Intro to R

Data Summarization

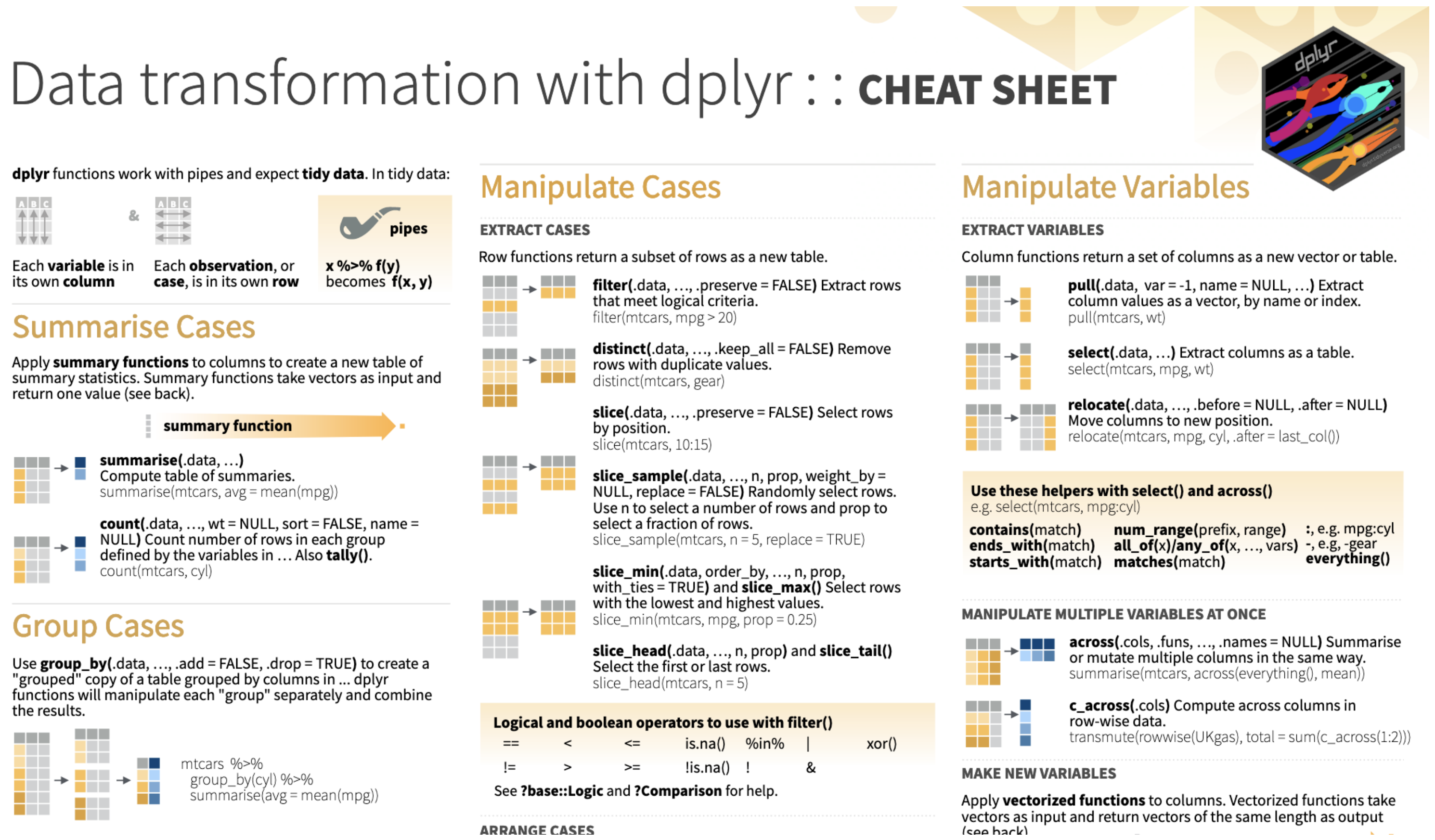
Recap

- `select()`: subset and/or reorder columns
- `filter()`: remove rows
- `arrange()`: reorder rows
- `mutate()`: create new columns or modify them
- `select()` and `filter()` can be combined together
- remove a column: `select()` with negative sign (`-col_name`)
- you can do sequential steps: especially using pipes `%>%`

[Cheatsheet]

Another Cheatsheet

https://raw.githubusercontent.com/rstudio/cheatsheets/main/data-transformation.pdf



Data transformation with dplyr : : **CHEAT SHEET**

dplyr functions work with pipes and expect **tidy data**. In tidy data:

Each **variable** is in its own **column** & Each **observation**, or **case**, is in its own **row**

pipes **x %>% f(y)** becomes **f(x, y)**

Summarise Cases

Apply **summary functions** to columns to create a new table of summary statistics. Summary functions take vectors as input and return one value (see back).

summary function

summarise(.data, …) Compute table of summaries.
summarise(mtcars, avg = mean(mpg))

count(.data, …, wt = NULL, sort = FALSE, name = NULL) Count number of rows in each group defined by the variables in … Also **tally()**.
count(mtcars, cyl)

Group Cases

Use **group_by(**.data, …, .add = FALSE, .drop = TRUE) to create a "grouped" copy of a table grouped by columns in ... dplyr functions will manipulate each "group" separately and combine the results.

```
mtcars %>%
  group_by(cyl) %>%
  summarise(avg = mean(mpg))
```

Manipulate Cases

EXTRACT CASES

Row functions return a subset of rows as a new table.

filter(.data, …, .preserve = FALSE) Extract rows that meet logical criteria.
filter(mtcars, mpg > 20)

distinct(.data, …, .keep_all = FALSE) Remove rows with duplicate values.
distinct(mtcars, gear)

slice(.data, …, .preserve = FALSE) Select rows by position.
slice(mtcars, 10:15)

slice_sample(.data, …, n, prop, weight_by = NULL, replace = FALSE) Randomly select rows. Use n to select a number of rows and prop to select a fraction of rows.
slice_sample(mtcars, n = 5, replace = TRUE)

slice_min(.data, order_by, …, n, prop, with_ties = TRUE) and **slice_max()** Select rows with the lowest and highest values.
slice_min(mtcars, mpg, prop = 0.25)

slice_head(.data, …, n, prop) and **slice_tail()** Select the first or last rows.
slice_head(mtcars, n = 5)

Logical and boolean operators to use with filter()

==	<	<=	is.na()	%in%	|	xor()
!=	>	>=	!is.na()	!	&	

See **?base::Logic** and **?Comparison** for help.

ARRANGE CASES

Manipulate Variables

EXTRACT VARIABLES

Column functions return a set of columns as a new vector or table.

pull(.data, var = -1, name = NULL, …) Extract column values as a vector, by name or index.
pull(mtcars, wt)

select(.data, …) Extract columns as a table.
select(mtcars, mpg, wt)

relocate(.data, …, .before = NULL, .after = NULL) Move columns to new position.
relocate(mtcars, mpg, cyl, .after = last_col())

Use these helpers with select() and across()
e.g. select(mtcars, mpg:cyl)

contains(match)	**num_range(**prefix, range)	:, e.g. mpg:cyl
ends_with(match)	**all_of(**x)/**any_of(**x, …, vars)	-, e.g, -gear
starts_with(match)	**matches(**match)	**everything()**

MANIPULATE MULTIPLE VARIABLES AT ONCE

across(.cols, .funs, …, .names = NULL) Summarise or mutate multiple columns in the same way.
summarise(mtcars, across(everything(), mean))

c_across(.cols) Compute across columns in row-wise data.
transmute(rowwise(UKgas), total = sum(c_across(1:2)))

MAKE NEW VARIABLES

Apply **vectorized functions** to columns. Vectorized functions take vectors as input and return vectors of the same length as output (see back).

Data Summarization

- Basic statistical summarization
    - `mean(x)`: takes the mean of x
    - `sd(x)`: takes the standard deviation of x
    - `median(x)`: takes the median of x
    - `quantile(x)`: displays sample quantiles of x. Default is min, IQR, max
    - `range(x)`: displays the range. Same as `c(min(x), max(x))`
    - `sum(x)`: sum of x
    - `max(x)`: maximum value in x
    - `min(x)`: minimum value in x
- **all have the `na.rm =` argument for missing data**

Statistical summarization

The vector getting summarized goes inside the parentheses:

```r
x <- c(1, 5, 7, 4, 2, 8)
mean(x)
```

```
[1] 4.5
```

```r
range(x)
```

```
[1] 1 8
```

```r
sum(x)
```

```
[1] 27
```

Statistical summarization

Note that many of these functions have additional inputs regarding missing data, typically requiring the `na.rm` argument ("remove NAs").

```r
x <- c(1, 5, 7, 4, 2, 8, NA)
mean(x)
```

```
[1] NA
```

```r
mean(x, na.rm = TRUE)
```

```
[1] 4.5
```

```r
quantile(x)
```

```
Error in quantile.default(x): missing values and NaN's not allowed if 'na.rm' is FALSE
```

```r
quantile(x, na.rm = TRUE)
```

```
  0%  25%  50%  75% 100% 
 1.0  2.5  4.5  6.5  8.0 
```

Statistical summarization

We will talk more about data types later, but you can only do summarization on numeric or logical types. Not characters.

```r
x <- c(1, 5, 7, 4, 2, 8)
sum(x)
```

```
[1] 27
```

```r
y <- c(TRUE, FALSE, FALSE, TRUE) # FALSE == 0 and TRUE == 1
sum(y)
```

```
[1] 2
```

```r
z <- c("TRUE", "FALSE", "FALSE", "TRUE")
sum(z)
```

```
Error in sum(z): invalid 'type' (character) of argument
```

Some examples

We can use the `jhu_cars` to explore different ways of summarizing data. The `head` command displays the first rows of an object:

```
library(jhur)
head(jhu_cars)
```

```
                car  mpg cyl disp  hp drat    wt  qsec vs am gear carb
1         Mazda RX4 21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
2     Mazda RX4 Wag 21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
3        Datsun 710 22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
4    Hornet 4 Drive 21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
5 Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
6           Valiant 18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
```

Statistical summarization

You might see base R `$` to reference/select columns from a `data.frame`/`tibble`:

```
mean(jhu_cars$hp)
```

```
[1] 146.6875
```

```
quantile(jhu_cars$hp)
```

```
   0%   25%   50%   75%  100% 
 52.0  96.5 123.0 180.0 335.0 
```

Statistical summarization

The “tidy” way:

```
jhu_cars %>% pull(hp) %>% mean() # alt: pull(jhu_cars, hp) %>% mean()
```

```
[1] 146.6875
```

```
jhu_cars %>% pull(hp) %>% quantile()
```

```
   0%   25%   50%   75%  100% 
 52.0  96.5 123.0 180.0 335.0 
```

Statistical summarization

```r
jhu_cars %>% pull(wt) %>% median()
```

```
[1] 3.325
```

```r
jhu_cars %>% pull(wt) %>% quantile(probs = 0.6)
```

```
 60% 
3.44 
```

Data Summarization on data frames

- Basic statistical summarization
  - `rowMeans(x)`: takes the means of each row of x
  - `colMeans(x)`: takes the means of each column of x
  - `rowSums(x)`: takes the sum of each row of x
  - `colSums(x)`: takes the sum of each column of x
  - `summary(x)`: for data frames, displays the quantile information

TB Incidence

Let’s read in a `tibble` of values from TB incidence.

If you have the `jhur` package installed successfully:

```
library(jhur)
tb <- read_tb()
```

If not, download the `xlsx` file from http://jhudatascience.org/intro_to_r/data/tb_incidence.xlsx and read it in:

```
library(readxl)
tb <- read_excel("tb_incidence.xlsx")
```

TB Incidence

Check out the data:

```
head(tb)
```

```
# A tibble: 6 × 19
  `TB incidence, all f…` `1990` `1991` `1992` `1993` `1994` `1995` `1996` `1997`
  <chr>                   <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
1 Afghanistan               168    168    168    168    168    168    168    168
2 Albania                    25     24     25     26     26     27     27     28
3 Algeria                    38     38     39     40     41     42     43     44
4 American Samoa             21      7      2      9      9     11      0     12
5 Andorra                    36     34     32     30     29     27     26     26
6 Angola                    205    209    214    218    222    226    231    236
# … with 10 more variables: `1998` <dbl>, `1999` <dbl>, `2000` <dbl>,
#   `2001` <dbl>, `2002` <dbl>, `2003` <dbl>, `2004` <dbl>, `2005` <dbl>,
#   `2006` <dbl>, `2007` <dbl>
```

TB Incidence

Check out the data:

```
str(tb)
```

```
tibble [208 × 19] (S3: tbl_df/tbl/data.frame)
 $ TB incidence, all forms (per 100 000 population per year): chr [1:208] "Afghanistan" "Albani
 $ 1990                                                     : num [1:208] 168 25 38 21 36 205 2
 $ 1991                                                     : num [1:208] 168 24 38 7 34 209 24
 $ 1992                                                     : num [1:208] 168 25 39 2 32 214 24
 $ 1993                                                     : num [1:208] 168 26 40 9 30 218 24
 $ 1994                                                     : num [1:208] 168 26 41 9 29 222 23
 $ 1995                                                     : num [1:208] 168 27 42 11 27 226 2
 $ 1996                                                     : num [1:208] 168 27 43 0 26 231 23
 $ 1997                                                     : num [1:208] 168 28 44 12 26 236 2
 $ 1998                                                     : num [1:208] 168 28 46 6 25 240 23
 $ 1999                                                     : num [1:208] 168 27 47 8 23 245 23
 $ 2000                                                     : num [1:208] 168 25 48 6 22 250 23
 $ 2001                                                     : num [1:208] 168 23 49 6 21 255 22
 $ 2002                                                     : num [1:208] 168 23 50 4 21 260 22
 $ 2003                                                     : num [1:208] 168 22 51 5 20 265 22
 $ 2004                                                     : num [1:208] 168 21 53 9 20 270 22
 $ 2005                                                     : num [1:208] 168 20 54 10 19 276 2
 $ 2006                                                     : num [1:208] 168 18 55 7 19 281 22
 $ 2007                                                     : num [1:208] 168 17 57 5 19 287 22
```

Indicator of TB

Before we go further, let's rename the first column using the `rename()` function in `dplyr`.

In this case, we have to use the backticks (`` ` ``) because there are spaces and funky characters in the name:

```
library(dplyr)
tb <- tb %>% rename(country = `TB incidence, all forms (per 100 000 population per year)`)
```

Indicator of TB

`colnames()` will show us the column names and show that country is renamed:

```
colnames(tb)
```

```
 [1] "country" "1990"    "1991"    "1992"    "1993"    "1994"    "1995"   
 [8] "1996"    "1997"    "1998"    "1999"    "2000"    "2001"    "2002"   
[15] "2003"    "2004"    "2005"    "2006"    "2007"   
```

Summarize the data: `dplyr summarize()` function

`summarize` creates a summary table of a column you’re interested in.

```
# General format - Not the code!
{data to use} %>%
   summarize({summary column name} = {operator(source column)})
```

Summarize the data: `dplyr summarize()` function

`summarize` creates a summary table of a column you're interested in.

```
# General format - Not the code!
{data to use} %>%
   summarize({summary column name} = {operator(source column)})
```

```
tb %>%
  summarize(mean_1991 = mean(`1991`))
```

```
# A tibble: 1 × 1
  mean_1991
      <dbl>
1        NA
```

```
tb %>%
  summarize(mean_1991 = mean(`1991`, na.rm = TRUE))
```

```
# A tibble: 1 × 1
  mean_1991
      <dbl>
1      108.
```

Summarize the data: **dplyr summarize()** function

`summarize()` can do multiple operations at once. Just separate by a comma.

```
tb %>%
  summarize(mean_1991 = mean(`1991`, na.rm = TRUE),
            median_1991 = median(`1991`, na.rm = TRUE),
            median(`2000`, na.rm = TRUE))
```

```
# A tibble: 1 × 3
  mean_1991 median_1991 `median(\`2000\`, na.rm = TRUE)`
      <dbl>       <dbl>                            <dbl>
1      108.          58                               60
```

Notice how when we forget to provide a new name, output is still provided, but the column name is messy.

Summarize the data: **`dplyr summarize()`** function

This looks better.

```
tb %>%
  summarize(mean_1991 = mean(`1991`, na.rm = TRUE),
            median_1991 = median(`1991`, na.rm = TRUE),
            median_2000 = median(`2000`, na.rm = TRUE))
```

```
# A tibble: 1 × 3
  mean_1991 median_1991 median_2000
      <dbl>       <dbl>       <dbl>
1      108.          58          60
```

Row means

`colMeans()` and `rowMeans()` require **all numeric data**.

Let's see what the mean is across each row (country):

```
tb_2 <- column_to_rownames(tb, var = "country") # opposite of rownames_to_column() !
head(tb_2, n = 2)
```

```
            1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Afghanistan  168  168  168  168  168  168  168  168  168  168  168  168  168
Albania       25   24   25   26   26   27   27   28   28   27   25   23   23
            2003 2004 2005 2006 2007
Afghanistan  168  168  168  168  168
Albania       22   21   20   18   17
```

```
rowMeans(tb_2, na.rm = TRUE)
```

```
                     Afghanistan                          Albania 
                      168.000000                        24.000000 
                         Algeria                   American Samoa 
                       46.388889                         7.611111 
                         Andorra                           Angola 
                       24.944444                       243.888889 
                        Anguilla              Antigua and Barbuda 
                       22.833333                         7.222222 
                       Argentina                          Armenia 
                       43.666667                        57.611111 
                       Australia                          Austria 
                        6.444444                        16.333333 
                      Azerbaijan                          Bahamas 
```

Column means

`colMeans()` and `rowMeans()` require **all numeric data**.

Let’s see what the mean is across each column (year):

```
colMeans(tb_2, na.rm = TRUE)
```

```
    1990     1991     1992     1993     1994     1995     1996     1997 
105.5797 107.6715 108.3140 110.3188 111.9662 114.1981 115.3527 118.8792 
    1998     1999     2000     2001     2002     2003     2004     2005 
121.5169 125.0435 127.8454 130.7488 136.1739 136.1932 136.9662 135.6683 
    2006     2007 
134.6106 133.3865 
```

`summary()` Function

Using `summary()` can give you rough snapshots of each numeric column (character columns are skipped):

```
summary(tb)
```

```
   country               1990            1991            1992
 Length:208         Min.   :  0.0   Min.   :  4.0   Min.   :  2.0
 Class :character   1st Qu.: 27.5   1st Qu.: 27.0   1st Qu.: 27.0
 Mode  :character   Median : 60.0   Median : 58.0   Median : 56.0
                    Mean   :105.6   Mean   :107.7   Mean   :108.3
                    3rd Qu.:165.0   3rd Qu.:171.0   3rd Qu.:171.5
                    Max.   :585.0   Max.   :594.0   Max.   :606.0
                    NA's   :1       NA's   :1       NA's   :1
      1993            1994          1995            1996            1997
 Min.   :  4.0   Min.   :  0   Min.   :  3.0   Min.   :  0.0   Min.   :  0.0
 1st Qu.: 27.5   1st Qu.: 26   1st Qu.: 26.5   1st Qu.: 25.5   1st Qu.: 24.5
 Median : 56.0   Median : 57   Median : 58.0   Median : 60.0   Median : 64.0
 Mean   :110.3   Mean   :112   Mean   :114.2   Mean   :115.4   Mean   :118.9
 3rd Qu.:171.0   3rd Qu.:174   3rd Qu.:177.5   3rd Qu.:179.0   3rd Qu.:181.0
 Max.   :618.0   Max.   :630   Max.   :642.0   Max.   :655.0   Max.   :668.0
 NA's   :1       NA's   :1     NA's   :1       NA's   :1       NA's   :1
      1998            1999            2000            2001
 Min.   :  0.0   Min.   :  0.0   Min.   :  0.0   Min.   :  0.0
 1st Qu.: 23.5   1st Qu.: 22.5   1st Qu.: 21.5   1st Qu.: 19.0
 Median : 63.0   Median : 66.0   Median : 60.0   Median : 59.0
 Mean   :121.5   Mean   :125.0   Mean   :127.8   Mean   :130.7
 3rd Qu.:188.5   3rd Qu.:192.5   3rd Qu.:191.0   3rd Qu.:189.5
 Max.   :681.0   Max.   :695.0   Max.   :801.0   Max.   :916.0
 NA's   :1       NA's   :1       NA's   :1       NA's   :1
```

Summary & Lab Part 1

- summary stats (`mean()`) work with `pull()`
- don't forget the `na.rm = TRUE` argument!
- `summary(x)`: quantile information
- `summarize`: creates a summary table of columns of interest

Class Website

Lab

Youth Tobacco Survey

Here we will be using the Youth Tobacco Survey data: http://jhudatascience.org/intro_to_r/data/Youth_Tobacco_Survey_YTS_Data.csv

```
yts <- read_yts()
head(yts)
```

```
# A tibble: 6 × 31
   YEAR LocationAbbr LocationDesc TopicType     TopicDesc MeasureDesc DataSource
  <dbl> <chr>        <chr>        <chr>         <chr>     <chr>       <chr>
1  2015 AZ           Arizona      Tobacco Use … Cessatio… Percent of… YTS
2  2015 AZ           Arizona      Tobacco Use … Cessatio… Percent of… YTS
3  2015 AZ           Arizona      Tobacco Use … Cessatio… Percent of… YTS
4  2015 AZ           Arizona      Tobacco Use … Cessatio… Quit Attem… YTS
5  2015 AZ           Arizona      Tobacco Use … Cessatio… Quit Attem… YTS
6  2015 AZ           Arizona      Tobacco Use … Cessatio… Quit Attem… YTS
# … with 24 more variables: Response <chr>, Data_Value_Unit <chr>,
#   Data_Value_Type <chr>, Data_Value <dbl>, Data_Value_Footnote_Symbol <chr>,
#   Data_Value_Footnote <chr>, Data_Value_Std_Err <dbl>,
#   Low_Confidence_Limit <dbl>, High_Confidence_Limit <dbl>, Sample_Size <dbl>,
#   Gender <chr>, Race <chr>, Age <chr>, Education <chr>, GeoLocation <chr>,
#   TopicTypeId <chr>, TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>,
#   StratificationID2 <chr>, StratificationID3 <chr>, …
```

Column to vector

Let’s work with one column as a vector using `pull()`.

```
locations <- yts %>% pull(LocationDesc)
locations
```

```
   [1] "Arizona"                          "Arizona"
   [3] "Arizona"                          "Arizona"
   [5] "Arizona"                          "Arizona"
   [7] "Arizona"                          "Arizona"
   [9] "Arizona"                          "Arizona"
  [11] "Arizona"                          "Arizona"
  [13] "Arizona"                          "Arizona"
  [15] "Arizona"                          "Arizona"
  [17] "Arizona"                          "Arizona"
  [19] "Arizona"                          "Arizona"
  [21] "Arizona"                          "Arizona"
  [23] "Arizona"                          "Arizona"
  [25] "Connecticut"                      "Connecticut"
  [27] "Connecticut"                      "Connecticut"
  [29] "Connecticut"                      "Connecticut"
  [31] "Connecticut"                      "Connecticut"
  [33] "Connecticut"                      "Connecticut"
  [35] "Connecticut"                      "Connecticut"
  [37] "Connecticut"                      "Connecticut"
  [39] "Connecticut"                      "Connecticut"
  [41] "Connecticut"                      "Connecticut"
  [43] "Connecticut"                      "Connecticut"
  [45] "Connecticut"                      "Connecticut"
  [47] "Connecticut"                      "Connecticut"
  [49] "Connecticut"                      "Connecticut"
```

Length and unique

`unique(x)` will return the unique elements of `x`

```
unique(locations)
```

```
 [1] "Arizona"                    "Connecticut"               
 [3] "Georgia"                    "Hawaii"                    
 [5] "Illinois"                   "Louisiana"                 
 [7] "Mississippi"                "Utah"                      
 [9] "Missouri"                   "National (States and DC)"  
[11] "Nebraska"                   "New Jersey"                
[13] "North Carolina"             "North Dakota"              
[15] "Pennsylvania"               "South Carolina"            
[17] "West Virginia"              "Alabama"                   
[19] "Delaware"                   "Minnesota"                 
[21] "Guam"                       "Ohio"                      
[23] "Indiana"                    "Kansas"                    
[25] "Oklahoma"                   "Wisconsin"                 
[27] "Michigan"                   "New Hampshire"             
[29] "Arkansas"                   "Kentucky"                  
[31] "Iowa"                       "South Dakota"              
[33] "Virginia"                   "Puerto Rico"               
[35] "Rhode Island"               "New Mexico"                
[37] "Tennessee"                  "Vermont"                   
[39] "Virgin Islands"             "California"                
[41] "Idaho"                      "Florida"                   
[43] "Maryland"                   "Massachusetts"             
[45] "New York"                   "Maine"                     
[47] "Colorado"                   "District of Columbia"      
[49] "Texas"                      "Wyoming"                   
```

Length and unique

`length` will tell you the length of a vector. Combined with `unique`, tells you the number of unique elements:

```
length(unique(locations))
```

```
[1] 50
```

`unique()` and `distinct()`

These functions work similarly, but expect different types of objects

```
unique(locations) # vector
```

```
 [1] "Arizona"                    "Connecticut"
 [3] "Georgia"                    "Hawaii"
 [5] "Illinois"                   "Louisiana"
 [7] "Mississippi"                "Utah"
 [9] "Missouri"                   "National (States and DC)"
[11] "Nebraska"                   "New Jersey"
[13] "North Carolina"             "North Dakota"
[15] "Pennsylvania"
 [ reached getOption("max.print") -- omitted 35 entries ]
```

```
yts %>% distinct(LocationDesc) # tibble / data frame
```

```
# A tibble: 50 × 1
   LocationDesc
   <chr>
 1 Arizona
 2 Connecticut
 3 Georgia
 4 Hawaii
 5 Illinois
 6 Louisiana
 7 Mississippi
 8 Utah
 9 Missouri
10 National (States and DC)
# … with 40 more rows
```

dplyr: count

Use `count` to return a frequency table of unique elements of a data.frame.

```
yts %>% count(LocationDesc)
```

```
# A tibble: 50 × 2
   LocationDesc             n
   <chr>                <int>
 1 Alabama                378
 2 Arizona                240
 3 Arkansas               210
 4 California              96
 5 Colorado                48
 6 Connecticut            384
 7 Delaware               312
 8 District of Columbia    48
 9 Florida                 96
10 Georgia                282
# … with 40 more rows
```

dplyr: count

Multiple columns listed further subdivides the count.

```
yts %>% count(LocationDesc, TopicDesc)
```

```
# A tibble: 146 × 3
   LocationDesc TopicDesc                         n
   <chr>        <chr>                         <int>
 1 Alabama      Cessation (Youth)                90
 2 Alabama      Cigarette Use (Youth)           144
 3 Alabama      Smokeless Tobacco Use (Youth)   144
 4 Arizona      Cessation (Youth)                60
 5 Arizona      Cigarette Use (Youth)            99
 6 Arizona      Smokeless Tobacco Use (Youth)    81
 7 Arkansas     Cessation (Youth)                42
 8 Arkansas     Cigarette Use (Youth)            78
 9 Arkansas     Smokeless Tobacco Use (Youth)    90
10 California   Cessation (Youth)                24
# … with 136 more rows
```

dplyr: count

Multiple columns listed further subdivides the count.

```
yts %>% count(LocationDesc, TopicDesc)
```

```
# A tibble: 146 × 3
   LocationDesc TopicDesc                            n
   <chr>        <chr>                            <int>
 1 Alabama      Cessation (Youth)                   90
 2 Alabama      Cigarette Use (Youth)              144
 3 Alabama      Smokeless Tobacco Use (Youth)      144
 4 Arizona      Cessation (Youth)                   60
 5 Arizona      Cigarette Use (Youth)               99
 6 Arizona      Smokeless Tobacco Use (Youth)       81
 7 Arkansas     Cessation (Youth)                   42
 8 Arkansas     Cigarette Use (Youth)               78
 9 Arkansas     Smokeless Tobacco Use (Youth)       90
10 California   Cessation (Youth)                   24
# … with 136 more rows
```

Note: `count()` includes NAs

Grouping

Perform Operations By Groups: dplyr

`group_by` allows you group the data set by variables/columns you specify:

```r
# Regular data
yts
```

```
# A tibble: 9,794 × 31
    YEAR LocationAbbr LocationDesc TopicType    TopicDesc MeasureDesc DataSource
   <dbl> <chr>        <chr>        <chr>        <chr>     <chr>       <chr>     
 1  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS       
 2  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS       
 3  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS       
 4  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS       
 5  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS       
 6  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS       
 7  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS       
 8  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS       
 9  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS       
10  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS       
# … with 9,784 more rows, and 24 more variables: Response <chr>,
#   Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
#   Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
#   Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
#   High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
#   Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
#   TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>, …
```

Perform Operations By Groups: dplyr

`group_by` allows you group the data set by variables/columns you specify:

```
yts_grouped <- yts %>% group_by(Response)
yts_grouped
```

```
# A tibble: 9,794 × 31
# Groups:   Response [4]
    YEAR LocationAbbr LocationDesc TopicType    TopicDesc MeasureDesc DataSource
   <dbl> <chr>        <chr>        <chr>        <chr>     <chr>       <chr>
 1  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS
 2  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS
 3  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS
 4  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS
 5  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS
 6  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS
 7  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
 8  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
 9  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
10  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
# … with 9,784 more rows, and 24 more variables: Response <chr>,
#   Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
#   Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
#   Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
#   High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
#   Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
#   TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>, …
```

Summarize the grouped data

It's grouped! Grouping doesn't change the data in any way, but how **functions operate on it**. Now we can summarize `Data_Value` (percent of respondents) by group:

```
yts_grouped %>% summarize(avg_percent = mean(Data_Value, na.rm = TRUE))
```

```
# A tibble: 4 × 2
  Response avg_percent
  <chr>          <dbl>
1 Current         9.68
2 Ever           26.1
3 Frequent        3.48
4 <NA>           53.5
```

Use the **`pipe`** to string these together!

Pipe `yts` into `group_by`, then pipe that into `summarize`:

```
yts %>%
  group_by(Response) %>%
  summarize(avg_percent = mean(Data_Value, na.rm = TRUE),
            max_percent = max(Data_Value, na.rm = TRUE))
```

```
# A tibble: 4 × 3
  Response avg_percent max_percent
  <chr>          <dbl>       <dbl>
1 Current         9.68        40.6
2 Ever           26.1         98  
3 Frequent        3.48        23.9
4 <NA>           53.5         81.9
```

Group by as many variables as you want

`group_by` Response and Education:

```
yts %>%
  group_by(Response, Education) %>%
  summarize(avg_percent = mean(Data_Value, na.rm = TRUE),
            max_percent = max(Data_Value, na.rm = TRUE))
```

```
# A tibble: 8 × 4
# Groups:   Response [4]
  Response Education     avg_percent max_percent
  <chr>    <chr>               <dbl>       <dbl>
1 Current  High School         14.1         40.6
2 Current  Middle School        5.73       26.1
3 Ever     High School         34.7         96.2
4 Ever     Middle School       18.6         98
5 Frequent High School          5.91        23.9
6 Frequent Middle School        1.33         8
7 <NA>     High School         53.8         78.9
8 <NA>     Middle School       53.2         81.9
```

Ungroup the data

The `ungroup` function will allow you to clear the groups from the data. You can also overwrite the first `group_by` with a new one.

```
yts <- ungroup(yts)
yts
```

```
# A tibble: 9,794 × 31
    YEAR LocationAbbr LocationDesc TopicType    TopicDesc MeasureDesc DataSource
   <dbl> <chr>        <chr>        <chr>        <chr>     <chr>       <chr>
 1  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS
 2  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS
 3  2015 AZ           Arizona      Tobacco Use… Cessatio… Percent of… YTS
 4  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS
 5  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS
 6  2015 AZ           Arizona      Tobacco Use… Cessatio… Quit Attem… YTS
 7  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
 8  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
 9  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
10  2015 AZ           Arizona      Tobacco Use… Cigarett… Smoking St… YTS
# … with 9,784 more rows, and 24 more variables: Response <chr>,
#   Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
#   Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
#   Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
#   High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
#   Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
#   TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>, …
```

group_by with mutate - just add data

We can also use `mutate` to calculate the mean value for each year and add it as a column:

```
yts %>%
  group_by(YEAR) %>%
  mutate(year_avg = mean(Data_Value, na.rm = TRUE)) %>%
  select(LocationDesc, Data_Value, year_avg)
```

```
# A tibble: 9,794 × 4
# Groups:   YEAR [17]
    YEAR LocationDesc Data_Value year_avg
   <dbl> <chr>             <dbl>    <dbl>
 1  2015 Arizona            NA       15.2
 2  2015 Arizona            NA       15.2
 3  2015 Arizona            NA       15.2
 4  2015 Arizona            NA       15.2
 5  2015 Arizona            NA       15.2
 6  2015 Arizona            NA       15.2
 7  2015 Arizona             3.2     15.2
 8  2015 Arizona             3.2     15.2
 9  2015 Arizona             3.1     15.2
10  2015 Arizona            12.5     15.2
# … with 9,784 more rows
```

Counting

There are other functions, such as `n()` count the number of observations (NAs included).

```
yts %>%
  group_by(YEAR) %>%
  summarize(n = n(),
            mean = mean(Data_Value, na.rm = TRUE))
```

```
# A tibble: 17 × 3
    YEAR     n  mean
   <dbl> <int> <dbl>
 1  1999   372  26.1
 2  2000  1224  26.7
 3  2001   426  23.4
 4  2002  1016  25.2
 5  2003   498  21.3
 6  2004   611  20.7
 7  2005   636  21.8
 8  2006   518  21.8
 9  2007   516  20.0
10  2008   483  18.2
11  2009   686  18.3
12  2010   447  17.8
13  2011   521  17.8
14  2012   244  15.5
15  2013   685  16.7
16  2014   334  15.7
17  2015   577  15.2
```

Counting

`count()` and `n()` can give very similar information.

```
mtcars %>% count(cyl)
```

```
  cyl  n
1   4 11
2   6  7
3   8 14
```

```
mtcars %>% group_by(cyl) %>% summarize(n()) # n() typically used with summarize
```

```
# A tibble: 3 × 2
    cyl `n()`
  <dbl> <int>
1     4    11
2     6     7
3     8    14
```

Summary & Lab Part 2

- `count(x)`: what unique values do you have?
  - `pull()` gives a vector
  - `unique()` combined with `length()`
- `group_by()`: changes all subsequent functions
  - combine with `summarize()` to get statistics per group
  - combine with `mutate()` to add column
- `summarize()` with `n()` gives the count (NAs included)

Class Website

Lab

Preview: plotting

Basic Plots

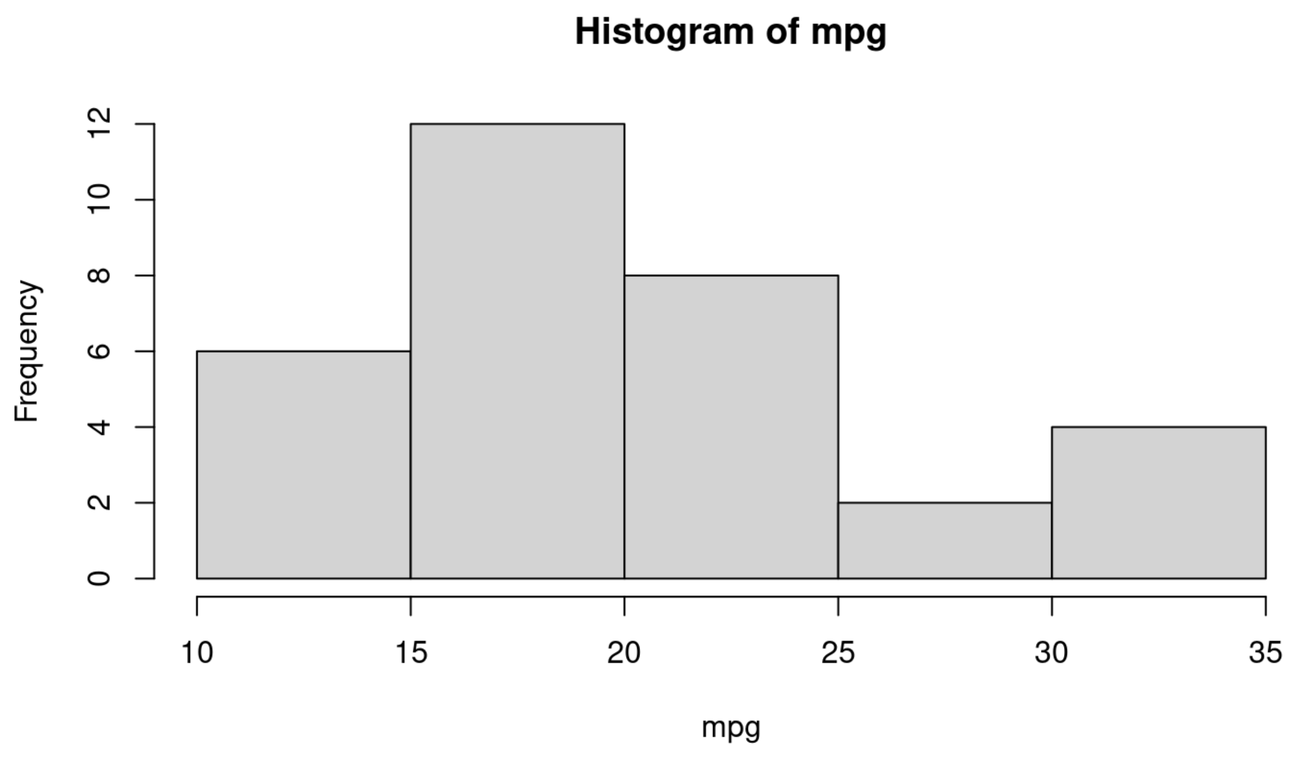
Plotting is an important component of exploratory data analysis. These are some rough plots that you can use in real time while exploring your data.

We will go over formatting and making plots look nicer in additional lectures.

- Basic summarization plots:
  - `hist(x)`: histogram of x
  - `plot(x,y)`: scatterplot of x and y
  - `boxplot(y~x)`: boxplot of y against levels of x

Histogram

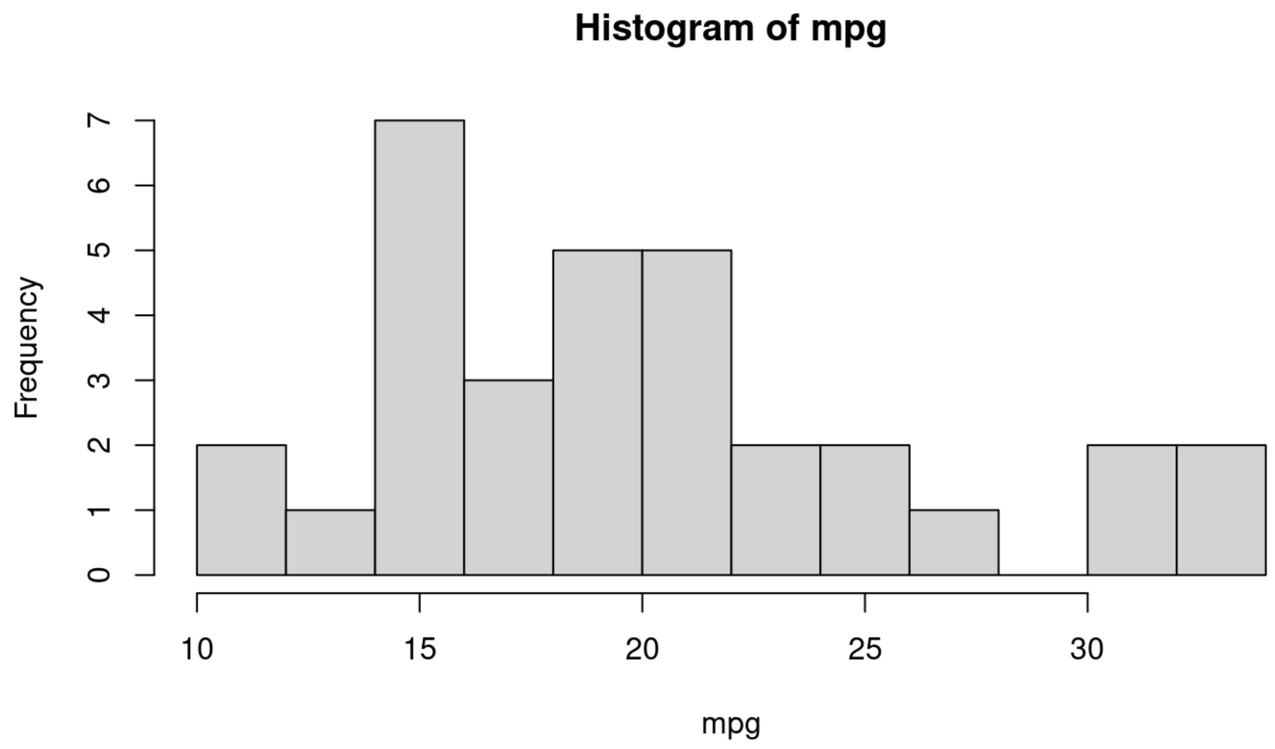
```
mpg <- jhu_cars %>% pull(mpg)
hist(x = mpg)
```



Histogram

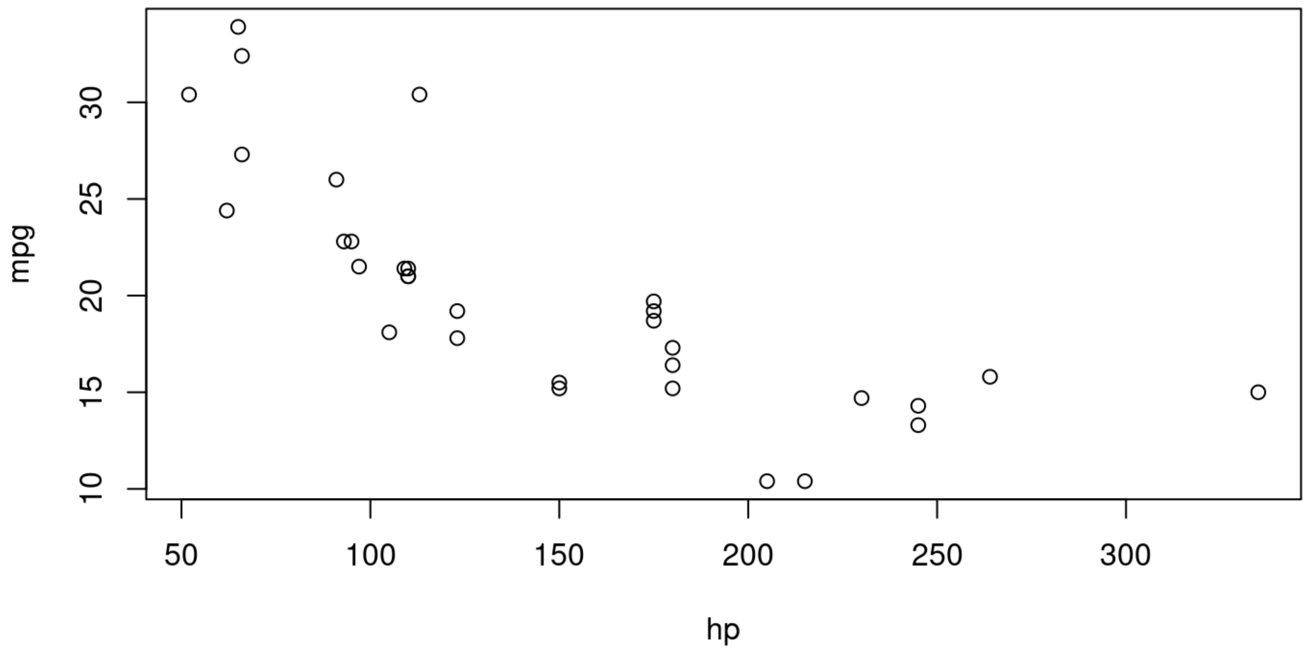
Use the `breaks =` argument to tweak the resolution:

```r
hist(x = mpg, breaks = 10)
```



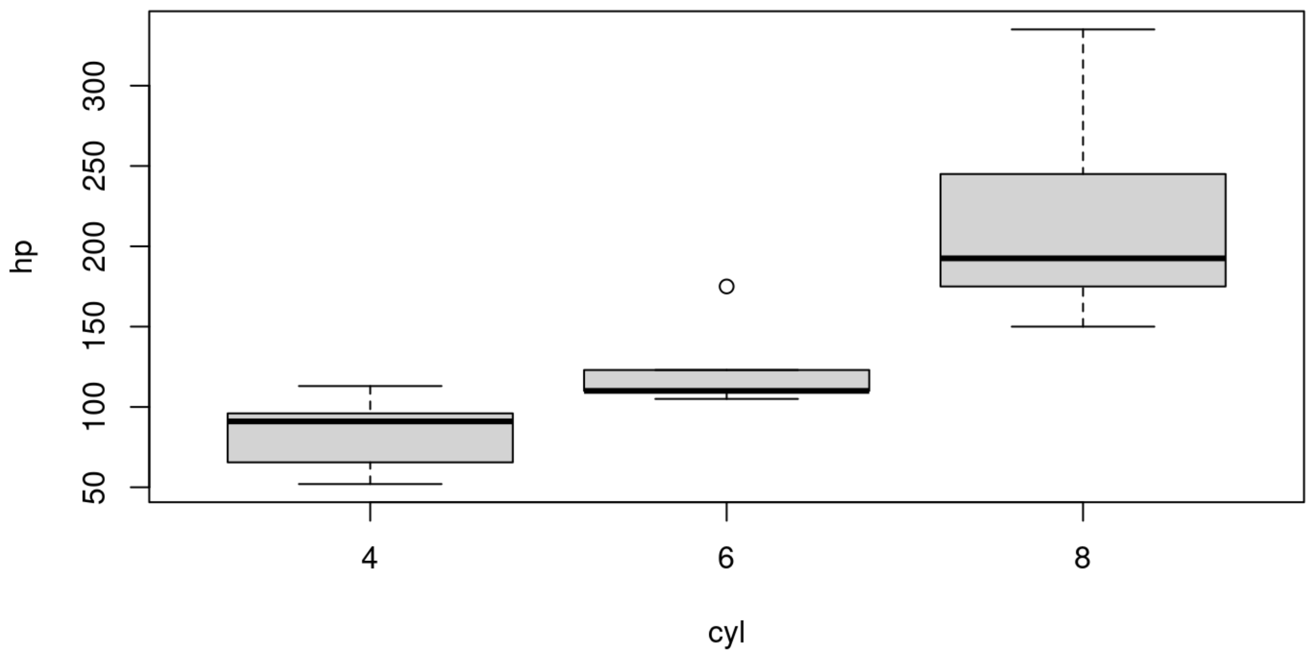
Scatterplot

```
mpg <- jhu_cars %>% pull(mpg)
hp <- jhu_cars %>% pull(hp)
plot(x = hp, y = mpg) # plot(hp, mpg)
```



Boxplot

```
cyl <- jhu_cars %>% pull(cyl)
hp <- jhu_cars %>% pull(hp)
boxplot(formula = hp ~ cyl)
```



Summary & Lab Part 3

- `plot(x,y)` and `hist(x)` are great for a **quick snapshot** of the data
- `boxplot(y ~ x)` works for categorical data

Class Website

Lab

Image by Gerd Altmann from Pixabay