NC STATE UNIVERSITY

Introduction to Data Science Using R Part I

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Course Schedule

Daily agenda:

- 9:30-10:40 Session
- 10-minute break
- 10:50-12:00 Session
- 12:00-1:30 Lunch
- 1:30-2:40 Session
- 10-minute break
- 2:50-4:00 Session

What do we want to be able to do?

- Read in data
- Manipulate data
- Plot data
- Summarize data
- Analyze data

Where do we start?

Day 1

- Install R/R studio
- R Studio Interface
- Classes and Objects
- Attributes and Basic Data Object Manipulation
- Reading in Data/Writing Out Data
- Logical Statements and Subsetting/Manipulating Data

Day 2

- Logical Statements and Subsetting/Manipulating Data?
- Numerical and Graphical Summaries
- Basic Analyses

Why learn R?

- It's free, open source, available on all major platforms.
- Tons of packages for modeling, visualization, data manipulation, etc.
- Access to the newest methods.
- Great community support (stackoverflow, R-help mailing list, etc.)
- Can *easily* create pdfs, slides, reports, html files, and interactive apps.

Drawbacks of Using R

- Somewhat slow generally (although ways to speed it up)
- Code style differs greatly!
- New code not necessarily verified
- Confusing! Often many ways to do the same thing

Installing R

- Check out the course website
- Info on installing R and R studio available here
- Let's take a few minutes and make sure everyone has these installed and working properly!

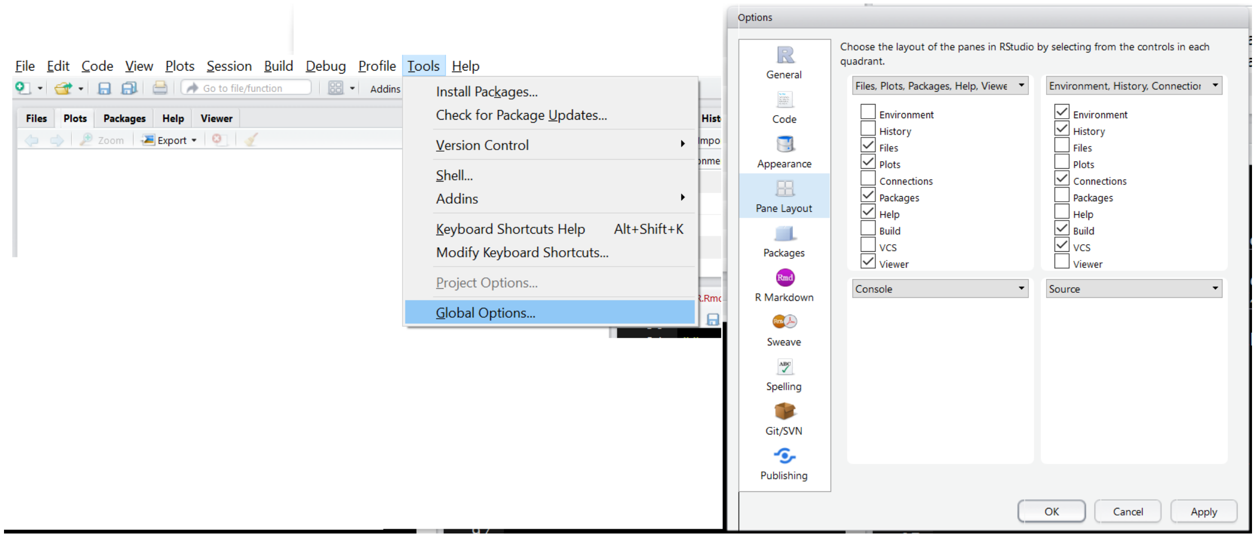
If installed, go to console and type `install.packages("tidyverse")`

R Studio Interface

- Four main 'areas' we'll use
  - Scripting and Viewing Area
  - Environment/History
  - Plots/Packages/Help
  - Console

R Studio Interface

To rearrange panes



Choose the layout of the panes in RStudio by selecting from the controls in each quadrant.

Files, Plots, Packages, Help, Viewe

□ Environment
□ History
☑ Files
☑ Plots
□ Connections
☑ Packages
☑ Help
□ Build
□ VCS
☑ Viewer

Environment, History, Connectio

☑ Environment
☑ History
□ Files
□ Plots
☑ Connections
□ Packages
□ Help
☑ Build
☑ VCS
□ Viewer

Console

Source

- Global options –> Appearance allows font/background changes
- Global options –> Code allows for soft-wrap of script files

Basic Use of R

- You can type directly into the console to evaluate code
- R is the fanciest calculator you could ever want!

```
#simple math operations (# is a comment, not evaluated)
3 + 7
```

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

```
10 * exp(3) #exp is exponential function
```

```
## [1] 200.8554
```

```
log(pi^2) #log is natural log by default
```

```
## [1] 2.28946
```

Basic Use of R

- Usually want to keep code for later use
- Write code in a 'script'
- Save code script
- Send lines of code to console via:
    - "Run" button (runs current line)
    - CTRL+r (PC) or Command+Enter (MAC)
    - Highlight section and do above

Basic Use of R

- Go to file –> New File –> R Script
- Type `hist(cars$dist)`
- Submit to console using button or hot key
- Save script using file –> Save
- Note: All R code from slides on web!

Objects and Common Classes

- Often want to save result for later use
- Can store output in an R 'object'

```
#save for later
avg <- (5 + 7 + 6) / 3
#call avg object
avg
```

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

```
#strings (text) can be saved as well
words <- "Hello there!"
words
```

```
## [1] "Hello there!"
```

Objects and Common Classes

- You have data…
- Five major data structures used

1. Atomic Vector (1d)
2. Matrix (2d)
3. Array (nd) (we'll skip)
4. Data Frame (2d)
5. List (1d)

Objects and Common Classes

1. Atomic Vector (a set of elements with an ordering)

- `c()` function "combines" values together

Objects and Common Classes

1. Atomic Vector (a set of elements with an ordering)

- `c()` function "combines" values together

```
#vectors (1 dimensional) objects
#all elements of the same 'type'
x <- c(1, 3, 10, -20, sqrt(2))
y <- c("cat", "dog", "bird", "floor")
x
```

```
## [1]   1.000000   3.000000  10.000000 -20.000000   1.414214
```

```
y
```

```
## [1] "cat"   "dog"   "bird"  "floor"
```

Objects and Common Classes

- Many 'functions' output a numeric vector

```
1:20 / 20
```

```
##  [1] 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70
## [15] 0.75 0.80 0.85 0.90 0.95 1.00
```

```
seq(from = 1, to = 10, by = 2)
```

```
## [1] 1 3 5 7 9
```

```
runif(4, min = 0, max = 1)
```

```
## [1] 0.89755059 0.47137314 0.83907133 0.06927203
```

Help Files

- Functions are ubiquitous in R!
- To find out about a function's arguments use `help()`
- Understanding the help files is key to using code!

-
  ```
  - help(seq)
  - help(runif)
  ```

Objects and Common Classes

1. Atomic Vector (a set of elements with an ordering)

- Vectors useful to know about
- Not usually useful for your data
- Often 'building blocks' for other data types

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**

```
#populate vectors
x <- rep(0.2, times = 6)
y <- c(1, 3, 4, -1, 5, 6)
```

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**

```
#populate vectors
x <- rep(0.2, times = 6)
y <- c(1, 3, 4, -1, 5, 6)

#check 'type'
is.numeric(x)
```

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

```
is.numeric(y)
```

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

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**

```
#populate vectors
x <- rep(0.2, times = 6)
y <- c(1, 3, 4, -1, 5, 6)

#check 'length'
length(x)
```

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

```
length(y)
```

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

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**

```
#populate vectors
x <- rep(0.2, times = 6)
y <- c(1, 3, 4, -1, 5, 6)
#combine in a matrix (check help(matrix))
matrix(c(x, y), ncol = 2)
```

```
##      [,1] [,2]
## [1,]  0.2    1
## [2,]  0.2    3
## [3,]  0.2    4
## [4,]  0.2   -1
## [5,]  0.2    5
## [6,]  0.2    6
```

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**

```
#populate vectors
x <- rep(0.2, times = 6)
y <- c(1, 3, 4, -1, 5, 6)
#combine in a matrix (check help(matrix))
matrix(c(x, y), nrow = 2, byrow = TRUE)
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]  0.2  0.2  0.2  0.2  0.2  0.2
## [2,]  1.0  3.0  4.0 -1.0  5.0  6.0
```

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**

```
x <- c("Hi", "There", "!"); y <- c("a", "b", "c"); z <- c("One", "Two", "Three")
is.character(x)
```

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

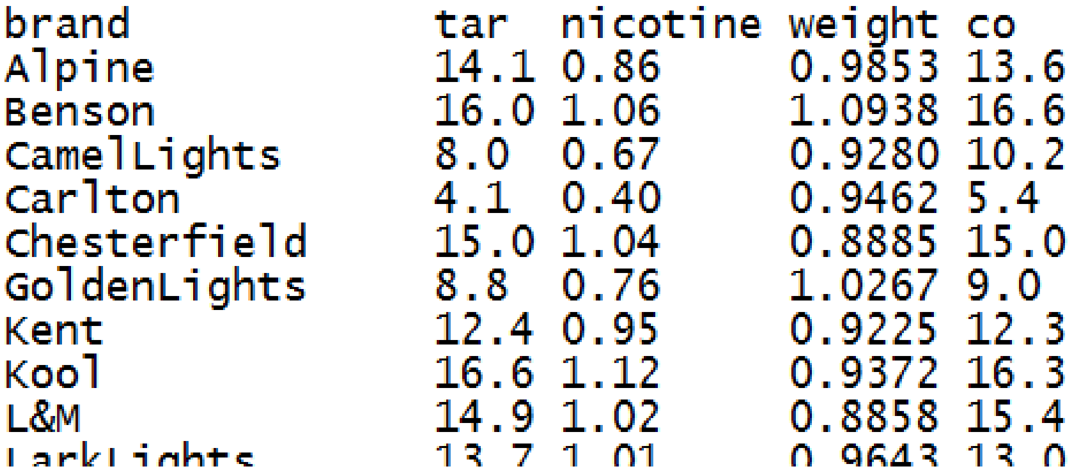
```
matrix(c(x, y, z), nrow = 3)
```

```
##      [,1]    [,2] [,3]   
## [1,] "Hi"    "a"  "One"  
## [2,] "There" "b"  "Two"  
## [3,] "!"     "c"  "Three"
```

Objects and Common Classes

2. Matrix

- collection of vectors of the same **type and length**
- Useful for some data
- Often some variables with numbers, some with text



```
brand             tar  nicotine weight co
Alpine            14.1 0.86     0.9853 13.6
Benson            16.0 1.06     1.0938 16.6
CamelLights       8.0  0.67     0.9280 10.2
Carlton           4.1  0.40     0.9462 5.4
Chesterfield      15.0 1.04     0.8885 15.0
GoldenLights      8.8  0.76     1.0267 9.0
Kent              12.4 0.95     0.9225 12.3
Kool              16.6 1.12     0.9372 16.3
L&M               14.9 1.02     0.8858 15.4
LarkLights        13.7 1.01     0.9643 13.0
```

Objects and Common Classes

4. Data Frame

- collection (list) of vectors of the same **length**

```
x <- c("a", "b", "c", "d", "e", "f")
y <- c(1, 3, 4, -1, 5, 6)
z <- 10:15
data.frame(x, y, z)
```

```
##   x  y  z
## 1 a  1 10
## 2 b  3 11
## 3 c  4 12
## 4 d -1 13
## 5 e  5 14
## 6 f  6 15
```

Objects and Common Classes

4. Data Frame

- collection (list) of vectors of the same **length**

```
x <- c("a", "b", "c", "d", "e", "f")
y <- c(1, 3, 4, -1, 5, 6)
z <- 10:15
data.frame(char = x, data1 = y, data2 = z)
```

- char, data1, and data2 become the variable names for the data frame

Objects and Common Classes

4. Data Frame

- collection (list) of vectors of the same **length**
- Perfect for most data sets!
- Most functions that read data in store it as a data frame

Objects and Common Classes

5. List

- a vector that can have differing elements

```
list("Hi", 1:3, rnorm(2), c("!", "?"))
```

```
## [[1]]
## [1] "Hi"
##
## [[2]]
## [1] 1 2 3
##
## [[3]]
## [1] -1.273529  1.075238
##
## [[4]]
## [1] "!" "?"
```

Objects and Common Classes

5. List

- a vector that can have differing elements
- More flexible than a Data Frame!
- Useful for more complex types of data

Recap!

Review:

Dimension	Homogeneous	Heterogeneous
1d	Atomic Vector	List
2d	Matrix	Data Frame

- For most data analysis you'll use data frames!
- Next up: How do we access/change parts of our objects?

Activity

- **Objects and Common Classes Activity** instructions available on web
- Work in small groups
- Ask questions! TAs and I will float about the room
- Feel free to ask questions about anything you didn't understand as well!

Attributes and Basic Data Manipulation

- Want to know how to handle complex data sets
- R has many 'built-in' data sets

```
iris
```

Attributes and Basic Data Manipulation

- What kind of object is iris?

Attributes and Basic Data Manipulation

- **What kind of object is iris?**
- `str()` function can tell us (structure)

```
str(iris)
```

```
## 'data.frame':    150 obs. of  5 variables:
##  $ 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 ...
```

Attributes and Basic Data Manipulation

- What characteristics does iris have?

Attributes and Basic Data Manipulation

- **What characteristics does iris have?**
- `attributes()` function can tell us metadata
    - Metadata = information about the data set
    - Returns a named list

```
attributes(iris)
```

Attributes and Basic Data Manipulation

```
## $names
## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Width" 
## [5] "Species"     
## 
## $class
## [1] "data.frame"
## 
## $row.names
##   [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
```

Basic Data Manipulation

- How do we access different parts of our object?

Basic Data Manipulation

- **How do we access different parts of our object?**
- For data may want
    - Data value

Basic Data Manipulation

- **How do we access different parts of our object?**
- For data may want
    - Data value
    - Just a column
    - Multiple columns

Basic Data Manipulation

- **How do we access different parts of our object?**
- For data may want
  - Data value
  - Just a column
  - Multiple columns
  - Just a row
  - Multiple rows

Basic Data Manipulation

- **How do we access different parts of our object?**
- For data may want
    - Data value
    - Just a column
    - Multiple columns
    - Just a row
    - Multiple rows
    - Access to values of an attribute

Basic Data Manipulation

- **How do we access different parts of our object?**
- For data may want
  - Data value
  - Just a column
  - Multiple columns
  - Just a row
  - Multiple rows
  - Access to values of an attribute
- Let's go through each of our common data types and work our way up!

Basic Data Manipulation

Atomic Vectors

- Access elements of a vector using square brackets

```
letters #built in vector
```

```
##  [1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j" "k" "l" "m" "n" "o" "p" "q"
## [18] "r" "s" "t" "u" "v" "w" "x" "y" "z"
```

```
letters[10]
```

```
## [1] "j"
```

Basic Data Manipulation

Atomic Vectors

- Can 'feed' R a vector of values to choose

```r
letters[1:4]
```

```
## [1] "a" "b" "c" "d"
```

```r
letters[c(5, 10, 15, 20, 25)]
```

```
## [1] "e" "j" "o" "t" "y"
```

```r
x <- c(1, 2, 5); letters[x]
```

```
## [1] "a" "b" "e"
```

Basic Data Manipulation

Matrices

- Access elements of a matrix using square brackets with a comma in between
- Notice the default row names and column names!

```
mat <- matrix(c(1:4, 20:17), ncol = 2)
mat
```

```
##      [,1] [,2]
## [1,]    1   20
## [2,]    2   19
## [3,]    3   18
## [4,]    4   17
```

Basic Data Manipulation

Matrices

- Access elements using square brackets with a comma

```
mat[2, 2]
```

```
## [1] 19
```

```
mat[ , 1]
```

```
## [1] 1 2 3 4
```

```
mat[2, ]
```

```
## [1]  2 19
```

```
mat[2:4, 1]
```

```
## [1] 2 3 4
```

```
mat[c(2, 4), ]
```

```
##      [,1] [,2]
## [1,]    2   19
## [2,]    4   17
```

Basic Data Manipulation

Matrices

- Can give columns names and use them for access
- `help(matrix)` can show us how!

Basic Data Manipulation

Matrices

- Can give columns names and use them for access

```
mat <- matrix(c(1:4, 20:17), ncol = 2,
          dimnames = list(NULL,
                c("First", "Second"))
        )
mat
```

```
##      First Second
## [1,]     1     20
## [2,]     2     19
## [3,]     3     18
## [4,]     4     17
```

```
mat[, "First"]
```

```
## [1] 1 2 3 4
```

Basic Data Manipulation

Matrices

- What about the structure and attributes of matrices?

```
str(mat)
```

```
##  int [1:4, 1:2] 1 2 3 4 20 19 18 17
##  - attr(*, "dimnames")=List of 2
##   ..$ : NULL
##   ..$ : chr [1:2] "First" "Second"
```

```
attributes(mat)
```

```
## $dim
## [1] 4 2
## 
## $dimnames
## $dimnames[[1]]
## NULL
## 
## $dimnames[[2]]
## [1] "First"  "Second"
```

Basic Data Manipulation

Data Frames

- 'Built in' `iris` data frame

```
str(iris)
```

```
## 'data.frame':    150 obs. of  5 variables:
##  $ 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 ...
```

Basic Data Manipulation

Data Frames

- Can access just like a matrix

```
iris[1:4, 2:4]
```

```
##   Sepal.Width Petal.Length Petal.Width
## 1         3.5          1.4         0.2
## 2         3.0          1.4         0.2
## 3         3.2          1.3         0.2
## 4         3.1          1.5         0.2
```

```
iris[1, ]
```

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

Basic Data Manipulation

Data Frames

- Can use variable names

```
iris[ , c("Sepal.Length", "Species")]
```

```
##     Sepal.Length    Species
## 1            5.1     setosa
## 2            4.9     setosa
## 3            4.7     setosa
## 4            4.6     setosa
## 5            5.0     setosa
## 6            5.4     setosa
## 7            4.6     setosa
## 8            5.0     setosa
## 9            4.4     setosa
## 10           4.9     setosa
## 11           5.4     setosa
## 12           4.8     setosa
## 13           4.8     setosa
## 14           4.3     setosa
## 15           5.8     setosa
## 16           5.7     setosa
```

Basic Data Manipulation

Data Frames

- Dollar sign allows access to columns! (Returns a vector.)

```
iris$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
```

Basic Data Manipulation

Data Frames

- Dollar sign allows access to columns! (Returns a vector.)
- Most used method for accessing a data frame
- RStudio fills in options.
    - Type `iris$`
    - If no choices - hit tab
    - Hit tab again to choose

Basic Data Manipulation

Lists

- Use double square brackets to get at list elements

```
x <- list("HI", c(10:20), 1)
x
```

```
## [[1]]
## [1] "HI"
##
## [[2]]
##  [1] 10 11 12 13 14 15 16 17 18 19 20
##
## [[3]]
## [1] 1
```

Basic Data Manipulation

Lists

- Use double square brackets to get at list elements

```
x <- list("HI", c(10:20), 1)
x[[1]]
```

```
## [1] "HI"
```

```
x[[3]]
```

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

```
x[[2]]
```

```
##  [1] 10 11 12 13 14 15 16 17 18 19 20
```

```
x[[2]][4:5]
```

```
## [1] 13 14
```

Basic Data Manipulation

Lists

- If named list elements, can use $

```
x <- list("HI", c(10:20), 1)
str(x)
```

```
## List of 3
##  $ : chr "HI"
##  $ : int [1:11] 10 11 12 13 14 15 16 17 18 19 ...
##  $ : num 1
```

```
x <- list(First="Hi", Second=c(10:20), Third=1)
x$Second
```

```
##  [1] 10 11 12 13 14 15 16 17 18 19 20
```

Basic Data Manipulation

Data Frames

- Connection: Data Frame = List of equal length vectors

```
str(iris)
```

```
## 'data.frame':    150 obs. of  5 variables:
##  $ 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 ...
```

```
iris[[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
##  [18] 3.5 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
##  [35] 3.1 3.2 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
##  [52] 3.2 3.1 2.3 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
##  [69] 2.2 2.5 3.2 2.8 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
##  [86] 3.4 3.1 2.3 3.0 2.5 2.6 3.0 2.6 2.3 2.7 3.0 2.9 2.9 2.5 2.8 3.3 2.7
## [103] 3.0 2.9 3.0 3.0 2.5 2.9 2.5 3.6 3.2 2.7 3.0 2.5 2.8 3.2 3.0 3.8 2.6
```

Accessing Attributes

- Often want to change or modify attributes

```
str(attributes(iris))
```

```
## List of 3
##  $ names    : chr [1:5] "Sepal.Length" "Sepal.Width" "Petal.Length" "Petal.Width" ...
##  $ class    : chr "data.frame"
##  $ row.names: int [1:150] 1 2 3 4 5 6 7 8 9 10 ...
```

- a list!

Accessing Attributes

- Often want to change or modify attributes

```
attributes(iris)$names
```

```
## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Width"
## [5] "Species"
```

```
attributes(iris)$names[1] <- "Sepal_Length"
attributes(iris)$names
```

```
## [1] "Sepal_Length" "Sepal.Width"  "Petal.Length" "Petal.Width"
## [5] "Species"
```

Attributes and Basic Data Manipulation

- Often want to change or modify attributes
- Most commonly modified attributes have 'helper' functions

```
names(iris)
```

```
## [1] "Sepal_Length" "Sepal.Width"  "Petal.Length" "Petal.Width" 
## [5] "Species"
```

```
names(iris)[2] <- "Sepal_Width"
names(iris)
```

```
## [1] "Sepal_Length" "Sepal_Width"  "Petal.Length" "Petal.Width" 
## [5] "Species"
```

Recap!

- Attributes and Structure important to understand
  - `attributes()`
  - `str()`
- Accessing common data structures
  - Atomic vectors - `x[ ]`
  - Matrices - `x[ , ]`
  - Data Frames - `x[ , ]` or `x$name`
  - Lists - `x[[ ]]` or `x$name`

Activity

- **Attributes and Basic Data Manipulation Activity** instructions available on web
- Work in small groups
- Ask questions! TAs and I will float about the room
- Feel free to ask questions about anything you didn't understand as well!