Lecture 5: Meet R

ECON 480 - Econometrics - Fall 2018

Ryan Safner

September 12, 2018

Writing and Saving R Code

Objects in R

Data Frames

Quick Data Analysis Example

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Excel, Stata, R

Excel	Stata	R
MS Office License	Expensive License	Free!
Proprietary	Proprietary	Open Source
Default, used in finance	Primary for economists	Largest use by data scientists
Not reproducible	Reproducible (.do files)	Reproducible (.R files)
Can't incorporate into docs	Can't incorporate into docs	Can run in chunks within docs
Very limited extensions	Many packages	Most packages written for R first
Point-and-click	Point-and-click or command line	Almost exclusively command line
Limited formulas	Just one command per task	Many alternative commands

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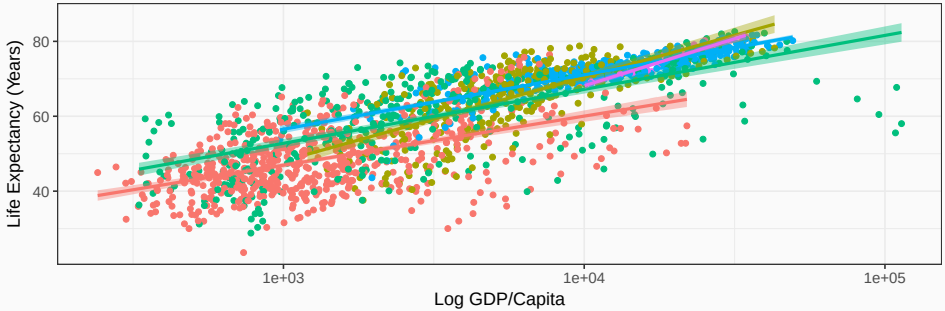
Stata and Excel Can't Do This (Right in the Slides)

```
ggplot(data = gapminder, aes(x = gdpPercap,
    y = lifeExp, color = continent, fill= continent))+
    geom_point()+geom_smooth(method = "lm") +
    scale_x_log10()+ylab("Life Expectancy (Years)")+
    xlab("Log GDP/Capita")
```



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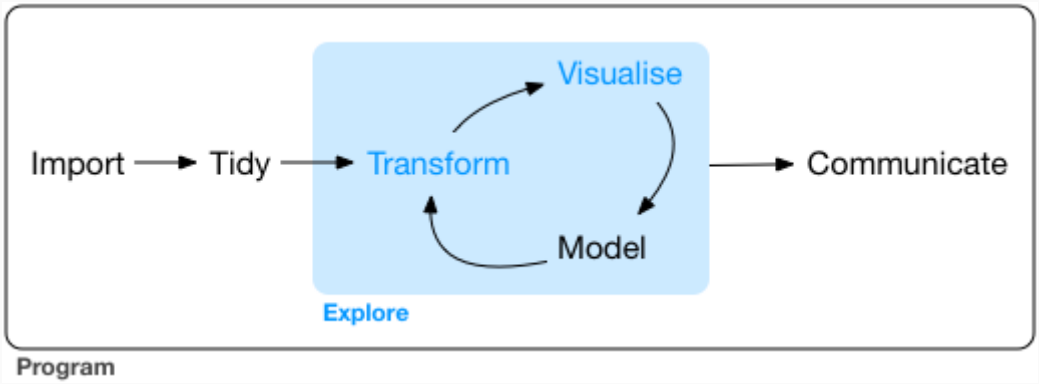
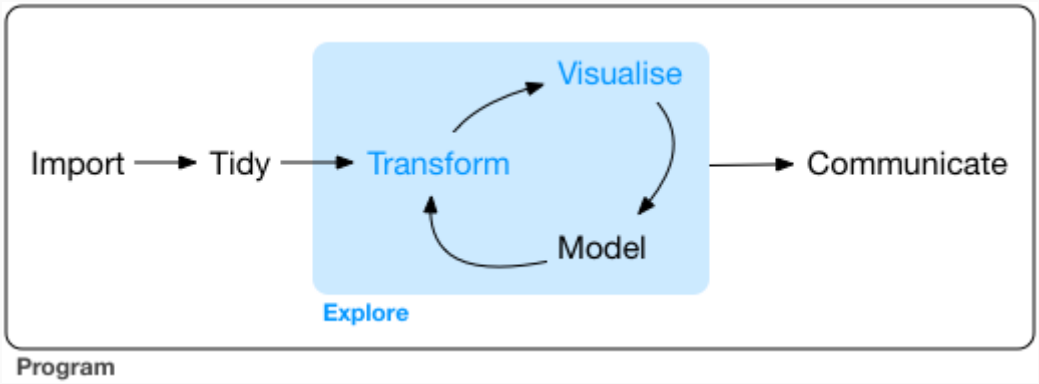


Workflow

- Need software that can import, tidy, analyze, plot, and present data



Workflow

- Need software that can import, tidy, analyze, plot, and present data
- R can do all of this (with *R Markdown*, all in the same document)

- You are literally learning a new language, complete with grammar and syntax rules, and specific vocabulary

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- R like all command line programming is *very literal*, a single typo or misplaced comma will lead to a different outcome than you intended, or fail completely

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"There's an implied contract between you and R: it will do the tedious computation for you, but in return, you must be completely precise in your instructions. Typos matter. Case matters."

R for Data Science

Hadley Wickham

Chief Scientist, R Studio

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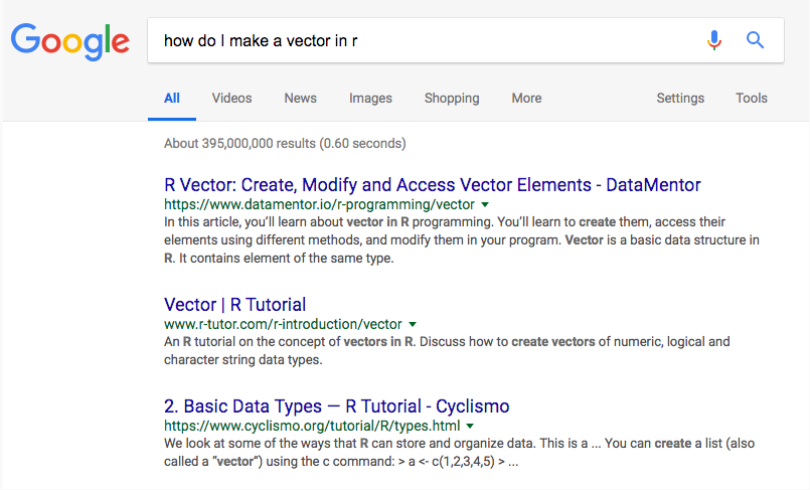
Say Hello to My Little Friend



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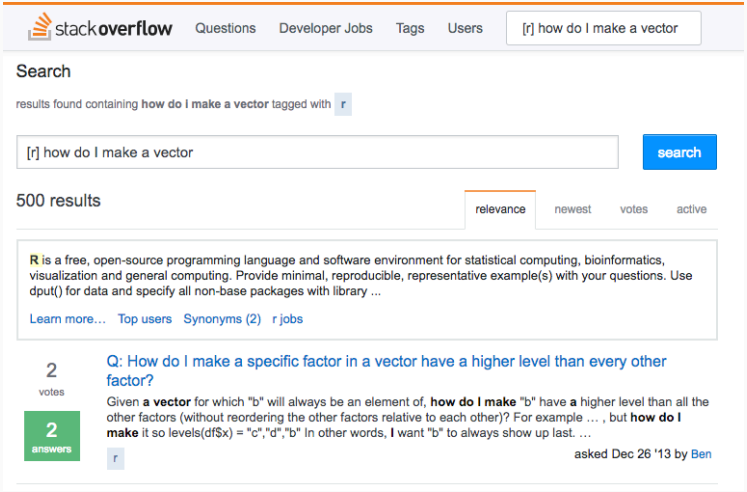
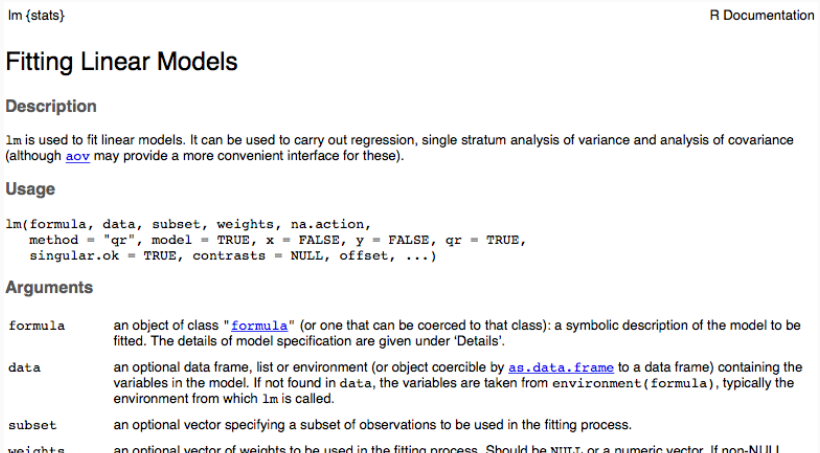
Say Hello to Your New BEST Friend



```
#type help("functionname") to get documentation on the command
help("lm")
```



lm {stats} R Documentation

Fitting Linear Models

Description

`lm` is used to fit linear models. It can be used to carry out regression, single stratum analysis of variance and analysis of covariance (although aov may provide a more convenient interface for these).

Usage

```
lm(formula, data, subset, weights, na.action,
   method = "qr", model = TRUE, x = FALSE, y = FALSE, qr = TRUE,
   singular.ok = TRUE, contrasts = NULL, offset, ...)
```

Arguments

`formula`	an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted. The details of model specification are given under 'Details'.
`data`	an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in `data`, the variables are taken from `environment(formula)`, typically the environment from which `lm` is called.
`subset`	an optional vector specifying a subset of observations to be used in the fitting process.
`weights`	an optional vector of weights to be used in the fitting process. Should be NULL or a numeric vector. If non-NULL

Writing and Saving R Code

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  - Consider both your R objects and your files and folder names on your computer...(`/School/ECON_480_Econometrics/Homeworks_and_Data/`)
- It will be wise to adopt some consistent standard for demarcating names:

```
i.use.snake.case
otherPeopleUseCamelCase
some_people_use_underscores
And_aFew.People_RENOUNCEconvention
```

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    - OS-specific to Windows vs. Mac vs. Linux

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Writing and Saving R Code: Tips

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```
# Run regression of y on x, save as reg1
reg1<-lm(y~x, data=data) #runs regression
summary(reg1$coefficients) #prints coefficients
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  - Better yet, ask me about version control and GitHub (later)

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    - Can write an entire document (text, equations, R commands, figures, tables, etc) with one file!
    - Can export to html, MS Word, Beamer, etc!
    - Markdown is a language that is intuitive, simple, human- and machine-readable

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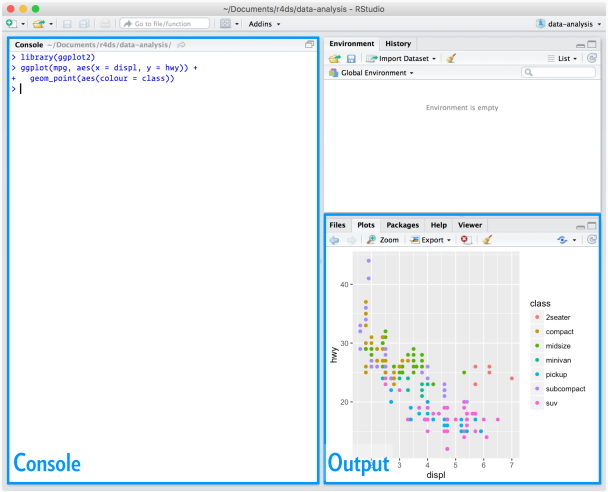

Rstudio Windows

Agenda for Today and for the Future

- **Today**: practice using the Command Line/Console in *R*

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- **Today**: practice using the Command Line/Console in *R*
  - Learn different commands and results relevant to data analysis
  - By the end, saving a script as a *.R* file
- **Later**: *R Markdown* and the benefits to plain text, literate programming, and workflow management

HOOD COLLEGE

- First, ecognize that R can be used as a simple calculator

```
2+2
```

```
## [1] 4
```

```
sqrt(100/4)
```

```
## [1] 5
```

```
log(5)
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## [1] 1.609438
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- This will be helpful later when we want to transform variables

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- If you do not have a package, they are easy to install with (yes, note the plural “s”)

```
install.packages("packagename")
```

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- Here is a list of the most important packages you will probably use for things relevant to econometrics

Package name	Use
`ggplot2`	Rendering beautiful graphics (scatterplots, histograms, etc)
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- We will explore each of these in more detail later

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```
1:5
```

```
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```

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Vectors II

- We can perform mathematical operations on a vector as a whole:

```
sum(1:5)
```

```
## [1] 15
```

```
mean(1:5)
```

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

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```
list
```

```
## [1] "red"    "blue"   "purple"
```

```
print(list)
```

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```

- Vectors **must** contain the same type of elements (e.g. numerical or text)

```
mixed<-c(5, pi, TRUE, 4.3, "cabbage")
class(mixed)
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```

- Character is a string of text: letters, numbers, and symbols, cannot perform mathematical operations

```
character<-c("one","two","7","orange")
```

Factors

- Factor is a special type of character variable, often used to indicate membership in one of several possible categories, called **levels** (e.g. for plotting, or conditional statistics and data work)

```
students<-factor(c("freshman", "senior", "senior", "junior", "freshman",
                   "sophomore", "freshman"))
levels(students) #extract unique levels
```

```
## [1] "freshman"  "junior"    "senior"    "sophomore"
```

```
nlevels(students) #count the number of levels
```

```
## [1] 4
```

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```
table(students) #tabulate number of values for each level
```

```
## students
##  freshman    junior    senior sophomore
##         3         1         2         1
```

- Again, check the type of data with **class()**

```
class(x)
```

```
## [1] "numeric"
```

```
x<-as.character(x)
class(x)
```

```
## [1] "character"
```

```
x<-as.numeric(x)
```

- Again, check the type of data with **class()**
- Change the type with **as.classname()**

```
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## [1] "character"
```

```
x<-as.numeric(x)
```

- Again, check the type of data with **class()**
- Change the type with **as.classname()**
  - Note you can't turn characters into numeric (if there's no numbers), but you can turn numeric into characters

```
class(x)
```

```
## [1] "numeric"
```

```
x<-as.character(x)
class(x)
```

```
## [1] "character"
```

```
x<-as.numeric(x)
```

- Use [square brackets] to isolate elements of a vector for commands

```
print(list) #Our original list
```

```
## [1] "red"    "blue"   "purple"
```

```
list[1] #Inspect first element
```

```
## [1] "red"
```

```
list[c(1,3)] #Inspect first and third elements
```

```
## [1] "red"    "purple"
```

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- Use **[square brackets]** to isolate elements of a vector for commands

```
list[2]<-"orange" #Change second element
print(list) #Our new list
```

```
## [1] "red"    "orange" "purple"
```

- Keeping our first vector *x*, let's create another object *y*

```
y<-10
```

- Keeping our first vector *x*, let's create another object *y*

```
y<-10
```

- Let's create a third object *z*, which is the product of *x* and *y*

```
z<-x*y
z
```

```
## [1] 10 20 30 40 50
```

Redefining Objects

- Objects and variables maintain their value until they are changed. We can redefine x as 6 simply with another command to define x.

```
x
```

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

```
x<-6
x
```

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

Functions

- Most of R: `functionname(objectname)`

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Functions

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- A function produces a (hopefully useful) output based on the input that it recieves.

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Functions

- Most of R: `functionname(objectname)`
- A function produces a (hopefully useful) output based on the input that it recieves.
- Functions can be recognized by the parentheses () at the end of their names.
- The `c()` command that produces a vector, was an example of a function.

HOOD COLLEGE

- Mathematical/Statistical Functions

Function	Use	Example
`sum()`	Takes the sum of an object	`sum(1:10)`
`mean()`	Takes the arithmetic mean of an object	`mean(1:10)`
`rnorm()`	Takes a number of draws (e.g. 5) from a normal distribution	`rnorm(5)`
`round()`	Rounds an object (e.g. x) to (e.g. 2) decimal places	`round(x,2)`

HOOD COLLEGE

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- Note functions can have functions in their arguments, e.g. `round(rnorm(5),2)`

HOOD COLLEGE

Data Frames

- The most important object in R is a data frame, used for statistics, plots, regressions, etc

```
gapminder
```

```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Afghanistan Asia       1957    30.3  9240934      821.
##  3 Afghanistan Asia       1962    32.0 10267083      853.
##  4 Afghanistan Asia       1967    34.0 11537966      836.
##  5 Afghanistan Asia       1972    36.1 13079460      740.
```

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- The most important object in R is a data frame, used for statistics, plots, regressions, etc
  - "Rectangular" data (i.e. "spreadsheet"): rows are observations, columns are variables
  - Can hold variables of different classes
  - All vectors (columns) must have the same length!

```
gapminder
```

```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
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```

- We often import existing data into a dataframe (see importing data below)

```
v1<-c(10,20,30,45,60) # A list of integers
v2<-LETTERS[1:5] # The first 5 letters
v3<-round(rnorm(5),2) #5 random draws from normal distr, rounded to 2 decimal pl
v4<-c("Apples","Oranges","Bananas","Kiwi","Watermelon") #Fruits
mydf<-data.frame(v1,v2,v3,v4) #make dataframe called mydf
```

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- We often import existing data into a dataframe (see importing data below)
- We could construct a data frame from scratch using **data.frame()**

```
v1<-c(10,20,30,45,60) # A list of integers
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```

HOOD COLLEGE

- We often import existing data into a dataframe (see importing data below)
- We could construct a data frame from scratch using **data.frame()**
- Suppose we have 4 different vectors, **v1**, **v2**, **v3**, and **v4**

```
v1<-c(10,20,30,45,60) # A list of integers
v2<-LETTERS[1:5] # The first 5 letters
v3<-round(rnorm(5),2) #5 random draws from normal distr, rounded to 2 decimal pl
v4<-c("Apples","Oranges","Bananas","Kiwi","Watermelon") #Fruits
mydf<-data.frame(v1,v2,v3,v4) #make dataframe called mydf
```

HOOD COLLEGE

- Check the structure of a data frame with `str()`

```
str(mydf) #examine structure
```

```
## 'data.frame':    5 obs. of  4 variables:
##  $ v1: num  10 20 30 45 60
##  $ v2: Factor w/ 5 levels "A","B","C","D",..: 1 2 3 4 5
##  $ v3: num  0.58 0.19 0.1 -0.14 0.81
##  $ v4: Factor w/ 5 levels "Apples","Bananas",..: 1 4 2 3 5
```

```
class(mydf) #check it's a dataframe
```

```
## [1] "data.frame"
```

HOOD COLLEGE

- Note instead of making the vectors first and then combining them, we could have done it all at once:

```
mydf<-data.frame(v1=c(10,20,30,45,60),
                 v2=LETTERS[1:5],
                 v3=round(rnorm(5),2),
                 v4=c("Apples","Oranges","Bananas","Kiwi","Watermelon"))
```

HOOD COLLEGE

- We will use the `gapminder` dataset as a quick example

```
library("gapminder")
str(gapminder)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    1704 obs. of  6 variables:
##  $ country  : Factor w/ 142 levels "Afghanistan",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ continent: Factor w/ 5 levels "Africa","Americas",..: 3 3 3 3 3 3 3 3 3 3
##  $ year     : int  1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 ...
##  $ lifeExp  : num  28.8 30.3 32 34 36.1 ...
##  $ pop      : int  8425333 9240934 10267083 11537966 13079460 14880372 12881818
##  $ gdpPercap: num  779 821 853 836 740 ...
```

- We will use the `gapminder` dataset as a quick example
- `str()` will give us a sense of the structure

```
library("gapminder")
str(gapminder)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    1704 obs. of  6 variables:
##  $ country  : Factor w/ 142 levels "Afghanistan",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ continent: Factor w/ 5 levels "Africa","Americas",..: 3 3 3 3 3 3 3 3 3 3
##  $ year     : int  1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 ...
##  $ lifeExp  : num  28.8 30.3 32 34 36.1 ...
##  $ pop      : int  8425333 9240934 10267083 11537966 13079460 14880372 12881818
##  $ gdpPercap: num  779 821 853 836 740 ...
```

- **head()** will show us the top 6 rows (observations)

```
head(gapminder)
```

```
## # A tibble: 6 x 6
##   country     continent  year lifeExp      pop gdpPercap
##   <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
## 1 Afghanistan Asia       1952    28.8  8425333      779.
## 2 Afghanistan Asia       1957    30.3  9240934      821.
## 3 Afghanistan Asia       1962    32.0 10267083      853.
## 4 Afghanistan Asia       1967    34.0 11537966      836.
## 5 Afghanistan Asia       1972    36.1 13079460      740.
## 6 Afghanistan Asia       1977    38.4 14880372      786.
```

HOOD COLLEGE

- summary() will give us a summary statistics of each variable (columns)

```
summary(gapminder)
```

```
##         country        continent        year         lifeExp
##  Afghanistan:  12   Africa  :624   Min.   :1952   Min.   :23.60
##  Albania    :  12   Americas:300   1st Qu.:1966   1st Qu.:48.20
##  Algeria    :  12   Asia    :396   Median :1980   Median :60.71
##  Angola     :  12   Europe  :360   Mean   :1980   Mean   :59.47
##  Argentina  :  12   Oceania : 24   3rd Qu.:1993   3rd Qu.:70.85
##  Australia  :  12                  Max.   :2007   Max.   :82.60
##  (Other)    :1632
##       pop              gdpPercap
##  Min.   :6.001e+04   Min.   :   241.2
```

Data Frames: Selecting Columns (Variables)

- Each variable is stored as a part of a data frame that can be called with the $ sign

Data Frames: Selecting Columns (Variables)

- Each variable is stored as a part of a data frame that can be called with the $ sign
  - e.g. with the Diamonds data, price can be called with `Diamonds$price`:

```
summary(gapminder$gdpPercap)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
##     241.2    1202.1    3531.8    7215.3    9325.5 113523.1
```

```
mean(gapminder$gdpPercap)
```

```
## [1] 7215.327
```

HOOD COLLEGE

Quick Data Analysis Example

- Simple commands can help us learn about a dataset quickly

Function	Result
`min(distr)`	Find minimum value
`max(distr)`	Find maximum value
`range(distr)`	Find the range
`sort(distr)`	Sort values of distribution from smallest to largest
`sort(distr)[1]`	Find first value when sorted (equvalient to finding min)
`sort(distr, decreasing=TRUE)`	Sort from largest to smallest
`median(distr)`	Find the median
`mean(distr)`	Find the mean
`var(distr)`	Find the variance
`sd(distr)`	Find the standard deviation

Function	Result
`table(distr)`	Gives frequency table of categorical variable values
`fivenum(distr)`	Five number summary (min, q1, median, q3, max)
`summary(distr)`	Gives min, q1, median, mean, q3, max
`quantile(distr, 0.32)`	Find specific (e.g. 32nd) percentile
`summary(factor(distr))`	Lists all unique values in distr
`sum(distr)`	Takes the sum of all values in distr

HOOD COLLEGE

```
summary(gapminder$gdpPercap)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##    241.2   1202.1   3531.8   7215.3   9325.5 113523.1
```

```
mean(gapminder$pop)
```

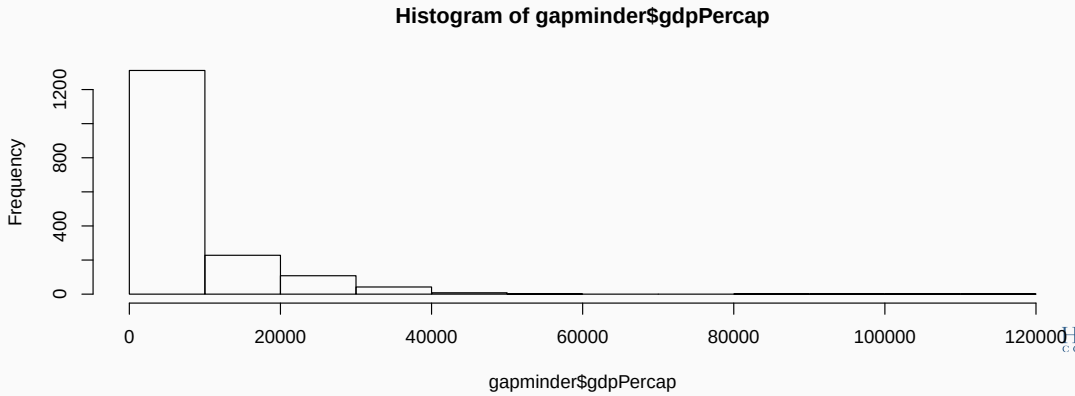
```
## [1] 29601212
```

```
table(gapminder$continent)
```

```
##
##   Africa Americas     Asia   Europe  Oceania
##      624      300      396      360       24
```

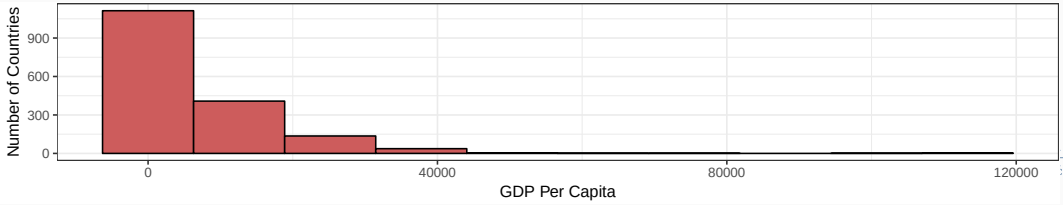
- Base R is very powerful and intuitive to plot, but not very sexy

```
hist(gapminder$gdpPercap)
```



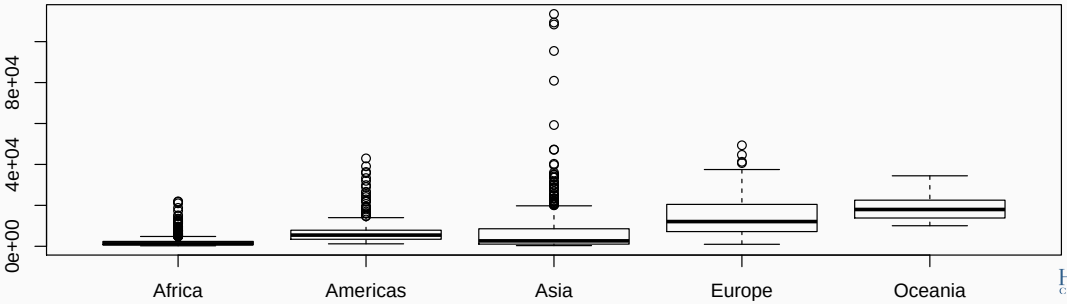
- This is where packages (like **ggplot2**) come in, but we'll have to learn later

```
library("ggplot2")
ggplot(gapminder, aes(x=gdpPercap))+
  geom_histogram(bins=10, color="black",fill="indianred")+
  xlab("GDP Per Capita")+ylab("Number of Countries")+
  theme_bw()
```



- Boxplots

```
boxplot(gdpPercap~continent,data=gapminder)
```



```
library("ggplot2")
library("gapminder")
ggplot(gapminder, aes(x=continent,y=gdpPercap ,fill=continent))+
    geom_boxplot()+ theme_bw()
```