ComputationalThinking1

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```r
library(tidyverse)
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.4     v readr     2.1.6
v forcats   1.0.1     v stringr   1.6.0
v ggplot2   4.0.1     v tibble    3.3.1
v lubridate 1.9.4     v tidyr     1.3.2
v purrr     1.2.0
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becon
```

```r
library(here)
```

```
here() starts at C:/Users/betty/Desktop/Exchange student program/class/data science for EEB/C
```

1. Functions

```r
# Create a new function called add_one
# x will be the only input to the function
add_one  <- function(x){

  # Add x and 1 together, store as the object "output"
  output <- x + 1

  # Print out whatever is stored in "output"
  return(output)
```

```
}
# Supply 10 to our function
add_one(x = 10)
```

```
[1] 11
```

```
# Create a new function called add_together
# x and y will be the two arguments to the function
add_together  <- function(x, y){

  # Add x and y together, store as the object "output"
  output <- x + y

  # Print out whatever is stored in "output"
  return(output)

}
```

Q1.1

```
add_together(3,5)
```

```
[1] 8
```

Q1.2

```
add_together(3,'five')
```

Error in x + y : non-numeric argument to binary operator

'five' is not number, but the function require the number. So the error talks about it.

Q1.3 Create your own function

```
math_time  <- function(x, y, z){
  output<-(((x-y)^2)/z)

  # Print out whatever is stored in "output"
  return(output)

}

math_time(5,2,9)
```

```
[1] 1
```

output: 1

Working with vectors as input

```
# Create a function called lbs_to_kg that takes a data object 'weights' as input
lbs_to_kg  <- function(weights){

  # Multiply weights by 0.454, store as the object "output"
  output <- weights*0.454

  # Print out whatever is stored in "output"
  return(output)

}

bison <- c(1000, 800, 1200, 1400)

lbs_to_kg(weights = bison)
```

```
[1] 454.0 363.2 544.8 635.6
```

Q1.4

```r
deviation<-function(vector){
  mean_value<-mean(vector)
  output<-vector-mean_value
  return(output)
}

deviation(bison)
```

```
[1] -100 -300  100  300
```

2. Iteration

```r
# Look at the first 6 rows of iris
head(iris)
```

```
  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
```

```r
iris %>%
  group_by(Species) %>%
  summarize(Sepal.Length = mean(Sepal.Length),
            Sepal.Width = mean(Sepal.Width),
            Petal.Length = mean(Petal.Length),
            Petal.Width = mean(Petal.Width))
```

```
# A tibble: 3 x 5
  Species    Sepal.Length Sepal.Width Petal.Length Petal.Width
  <fct>             <dbl>       <dbl>        <dbl>       <dbl>
1 setosa             5.01        3.43         1.46       0.246
2 versicolor         5.94        2.77         4.26       1.33
3 virginica          6.59        2.97         5.55       2.03
```

```
iris %>%
  group_by(Species) %>%
  summarize(across(.cols = c(Sepal.Length, Sepal.Width, Petal.Length, Petal.Width),
                   .fns = mean))
```

```
# A tibble: 3 x 5
  Species    Sepal.Length Sepal.Width Petal.Length Petal.Width
  <fct>             <dbl>       <dbl>        <dbl>       <dbl>
1 setosa             5.01        3.43         1.46       0.246
2 versicolor         5.94        2.77         4.26       1.33
3 virginica          6.59        2.97         5.55       2.03
```

```
iris %>%
  group_by(Species) %>%
  summarize(across(.cols = Sepal.Length:Petal.Width,
                   .fns = mean))
```

```
# A tibble: 3 x 5
  Species    Sepal.Length Sepal.Width Petal.Length Petal.Width
  <fct>             <dbl>       <dbl>        <dbl>       <dbl>
1 setosa             5.01        3.43         1.46       0.246
2 versicolor         5.94        2.77         4.26       1.33
3 virginica          6.59        2.97         5.55       2.03
```

```
iris %>%
  group_by(Species) %>%
  summarize(across(.cols = everything(),
                   .fns = mean))
```

```
# A tibble: 3 x 5
  Species    Sepal.Length Sepal.Width Petal.Length Petal.Width
  <fct>             <dbl>       <dbl>        <dbl>       <dbl>
1 setosa             5.01        3.43         1.46       0.246
2 versicolor         5.94        2.77         4.26       1.33
3 virginica          6.59        2.97         5.55       2.03
```

Q2.2

```r
iris %>%
  group_by(Species) %>%
  summarize(across(.cols = everything(),
                   .fns = median))
```

```
# A tibble: 3 x 5
  Species    Sepal.Length Sepal.Width Petal.Length Petal.Width
  <fct>             <dbl>       <dbl>        <dbl>       <dbl>
1 setosa              5           3.4         1.5          0.2
2 versicolor          5.9         2.8         4.35         1.3
3 virginica           6.5         3           5.55         2
```

```r
iris %>%
  group_by(Species) %>%
  summarize(across(.cols = where(is.numeric),
                   .fns = mean))
```

```
# A tibble: 3 x 5
  Species    Sepal.Length Sepal.Width Petal.Length Petal.Width
  <fct>             <dbl>       <dbl>        <dbl>       <dbl>
1 setosa             5.01        3.43         1.46       0.246
2 versicolor         5.94        2.77         4.26       1.33
3 virginica          6.59        2.97         5.55       2.03
```

Q2.3

```r
cereal<-read.csv("data/cereal.csv")
cereal %>%
  group_by(mfr) %>%
  summarize(across(.cols = where(is.numeric),
                   .fns = mean))
```

```
# A tibble: 7 x 14
  mfr     calories protein   fat sodium fiber carbo sugars potass vitamins shelf
  <chr>      <dbl>   <dbl> <dbl>  <dbl> <dbl> <dbl>  <dbl>  <dbl>    <dbl> <dbl>
1 Americ~     100     4    1         0   0     16     3       95      25     2
2 Genera~     111.    2.32 1.36    200.  1.27  14.7   7.95    85.2    35.2   2.14
3 Kellog~     109.    2.65 0.609   175.  2.74  15.1   7.57   103.     34.8   2.35
```

```
4 Nabisco      86.7     2.83 0.167   37.5  4      16      1.83  121.       8.33  1.67
5 Post        109.      2.44 0.889  146.   2.78  13.2    8.78  114.      25     2.44
6 Quaker~      95       2.62 1.75    92.5  1.34  10      5.25   74.4    12.5   2.38
7 Ralsto~     115       2.5  1.25   198.   1.88  17.6    6.12   89.2    25     2
# i 3 more variables: weight <dbl>, cups <dbl>, rating <dbl>
```

For-loops

```r
for (i in 1:5) {
  # Print out whatever the value of i is
  print(i)
}
```

```
[1] 1
[1] 2
[1] 3
[1] 4
[1] 5
```

```r
for (i in 1:5) {
  print(i*2)
}
```

```
[1] 2
[1] 4
[1] 6
[1] 8
[1] 10
```

Q2.4

```r
for (i in 1:10) {
  print(i*2)
}
```

```
[1] 2
[1] 4
```

```
[1] 6
[1] 8
[1] 10
[1] 12
[1] 14
[1] 16
[1] 18
[1] 20
```

```
N0 = 100  #initial population size

years = 20  #number of years into the future

N = vector(length = years)  # create an empty vector to store pop. sizes

N[1] = N0  #initial population size should be the first N

lambda = 1.2  #growth rate

print(N)
```

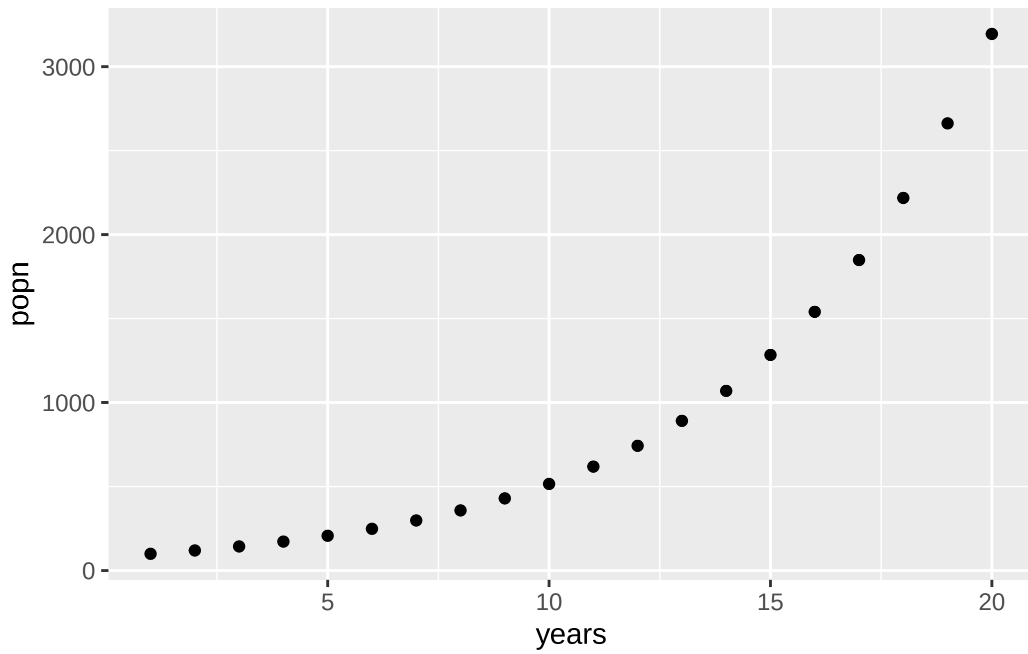
```
 [1] 100   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
[20]   0
```

```
# For every year t in 2 through 20 (remember, "years" also equals 20), apply the following eq
for (t in 2:20) {
  N[t] = N[t - 1] * lambda # Apply the equation
}

N
```

```
 [1]  100.0000  120.0000  144.0000  172.8000  207.3600  248.8320  298.5984
 [8]  358.3181  429.9817  515.9780  619.1736  743.0084  891.6100 1069.9321
[15] 1283.9185 1540.7022 1848.8426 2218.6111 2662.3333 3194.8000
```

```
# Store the data output as a dataframe for plotting
popn_data <- tibble(years = 1:years, # Make the years column = 1, 2, 3, ..., 20
                    popn = N) # Make the population column the corresponding population vecto

# Now plot the data with years on the x axis and population on the y
popn_data %>%
```

```r
ggplot(aes(x = years, y = popn)) +
geom_point()
```



Q2.5a

```r
N0 = 300  #initial population size

years = 50  #number of years into the future

N = vector(length = years)  # create an empty vector to store pop. sizes

N[1] = N0  #initial population size should be the first N

lambda = 0.95  #growth rate

print(N)
```

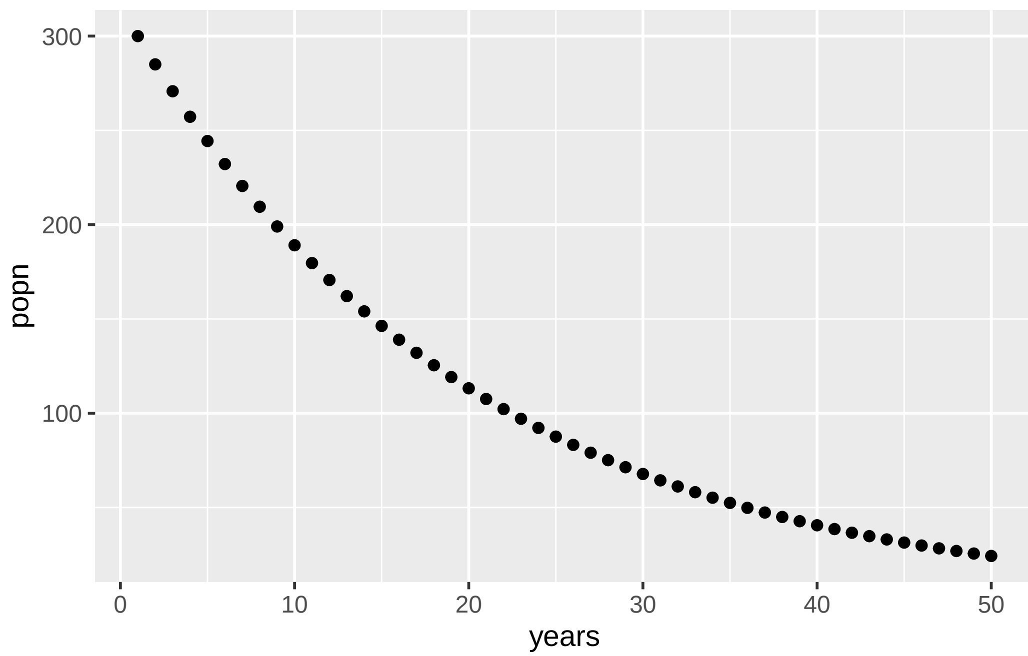
```
 [1] 300   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
[20]   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
[39]   0   0   0   0   0   0   0   0   0   0   0   0
```

```r
# For every year t in 2 through 20 (remember, "years" also equals 20), apply the following ec
for (t in 2:years) {
  N[t] = N[t - 1] * lambda # Apply the equation
}

N
```

```
 [1] 300.00000 285.00000 270.75000 257.21250 244.35187 232.13428 220.52757
 [8] 209.50119 199.02613 189.07482 179.62108 170.64003 162.10803 154.00262
[15] 146.30249 138.98737 132.03800 125.43610 119.16430 113.20608 107.54578
[22] 102.16849  97.06006  92.20706  87.59671  83.21687  79.05603  75.10323
[29]  71.34807  67.78066  64.39163  61.17205  58.11345  55.20777  52.44738
[36]  49.82502  47.33376  44.96708  42.71872  40.58279  38.55365  36.62596
[43]  34.79467  33.05493  31.40219  29.83208  28.34047  26.92345  25.57728
[50]  24.29841
```

Q2.5b

```r
popn_data <- tibble(years = 1:years, # Make the years column = 1, 2, 3, ..., 20
                    popn = N) # Make the population column the corresponding population vecto

# Now plot the data with years on the x axis and population on the y
popn_data %>%
  ggplot(aes(x = years, y = popn)) +
  geom_point()
```



Loop through data frames

```
head(iris)
```

```
  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
```

```
iris[1,]
```

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

```
iris[,3]
```

```
  [1] 1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 1.5 1.6 1.4 1.1 1.2 1.5 1.3 1.4
 [19] 1.7 1.5 1.7 1.5 1.0 1.7 1.9 1.6 1.6 1.5 1.4 1.6 1.6 1.5 1.5 1.4 1.5 1.2
 [37] 1.3 1.4 1.3 1.5 1.3 1.3 1.3 1.6 1.9 1.4 1.6 1.4 1.5 1.4 4.7 4.5 4.9 4.0
 [55] 4.6 4.5 4.7 3.3 4.6 3.9 3.5 4.2 4.0 4.7 3.6 4.4 4.5 4.1 4.5 3.9 4.8 4.0
 [73] 4.9 4.7 4.3 4.4 4.8 5.0 4.5 3.5 3.8 3.7 3.9 5.1 4.5 4.5 4.7 4.4 4.1 4.0
 [91] 4.4 4.6 4.0 3.3 4.2 4.2 4.2 4.3 3.0 4.1 6.0 5.1 5.9 5.6 5.8 6.6 4.5 6.3
[109] 5.8 6.1 5.1 5.3 5.5 5.0 5.1 5.3 5.5 6.7 6.9 5.0 5.7 4.9 6.7 4.9 5.7 6.0
[127] 4.8 4.9 5.6 5.8 6.1 6.4 5.6 5.1 5.6 6.1 5.6 5.5 4.8 5.4 5.6 5.1 5.1 5.9
[145] 5.7 5.2 5.0 5.2 5.4 5.1
```

```r
iris[1,3]
```

```
[1] 1.4
```

```r
for (i in 1:5) {

  # This prints out a statement saying "Here's column i",
  #but the i gets replaced with the number that it's currently at
  print(paste("Here's column",i))

  # This prints out column i
  print(iris[,i])
}
```

```
[1] "Here's column 1"
  [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 5.1
 [19] 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 4.9 5.0
 [37] 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 6.4 6.9 5.5
 [55] 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 6.2 5.6 5.9 6.1
 [73] 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 6.0 6.7 6.3 5.6 5.5
 [91] 5.5 6.1 5.8 5.0 5.6 5.7 5.7 6.2 5.1 5.7 6.3 5.8 7.1 6.3 6.5 7.6 4.9 7.3
[109] 6.7 7.2 6.5 6.4 6.8 5.7 5.8 6.4 6.5 7.7 7.7 6.0 6.9 5.6 7.7 6.3 6.7 7.2
[127] 6.2 6.1 6.4 7.2 7.4 7.9 6.4 6.3 6.1 7.7 6.3 6.4 6.0 6.9 6.7 6.9 5.8 6.8
[145] 6.7 6.7 6.3 6.5 6.2 5.9
[1] "Here's column 2"
  [1] 3.5 3.0 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1 3.7 3.4 3.0 3.0 4.0 4.4 3.9 3.5
 [19] 3.8 3.8 3.4 3.7 3.6 3.3 3.4 3.0 3.4 3.5 3.4 3.2 3.1 3.4 4.1 4.2 3.1 3.2
 [37] 3.5 3.6 3.0 3.4 3.5 2.3 3.2 3.5 3.8 3.0 3.8 3.2 3.7 3.3 3.2 3.2 3.1 2.3
 [55] 2.8 2.8 3.3 2.4 2.9 2.7 2.0 3.0 2.2 2.9 2.9 3.1 3.0 2.7 2.2 2.5 3.2 2.8
 [73] 2.5 2.8 2.9 3.0 2.8 3.0 2.9 2.6 2.4 2.4 2.7 2.7 3.0 3.4 3.1 2.3 3.0 2.5
 [91] 2.6 3.0 2.6 2.3 2.7 3.0 2.9 2.9 2.5 2.8 3.3 2.7 3.0 2.9 3.0 3.0 2.5 2.9
```

```
[109] 2.5 3.6 3.2 2.7 3.0 2.5 2.8 3.2 3.0 3.8 2.6 2.2 3.2 2.8 2.8 2.7 3.3 3.2
[127] 2.8 3.0 2.8 3.0 2.8 3.8 2.8 2.8 2.6 3.0 3.4 3.1 3.0 3.1 3.1 3.1 2.7 3.2
[145] 3.3 3.0 2.5 3.0 3.4 3.0
[1] "Here's column 3"
  [1] 1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 1.5 1.6 1.4 1.1 1.2 1.5 1.3 1.4
 [19] 1.7 1.5 1.7 1.5 1.0 1.7 1.9 1.6 1.6 1.5 1.4 1.6 1.6 1.5 1.5 1.4 1.5 1.2
 [37] 1.3 1.4 1.3 1.5 1.3 1.3 1.3 1.6 1.9 1.4 1.6 1.4 1.5 1.4 4.7 4.5 4.9 4.0
 [55] 4.6 4.5 4.7 3.3 4.6 3.9 3.5 4.2 4.0 4.7 3.6 4.4 4.5 4.1 4.5 3.9 4.8 4.0
 [73] 4.9 4.7 4.3 4.4 4.8 5.0 4.5 3.5 3.8 3.7 3.9 5.1 4.5 4.5 4.7 4.4 4.1 4.0
 [91] 4.4 4.6 4.0 3.3 4.2 4.2 4.2 4.3 3.0 4.1 6.0 5.1 5.9 5.6 5.8 6.6 4.5 6.3
[109] 5.8 6.1 5.1 5.3 5.5 5.0 5.1 5.3 5.5 6.7 6.9 5.0 5.7 4.9 6.7 4.9 5.7 6.0
[127] 4.8 4.9 5.6 5.8 6.1 6.4 5.6 5.1 5.6 6.1 5.6 5.5 4.8 5.4 5.6 5.1 5.1 5.9
[145] 5.7 5.2 5.0 5.2 5.4 5.1
[1] "Here's column 4"
  [1] 0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1 0.2 0.2 0.1 0.1 0.2 0.4 0.4 0.3
 [19] 0.3 0.3 0.2 0.4 0.2 0.5 0.2 0.2 0.4 0.2 0.2 0.2 0.2 0.4 0.1 0.2 0.2 0.2
 [37] 0.2 0.1 0.2 0.2 0.3 0.3 0.2 0.6 0.4 0.3 0.2 0.2 0.2 0.2 1.4 1.5 1.5 1.3
 [55] 1.5 1.3 1.6 1.0 1.3 1.4 1.0 1.5 1.0 1.4 1.3 1.4 1.5 1.0 1.5 1.1 1.8 1.3
 [73] 1.5 1.2 1.3 1.4 1.4 1.7 1.5 1.0 1.1 1.0 1.2 1.6 1.5 1.6 1.5 1.3 1.3 1.3
 [91] 1.2 1.4 1.2 1.0 1.3 1.2 1.3 1.3 1.1 1.3 2.5 1.9 2.1 1.8 2.2 2.1 1.7 1.8
[109] 1.8 2.5 2.0 1.9 2.1 2.0 2.4 2.3 1.8 2.2 2.3 1.5 2.3 2.0 2.0 1.8 2.1 1.8
[127] 1.8 1.8 2.1 1.6 1.9 2.0 2.2 1.5 1.4 2.3 2.4 1.8 1.8 2.1 2.4 2.3 1.9 2.3
[145] 2.5 2.3 1.9 2.0 2.3 1.8
[1] "Here's column 5"
  [1] setosa     setosa     setosa     setosa     setosa     setosa
  [7] setosa     setosa     setosa     setosa     setosa     setosa
 [13] setosa     setosa     setosa     setosa     setosa     setosa
 [19] setosa     setosa     setosa     setosa     setosa     setosa
 [25] setosa     setosa     setosa     setosa     setosa     setosa
 [31] setosa     setosa     setosa     setosa     setosa     setosa
 [37] setosa     setosa     setosa     setosa     setosa     setosa
 [43] setosa     setosa     setosa     setosa     setosa     setosa
 [49] setosa     setosa     versicolor versicolor versicolor versicolor
 [55] versicolor versicolor versicolor versicolor versicolor versicolor
 [61] versicolor versicolor versicolor versicolor versicolor versicolor
 [67] versicolor versicolor versicolor versicolor versicolor versicolor
 [73] versicolor versicolor versicolor versicolor versicolor versicolor
 [79] versicolor versicolor versicolor versicolor versicolor versicolor
 [85] versicolor versicolor versicolor versicolor versicolor versicolor
 [91] versicolor versicolor versicolor versicolor versicolor versicolor
 [97] versicolor versicolor versicolor versicolor virginica  virginica
[103] virginica  virginica  virginica  virginica  virginica  virginica
[109] virginica  virginica  virginica  virginica  virginica  virginica
```

```
[115] virginica  virginica  virginica  virginica  virginica  virginica
[121] virginica  virginica  virginica  virginica  virginica  virginica
[127] virginica  virginica  virginica  virginica  virginica  virginica
[133] virginica  virginica  virginica  virginica  virginica  virginica
[139] virginica  virginica  virginica  virginica  virginica  virginica
[145] virginica  virginica  virginica  virginica  virginica  virginica
Levels: setosa versicolor virginica
```

```r
for (i in 1:4) {

  # This prints out a statement saying "Here's column i", but the i gets replaced with the nu
  print(paste("Here's column",i))

  # This prints out column i
  print(mean(iris[,i]))
}
```

```
[1] "Here's column 1"
[1] 5.843333
[1] "Here's column 2"
[1] 3.057333
[1] "Here's column 3"
[1] 3.758
[1] "Here's column 4"
[1] 1.199333
```

```r
iris %>%
  summarize(across(.cols = 1:4,
                   .fns = mean))
```

```
  Sepal.Length Sepal.Width Petal.Length Petal.Width
1     5.843333    3.057333        3.758    1.199333
```

Q2.6

It depends on what kind of data it is. I usually prefer to use a for loop because I'm not good at using various functions and I can make changes I want with a for loop. But I think summarize/across functions are convenient for data in this course.

```r
for (i in 1:4) {
  # Fetch the column names of the dataframe, store in a vector "names"
  names <- colnames(iris)

  # Print out the "i"th element of the vector to print alongside the output
  print(names[i])

  # This prints out column i
  print(mean(iris[,i]))
}
```

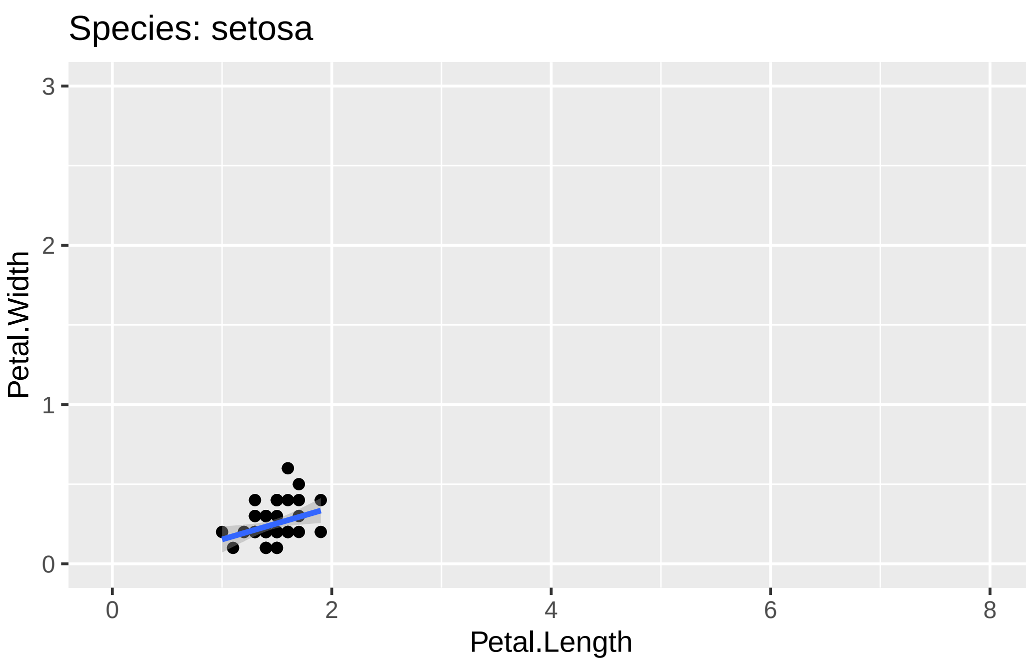
```
[1] "Sepal.Length"
[1] 5.843333
[1] "Sepal.Width"
[1] 3.057333
[1] "Petal.Length"
[1] 3.758
[1] "Petal.Width"
[1] 1.199333
```

Q2.7

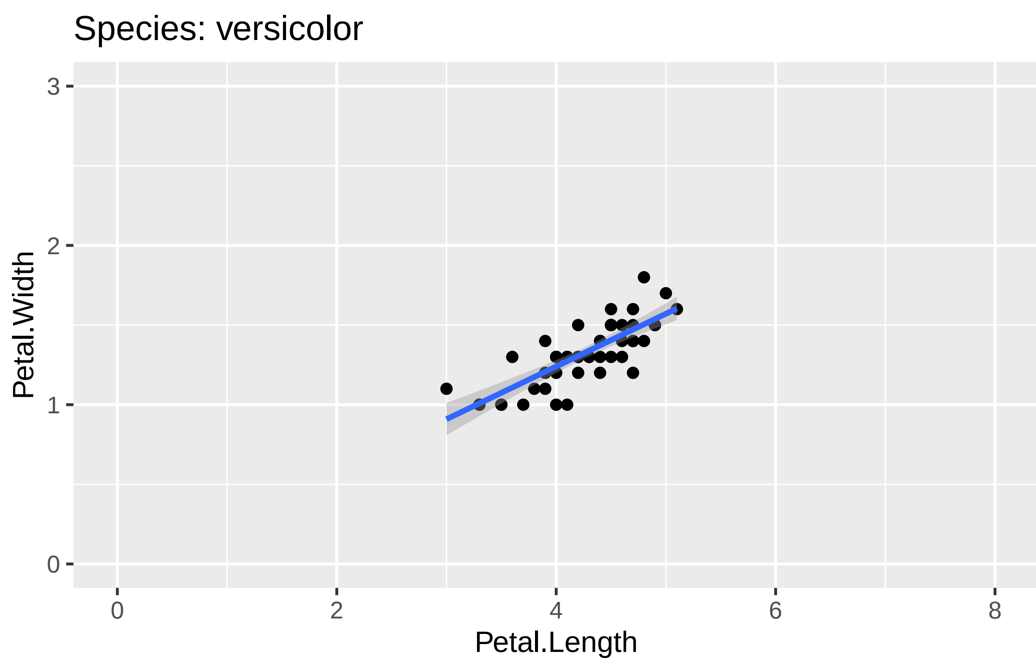
```r
# Store a vector of unique species names from the Species column of Iris
spp_names <- unique(iris$Species)

# do for-loop for each unique species names
for (i in 1:length(spp_names)) {

  filt_data <- iris %>%
    # Filter the data has specific species name
    filter(Species == spp_names[i])

  # Draw plot with filtered data
  plot <- filt_data %>%
    # Draw plot which x-axis is Petal.Length and y-axis is Petal.Width
    ggplot(aes(x = Petal.Length,
               y = Petal.Width)) +
    # Show point that describe the value of each data
    geom_point() +
    # Smoothed conditional means for the value
```

```
    geom_smooth(method = "lm") +
    # Set scale limits
    lims(x = c(0,8),
         y = c(0,3)) +
    # Put each species' name to the title
    ggtitle(paste("Species:", spp_names[i]))

  # Print the plot
  print(plot)
}
```

```
`geom_smooth()` using formula = 'y ~ x'
```




```
`geom_smooth()` using formula = 'y ~ x'
```




```
`geom_smooth()` using formula = 'y ~ x'
```