# Lecture 05 – Documenting with R Markdown

## Specific Learning Objectives:

1 – Create reproducible scripts in R.

2 – Include effective documentation in scripts and projects.

3 – Create and use Notebooks and documents using RMarkdown.

4 – Learn how to plot quickly using R's base graphics.

# Best Practices Discussion

- Pick one of the 5 papers listed on Slack, sign up on Slack.

- Prepare a short summary (100-200 words) of the paper's main points to discuss and share with the class on Wed.

# More Basic R

- Slack me any R topics you want covered on Monday 9/27!

# Literate Programming and Reproducible Science

- One of the basic tenets of science is that work is reproducible. This applies to code as well!

    - We will talk more about how to accomplish this in the next unit, but for now, we'll focus on using **documentation** and **literate programming** to build reproducible analyses.

- What is **documentation**?

    - Code documentation refers to all of the notes, instructions, and comments that provide context and help a user run the code successfully

- What is **literate programming**?

    - Literate programming is the method of directly embedding chunks of code in the documentation that helps the user understand the code and its outputs.

# R Markdown – a laboratory notebook for code!

- R Markdown documents help by giving you the ability to embed your code into a regular document.

    - This gives you the space to explain your code, plots, figures, and analyses in context!

    - It helps you by providing a reproducible environment for your code and plots.

- We'll use R Markdown documents with R Projects

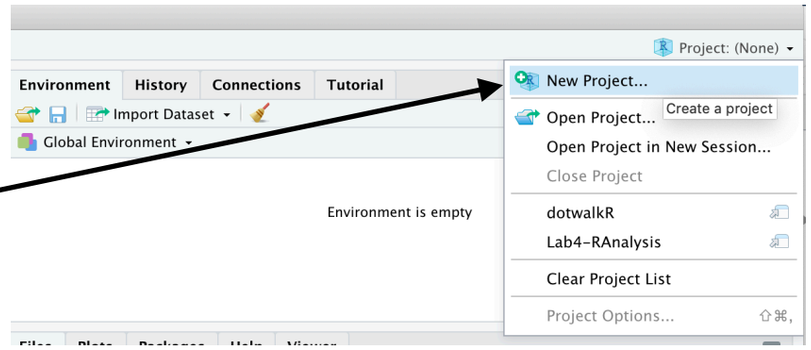
    - R projects help you organize your data and code into a neat package.

    - R projects will automatically set the working directory for you, so you don't have to worry about it!

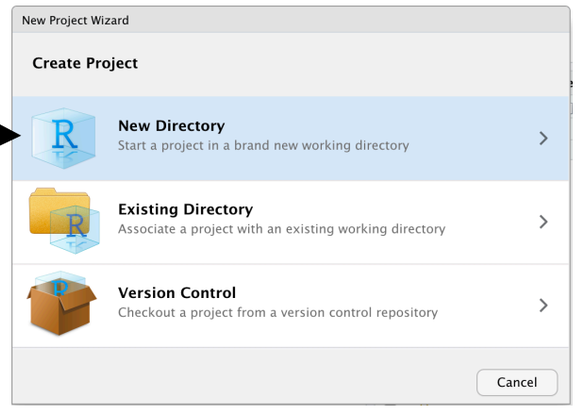
    - R projects will keep track of the work you do in that specific project so it doesn't get mixed up with other projects!

# Creating an R Project

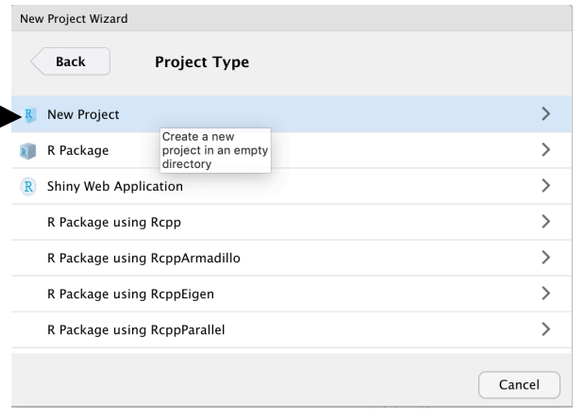
1. **Either under “File…” or at the top right corner, select “New Project…”**



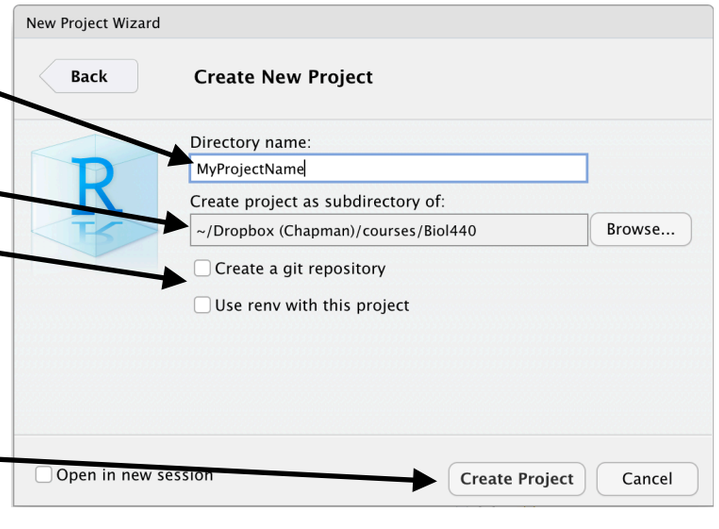

2. **Select “New Directory” in the Wizard.**




3. **Select “New Project” again.**



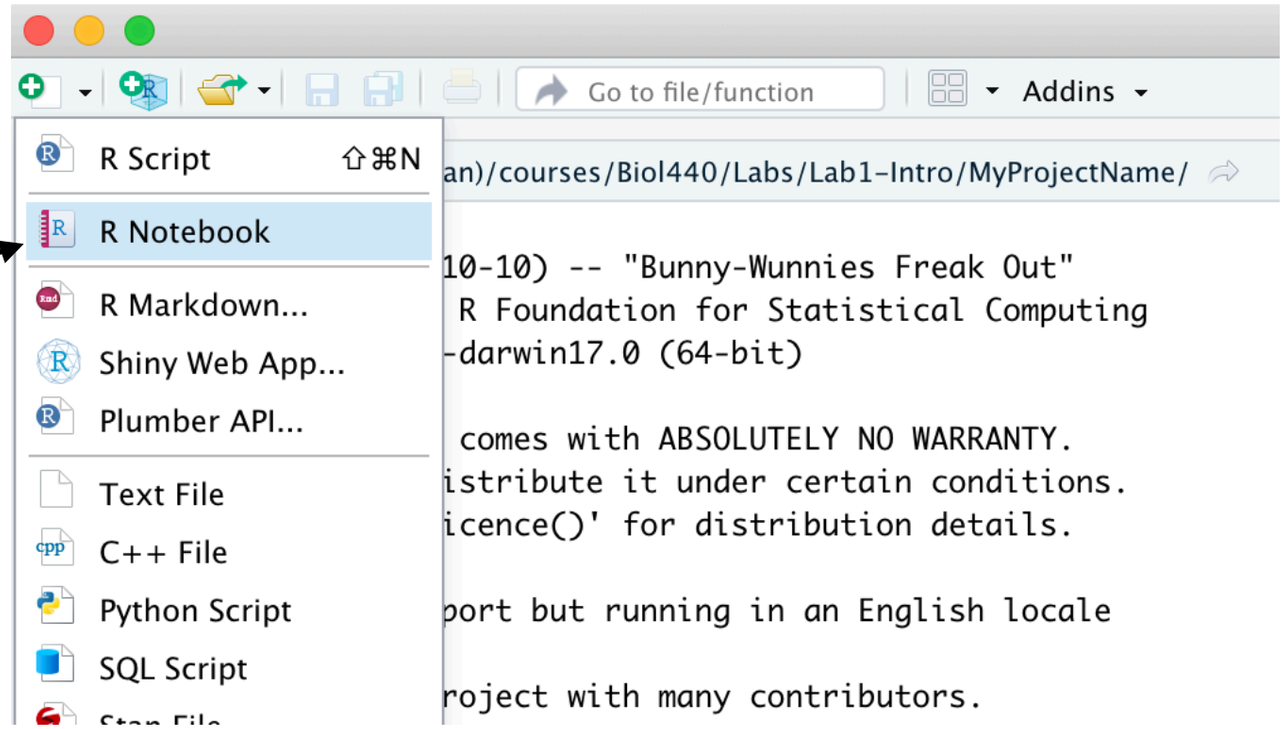

4. **Create a directory name for your project. Choose where you want the project directory to be (using Browse…). Uncheck both boxes.**

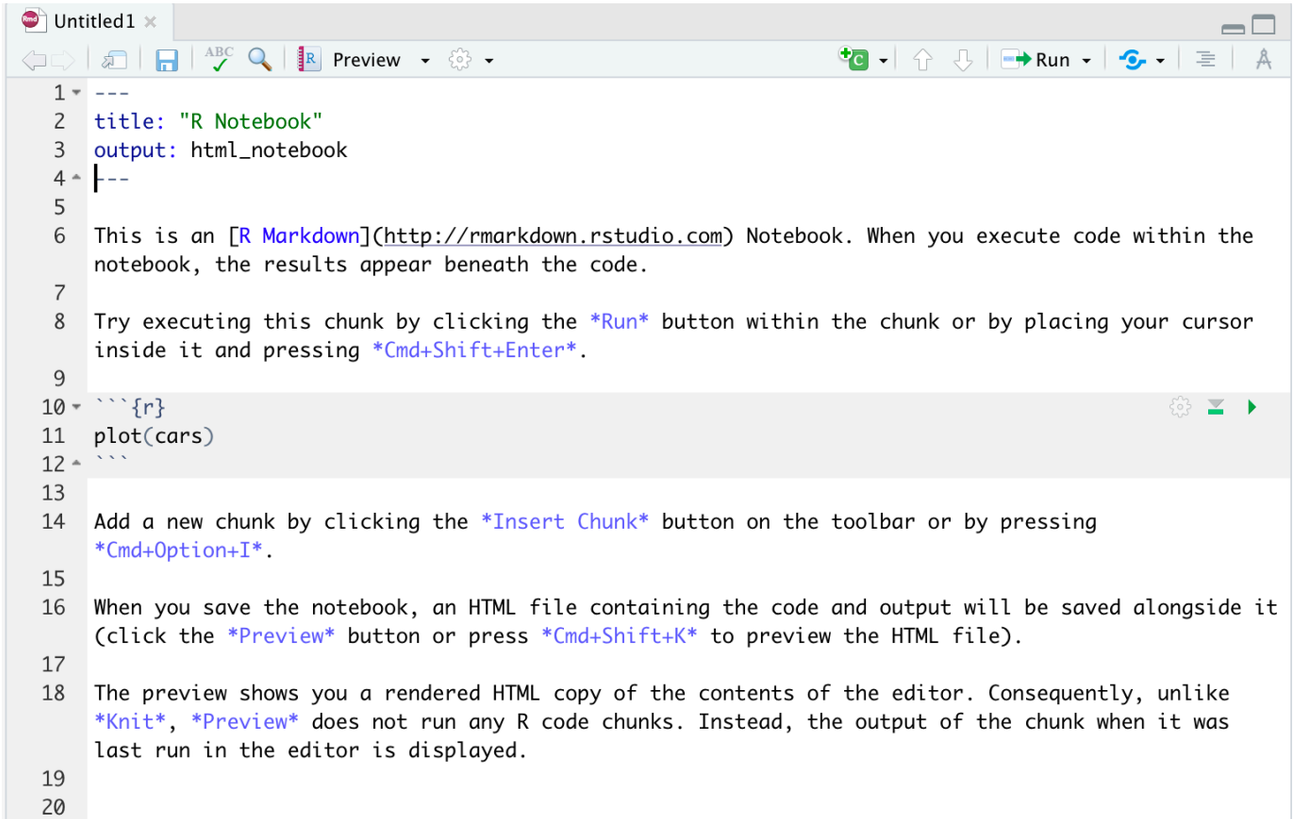



5. **Click “Create Project”!**

# Your First R Markdown Notebook

**Click on “New File” tab the in upper left and select “R Notebook”.**




**You’ll get an untitled notebook template to use. Change the title and save with a name ending in .Rmd**

# R Markdown Notebook Features

- R Markdown documents consist of **Markdown text** and **R code chunks.**

**Markdown text**

**R code "chunk"**

**Markdown text**

Untitled1

Preview | Run

```
1  ---
2  title: "R Notebook"
3  output: html_notebook
4  ---
5
6  This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute code within the
   notebook, the results appear beneath the code.
7
8  Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor
   inside it and pressing *Cmd+Shift+Enter*.
9
10 ```{r}
11 plot(cars)
12 ```
13
14 Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing
   *Cmd+Option+I*.
15
16 When you save the notebook, an HTML file containing the code and output will be saved alongside it
   (click the *Preview* button or press *Cmd+Shift+K* to preview the HTML file).
17
18 The preview shows you a rendered HTML copy of the contents of the editor. Consequently, unlike
   *Knit*, *Preview* does not run any R code chunks. Instead, the output of the chunk when it was
   last run in the editor is displayed.
19
20
```

**Writing goes here.**

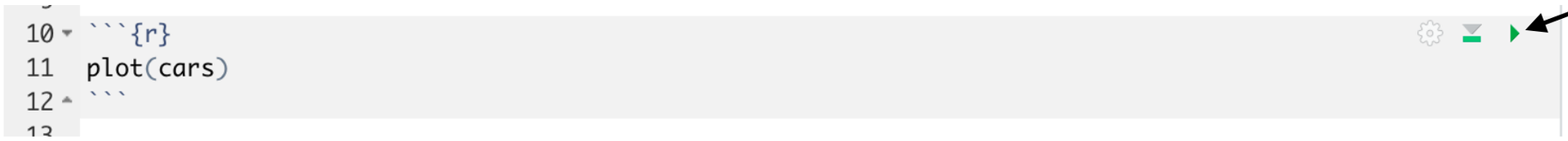
**R code goes here!**

**Writing goes here.**

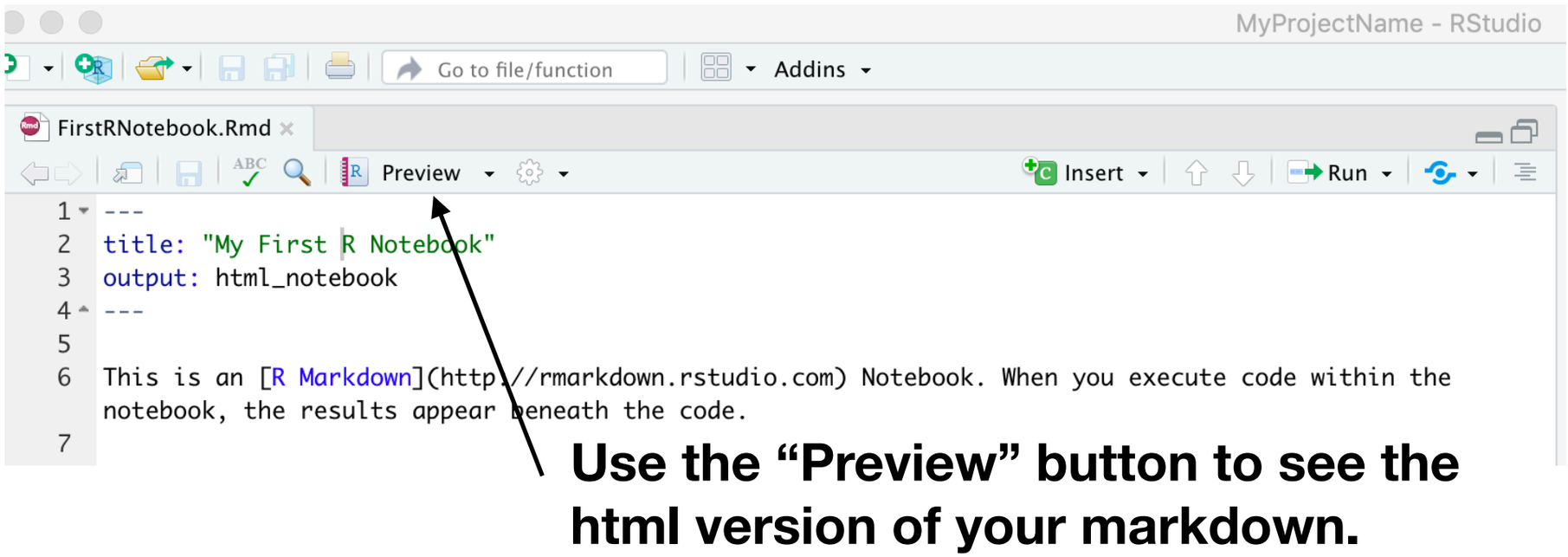
- **R code will not work in Markdown text!!!**

# R Markdown Notebook Features

- Running R code chunks will produce output for you embedded in the Markdown document.




- To view the full document, hit “Preview”.



# R Markdown Notebook Features

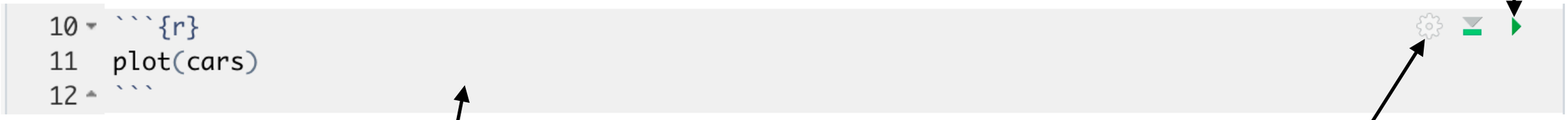
- Markdown text is very simple to manipulate.

    - Link to website: `[R Markdown](https://rmarkdown.rstudio.com)`
    - Italics text: `*text*`
    - Bold text: `__text__`
    - Strikethrough text: `~~text~~`
    - Superscript: `text^2^`
    - Subscript: `text~2~`
    - Headers: `# header text`

# R Markdown Notebook Features

- R Code Chunks:
    - begin with: ```` ```{r} ````
    - end with: ```` ``` ````

**Click play button to run the chunk**




**click cog to get different options for running code chunk**

**If this field isn't gray, then the document doesn't recognize it as a code chunk!**

**From now on, work in an R Markdown document!**

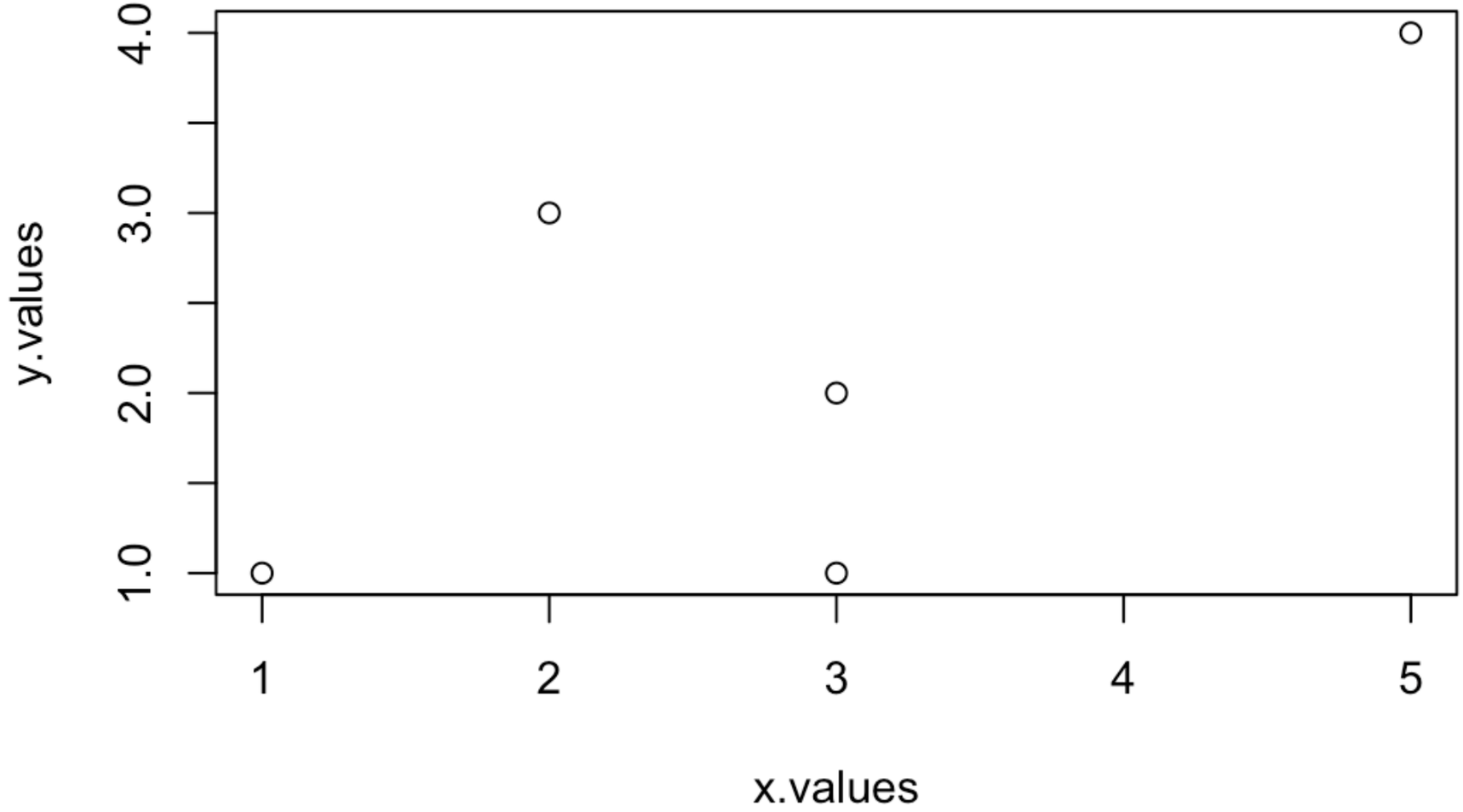
# Basic Plotting

- R is a popular language because of how easy it is to produce beautiful plots!

**Basic plot using the `plot()` command**

```r
x.values <- c(3, 2, 5, 1, 3)
y.values <- c(1, 3, 4, 1, 2)

plot(x = x.values, y = y.values)
```

**Note: the vectors must be the same length!**



# Basic Plotting

**Basic plot using the `plot()` command and a data frame**

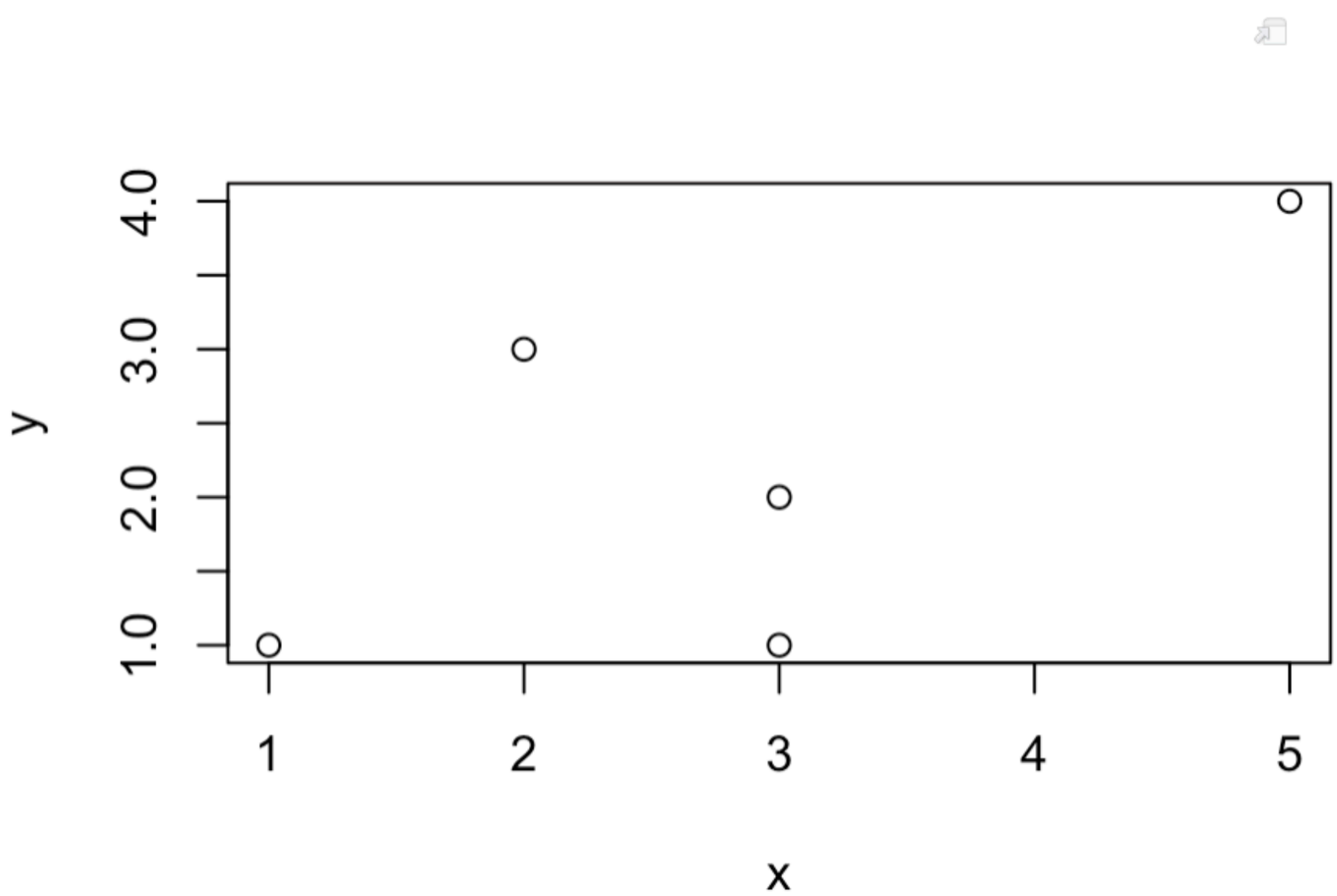
```r
x.values <- c(3, 2, 5, 1, 3)
y.values <- c(1, 3, 4, 1, 2)

df <- data.frame(x = x.values, y = y.values)

plot(y~x, data = df)
```

**Using a formula (`y~x`) and the argument `data=df` will give you the same result.**

**Remember: there's often multiple ways to do the same thing!**



# Basic Plotting: Titles and Axis Labels

- Additional arguments in **`plot()`** can edit different features of the plot.

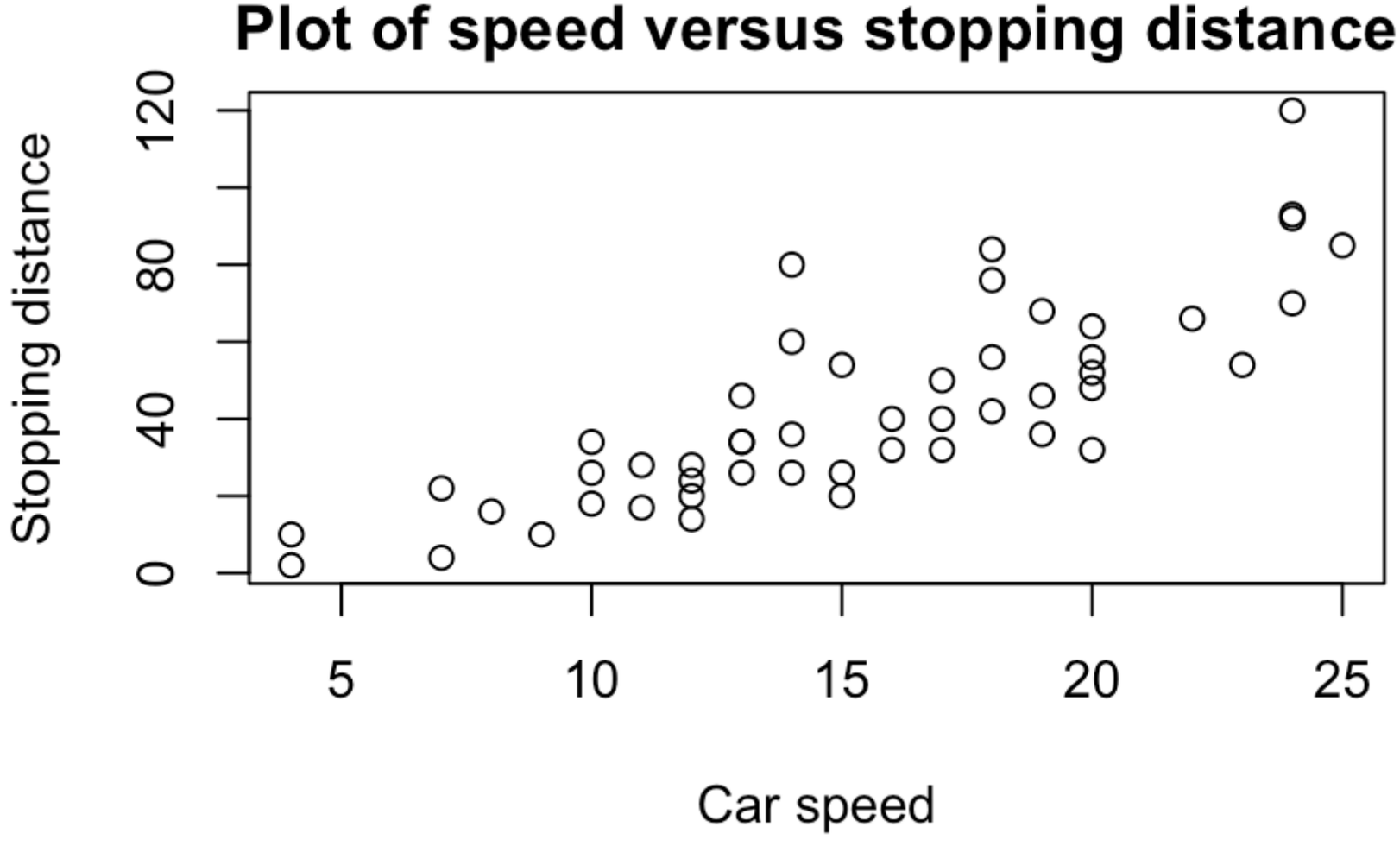
**Hitting enter after a comma will help indent the function, making it easier to read!**

**`xlab`: x-axis label**

**`ylab`: y-axis label**

**`main`: main plot title**

```
```{r, include=TRUE}
plot(dist ~ speed, data = cars,
     xlab = "Car speed",
     ylab  = "Stopping distance",
     main = "Plot of speed versus stopping distance")
```
```

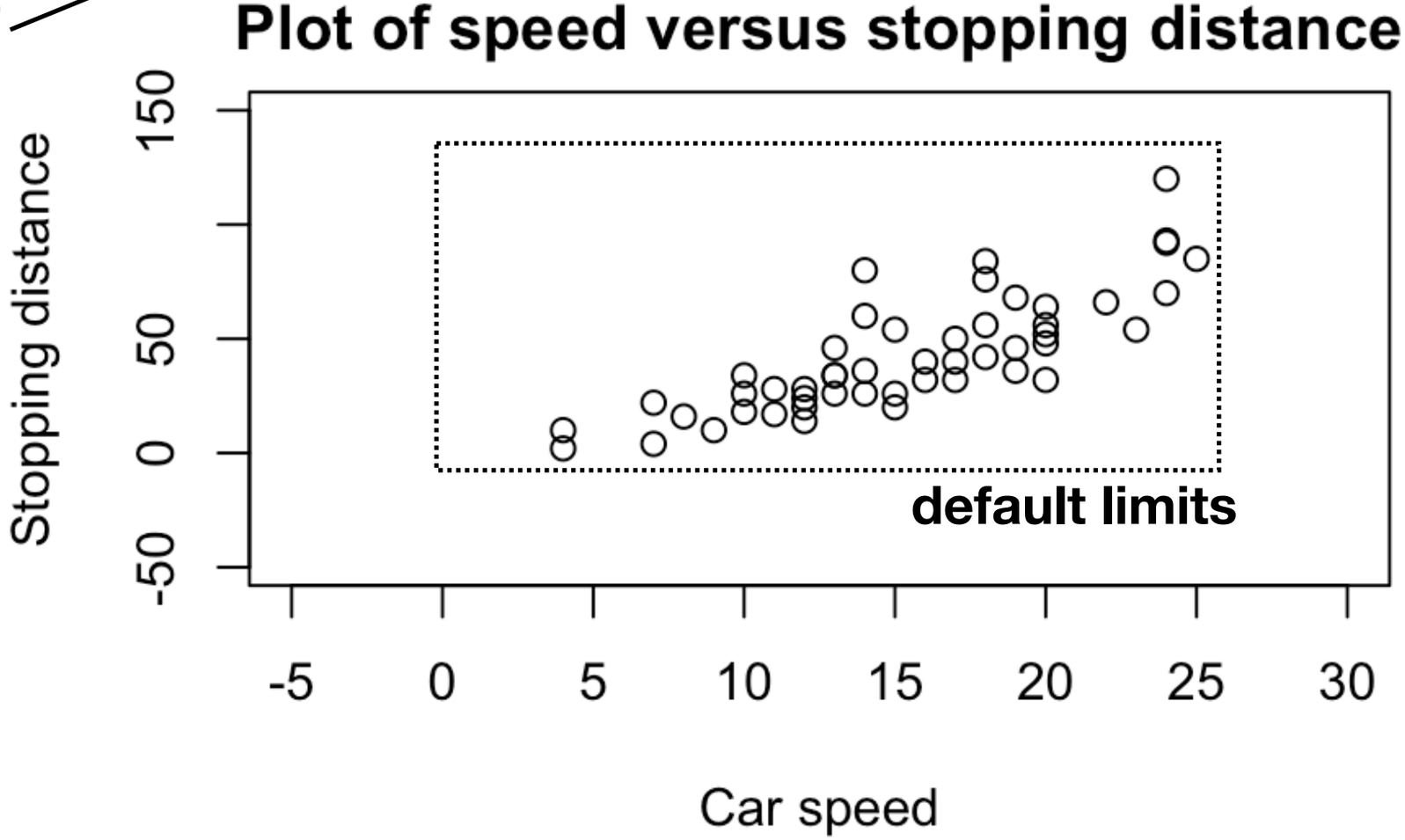


# Basic Plotting: Axis Limits

**`xlim`: vector length 2 that sets x-axis limits**

**`ylim`: vector length 2 that sets y-axis limits**

```r
plot(dist ~ speed, data = cars,
     xlab = "Car speed",
     ylab  = "Stopping distance",
     main = "Plot of speed versus stopping distance",
     xlim = c(-5,30), ylim = c(-50,150))
```



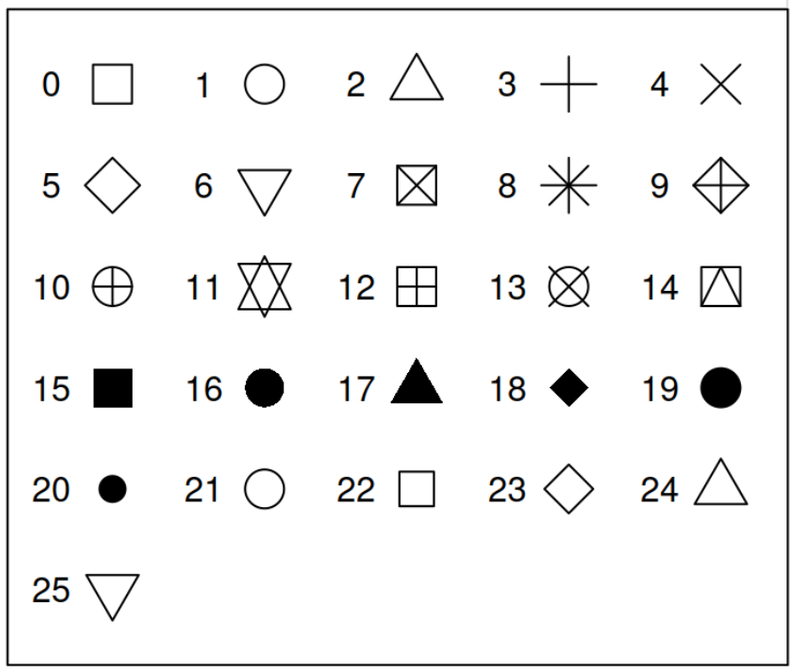
# Basic Plotting: Formatting Plots

- Many attributes can be included as argument in plot:

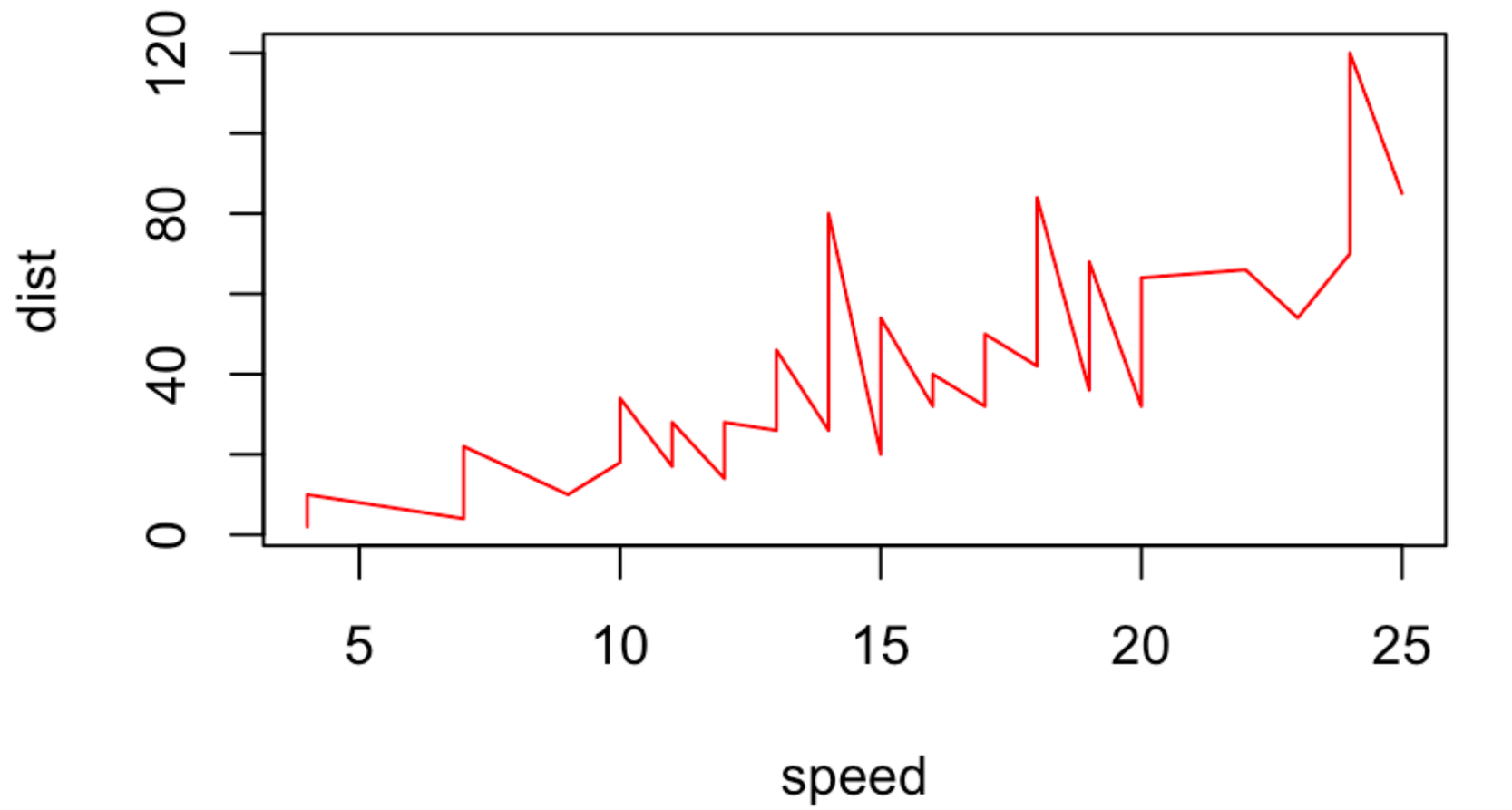
**`type`: plot style (`l`, `p`, or `b`)**

**`col`: color of plot, must be character (most basic colors are valid)**

**`pch`: shape of points (integer/numeric)**




```r
plot(dist ~ speed, data = cars,
     type="l", col = "red")
```



# Basic Plotting: Formatting Plots

- Color can be assigned based on factors!

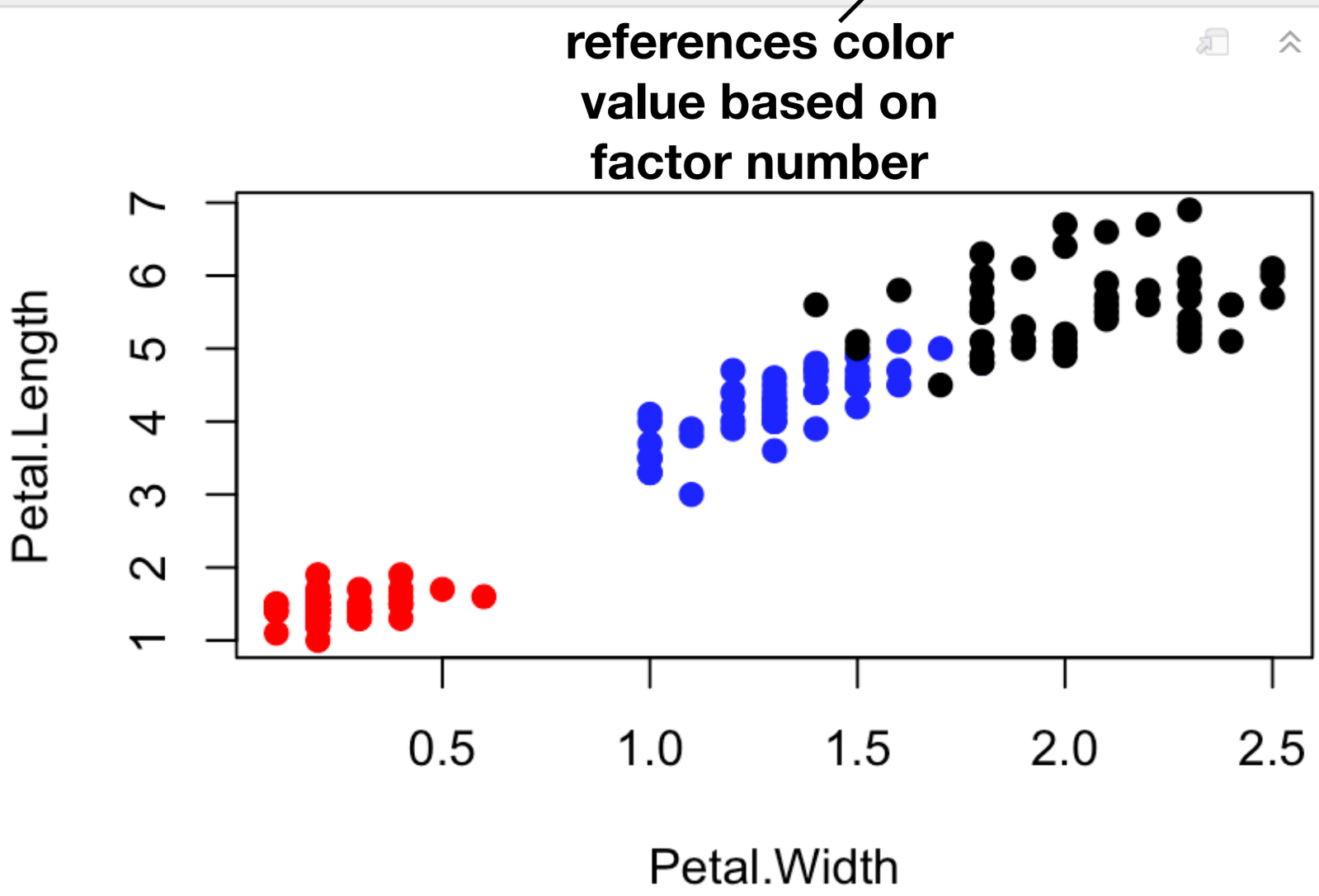
**vector with colors, length = number of factors**

```{r, include=TRUE}
iriscolors <- c("red", "blue", "black")
plot(Petal.Length ~ Petal.Width, data = iris,
     type="p", pch = 19, col = iriscolors[iris$Species])
```

**references color value based on factor number**

**Find number of levels:**

`nlevels(iris$Species)`



# Check Your Understanding

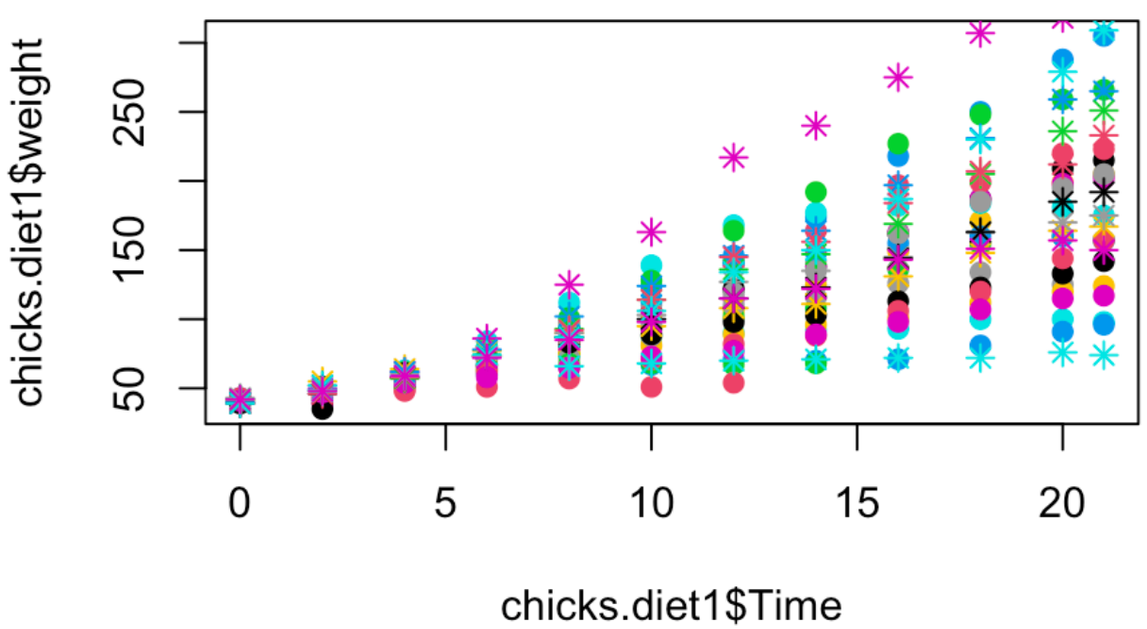
**Make a plot of circumference versus age of the orange trees in the data set `Orange`. Give each tree a unique color *and* point shape.**

# Basic Plotting: Adding Things to Existing Plots

- You can add separate data sources to plots using **`points()`**, **`lines()`**, or **`arrows()`**.

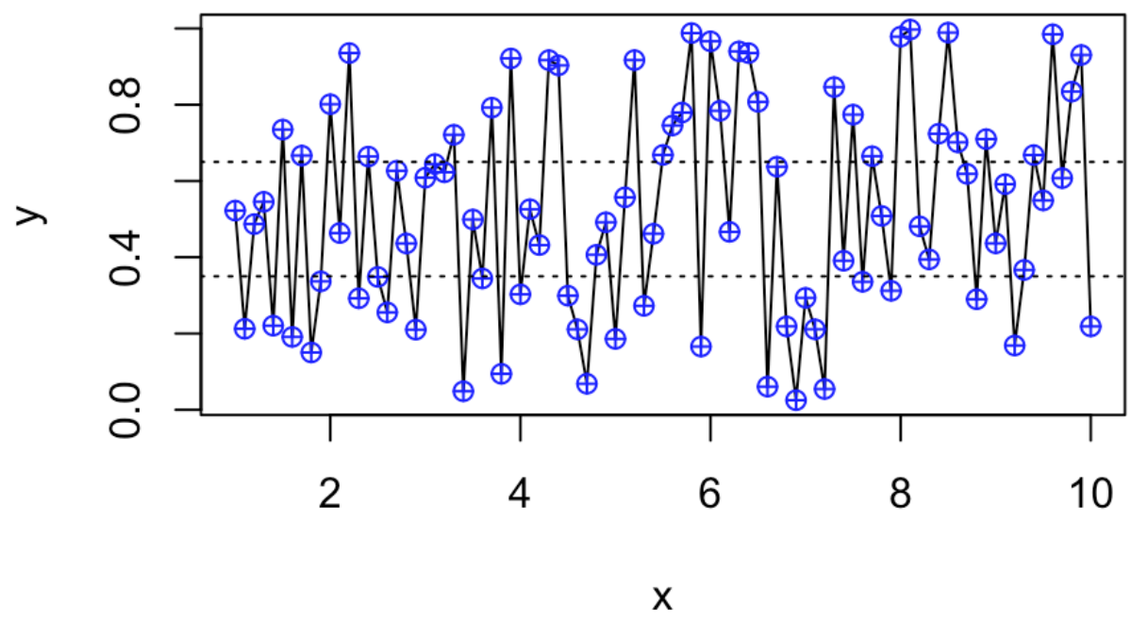
### Breaking `ChickWeight` into two subsets, plotting one and then the other.

```{r, include=TRUE}
chicks.diet1 <- subset(ChickWeight, ChickWeight$Diet==1)
plot(x = chicks.diet1$Time, y = chicks.diet1$weight,
col=chicks.diet1$Chick, pch=19)

chicks.diet2 <- subset(ChickWeight, ChickWeight$Diet==2)
points(x = chicks.diet2$Time, y = chicks.diet2$weight,
col=chicks.diet2$Chick, pch = 8)

```




### Plotting y values with lines and points, adding bounding lines on the y axis.

```{r, include=TRUE}
x.values <- seq(1,10, by=0.1)
y.values <- runif(length(x.values))
df2 <- data.frame(x = x.values, y = y.values)

plot(y ~ x, data = df2, type = "l")
points(x = df2$x, y = df2$y, pch = 10, col = "blue")
lines(x = c(-1,11), y = c(0.65, 0.65), lty = 3)
lines(x = c(-1,11), y = c(0.35, 0.35), lty = 3)
```



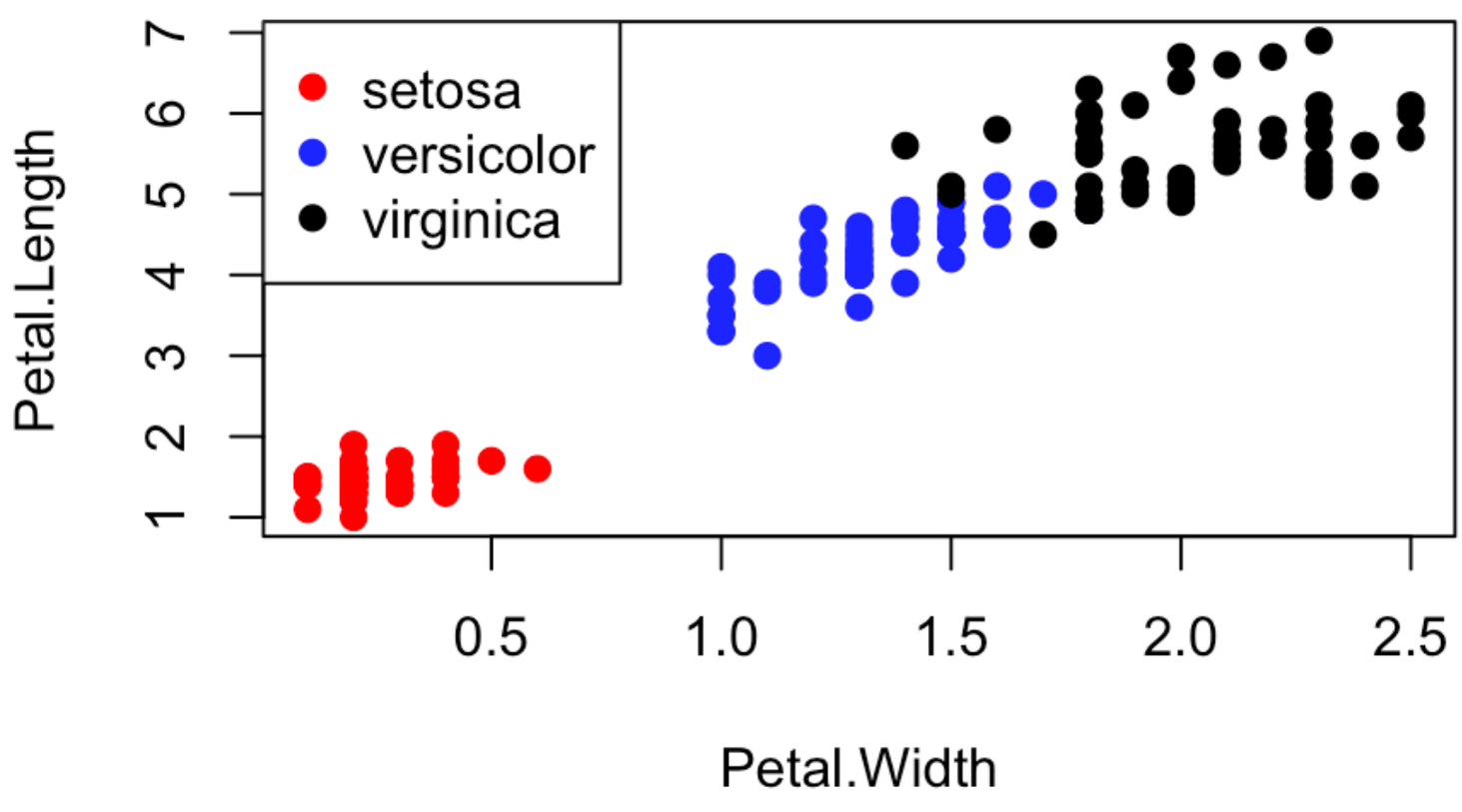
# Basic Plotting: Adding a Legend

- You can add a plot legend with **`legend()`**.

**sets placement, options are `topright`, `topleft`, `bottomright`, `bottomleft`, or `center`**

```{r, include=TRUE}
iriscolors <- c("red", "blue", "black")
plot(Petal.Length ~ Petal.Width, data = iris,
     type="p", pch = 19, col = iriscolors[iris$Species])

legend("topleft", legend=levels(iris$Species), col=iriscolors,
       pch=rep(19,3))
```

**`legend`: sets text**
**`pch`: shapes**
**`col`: colors**



# Check Your Understanding

**Add a legend to your graph of `Orange` trees.**

# Action Items

1. **Complete Assignment 2.1 using R Markdown.**

2. **Read Davies Chapter 8 and Chang Chapters 1-2 for next time.**