60  61  62  63  64  65  66  67  68
##  [69]  69  70  71  72  73  74  75  76  77  78  79  80  81  82  83  84  85
##  [86]  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100 101 102
## [103] 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119
## [120] 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136
## [137] 137 138 139 140 141 142 143 144 145 146 147 148 149 150
```

```
irisdata[1,1] # value at row 1, column 1
```

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

```
irisdata[,1:3] # all values in columns 1 to 3
```

```
##       X Sepal.Length Sepal.Width
## 1     1          5.1         3.5
## 2     2          4.9         3.0
## 3     3          4.7         3.2
## 4     4          4.6         3.1
## 5     5          5.0         3.6
## 6     6          5.4         3.9
## 7     7          4.6         3.4
## 8     8          5.0         3.4
## 9     9          4.4         2.9
## 10   10          4.9         3.1
## 11   11          5.4         3.7
## 12   12          4.8         3.4
## 13   13          4.8         3.0
## 14   14          4.3         3.0
## 15   15          5.8         4.0
## 16   16          5.7         4.4
## 17   17          5.4         3.9
## 18   18          5.1         3.5
```

```
## 19   19          5.7         3.8
## 20   20          5.1         3.8
## 21   21          5.4         3.4
## 22   22          5.1         3.7
## 23   23          4.6         3.6
## 24   24          5.1         3.3
## 25   25          4.8         3.4
## 26   26          5.0         3.0
## 27   27          5.0         3.4
## 28   28          5.2         3.5
## 29   29          5.2         3.4
## 30   30          4.7         3.2
## 31   31          4.8         3.1
## 32   32          5.4         3.4
## 33   33          5.2         4.1
## 34   34          5.5         4.2
## 35   35          4.9         3.1
## 36   36          5.0         3.2
## 37   37          5.5         3.5
## 38   38          4.9         3.6
## 39   39          4.4         3.0
## 40   40          5.1         3.4
## 41   41          5.0         3.5
## 42   42          4.5         2.3
## 43   43          4.4         3.2
## 44   44          5.0         3.5
## 45   45          5.1         3.8
## 46   46          4.8         3.0
## 47   47          5.1         3.8
## 48   48          4.6         3.2
## 49   49          5.3         3.7
## 50   50          5.0         3.3
## 51   51          7.0         3.2
## 52   52          6.4         3.2
## 53   53          6.9         3.1
## 54   54          5.5         2.3
## 55   55          6.5         2.8
## 56   56          5.7         2.8
## 57   57          6.3         3.3
## 58   58          4.9         2.4
## 59   59          6.6         2.9
## 60   60          5.2         2.7
## 61   61          5.0         2.0
## 62   62          5.9         3.0
## 63   63          6.0         2.2
## 64   64          6.1         2.9
## 65   65          5.6         2.9
## 66   66          6.7         3.1
## 67   67          5.6         3.0
## 68   68          5.8         2.7
## 69   69          6.2         2.2
## 70   70          5.6         2.5
## 71   71          5.9         3.2
## 72   72          6.1         2.8
```

```
## 73   73          6.3         2.5
## 74   74          6.1         2.8
## 75   75          6.4         2.9
## 76   76          6.6         3.0
## 77   77          6.8         2.8
## 78   78          6.7         3.0
## 79   79          6.0         2.9
## 80   80          5.7         2.6
## 81   81          5.5         2.4
## 82   82          5.5         2.4
## 83   83          5.8         2.7
## 84   84          6.0         2.7
## 85   85          5.4         3.0
## 86   86          6.0         3.4
## 87   87          6.7         3.1
## 88   88          6.3         2.3
## 89   89          5.6         3.0
## 90   90          5.5         2.5
## 91   91          5.5         2.6
## 92   92          6.1         3.0
## 93   93          5.8         2.6
## 94   94          5.0         2.3
## 95   95          5.6         2.7
## 96   96          5.7         3.0
## 97   97          5.7         2.9
## 98   98          6.2         2.9
## 99   99          5.1         2.5
## 100 100          5.7         2.8
## 101 101          6.3         3.3
## 102 102          5.8         2.7
## 103 103          7.1         3.0
## 104 104          6.3         2.9
## 105 105          6.5         3.0
## 106 106          7.6         3.0
## 107 107          4.9         2.5
## 108 108          7.3         2.9
## 109 109          6.7         2.5
## 110 110          7.2         3.6
## 111 111          6.5         3.2
## 112 112          6.4         2.7
## 113 113          6.8         3.0
## 114 114          5.7         2.5
## 115 115          5.8         2.8
## 116 116          6.4         3.2
## 117 117          6.5         3.0
## 118 118          7.7         3.8
## 119 119          7.7         2.6
## 120 120          6.0         2.2
## 121 121          6.9         3.2
## 122 122          5.6         2.8
## 123 123          7.7         2.8
## 124 124          6.3         2.7
## 125 125          6.7         3.3
## 126 126          7.2         3.2
```

```
## 127 127          6.2         2.8
## 128 128          6.1         3.0
## 129 129          6.4         2.8
## 130 130          7.2         3.0
## 131 131          7.4         2.8
## 132 132          7.9         3.8
## 133 133          6.4         2.8
## 134 134          6.3         2.8
## 135 135          6.1         2.6
## 136 136          7.7         3.0
## 137 137          6.3         3.4
## 138 138          6.4         3.1
## 139 139          6.0         3.0
## 140 140          6.9         3.1
## 141 141          6.7         3.1
## 142 142          6.9         3.1
## 143 143          5.8         2.7
## 144 144          6.8         3.2
## 145 145          6.7         3.3
## 146 146          6.7         3.0
## 147 147          6.3         2.5
## 148 148          6.5         3.0
## 149 149          6.2         3.4
## 150 150          5.9         3.0
```

```
irisdata[c(1,3,5), c(4,6)] # value at row 1, 3, and 5, column 4 and 6
```

```
##   Petal.Length Species
## 1          1.4  setosa
## 3          1.3  setosa
## 5          1.4  setosa
```

```
irisdata['Species'] # all values in column with column name 'Species'
```

```
##        Species
## 1       setosa
## 2       setosa
## 3       setosa
## 4       setosa
## 5       setosa
## 6       setosa
## 7       setosa
## 8       setosa
## 9       setosa
## 10      setosa
## 11      setosa
## 12      setosa
## 13      setosa
## 14      setosa
## 15      setosa
## 16      setosa
## 17      setosa
## 18      setosa
```

```
## 19      setosa
## 20      setosa
## 21      setosa
## 22      setosa
## 23      setosa
## 24      setosa
## 25      setosa
## 26      setosa
## 27      setosa
## 28      setosa
## 29      setosa
## 30      setosa
## 31      setosa
## 32      setosa
## 33      setosa
## 34      setosa
## 35      setosa
## 36      setosa
## 37      setosa
## 38      setosa
## 39      setosa
## 40      setosa
## 41      setosa
## 42      setosa
## 43      setosa
## 44      setosa
## 45      setosa
## 46      setosa
## 47      setosa
## 48      setosa
## 49      setosa
## 50      setosa
## 51  versicolor
## 52  versicolor
## 53  versicolor
## 54  versicolor
## 55  versicolor
## 56  versicolor
## 57  versicolor
## 58  versicolor
## 59  versicolor
## 60  versicolor
## 61  versicolor
## 62  versicolor
## 63  versicolor
## 64  versicolor
## 65  versicolor
## 66  versicolor
## 67  versicolor
## 68  versicolor
## 69  versicolor
## 70  versicolor
## 71  versicolor
## 72  versicolor
```

```
## 73  versicolor
## 74  versicolor
## 75  versicolor
## 76  versicolor
## 77  versicolor
## 78  versicolor
## 79  versicolor
## 80  versicolor
## 81  versicolor
## 82  versicolor
## 83  versicolor
## 84  versicolor
## 85  versicolor
## 86  versicolor
## 87  versicolor
## 88  versicolor
## 89  versicolor
## 90  versicolor
## 91  versicolor
## 92  versicolor
## 93  versicolor
## 94  versicolor
## 95  versicolor
## 96  versicolor
## 97  versicolor
## 98  versicolor
## 99  versicolor
## 100 versicolor
## 101  virginica
## 102  virginica
## 103  virginica
## 104  virginica
## 105  virginica
## 106  virginica
## 107  virginica
## 108  virginica
## 109  virginica
## 110  virginica
## 111  virginica
## 112  virginica
## 113  virginica
## 114  virginica
## 115  virginica
## 116  virginica
## 117  virginica
## 118  virginica
## 119  virginica
## 120  virginica
## 121  virginica
## 122  virginica
## 123  virginica
## 124  virginica
## 125  virginica
## 126  virginica
```

```
## 127  virginica
## 128  virginica
## 129  virginica
## 130  virginica
## 131  virginica
## 132  virginica
## 133  virginica
## 134  virginica
## 135  virginica
## 136  virginica
## 137  virginica
## 138  virginica
## 139  virginica
## 140  virginica
## 141  virginica
## 142  virginica
## 143  virginica
## 144  virginica
## 145  virginica
## 146  virginica
## 147  virginica
## 148  virginica
## 149  virginica
## 150  virginica
```

```
irisdata$Sepal.Length # all values in column with column name 'Sepal.length'
```

```
##   [1] 5.1 4.9 4.7 4.6 5.0 5.4 4.6 5.0 4.4 4.9 5.4 4.8 4.8 4.3 5.8 5.7 5.4
##  [18] 5.1 5.7 5.1 5.4 5.1 4.6 5.1 4.8 5.0 5.0 5.2 5.2 4.7 4.8 5.4 5.2 5.5
##  [35] 4.9 5.0 5.5 4.9 4.4 5.1 5.0 4.5 4.4 5.0 5.1 4.8 5.1 4.6 5.3 5.0 7.0
##  [52] 6.4 6.9 5.5 6.5 5.7 6.3 4.9 6.6 5.2 5.0 5.9 6.0 6.1 5.6 6.7 5.6 5.8
##  [69] 6.2 5.6 5.9 6.1 6.3 6.1 6.4 6.6 6.8 6.7 6.0 5.7 5.5 5.5 5.8 6.0 5.4
##  [86] 6.0 6.7 6.3 5.6 5.5 5.5 6.1 5.8 5.0 5.6 5.7 5.7 6.2 5.1 5.7 6.3 5.8
## [103] 7.1 6.3 6.5 7.6 4.9 7.3 6.7 7.2 6.5 6.4 6.8 5.7 5.8 6.4 6.5 7.7 7.7
## [120] 6.0 6.9 5.6 7.7 6.3 6.7 7.2 6.2 6.1 6.4 7.2 7.4 7.9 6.4 6.3 6.1 7.7
## [137] 6.3 6.4 6.0 6.9 6.7 6.9 5.8 6.8 6.7 6.7 6.3 6.5 6.2 5.9
```

```
#as.matrix(irisdata)$Sepal.Length

# this won't work, atomic vectors = (logical, integer, double (sometimes called numeric), and character

# this will work
as.matrix(irisdata)
```

```
##        X     Sepal.Length Sepal.Width Petal.Length Petal.Width
##   [1,] "  1" "5.1"        "3.5"       "1.4"        "0.2"
##   [2,] "  2" "4.9"        "3.0"       "1.4"        "0.2"
##   [3,] "  3" "4.7"        "3.2"       "1.3"        "0.2"
##   [4,] "  4" "4.6"        "3.1"       "1.5"        "0.2"
##   [5,] "  5" "5.0"        "3.6"       "1.4"        "0.2"
##   [6,] "  6" "5.4"        "3.9"       "1.7"        "0.4"
##   [7,] "  7" "4.6"        "3.4"       "1.4"        "0.3"
##   [8,] "  8" "5.0"        "3.4"       "1.5"        "0.2"
```

```
##   [9,] "  9" "4.4"       "2.9"       "1.4"       "0.2"
##  [10,] " 10" "4.9"       "3.1"       "1.5"       "0.1"
##  [11,] " 11" "5.4"       "3.7"       "1.5"       "0.2"
##  [12,] " 12" "4.8"       "3.4"       "1.6"       "0.2"
##  [13,] " 13" "4.8"       "3.0"       "1.4"       "0.1"
##  [14,] " 14" "4.3"       "3.0"       "1.1"       "0.1"
##  [15,] " 15" "5.8"       "4.0"       "1.2"       "0.2"
##  [16,] " 16" "5.7"       "4.4"       "1.5"       "0.4"
##  [17,] " 17" "5.4"       "3.9"       "1.3"       "0.4"
##  [18,] " 18" "5.1"       "3.5"       "1.4"       "0.3"
##  [19,] " 19" "5.7"       "3.8"       "1.7"       "0.3"
##  [20,] " 20" "5.1"       "3.8"       "1.5"       "0.3"
##  [21,] " 21" "5.4"       "3.4"       "1.7"       "0.2"
##  [22,] " 22" "5.1"       "3.7"       "1.5"       "0.4"
##  [23,] " 23" "4.6"       "3.6"       "1.0"       "0.2"
##  [24,] " 24" "5.1"       "3.3"       "1.7"       "0.5"
##  [25,] " 25" "4.8"       "3.4"       "1.9"       "0.2"
##  [26,] " 26" "5.0"       "3.0"       "1.6"       "0.2"
##  [27,] " 27" "5.0"       "3.4"       "1.6"       "0.4"
##  [28,] " 28" "5.2"       "3.5"       "1.5"       "0.2"
##  [29,] " 29" "5.2"       "3.4"       "1.4"       "0.2"
##  [30,] " 30" "4.7"       "3.2"       "1.6"       "0.2"
##  [31,] " 31" "4.8"       "3.1"       "1.6"       "0.2"
##  [32,] " 32" "5.4"       "3.4"       "1.5"       "0.4"
##  [33,] " 33" "5.2"       "4.1"       "1.5"       "0.1"
##  [34,] " 34" "5.5"       "4.2"       "1.4"       "0.2"
##  [35,] " 35" "4.9"       "3.1"       "1.5"       "0.2"
##  [36,] " 36" "5.0"       "3.2"       "1.2"       "0.2"
##  [37,] " 37" "5.5"       "3.5"       "1.3"       "0.2"
##  [38,] " 38" "4.9"       "3.6"       "1.4"       "0.1"
##  [39,] " 39" "4.4"       "3.0"       "1.3"       "0.2"
##  [40,] " 40" "5.1"       "3.4"       "1.5"       "0.2"
##  [41,] " 41" "5.0"       "3.5"       "1.3"       "0.3"
##  [42,] " 42" "4.5"       "2.3"       "1.3"       "0.3"
##  [43,] " 43" "4.4"       "3.2"       "1.3"       "0.2"
##  [44,] " 44" "5.0"       "3.5"       "1.6"       "0.6"
##  [45,] " 45" "5.1"       "3.8"       "1.9"       "0.4"
##  [46,] " 46" "4.8"       "3.0"       "1.4"       "0.3"
##  [47,] " 47" "5.1"       "3.8"       "1.6"       "0.2"
##  [48,] " 48" "4.6"       "3.2"       "1.4"       "0.2"
##  [49,] " 49" "5.3"       "3.7"       "1.5"       "0.2"
##  [50,] " 50" "5.0"       "3.3"       "1.4"       "0.2"
##  [51,] " 51" "7.0"       "3.2"       "4.7"       "1.4"
##  [52,] " 52" "6.4"       "3.2"       "4.5"       "1.5"
##  [53,] " 53" "6.9"       "3.1"       "4.9"       "1.5"
##  [54,] " 54" "5.5"       "2.3"       "4.0"       "1.3"
##  [55,] " 55" "6.5"       "2.8"       "4.6"       "1.5"
##  [56,] " 56" "5.7"       "2.8"       "4.5"       "1.3"
##  [57,] " 57" "6.3"       "3.3"       "4.7"       "1.6"
##  [58,] " 58" "4.9"       "2.4"       "3.3"       "1.0"
##  [59,] " 59" "6.6"       "2.9"       "4.6"       "1.3"
##  [60,] " 60" "5.2"       "2.7"       "3.9"       "1.4"
##  [61,] " 61" "5.0"       "2.0"       "3.5"       "1.0"
##  [62,] " 62" "5.9"       "3.0"       "4.2"       "1.5"
```

```
##  [63,] " 63" "6.0"        "2.2"       "4.0"       "1.0"
##  [64,] " 64" "6.1"        "2.9"       "4.7"       "1.4"
##  [65,] " 65" "5.6"        "2.9"       "3.6"       "1.3"
##  [66,] " 66" "6.7"        "3.1"       "4.4"       "1.4"
##  [67,] " 67" "5.6"        "3.0"       "4.5"       "1.5"
##  [68,] " 68" "5.8"        "2.7"       "4.1"       "1.0"
##  [69,] " 69" "6.2"        "2.2"       "4.5"       "1.5"
##  [70,] " 70" "5.6"        "2.5"       "3.9"       "1.1"
##  [71,] " 71" "5.9"        "3.2"       "4.8"       "1.8"
##  [72,] " 72" "6.1"        "2.8"       "4.0"       "1.3"
##  [73,] " 73" "6.3"        "2.5"       "4.9"       "1.5"
##  [74,] " 74" "6.1"        "2.8"       "4.7"       "1.2"
##  [75,] " 75" "6.4"        "2.9"       "4.3"       "1.3"
##  [76,] " 76" "6.6"        "3.0"       "4.4"       "1.4"
##  [77,] " 77" "6.8"        "2.8"       "4.8"       "1.4"
##  [78,] " 78" "6.7"        "3.0"       "5.0"       "1.7"
##  [79,] " 79" "6.0"        "2.9"       "4.5"       "1.5"
##  [80,] " 80" "5.7"        "2.6"       "3.5"       "1.0"
##  [81,] " 81" "5.5"        "2.4"       "3.8"       "1.1"
##  [82,] " 82" "5.5"        "2.4"       "3.7"       "1.0"
##  [83,] " 83" "5.8"        "2.7"       "3.9"       "1.2"
##  [84,] " 84" "6.0"        "2.7"       "5.1"       "1.6"
##  [85,] " 85" "5.4"        "3.0"       "4.5"       "1.5"
##  [86,] " 86" "6.0"        "3.4"       "4.5"       "1.6"
##  [87,] " 87" "6.7"        "3.1"       "4.7"       "1.5"
##  [88,] " 88" "6.3"        "2.3"       "4.4"       "1.3"
##  [89,] " 89" "5.6"        "3.0"       "4.1"       "1.3"
##  [90,] " 90" "5.5"        "2.5"       "4.0"       "1.3"
##  [91,] " 91" "5.5"        "2.6"       "4.4"       "1.2"
##  [92,] " 92" "6.1"        "3.0"       "4.6"       "1.4"
##  [93,] " 93" "5.8"        "2.6"       "4.0"       "1.2"
##  [94,] " 94" "5.0"        "2.3"       "3.3"       "1.0"
##  [95,] " 95" "5.6"        "2.7"       "4.2"       "1.3"
##  [96,] " 96" "5.7"        "3.0"       "4.2"       "1.2"
##  [97,] " 97" "5.7"        "2.9"       "4.2"       "1.3"
##  [98,] " 98" "6.2"        "2.9"       "4.3"       "1.3"
##  [99,] " 99" "5.1"        "2.5"       "3.0"       "1.1"
## [100,] "100" "5.7"        "2.8"       "4.1"       "1.3"
## [101,] "101" "6.3"        "3.3"       "6.0"       "2.5"
## [102,] "102" "5.8"        "2.7"       "5.1"       "1.9"
## [103,] "103" "7.1"        "3.0"       "5.9"       "2.1"
## [104,] "104" "6.3"        "2.9"       "5.6"       "1.8"
## [105,] "105" "6.5"        "3.0"       "5.8"       "2.2"
## [106,] "106" "7.6"        "3.0"       "6.6"       "2.1"
## [107,] "107" "4.9"        "2.5"       "4.5"       "1.7"
## [108,] "108" "7.3"        "2.9"       "6.3"       "1.8"
## [109,] "109" "6.7"        "2.5"       "5.8"       "1.8"
## [110,] "110" "7.2"        "3.6"       "6.1"       "2.5"
## [111,] "111" "6.5"        "3.2"       "5.1"       "2.0"
## [112,] "112" "6.4"        "2.7"       "5.3"       "1.9"
## [113,] "113" "6.8"        "3.0"       "5.5"       "2.1"
## [114,] "114" "5.7"        "2.5"       "5.0"       "2.0"
## [115,] "115" "5.8"        "2.8"       "5.1"       "2.4"
## [116,] "116" "6.4"        "3.2"       "5.3"       "2.3"
```

```
## [117,] "117" "6.5"        "3.0"       "5.5"        "1.8"
## [118,] "118" "7.7"        "3.8"       "6.7"        "2.2"
## [119,] "119" "7.7"        "2.6"       "6.9"        "2.3"
## [120,] "120" "6.0"        "2.2"       "5.0"        "1.5"
## [121,] "121" "6.9"        "3.2"       "5.7"        "2.3"
## [122,] "122" "5.6"        "2.8"       "4.9"        "2.0"
## [123,] "123" "7.7"        "2.8"       "6.7"        "2.0"
## [124,] "124" "6.3"        "2.7"       "4.9"        "1.8"
## [125,] "125" "6.7"        "3.3"       "5.7"        "2.1"
## [126,] "126" "7.2"        "3.2"       "6.0"        "1.8"
## [127,] "127" "6.2"        "2.8"       "4.8"        "1.8"
## [128,] "128" "6.1"        "3.0"       "4.9"        "1.8"
## [129,] "129" "6.4"        "2.8"       "5.6"        "2.1"
## [130,] "130" "7.2"        "3.0"       "5.8"        "1.6"
## [131,] "131" "7.4"        "2.8"       "6.1"        "1.9"
## [132,] "132" "7.9"        "3.8"       "6.4"        "2.0"
## [133,] "133" "6.4"        "2.8"       "5.6"        "2.2"
## [134,] "134" "6.3"        "2.8"       "5.1"        "1.5"
## [135,] "135" "6.1"        "2.6"       "5.6"        "1.4"
## [136,] "136" "7.7"        "3.0"       "6.1"        "2.3"
## [137,] "137" "6.3"        "3.4"       "5.6"        "2.4"
## [138,] "138" "6.4"        "3.1"       "5.5"        "1.8"
## [139,] "139" "6.0"        "3.0"       "4.8"        "1.8"
## [140,] "140" "6.9"        "3.1"       "5.4"        "2.1"
## [141,] "141" "6.7"        "3.1"       "5.6"        "2.4"
## [142,] "142" "6.9"        "3.1"       "5.1"        "2.3"
## [143,] "143" "5.8"        "2.7"       "5.1"        "1.9"
## [144,] "144" "6.8"        "3.2"       "5.9"        "2.3"
## [145,] "145" "6.7"        "3.3"       "5.7"        "2.5"
## [146,] "146" "6.7"        "3.0"       "5.2"        "2.3"
## [147,] "147" "6.3"        "2.5"       "5.0"        "1.9"
## [148,] "148" "6.5"        "3.0"       "5.2"        "2.0"
## [149,] "149" "6.2"        "3.4"       "5.4"        "2.3"
## [150,] "150" "5.9"        "3.0"       "5.1"        "1.8"
##        Species
##   [1,] "setosa"
##   [2,] "setosa"
##   [3,] "setosa"
##   [4,] "setosa"
##   [5,] "setosa"
##   [6,] "setosa"
##   [7,] "setosa"
##   [8,] "setosa"
##   [9,] "setosa"
##  [10,] "setosa"
##  [11,] "setosa"
##  [12,] "setosa"
##  [13,] "setosa"
##  [14,] "setosa"
##  [15,] "setosa"
##  [16,] "setosa"
##  [17,] "setosa"
##  [18,] "setosa"
##  [19,] "setosa"
```

```
##  [20,] "setosa"
##  [21,] "setosa"
##  [22,] "setosa"
##  [23,] "setosa"
##  [24,] "setosa"
##  [25,] "setosa"
##  [26,] "setosa"
##  [27,] "setosa"
##  [28,] "setosa"
##  [29,] "setosa"
##  [30,] "setosa"
##  [31,] "setosa"
##  [32,] "setosa"
##  [33,] "setosa"
##  [34,] "setosa"
##  [35,] "setosa"
##  [36,] "setosa"
##  [37,] "setosa"
##  [38,] "setosa"
##  [39,] "setosa"
##  [40,] "setosa"
##  [41,] "setosa"
##  [42,] "setosa"
##  [43,] "setosa"
##  [44,] "setosa"
##  [45,] "setosa"
##  [46,] "setosa"
##  [47,] "setosa"
##  [48,] "setosa"
##  [49,] "setosa"
##  [50,] "setosa"
##  [51,] "versicolor"
##  [52,] "versicolor"
##  [53,] "versicolor"
##  [54,] "versicolor"
##  [55,] "versicolor"
##  [56,] "versicolor"
##  [57,] "versicolor"
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##  [66,] "versicolor"
##  [67,] "versicolor"
##  [68,] "versicolor"
##  [69,] "versicolor"
##  [70,] "versicolor"
##  [71,] "versicolor"
##  [72,] "versicolor"
##  [73,] "versicolor"
```

```
##  [74,] "versicolor"
##  [75,] "versicolor"
##  [76,] "versicolor"
##  [77,] "versicolor"
##  [78,] "versicolor"
##  [79,] "versicolor"
##  [80,] "versicolor"
##  [81,] "versicolor"
##  [82,] "versicolor"
##  [83,] "versicolor"
##  [84,] "versicolor"
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##  [89,] "versicolor"
##  [90,] "versicolor"
##  [91,] "versicolor"
##  [92,] "versicolor"
##  [93,] "versicolor"
##  [94,] "versicolor"
##  [95,] "versicolor"
##  [96,] "versicolor"
##  [97,] "versicolor"
##  [98,] "versicolor"
##  [99,] "versicolor"
## [100,] "versicolor"
## [101,] "virginica"
## [102,] "virginica"
## [103,] "virginica"
## [104,] "virginica"
## [105,] "virginica"
## [106,] "virginica"
## [107,] "virginica"
## [108,] "virginica"
## [109,] "virginica"
## [110,] "virginica"
## [111,] "virginica"
## [112,] "virginica"
## [113,] "virginica"
## [114,] "virginica"
## [115,] "virginica"
## [116,] "virginica"
## [117,] "virginica"
## [118,] "virginica"
## [119,] "virginica"
## [120,] "virginica"
## [121,] "virginica"
## [122,] "virginica"
## [123,] "virginica"
## [124,] "virginica"
## [125,] "virginica"
## [126,] "virginica"
## [127,] "virginica"
```

```
## [128,] "virginica"
## [129,] "virginica"
## [130,] "virginica"
## [131,] "virginica"
## [132,] "virginica"
## [133,] "virginica"
## [134,] "virginica"
## [135,] "virginica"
## [136,] "virginica"
## [137,] "virginica"
## [138,] "virginica"
## [139,] "virginica"
## [140,] "virginica"
## [141,] "virginica"
## [142,] "virginica"
## [143,] "virginica"
## [144,] "virginica"
## [145,] "virginica"
## [146,] "virginica"
## [147,] "virginica"
## [148,] "virginica"
## [149,] "virginica"
## [150,] "virginica"
```

```
# why won't this run?

# irisdata[1, 1:7] # first row only of values in columns 1 to 7

# fixed

irisdata[1, 1:6]
```

```
##   X Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1 1          5.1         3.5          1.4         0.2  setosa
```

```
dim(irisdata) #shows dimensions
```

```
## [1] 150   6
```

What is the X column in irisdata?

```
irisdata
```

```
##       X Sepal.Length Sepal.Width Petal.Length Petal.Width    Species
## 1     1          5.1         3.5          1.4         0.2     setosa
## 2     2          4.9         3.0          1.4         0.2     setosa
## 3     3          4.7         3.2          1.3         0.2     setosa
## 4     4          4.6         3.1          1.5         0.2     setosa
## 5     5          5.0         3.6          1.4         0.2     setosa
## 6     6          5.4         3.9          1.7         0.4     setosa
```

```
## 7     7          4.6         3.4          1.4         0.3     setosa
## 8     8          5.0         3.4          1.5         0.2     setosa
## 9     9          4.4         2.9          1.4         0.2     setosa
## 10   10          4.9         3.1          1.5         0.1     setosa
## 11   11          5.4         3.7          1.5         0.2     setosa
## 12   12          4.8         3.4          1.6         0.2     setosa
## 13   13          4.8         3.0          1.4         0.1     setosa
## 14   14          4.3         3.0          1.1         0.1     setosa
## 15   15          5.8         4.0          1.2         0.2     setosa
## 16   16          5.7         4.4          1.5         0.4     setosa
## 17   17          5.4         3.9          1.3         0.4     setosa
## 18   18          5.1         3.5          1.4         0.3     setosa
## 19   19          5.7         3.8          1.7         0.3     setosa
## 20   20          5.1         3.8          1.5         0.3     setosa
## 21   21          5.4         3.4          1.7         0.2     setosa
## 22   22          5.1         3.7          1.5         0.4     setosa
## 23   23          4.6         3.6          1.0         0.2     setosa
## 24   24          5.1         3.3          1.7         0.5     setosa
## 25   25          4.8         3.4          1.9         0.2     setosa
## 26   26          5.0         3.0          1.6         0.2     setosa
## 27   27          5.0         3.4          1.6         0.4     setosa
## 28   28          5.2         3.5          1.5         0.2     setosa
## 29   29          5.2         3.4          1.4         0.2     setosa
## 30   30          4.7         3.2          1.6         0.2     setosa
## 31   31          4.8         3.1          1.6         0.2     setosa
## 32   32          5.4         3.4          1.5         0.4     setosa
## 33   33          5.2         4.1          1.5         0.1     setosa
## 34   34          5.5         4.2          1.4         0.2     setosa
## 35   35          4.9         3.1          1.5         0.2     setosa
## 36   36          5.0         3.2          1.2         0.2     setosa
## 37   37          5.5         3.5          1.3         0.2     setosa
## 38   38          4.9         3.6          1.4         0.1     setosa
## 39   39          4.4         3.0          1.3         0.2     setosa
## 40   40          5.1         3.4          1.5         0.2     setosa
## 41   41          5.0         3.5          1.3         0.3     setosa
## 42   42          4.5         2.3          1.3         0.3     setosa
## 43   43          4.4         3.2          1.3         0.2     setosa
## 44   44          5.0         3.5          1.6         0.6     setosa
## 45   45          5.1         3.8          1.9         0.4     setosa
## 46   46          4.8         3.0          1.4         0.3     setosa
## 47   47          5.1         3.8          1.6         0.2     setosa
## 48   48          4.6         3.2          1.4         0.2     setosa
## 49   49          5.3         3.7          1.5         0.2     setosa
## 50   50          5.0         3.3          1.4         0.2     setosa
## 51   51          7.0         3.2          4.7         1.4 versicolor
## 52   52          6.4         3.2          4.5         1.5 versicolor
## 53   53          6.9         3.1          4.9         1.5 versicolor
## 54   54          5.5         2.3          4.0         1.3 versicolor
## 55   55          6.5         2.8          4.6         1.5 versicolor
## 56   56          5.7         2.8          4.5         1.3 versicolor
## 57   57          6.3         3.3          4.7         1.6 versicolor
## 58   58          4.9         2.4          3.3         1.0 versicolor
## 59   59          6.6         2.9          4.6         1.3 versicolor
## 60   60          5.2         2.7          3.9         1.4 versicolor
```

```
## 61   61          5.0         2.0          3.5         1.0 versicolor
## 62   62          5.9         3.0          4.2         1.5 versicolor
## 63   63          6.0         2.2          4.0         1.0 versicolor
## 64   64          6.1         2.9          4.7         1.4 versicolor
## 65   65          5.6         2.9          3.6         1.3 versicolor
## 66   66          6.7         3.1          4.4         1.4 versicolor
## 67   67          5.6         3.0          4.5         1.5 versicolor
## 68   68          5.8         2.7          4.1         1.0 versicolor
## 69   69          6.2         2.2          4.5         1.5 versicolor
## 70   70          5.6         2.5          3.9         1.1 versicolor
## 71   71          5.9         3.2          4.8         1.8 versicolor
## 72   72          6.1         2.8          4.0         1.3 versicolor
## 73   73          6.3         2.5          4.9         1.5 versicolor
## 74   74          6.1         2.8          4.7         1.2 versicolor
## 75   75          6.4         2.9          4.3         1.3 versicolor
## 76   76          6.6         3.0          4.4         1.4 versicolor
## 77   77          6.8         2.8          4.8         1.4 versicolor
## 78   78          6.7         3.0          5.0         1.7 versicolor
## 79   79          6.0         2.9          4.5         1.5 versicolor
## 80   80          5.7         2.6          3.5         1.0 versicolor
## 81   81          5.5         2.4          3.8         1.1 versicolor
## 82   82          5.5         2.4          3.7         1.0 versicolor
## 83   83          5.8         2.7          3.9         1.2 versicolor
## 84   84          6.0         2.7          5.1         1.6 versicolor
## 85   85          5.4         3.0          4.5         1.5 versicolor
## 86   86          6.0         3.4          4.5         1.6 versicolor
## 87   87          6.7         3.1          4.7         1.5 versicolor
## 88   88          6.3         2.3          4.4         1.3 versicolor
## 89   89          5.6         3.0          4.1         1.3 versicolor
## 90   90          5.5         2.5          4.0         1.3 versicolor
## 91   91          5.5         2.6          4.4         1.2 versicolor
## 92   92          6.1         3.0          4.6         1.4 versicolor
## 93   93          5.8         2.6          4.0         1.2 versicolor
## 94   94          5.0         2.3          3.3         1.0 versicolor
## 95   95          5.6         2.7          4.2         1.3 versicolor
## 96   96          5.7         3.0          4.2         1.2 versicolor
## 97   97          5.7         2.9          4.2         1.3 versicolor
## 98   98          6.2         2.9          4.3         1.3 versicolor
## 99   99          5.1         2.5          3.0         1.1 versicolor
## 100 100          5.7         2.8          4.1         1.3 versicolor
## 101 101          6.3         3.3          6.0         2.5  virginica
## 102 102          5.8         2.7          5.1         1.9  virginica
## 103 103          7.1         3.0          5.9         2.1  virginica
## 104 104          6.3         2.9          5.6         1.8  virginica
## 105 105          6.5         3.0          5.8         2.2  virginica
## 106 106          7.6         3.0          6.6         2.1  virginica
## 107 107          4.9         2.5          4.5         1.7  virginica
## 108 108          7.3         2.9          6.3         1.8  virginica
## 109 109          6.7         2.5          5.8         1.8  virginica
## 110 110          7.2         3.6          6.1         2.5  virginica
## 111 111          6.5         3.2          5.1         2.0  virginica
## 112 112          6.4         2.7          5.3         1.9  virginica
## 113 113          6.8         3.0          5.5         2.1  virginica
## 114 114          5.7         2.5          5.0         2.0  virginica
```

```
## 115 115          5.8         2.8          5.1         2.4  virginica
## 116 116          6.4         3.2          5.3         2.3  virginica
## 117 117          6.5         3.0          5.5         1.8  virginica
## 118 118          7.7         3.8          6.7         2.2  virginica
## 119 119          7.7         2.6          6.9         2.3  virginica
## 120 120          6.0         2.2          5.0         1.5  virginica
## 121 121          6.9         3.2          5.7         2.3  virginica
## 122 122          5.6         2.8          4.9         2.0  virginica
## 123 123          7.7         2.8          6.7         2.0  virginica
## 124 124          6.3         2.7          4.9         1.8  virginica
## 125 125          6.7         3.3          5.7         2.1  virginica
## 126 126          7.2         3.2          6.0         1.8  virginica
## 127 127          6.2         2.8          4.8         1.8  virginica
## 128 128          6.1         3.0          4.9         1.8  virginica
## 129 129          6.4         2.8          5.6         2.1  virginica
## 130 130          7.2         3.0          5.8         1.6  virginica
## 131 131          7.4         2.8          6.1         1.9  virginica
## 132 132          7.9         3.8          6.4         2.0  virginica
## 133 133          6.4         2.8          5.6         2.2  virginica
## 134 134          6.3         2.8          5.1         1.5  virginica
## 135 135          6.1         2.6          5.6         1.4  virginica
## 136 136          7.7         3.0          6.1         2.3  virginica
## 137 137          6.3         3.4          5.6         2.4  virginica
## 138 138          6.4         3.1          5.5         1.8  virginica
## 139 139          6.0         3.0          4.8         1.8  virginica
## 140 140          6.9         3.1          5.4         2.1  virginica
## 141 141          6.7         3.1          5.6         2.4  virginica
## 142 142          6.9         3.1          5.1         2.3  virginica
## 143 143          5.8         2.7          5.1         1.9  virginica
## 144 144          6.8         3.2          5.9         2.3  virginica
## 145 145          6.7         3.3          5.7         2.5  virginica
## 146 146          6.7         3.0          5.2         2.3  virginica
## 147 147          6.3         2.5          5.0         1.9  virginica
## 148 148          6.5         3.0          5.2         2.0  virginica
## 149 149          6.2         3.4          5.4         2.3  virginica
## 150 150          5.9         3.0          5.1         1.8  virginica
```

We can remove the X column by accessing only values from columns 2 to 6

```
irisdata[,2:6]
```

```
##     Sepal.Length Sepal.Width Petal.Length Petal.Width    Species
## 1            5.1         3.5          1.4         0.2     setosa
## 2            4.9         3.0          1.4         0.2     setosa
## 3            4.7         3.2          1.3         0.2     setosa
## 4            4.6         3.1          1.5         0.2     setosa
## 5            5.0         3.6          1.4         0.2     setosa
## 6            5.4         3.9          1.7         0.4     setosa
## 7            4.6         3.4          1.4         0.3     setosa
## 8            5.0         3.4          1.5         0.2     setosa
```

```
## 9          4.4         2.9          1.4         0.2     setosa
## 10         4.9         3.1          1.5         0.1     setosa
## 11         5.4         3.7          1.5         0.2     setosa
## 12         4.8         3.4          1.6         0.2     setosa
## 13         4.8         3.0          1.4         0.1     setosa
## 14         4.3         3.0          1.1         0.1     setosa
## 15         5.8         4.0          1.2         0.2     setosa
## 16         5.7         4.4          1.5         0.4     setosa
## 17         5.4         3.9          1.3         0.4     setosa
## 18         5.1         3.5          1.4         0.3     setosa
## 19         5.7         3.8          1.7         0.3     setosa
## 20         5.1         3.8          1.5         0.3     setosa
## 21         5.4         3.4          1.7         0.2     setosa
## 22         5.1         3.7          1.5         0.4     setosa
## 23         4.6         3.6          1.0         0.2     setosa
## 24         5.1         3.3          1.7         0.5     setosa
## 25         4.8         3.4          1.9         0.2     setosa
## 26         5.0         3.0          1.6         0.2     setosa
## 27         5.0         3.4          1.6         0.4     setosa
## 28         5.2         3.5          1.5         0.2     setosa
## 29         5.2         3.4          1.4         0.2     setosa
## 30         4.7         3.2          1.6         0.2     setosa
## 31         4.8         3.1          1.6         0.2     setosa
## 32         5.4         3.4          1.5         0.4     setosa
## 33         5.2         4.1          1.5         0.1     setosa
## 34         5.5         4.2          1.4         0.2     setosa
## 35         4.9         3.1          1.5         0.2     setosa
## 36         5.0         3.2          1.2         0.2     setosa
## 37         5.5         3.5          1.3         0.2     setosa
## 38         4.9         3.6          1.4         0.1     setosa
## 39         4.4         3.0          1.3         0.2     setosa
## 40         5.1         3.4          1.5         0.2     setosa
## 41         5.0         3.5          1.3         0.3     setosa
## 42         4.5         2.3          1.3         0.3     setosa
## 43         4.4         3.2          1.3         0.2     setosa
## 44         5.0         3.5          1.6         0.6     setosa
## 45         5.1         3.8          1.9         0.4     setosa
## 46         4.8         3.0          1.4         0.3     setosa
## 47         5.1         3.8          1.6         0.2     setosa
## 48         4.6         3.2          1.4         0.2     setosa
## 49         5.3         3.7          1.5         0.2     setosa
## 50         5.0         3.3          1.4         0.2     setosa
## 51         7.0         3.2          4.7         1.4 versicolor
## 52         6.4         3.2          4.5         1.5 versicolor
## 53         6.9         3.1          4.9         1.5 versicolor
## 54         5.5         2.3          4.0         1.3 versicolor
## 55         6.5         2.8          4.6         1.5 versicolor
## 56         5.7         2.8          4.5         1.3 versicolor
## 57         6.3         3.3          4.7         1.6 versicolor
## 58         4.9         2.4          3.3         1.0 versicolor
## 59         6.6         2.9          4.6         1.3 versicolor
## 60         5.2         2.7          3.9         1.4 versicolor
## 61         5.0         2.0          3.5         1.0 versicolor
## 62         5.9         3.0          4.2         1.5 versicolor
```

```
## 63          6.0         2.2          4.0         1.0 versicolor
## 64          6.1         2.9          4.7         1.4 versicolor
## 65          5.6         2.9          3.6         1.3 versicolor
## 66          6.7         3.1          4.4         1.4 versicolor
## 67          5.6         3.0          4.5         1.5 versicolor
## 68          5.8         2.7          4.1         1.0 versicolor
## 69          6.2         2.2          4.5         1.5 versicolor
## 70          5.6         2.5          3.9         1.1 versicolor
## 71          5.9         3.2          4.8         1.8 versicolor
## 72          6.1         2.8          4.0         1.3 versicolor
## 73          6.3         2.5          4.9         1.5 versicolor
## 74          6.1         2.8          4.7         1.2 versicolor
## 75          6.4         2.9          4.3         1.3 versicolor
## 76          6.6         3.0          4.4         1.4 versicolor
## 77          6.8         2.8          4.8         1.4 versicolor
## 78          6.7         3.0          5.0         1.7 versicolor
## 79          6.0         2.9          4.5         1.5 versicolor
## 80          5.7         2.6          3.5         1.0 versicolor
## 81          5.5         2.4          3.8         1.1 versicolor
## 82          5.5         2.4          3.7         1.0 versicolor
## 83          5.8         2.7          3.9         1.2 versicolor
## 84          6.0         2.7          5.1         1.6 versicolor
## 85          5.4         3.0          4.5         1.5 versicolor
## 86          6.0         3.4          4.5         1.6 versicolor
## 87          6.7         3.1          4.7         1.5 versicolor
## 88          6.3         2.3          4.4         1.3 versicolor
## 89          5.6         3.0          4.1         1.3 versicolor
## 90          5.5         2.5          4.0         1.3 versicolor
## 91          5.5         2.6          4.4         1.2 versicolor
## 92          6.1         3.0          4.6         1.4 versicolor
## 93          5.8         2.6          4.0         1.2 versicolor
## 94          5.0         2.3          3.3         1.0 versicolor
## 95          5.6         2.7          4.2         1.3 versicolor
## 96          5.7         3.0          4.2         1.2 versicolor
## 97          5.7         2.9          4.2         1.3 versicolor
## 98          6.2         2.9          4.3         1.3 versicolor
## 99          5.1         2.5          3.0         1.1 versicolor
## 100         5.7         2.8          4.1         1.3 versicolor
## 101         6.3         3.3          6.0         2.5  virginica
## 102         5.8         2.7          5.1         1.9  virginica
## 103         7.1         3.0          5.9         2.1  virginica
## 104         6.3         2.9          5.6         1.8  virginica
## 105         6.5         3.0          5.8         2.2  virginica
## 106         7.6         3.0          6.6         2.1  virginica
## 107         4.9         2.5          4.5         1.7  virginica
## 108         7.3         2.9          6.3         1.8  virginica
## 109         6.7         2.5          5.8         1.8  virginica
## 110         7.2         3.6          6.1         2.5  virginica
## 111         6.5         3.2          5.1         2.0  virginica
## 112         6.4         2.7          5.3         1.9  virginica
## 113         6.8         3.0          5.5         2.1  virginica
## 114         5.7         2.5          5.0         2.0  virginica
## 115         5.8         2.8          5.1         2.4  virginica
## 116         6.4         3.2          5.3         2.3  virginica
```

```
## 117          6.5         3.0          5.5         1.8  virginica
## 118          7.7         3.8          6.7         2.2  virginica
## 119          7.7         2.6          6.9         2.3  virginica
## 120          6.0         2.2          5.0         1.5  virginica
## 121          6.9         3.2          5.7         2.3  virginica
## 122          5.6         2.8          4.9         2.0  virginica
## 123          7.7         2.8          6.7         2.0  virginica
## 124          6.3         2.7          4.9         1.8  virginica
## 125          6.7         3.3          5.7         2.1  virginica
## 126          7.2         3.2          6.0         1.8  virginica
## 127          6.2         2.8          4.8         1.8  virginica
## 128          6.1         3.0          4.9         1.8  virginica
## 129          6.4         2.8          5.6         2.1  virginica
## 130          7.2         3.0          5.8         1.6  virginica
## 131          7.4         2.8          6.1         1.9  virginica
## 132          7.9         3.8          6.4         2.0  virginica
## 133          6.4         2.8          5.6         2.2  virginica
## 134          6.3         2.8          5.1         1.5  virginica
## 135          6.1         2.6          5.6         1.4  virginica
## 136          7.7         3.0          6.1         2.3  virginica
## 137          6.3         3.4          5.6         2.4  virginica
## 138          6.4         3.1          5.5         1.8  virginica
## 139          6.0         3.0          4.8         1.8  virginica
## 140          6.9         3.1          5.4         2.1  virginica
## 141          6.7         3.1          5.6         2.4  virginica
## 142          6.9         3.1          5.1         2.3  virginica
## 143          5.8         2.7          5.1         1.9  virginica
## 144          6.8         3.2          5.9         2.3  virginica
## 145          6.7         3.3          5.7         2.5  virginica
## 146          6.7         3.0          5.2         2.3  virginica
## 147          6.3         2.5          5.0         1.9  virginica
## 148          6.5         3.0          5.2         2.0  virginica
## 149          6.2         3.4          5.4         2.3  virginica
## 150          5.9         3.0          5.1         1.8  virginica
```

There is another way to do this by selecting the column we would like to remove using a minus "-"

Give this a go below and assign it to the object called iris_without_rownames

```
iris_without_rownames <- irisdata[,-1]
```

```
head(iris_without_rownames)
```

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1          5.1         3.5          1.4         0.2  setosa
## 2          4.9         3.0          1.4         0.2  setosa
## 3          4.7         3.2          1.3         0.2  setosa
## 4          4.6         3.1          1.5         0.2  setosa
```

```
## 5          5.0         3.6          1.4         0.2  setosa
## 6          5.4         3.9          1.7         0.4  setosa
```

4. If we make any changes to our data, we can save our new data in a spreadsheet.

```
write.csv(irisdata, 'output/new_irisdata.csv', row.names=FALSE) # Why am I using row.names=FALSE?
write.csv(irisdata, 'output/new_irisdata_incl_rownames.csv')
```

Nice! We have learned a lot about manipulating data so far! Use R cheat sheets (just google R cheatsheets) to look up all those functions over and over again!

Last part! Our first data analysis!

1. Now we want to read in a new dataset called PlantGrowth.csv found in the input folder. Give this a go your yourself!

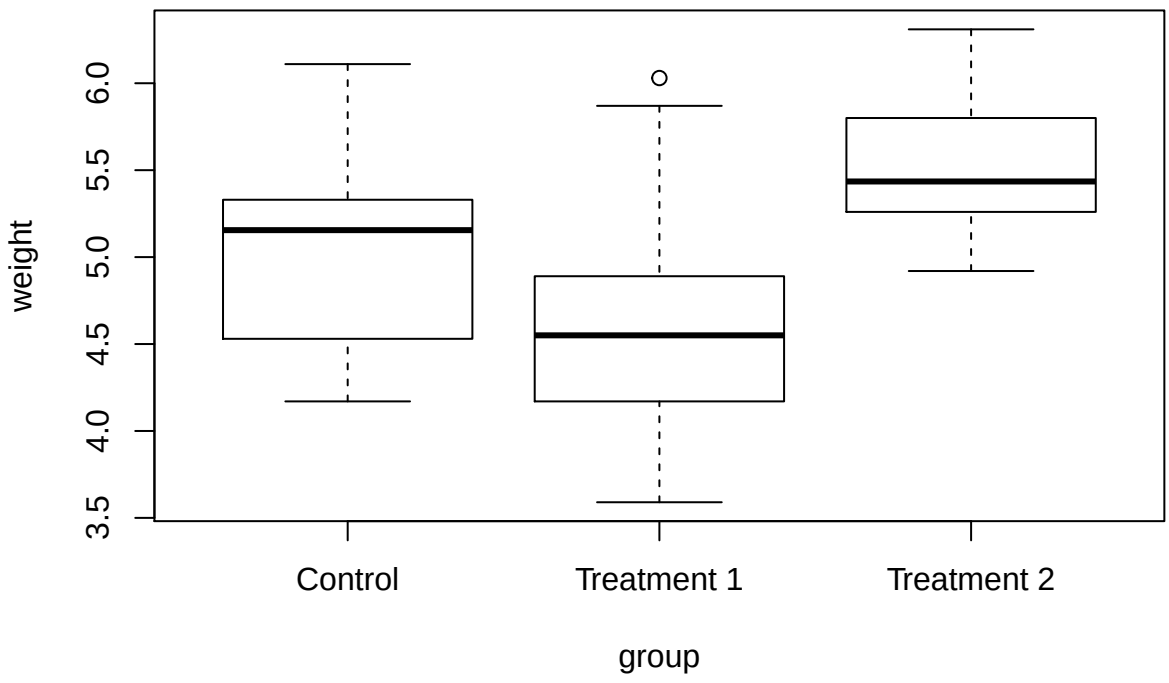
```
plant.df <- read.csv("input/PlantGrowth.csv")
```

2. Clean the data up a bit and specify that the group is a factor variable.

```
plant.df$group <- factor(plant.df$group,
  labels = c("Control", "Treatment 1", "Treatment 2"))
```

3. Visualise our data with a boxplot.

```
boxplot(weight~group, plant.df)
```



4. Create a folder to store the results.

```
# this line can be different for Mac users
dir.create("output/plots")
```

```
## Warning in dir.create("output/plots"): 'output\plots' already exists
```

And save it as a .pdf file in the output folder.

```
pdf('output/My Boxplot.pdf', width = 20, height = 10 , paper = 'a4r')
boxplot(weight~group, plant.df, ylab='Dried weight of plants [g]')
dev.off()
```

```
## pdf
##   2
```

4. Start statistical analysis. This is a simple linear model with an ANOVA.

```
plant.mod1 <- lm(weight ~ group, data = plant.df) # we're using lm() to create a pretty different objec
summary(plant.mod1) # summary() extracts some of this data and prints it out neatly for us
```

```
##
## Call:
## lm(formula = weight ~ group, data = plant.df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.0710 -0.4180 -0.0060  0.2627  1.3690
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)        5.0320     0.1971  25.527   <2e-16 ***
## groupTreatment 1  -0.3710     0.2788  -1.331   0.1944
## groupTreatment 2   0.4940     0.2788   1.772   0.0877 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6234 on 27 degrees of freedom
## Multiple R-squared:  0.2641, Adjusted R-squared:  0.2096
## F-statistic: 4.846 on 2 and 27 DF,  p-value: 0.01591
```

- We're using lm() to create a pretty different object called a list, which has lots of data in it, organised in a defined structure.
- Variable on the left-hand side of a tilde (~) (weight) is the dependent variable, while the right-hand side are the independent variables

```
anova(plant.mod1)
```

```
## Analysis of Variance Table
##
```

```
## Response: weight
##           Df  Sum Sq Mean Sq F value  Pr(>F)
## group      2  3.7663  1.8832  4.8461 0.01591 *
## Residuals 27 10.4921  0.3886
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
class(weight ~ group) # this is our formula
```

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

```
plant.mod1
```

```
##
## Call:
## lm(formula = weight ~ group, data = plant.df)
##
## Coefficients:
##      (Intercept)  groupTreatment 1  groupTreatment 2
##            5.032            -0.371             0.494
```

```
anova(plant.mod1)
```

```
## Analysis of Variance Table
##
## Response: weight
##           Df  Sum Sq Mean Sq F value  Pr(>F)
## group      2  3.7663  1.8832  4.8461 0.01591 *
## Residuals 27 10.4921  0.3886
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
names(plant.mod1)
```

```
##  [1] "coefficients"  "residuals"     "effects"       "rank"
##  [5] "fitted.values" "assign"        "qr"            "df.residual"
##  [9] "contrasts"     "xlevels"       "call"          "terms"
## [13] "model"
```

```
plant.mod1$coefficients
```

```
##      (Intercept) groupTreatment 1 groupTreatment 2
##            5.032           -0.371            0.494
```

5. There are hundreds of packages in R that have ready functions for us to use. All you need to do is look up which package you need, install it and load it into R.

```
# function to use an improved read.csv function

#install.packages('readr') #install
library(readr) #load
```

Now all we have to do is use a function within the newly loaded package!

```
irisdata <- read.csv("input/irisdata.csv") #old

irisdata <- read_csv("input/irisdata.csv") #new
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

```
## Parsed with column specification:
## cols(
##   X1 = col_double(),
##   Sepal.Length = col_double(),
##   Sepal.Width = col_double(),
##   Petal.Length = col_double(),
##   Petal.Width = col_double(),
##   Species = col_character()
## )
```

```
irisdata
```

```
## # A tibble: 150 x 6
##       X1 Sepal.Length Sepal.Width Petal.Length Petal.Width Species
##    <dbl>        <dbl>       <dbl>        <dbl>       <dbl> <chr>
##  1     1          5.1         3.5          1.4         0.2 setosa
##  2     2          4.9         3            1.4         0.2 setosa
##  3     3          4.7         3.2          1.3         0.2 setosa
##  4     4          4.6         3.1          1.5         0.2 setosa
##  5     5          5           3.6          1.4         0.2 setosa
##  6     6          5.4         3.9          1.7         0.4 setosa
##  7     7          4.6         3.4          1.4         0.3 setosa
##  8     8          5           3.4          1.5         0.2 setosa
##  9     9          4.4         2.9          1.4         0.2 setosa
## 10    10          4.9         3.1          1.5         0.1 setosa
## # ... with 140 more rows
```

More Information

Resources to learn R coding * Book A Beginner's Guide to R (Use R!) - Alain Zuur, Elena Ieno and Eric Meesters * Package (Swirl)

Resources to learn plotting with R Base Graphics * R Graph Cookbook - Hrishi V. Mittal

Resources to learn plotting with ggplot2 * ggplot2 (Use R!) - Hadley Wickham

Resources to learn data manipulation in R * Data manipulation with R (Use R!) - Phil Spector

Resources to learn stats in R * Introductory statistics with R (Use R!) - Peter Dalgaard

What we have learned

- Get familiar with R Studio and the differences to R
- How to import and export data in R?
- What do projects and setwd() have in common and what is its purpose?

- How to manipulate data?
- Your first data analysis
- How to proceed on your own