Introduction to Coding in R: Data Frames

Ellen Bledsoe

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2-Dimensional Data in R

Student Learning Outcomes

- Students will be able to describe the relationship between vectors and data frames
- Students will be able to do the following in the R language:
  - explore and describe data frames
  - filter specific values from data frames
  - calculate descriptive statistics from data frames
  - make histograms

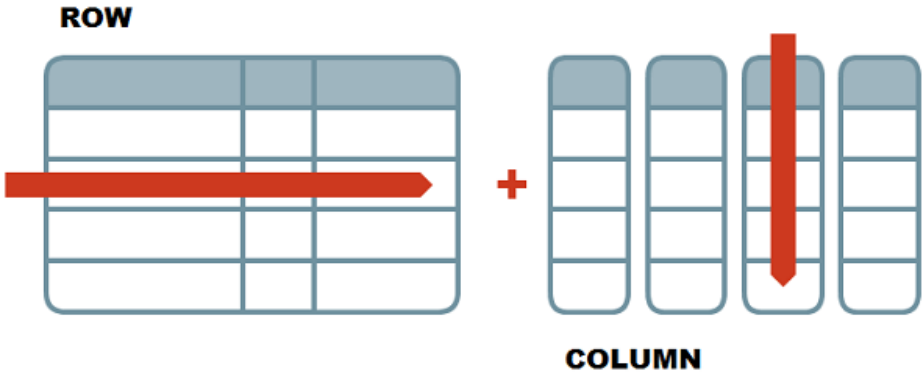
Working with Data Frames

In our previous lesson, we learned how to run lines of code, create objects using the assignment arrow, and work with 1-dimensional data objects called vectors.

Most of the data we work with, however, is two-dimensional data (i.e., has columns and rows). Its structure resembles a spreadsheet.

As a friendly reminder:

- **rows** go side-to-side
- **columns** go up-and-down



The R language is really good at working with 2-dimensional data objects. In R, we refer to them as data frames.

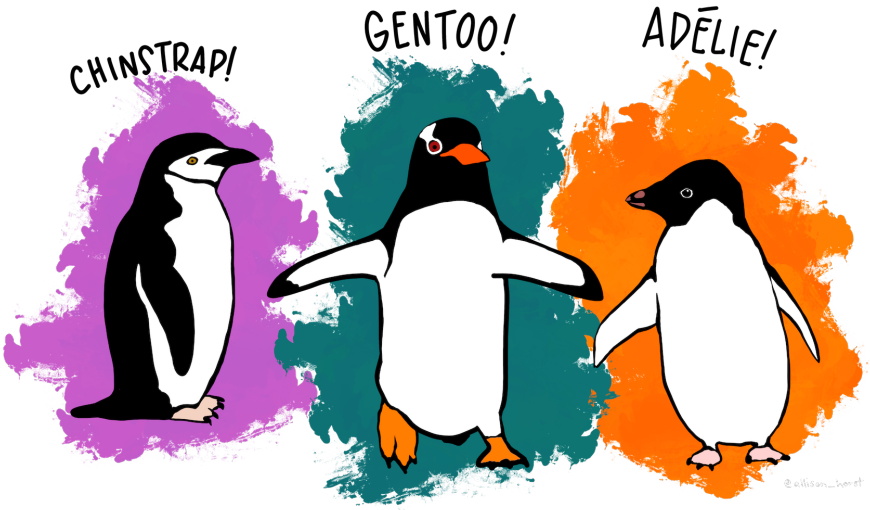
Data frames are made up of multiple vectors. Each vector becomes a column in a data frame.

Set Up

To explore data frames, we are going to use a package called `palmerpenguins`.

A package is a bunch of pre-written bit of code (usually functions) form of functions, which we can bring into R and use.

In this case, we are using a data package, which loads data into R that we can use. This is real data from penguins in Antarctica! You can learn more about the `palmerpenguins` package and data here.



Installing a Package

The first time that you want to use a certain package, you need to "install" the package, meaning download the contents of the package from the internet into your work space.

I have already installed the `palmerpenguins` package into this Posit Cloud project, so you do not need to install it. I've included the code here for future reference, if you need it.

```
# code for installing a package from the internet ONLY FOR FUTURE REFERENCE
# install.packages("palmerpenguins")
# to run the line of code above, remove the # symbol
```

Loading a Package

Although we have installed the package, we aren't ready to use it yet. Every time (for us, every new project) we want to use something from a package, we need to tell RStudio that we want to use it. We will need to do that every time we open Posit Cloud.

We do this through a function called `library()`.

```
library(palmerpenguins)
```

```
##
## Attaching package: 'palmerpenguins'

## The following objects are masked from 'package:datasets':
##
```

```
##     penguins, penguins_raw
```

Exploring the Penguin Data

Let's take a look at our data. The data we are using is in a data frame called `penguins`.

```
penguins
```

```
## # A tibble: 344 x 8
##    species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##    <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
##  1 Adelie  Torgersen           39.1          18.7               181        3750
##  2 Adelie  Torgersen           39.5          17.4               186        3800
##  3 Adelie  Torgersen           40.3          18                 195        3250
##  4 Adelie  Torgersen           NA            NA                  NA          NA
##  5 Adelie  Torgersen           36.7          19.3               193        3450
##  6 Adelie  Torgersen           39.3          20.6               190        3650
##  7 Adelie  Torgersen           38.9          17.8               181        3625
##  8 Adelie  Torgersen           39.2          19.6               195        4675
##  9 Adelie  Torgersen           34.1          18.1               193        3475
## 10 Adelie  Torgersen           42            20.2               190        4250
## # i 334 more rows
## # i 2 more variables: sex <fct>, year <int>
```

A quirk about using data that we've loaded in through a package instead of directly reading in data from a `.csv` file is that the data frame will not show up in our environment unless we specifically tell it to.

```
penguins <- penguins
```

Functions

As with vectors, there are many functions that are useful for taking a look at data frames. Many of the ones that work with vectors also work with data frames. Here are a few of the ones I find very helpful.

```
head(penguins)         # first 6 rows
```

```
## # A tibble: 6 x 8
##   species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##   <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
## 1 Adelie  Torgersen           39.1          18.7               181        3750
## 2 Adelie  Torgersen           39.5          17.4               186        3800
## 3 Adelie  Torgersen           40.3          18                 195        3250
## 4 Adelie  Torgersen           NA            NA                  NA          NA
## 5 Adelie  Torgersen           36.7          19.3               193        3450
## 6 Adelie  Torgersen           39.3          20.6               190        3650
## # i 2 more variables: sex <fct>, year <int>
```

```
head(penguins, n = 10) # can specify how many rows with an additional argument
```

```
## # A tibble: 10 x 8
##    species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##    <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
##  1 Adelie  Torgersen           39.1          18.7               181        3750
##  2 Adelie  Torgersen           39.5          17.4               186        3800
##  3 Adelie  Torgersen           40.3          18                 195        3250
##  4 Adelie  Torgersen           NA            NA                  NA          NA
##  5 Adelie  Torgersen           36.7          19.3               193        3450
```

```
##  6 Adelie  Torgersen           39.3          20.6               190        3650
##  7 Adelie  Torgersen           38.9          17.8               181        3625
##  8 Adelie  Torgersen           39.2          19.6               195        4675
##  9 Adelie  Torgersen           34.1          18.1               193        3475
## 10 Adelie  Torgersen           42            20.2               190        4250
## # i 2 more variables: sex <fct>, year <int>
```

```
tail(penguins)         # last 6 rows
```

```
## # A tibble: 6 x 8
##   species   island bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##   <fct>     <fct>           <dbl>         <dbl>             <int>       <int>
## 1 Chinstrap Dream            45.7          17                 195        3650
## 2 Chinstrap Dream            55.8          19.8               207        4000
## 3 Chinstrap Dream            43.5          18.1               202        3400
## 4 Chinstrap Dream            49.6          18.2               193        3775
## 5 Chinstrap Dream            50.8          19                 210        4100
## 6 Chinstrap Dream            50.2          18.7               198        3775
## # i 2 more variables: sex <fct>, year <int>
```

```
str(penguins)   # structure of the object
```

```
## tibble [344 x 8] (S3: tbl_df/tbl/data.frame)
##  $ species          : Factor w/ 3 levels "Adelie","Chinstrap",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ island           : Factor w/ 3 levels "Biscoe","Dream",..: 3 3 3 3 3 3 3 3 3 3 ...
##  $ bill_length_mm   : num [1:344] 39.1 39.5 40.3 NA 36.7 39.3 38.9 39.2 34.1 42 ...
##  $ bill_depth_mm    : num [1:344] 18.7 17.4 18 NA 19.3 20.6 17.8 19.6 18.1 20.2 ...
##  $ flipper_length_mm: int [1:344] 181 186 195 NA 193 190 181 195 193 190 ...
##  $ body_mass_g      : int [1:344] 3750 3800 3250 NA 3450 3650 3625 4675 3475 4250 ...
##  $ sex              : Factor w/ 2 levels "female","male": 2 1 1 NA 1 2 1 2 NA NA ...
##  $ year             : int [1:344] 2007 2007 2007 2007 2007 2007 2007 2007 2007 2007 ...
```

```
nrow(penguins)  # number of rows
```

```
## [1] 344
```

```
ncol(penguins)  # number of columns
```

```
## [1] 8
```

```
names(penguins) # same as colnames(penguins) in a data frame
```

```
## [1] "species"           "island"            "bill_length_mm"
## [4] "bill_depth_mm"     "flipper_length_mm" "body_mass_g"
## [7] "sex"               "year"
```

Sub-setting

When sub-setting data frames, we need to now specify 2 locations, the row and the column. In R, it is always row *then* column. The general structure looks like this:

`dataframe[rows, cols]`

Note that this pattern (rows, columns) is the opposite of how spreadsheets typically describe locations.

As with vectors, there are two ways by which we can subset data: (1) by index and (2) by condition.

Sub-setting by Index

```
# vectors are 1 dimension, so we only need to specify one location
# data frames are 2-dimensional (rows, columns), so we have to specify 2 different locations

penguins[1:10, c(2,3)]
```

```
## # A tibble: 10 x 2
##    island    bill_length_mm
##    <fct>              <dbl>
##  1 Torgersen           39.1
##  2 Torgersen           39.5
##  3 Torgersen           40.3
##  4 Torgersen           NA
##  5 Torgersen           36.7
##  6 Torgersen           39.3
##  7 Torgersen           38.9
##  8 Torgersen           39.2
##  9 Torgersen           34.1
## 10 Torgersen           42
```

```
penguins[1:10, ]
```

```
## # A tibble: 10 x 8
##    species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##    <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
##  1 Adelie  Torgersen           39.1          18.7               181        3750
##  2 Adelie  Torgersen           39.5          17.4               186        3800
##  3 Adelie  Torgersen           40.3          18                 195        3250
##  4 Adelie  Torgersen           NA            NA                  NA          NA
##  5 Adelie  Torgersen           36.7          19.3               193        3450
##  6 Adelie  Torgersen           39.3          20.6               190        3650
##  7 Adelie  Torgersen           38.9          17.8               181        3625
##  8 Adelie  Torgersen           39.2          19.6               195        4675
##  9 Adelie  Torgersen           34.1          18.1               193        3475
## 10 Adelie  Torgersen           42            20.2               190        4250
## # i 2 more variables: sex <fct>, year <int>
```

```
penguins[ , c(1:4)]
```

```
## # A tibble: 344 x 4
##    species island    bill_length_mm bill_depth_mm
##    <fct>   <fct>              <dbl>         <dbl>
##  1 Adelie  Torgersen           39.1          18.7
##  2 Adelie  Torgersen           39.5          17.4
##  3 Adelie  Torgersen           40.3          18
##  4 Adelie  Torgersen           NA            NA
##  5 Adelie  Torgersen           36.7          19.3
##  6 Adelie  Torgersen           39.3          20.6
##  7 Adelie  Torgersen           38.9          17.8
##  8 Adelie  Torgersen           39.2          19.6
##  9 Adelie  Torgersen           34.1          18.1
## 10 Adelie  Torgersen           42            20.2
## # i 334 more rows
```

Selecting an Individual Column

Often, we want to select a specific column to perform calculations on or to plot. We can do this via sub-setting, though the result is a data frame with 1 column, not a vector.

To select one column to treat as a vector, we can use the $ operator.

```
# with sub-setting by index
penguins[ ,1]    # requires position and creates a data frame with 1 column
```

```
## # A tibble: 344 x 1
##    species
##    <fct>
##  1 Adelie
##  2 Adelie
##  3 Adelie
##  4 Adelie
##  5 Adelie
##  6 Adelie
##  7 Adelie
##  8 Adelie
##  9 Adelie
## 10 Adelie
## # i 334 more rows
```

```
# sub-setting with $
penguins$species  # pulling out 1 column by name, as a vector
```

```
##   [1] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##   [8] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [15] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [22] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [29] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [36] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [43] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [50] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [57] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [64] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [71] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [78] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [85] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [92] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
##  [99] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [106] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [113] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [120] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [127] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [134] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [141] Adelie    Adelie    Adelie    Adelie    Adelie    Adelie    Adelie
## [148] Adelie    Adelie    Adelie    Adelie    Adelie    Gentoo    Gentoo
## [155] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [162] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [169] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [176] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [183] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [190] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
```

```
## [197] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [204] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [211] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [218] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [225] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [232] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [239] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [246] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [253] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [260] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [267] Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo    Gentoo
## [274] Gentoo    Gentoo    Gentoo    Chinstrap Chinstrap Chinstrap Chinstrap
## [281] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [288] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [295] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [302] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [309] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [316] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [323] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [330] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [337] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap
## [344] Chinstrap
## Levels: Adelie Chinstrap Gentoo
```

```r
unique(penguins$species) # we can then place the vector inside of a function
```

```
## [1] Adelie    Gentoo    Chinstrap
## Levels: Adelie Chinstrap Gentoo
```

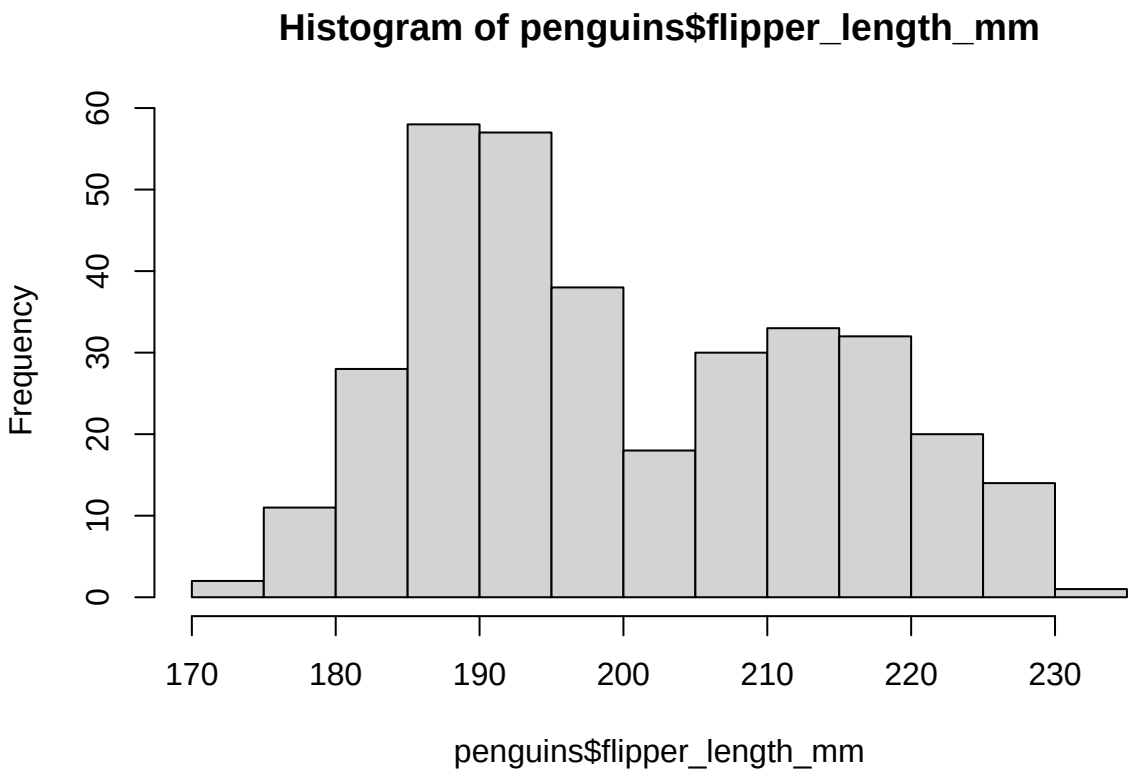
```r
# we can save single columns as vectors with the assignment operator
flipper_lenght_mm <- penguins$flipper_length_mm
```

Using the `$` is a great way to quickly make plots with your data or do calculations.

Histograms

Let's plot a histogram with the flipper length data.

```r
# Plot a histogram
hist(penguins$flipper_length_mm) # same as hist(flipper_length_mm) from above
```



Calculations

We can also perform calculations on these vectors, such as calculating measures of central tendency and measures of dispersion.

```
mean(penguins$flipper_length_mm)
```

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

Hmm. . . that is an odd value. We know that there are numbers in the `flipper_length_mm` column, so why is it returning a "missing" value of `NA`?

Let's look at the help page for the `mean()` function.

The `mean()` function has a few arguments with default settings, one of them being the `na.rm` argument. This determines whether or not the function includes `NA` values in the calculation.

In order to remove the `NA` values (and, therefore, the `NA` result), we need to change the default to the following: `na.rm = TRUE`. This will *remove* `NA` values from the calculation.

```
mean(penguins$flipper_length_mm, na.rm = TRUE)
```

```
## [1] 200.9152
```

Other functions where this might be necessary include the `median()`, `mode()`, `min()`, `max()`, and `sd()` functions.

Sub-setting by Condition

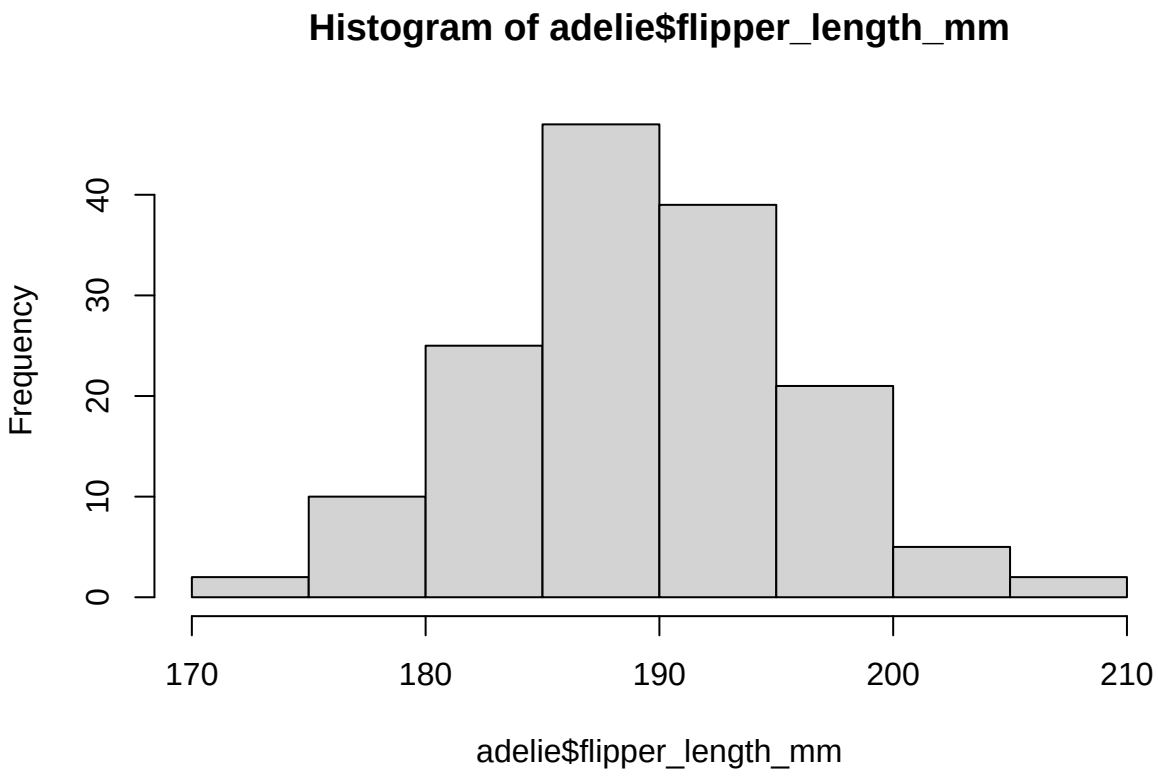
As with vectors, we can write conditional statements to select specific observations, which are typically the rows in the data frame.

When setting a condition for which observations to retain, you can think about the process as selecting which rows to keep based on whether or not that row has a specified value in a certain column.

```
# create a new data frame with only Adelie penguins
adelie <- penguins[penguins$species == 'Adelie', ]
adelie
```

```
## # A tibble: 152 x 8
##    species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##    <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
##  1 Adelie  Torgersen           39.1          18.7               181        3750
##  2 Adelie  Torgersen           39.5          17.4               186        3800
##  3 Adelie  Torgersen           40.3          18                 195        3250
##  4 Adelie  Torgersen           NA            NA                  NA          NA
##  5 Adelie  Torgersen           36.7          19.3               193        3450
##  6 Adelie  Torgersen           39.3          20.6               190        3650
##  7 Adelie  Torgersen           38.9          17.8               181        3625
##  8 Adelie  Torgersen           39.2          19.6               195        4675
##  9 Adelie  Torgersen           34.1          18.1               193        3475
## 10 Adelie  Torgersen           42            20.2               190        4250
## # i 142 more rows
## # i 2 more variables: sex <fct>, year <int>
```

```
# histogram with only Adelie penguin flipper lengths
hist(adelie$flipper_length_mm)
```




```
# average of only Adelie penguin flippers
mean(adelie$flipper_length_mm)
```

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

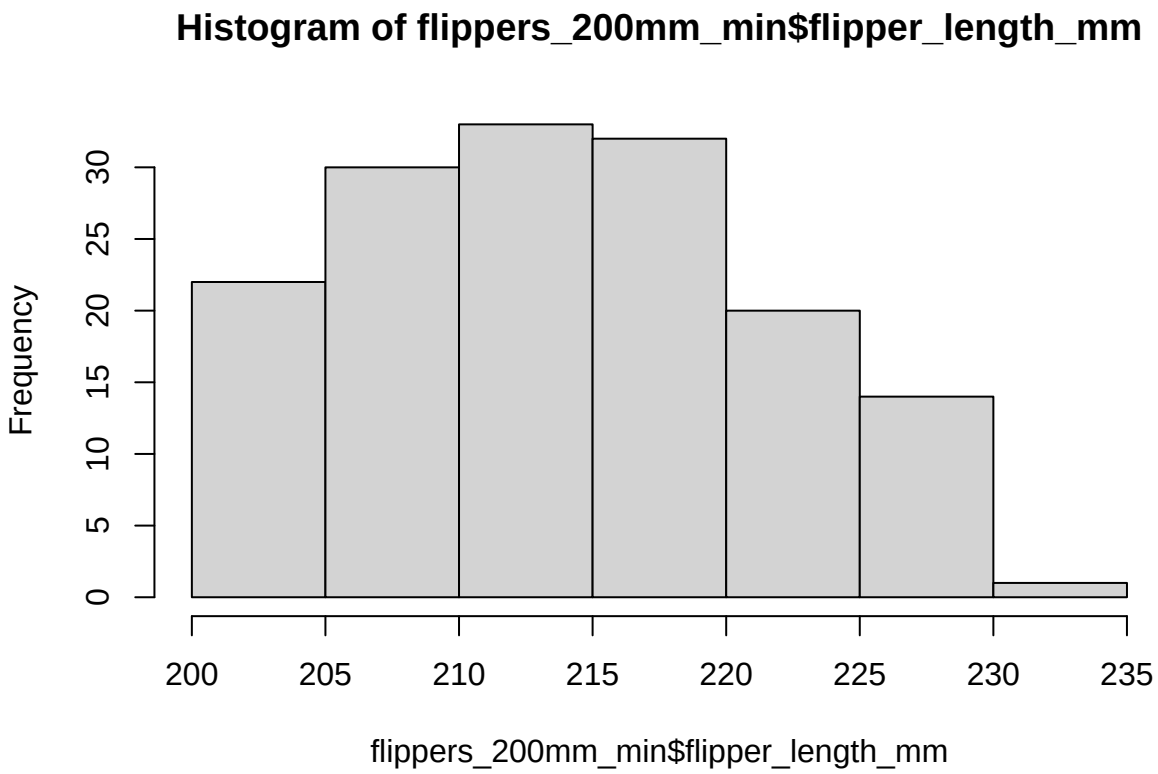
```
mean(adelie$flipper_length_mm, na.rm = TRUE)  # remove NA values from calculation
```

```
## [1] 189.9536
```

We can also use conditional formatting to filter rows based on numeric conditions.

```
# penguins with flippers greater than or equal to 200 mm
flippers_200mm_min <- penguins[penguins$flipper_length_mm >= 200, ]

# create a histogram
# hist(flippers_200mm_min) # why doesn't this work? We haven't specified a column
hist(flippers_200mm_min$flipper_length_mm)
```



Challenge

Write some lines of code to do the following: calculate the minimum (`min()`), maximum (`max()`), and the standard deviation (`sd()`) of the body mass values for Gentoo penguins. Remember the `na.rm` argument!

Then, plot a histogram of the Gentoo body mass data.

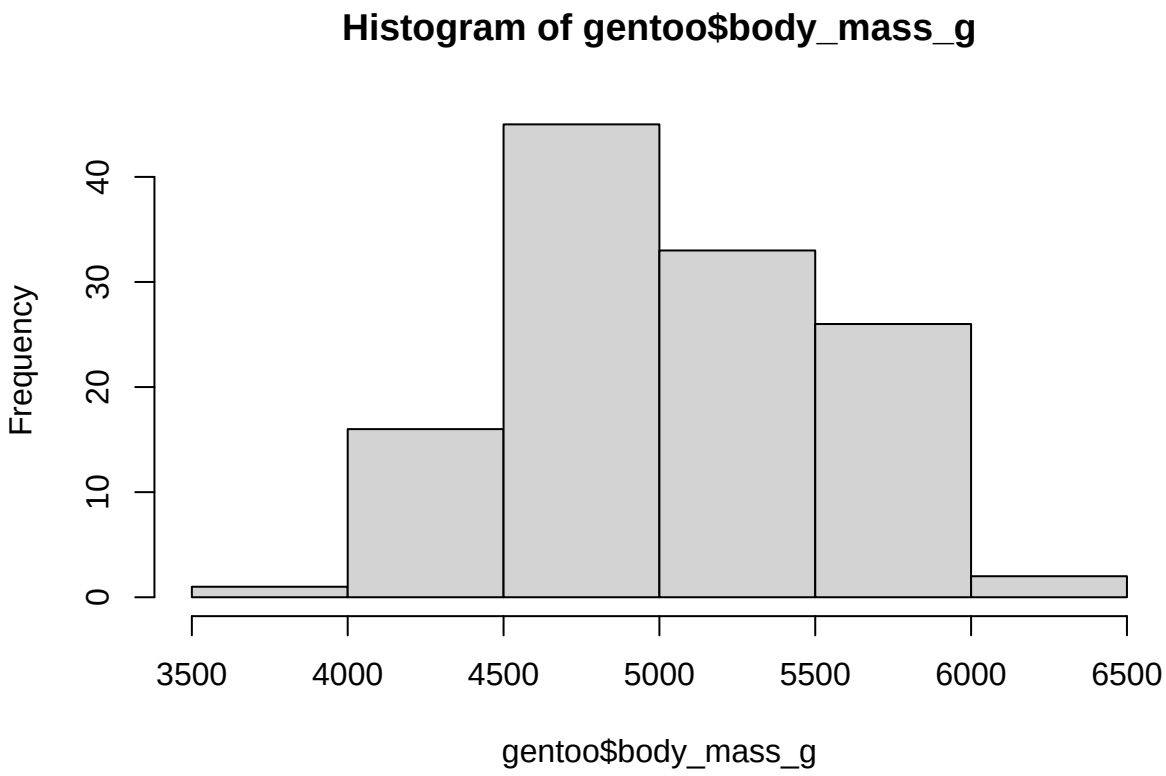
```
gentoo <- penguins[penguins$species == "Gentoo", ]
min(gentoo$body_mass_g, na.rm = TRUE)
```

```
## [1] 3950
```

```
max(gentoo$body_mass_g, na.rm = TRUE)
```

```
## [1] 6300
```

```
hist(gentoo$body_mass_g)
```


Histogram of gentoo$body_mass_g
Frequency
0
10
20
30
40
3500
4000
4500
5000
5500
6000
6500
gentoo$body_mass_g