Data Visualization with R & ggplot2

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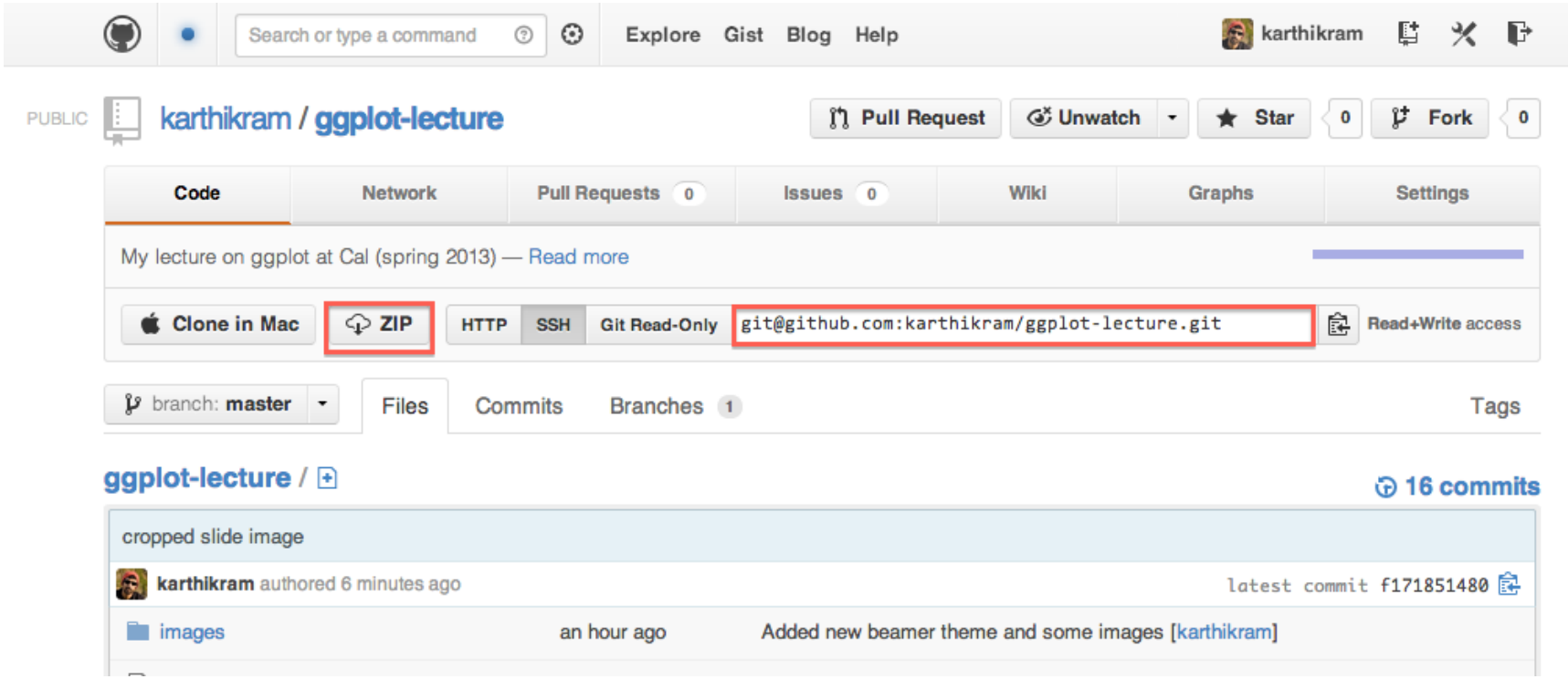
github.com/karthikram/ggplot-lecture
https://speakerdeck.com/karthik/



Some housekeeping

Install some packages (make sure you also have recent copies of reshape2 and plyr)

```
install.packages("ggplot2", dependencies = TRUE)
```

Base graphics

- Ugly, laborious, and verbose
- There are better ways to describe statistical visualizations.

Why ggplot2?

- Follows a grammar, just like any language.
- It defines basic components that make up a sentence. In this case, the grammar defines components in a plot.
- Grammar of graphics originally coined by Lee Wilkinson

Why ggplot2?

- Supports a continuum of expertise.
- Get started right away but with practice you can effortless build complex, publication quality figures.

Section 1

Basics

Some terminology

- **ggplot** - The main function where you specify the dataset and variables to plot
- **geoms** - geometric objects
  - geom_point(), geom_bar(), geom_density(), geom_line(), geom_area()
- **aes** - aesthetics
  - shape, transparency (alpha), color, fill, linetype.
- **scales** Define how your data will be plotted
  - *continuous*, *discrete*, *log*

Section 2

Assembling your first ggplot

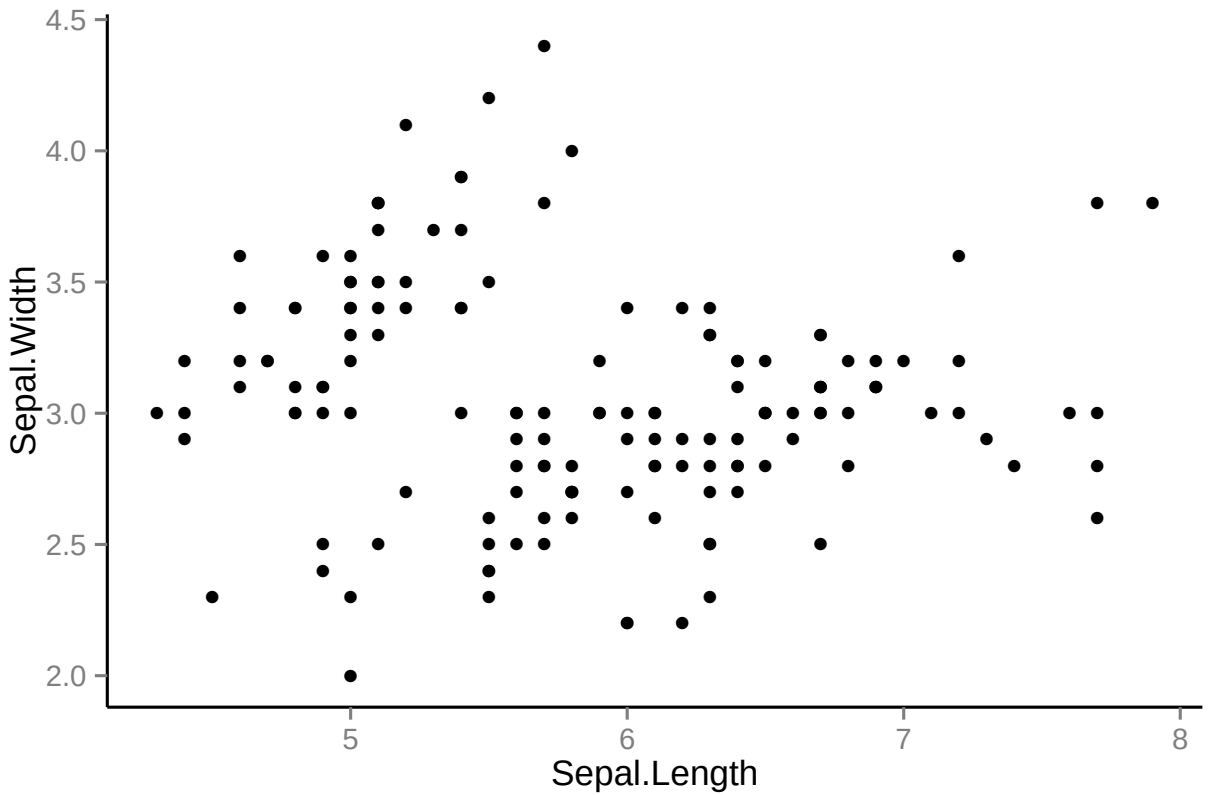
The iris dataset

```
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
```

Let's try an example

```
ggplot(data = iris, aes(x = Sepal.Length, y = Sepal.Width)) +
geom_point()
```



Basic structure

```
ggplot(data = iris, aes(x = Sepal.Length, y = Sepal.Width))
 + geom_point()
myplot <- ggplot(data = iris, aes(x = Sepal.Length, y = Sepal.Width))
myplot + geom_point()
```

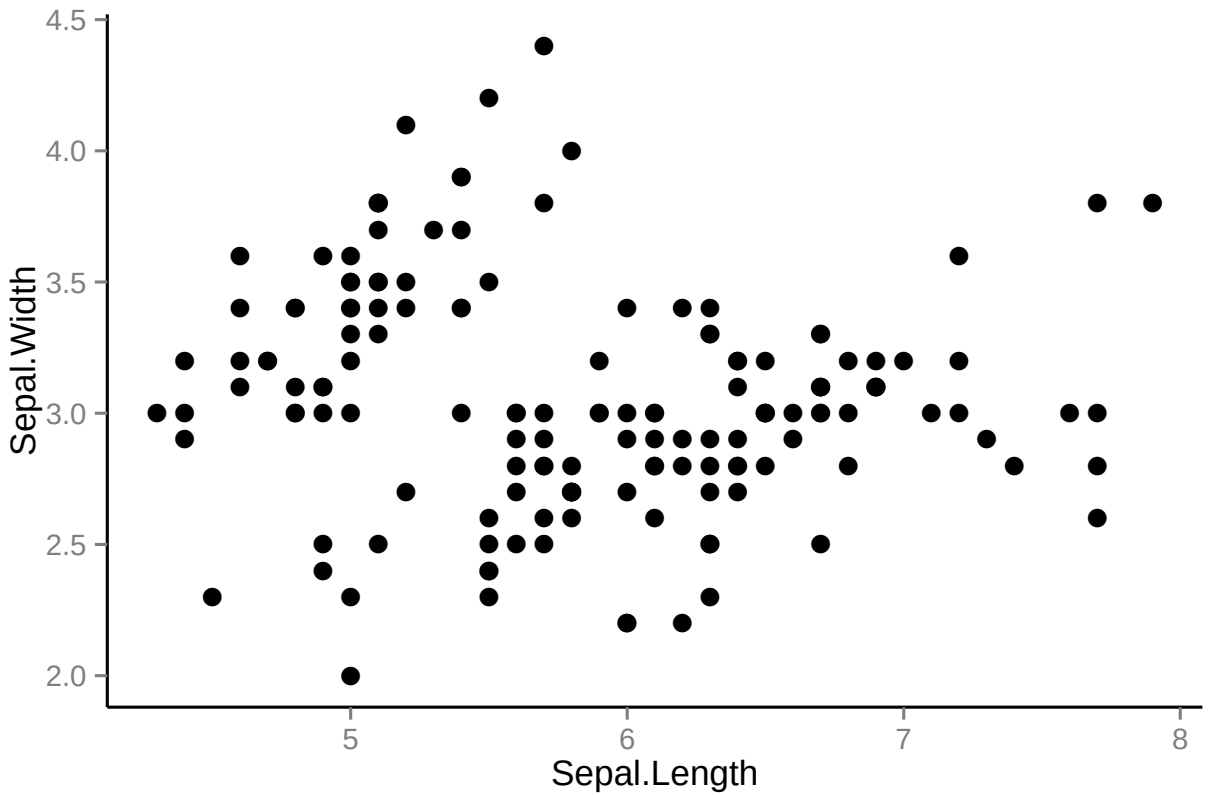
- Specify the data and variables inside the ggplot function.
- Anything else that goes in here becomes a global setting.
- Then add layers of geometric objects, statistical models, and panels.

Quick note

- Never use `qplot` - short for quick plot.
- You'll end up unlearning and relearning a good bit.

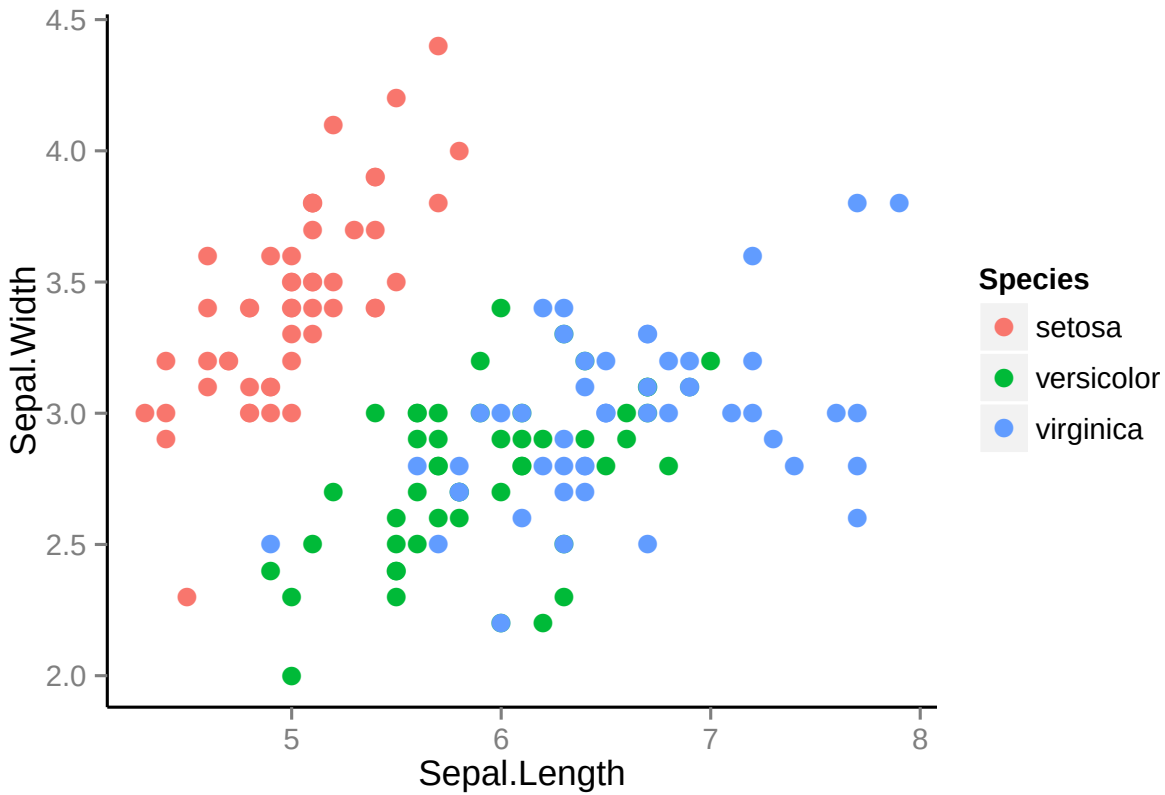
Increase the size of points

```
ggplot(data = iris, aes(x = Sepal.Length, y = Sepal.Width)) +
geom_point(size = 3)
```



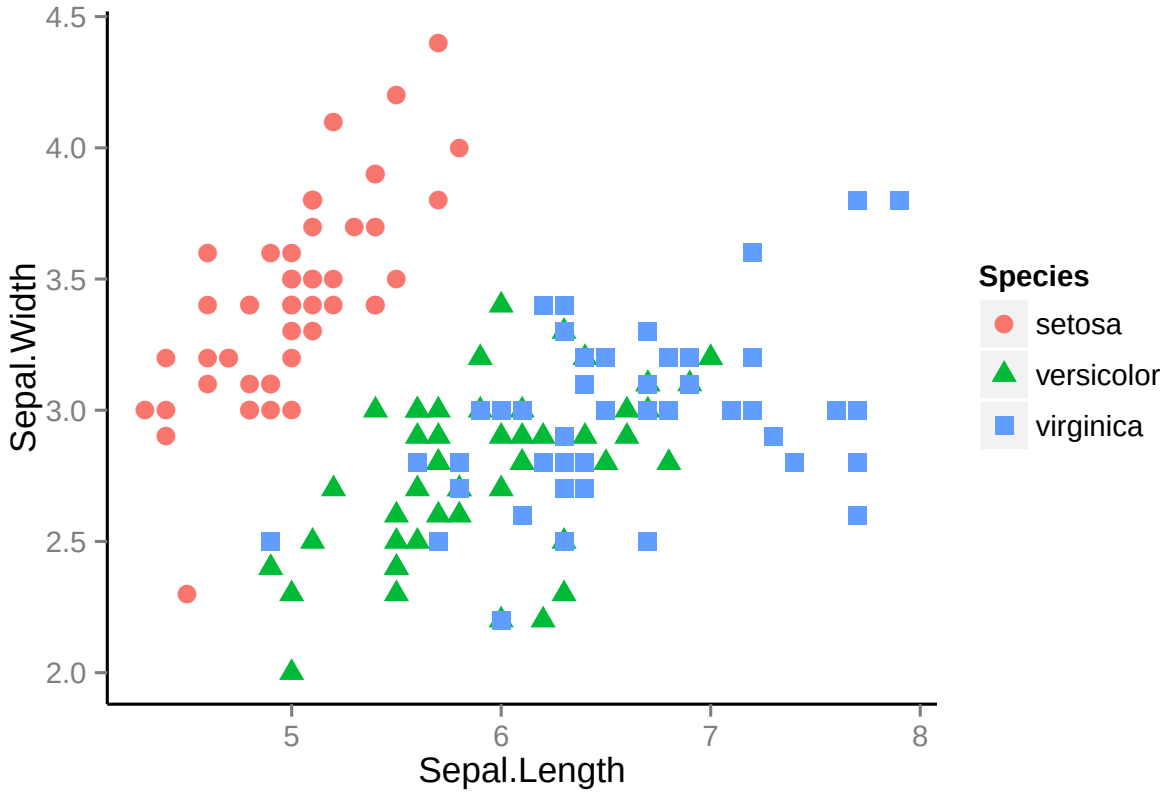
Add some color

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(size = 3)
```



Differentiate points by shape

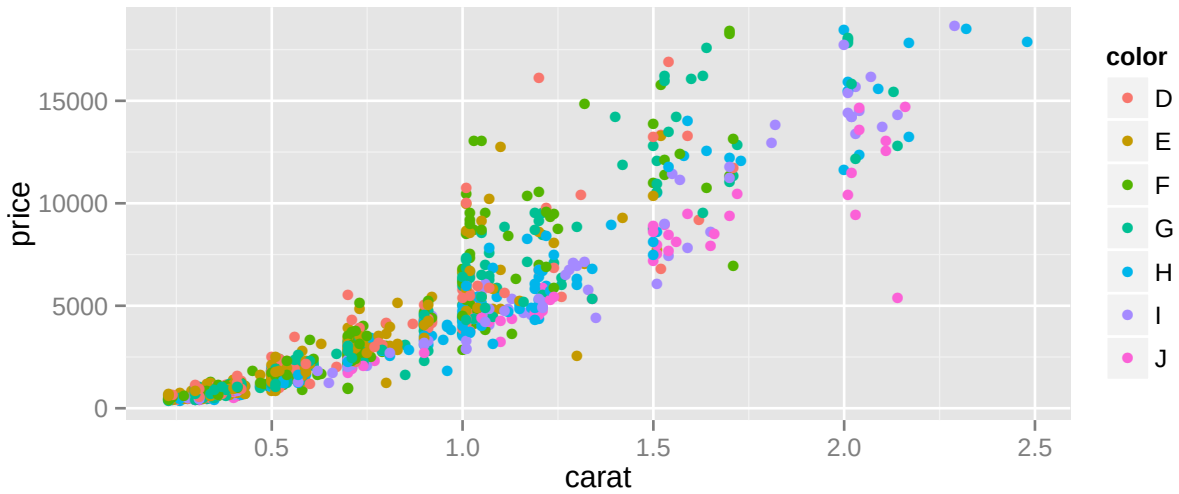
```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(aes(shape = Species), size = 3)
```



Exercise 1

```
# Make a small sample of the diamonds dataset
d2 <- diamonds[sample(1:dim(diamonds)[1], 1000), ]
```

Then generate this plot below.

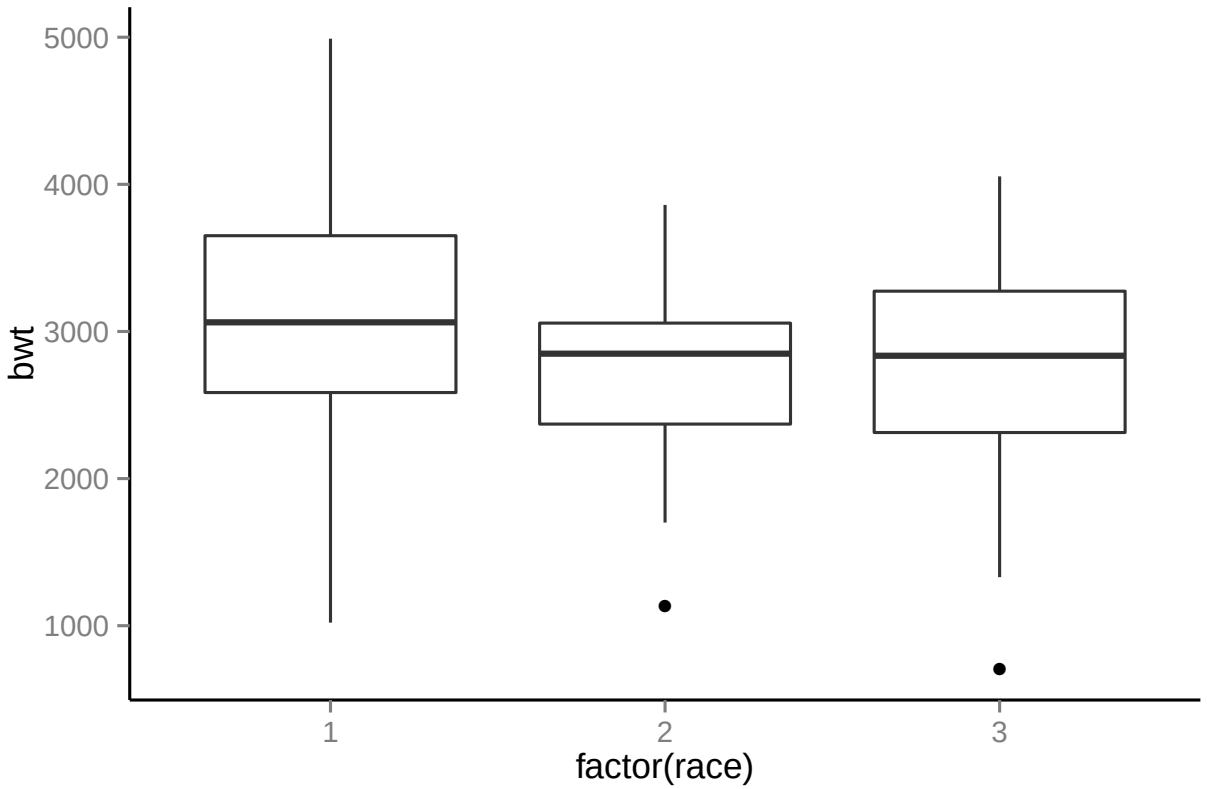


Section 3

Box plots

See ?geom_boxplot for list of options

```
library(MASS)
ggplot(birthwt, aes(factor(race), bwt)) + geom_boxplot()
```

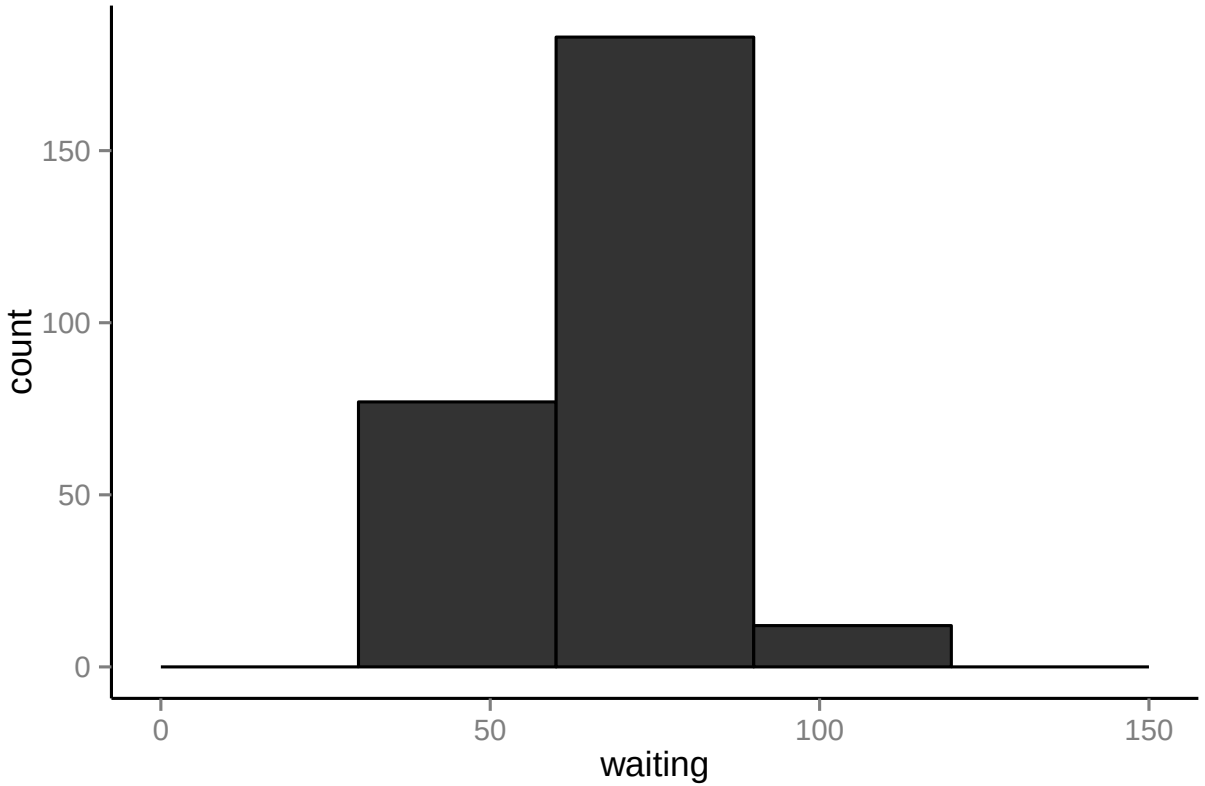


Section 4

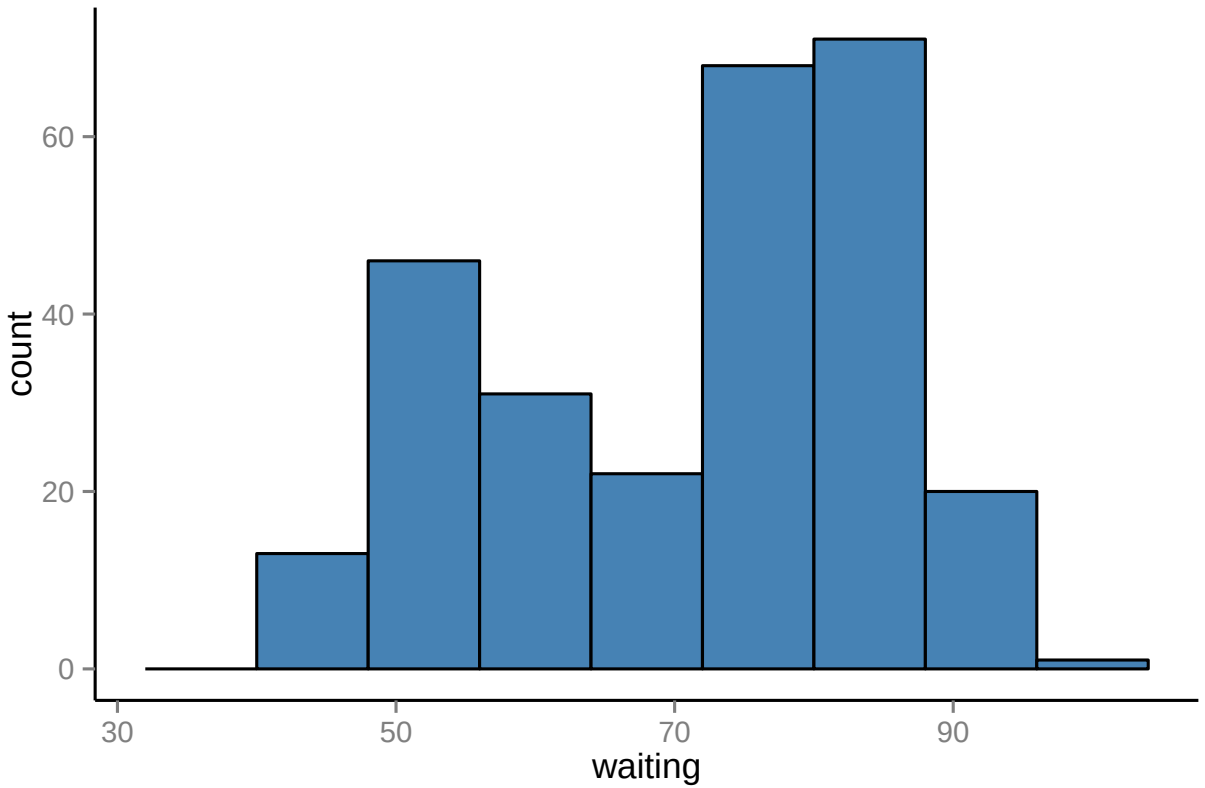
Histograms

See ?geom_histogram for list of options

```
h <- ggplot(faithful, aes(x = waiting))
h + geom_histogram(binwidth = 30, colour = "black")
```



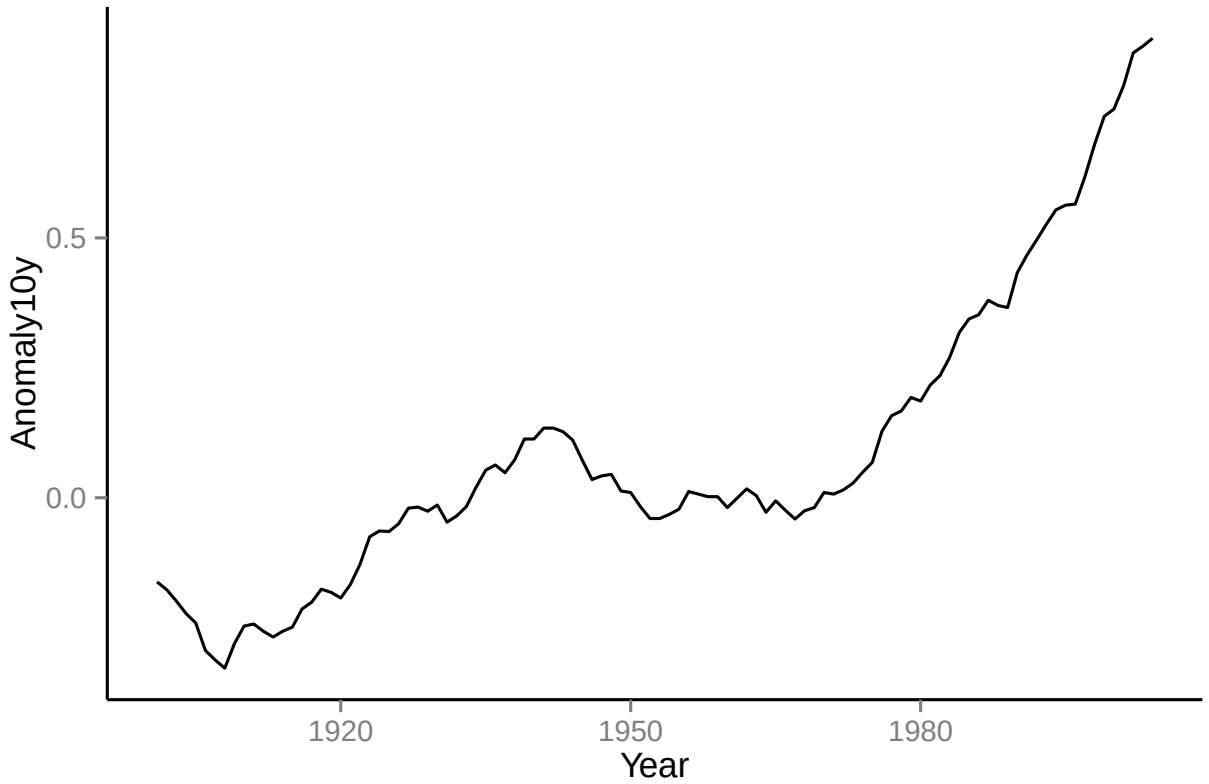
```
h <- ggplot(faithful, aes(x = waiting))
h + geom_histogram(binwidth = 8, fill = "steelblue",
colour = "black")
```



Section 5

Line plots

```r
climate <- read.csv("climate.csv", header = T)
ggplot(climate, aes(Year, Anomaly10y)) +
geom_line()
```

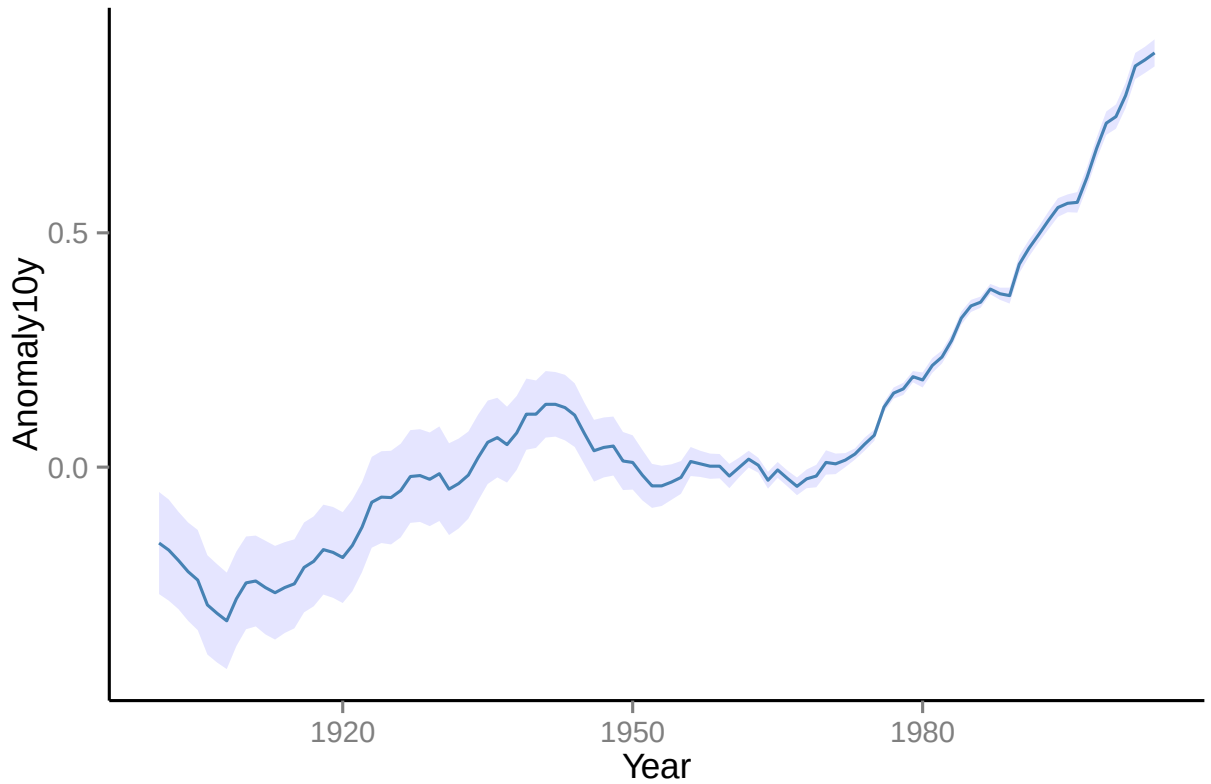



```r
climate <- read.csv(text =

RCurl::getURL(https://raw.github.com/karthikram/ggplot-lecture/master/climate.csv))
```

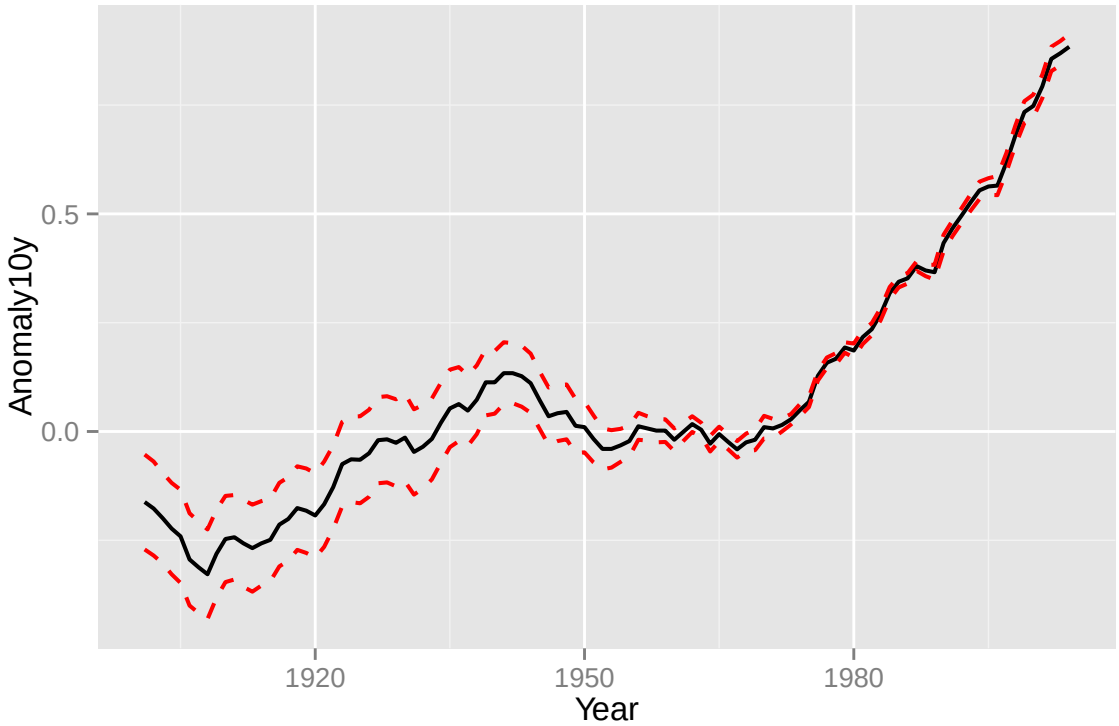
We can also plot confidence regions

```
ggplot(climate, aes(Year, Anomaly10y)) +
geom_ribbon(aes(ymin = Anomaly10y - Unc10y,
ymax = Anomaly10y + Unc10y),
fill = "blue", alpha = .1) +
geom_line(color = "steelblue")
```



Exercise 2

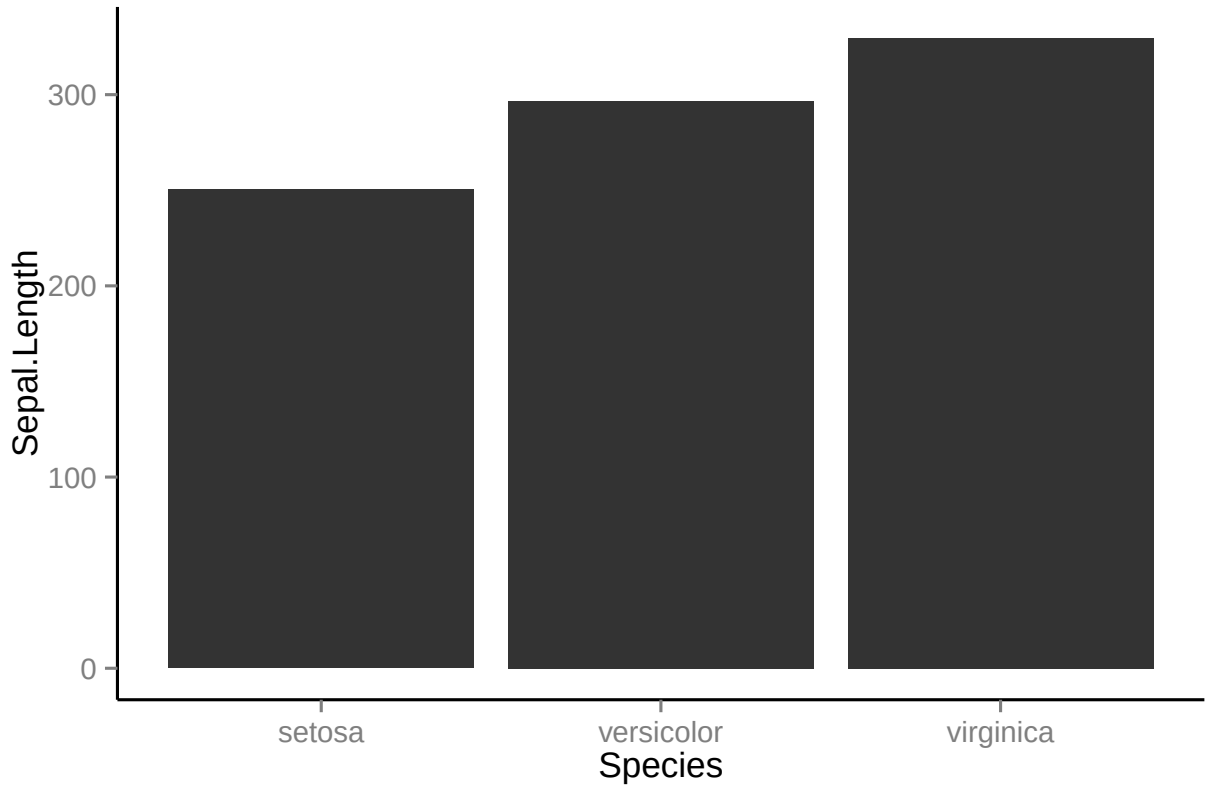
- Modify the previous plot and change it such that there are three lines instead of one with a confidence band.



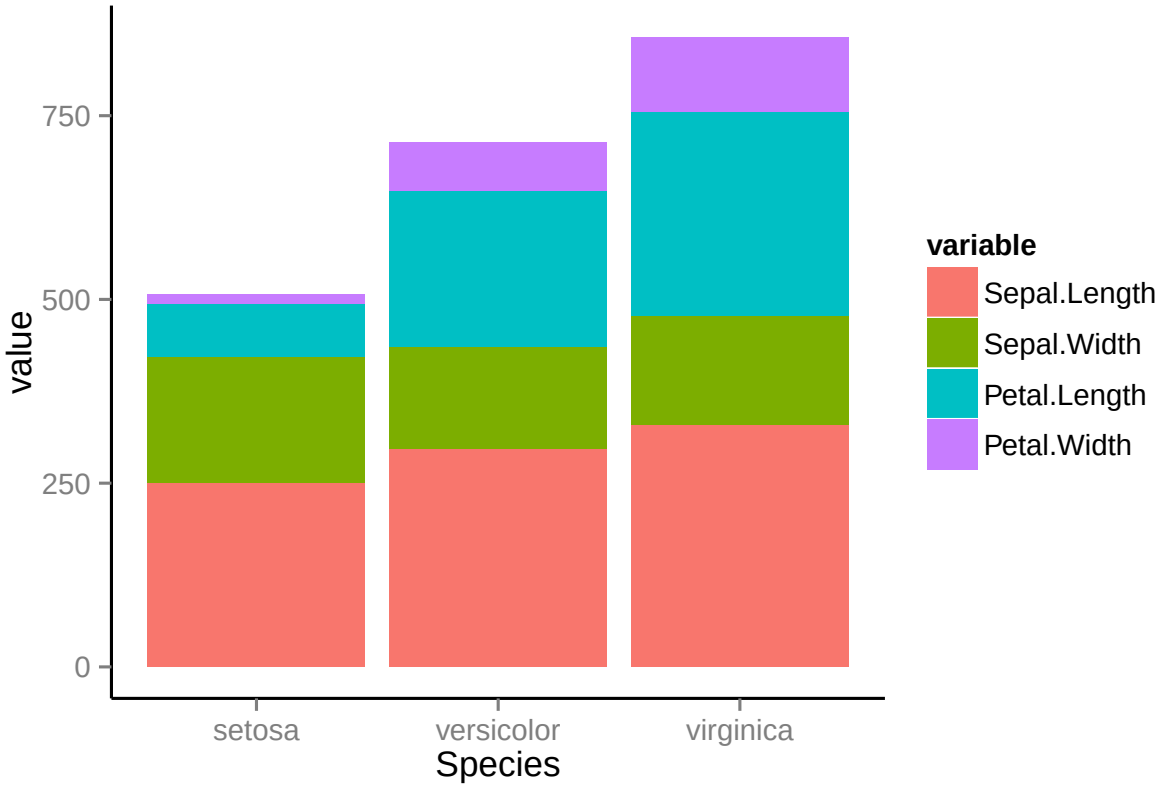
Section 6

Bar plots

```
ggplot(iris, aes(Species, Sepal.Length)) +
geom_bar(stat = "identity")
```



```
df  <- melt(iris, id.vars = "Species")
ggplot(df, aes(Species, value, fill = variable)) +
geom_bar(stat = "identity")
```



Section 7

plyr and reshape are key for using R

plyr and reshape

These two packages are the swiss army knives of R.

- `plyr`
  1. ddply
  2. llply
  3. join
- `reshape`.
  1. melt
  2. dcast
  3. acast

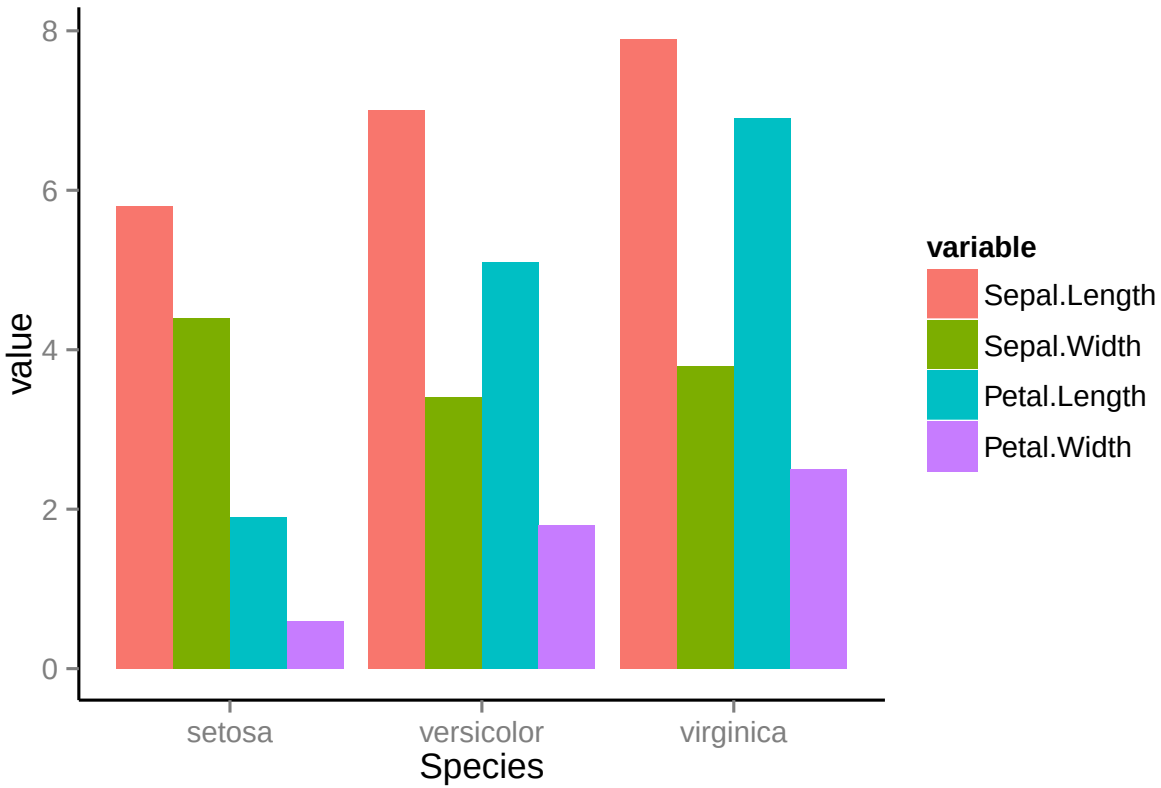
```r
iris[1:2, ]
```

```
##   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
```

```r
df  <- melt(iris, id.vars = "Species")
df[1:2, ]
```

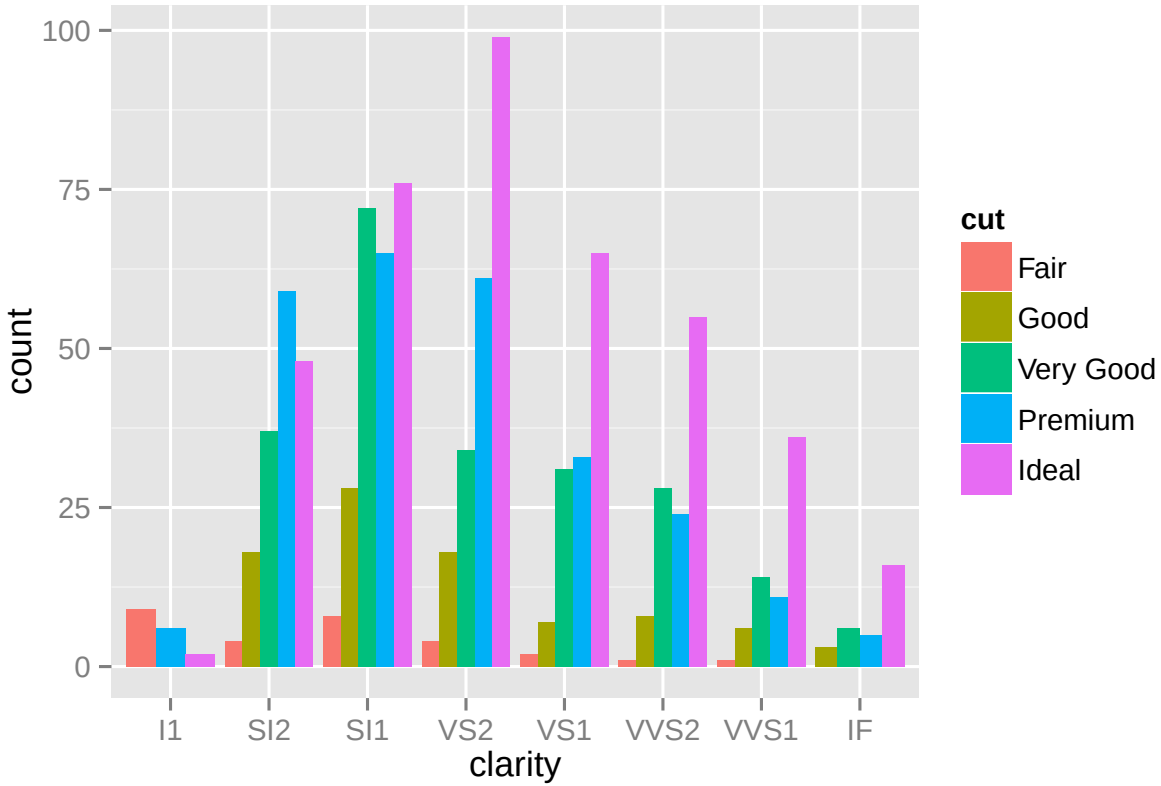
```
##   Species     variable value
## 1  setosa Sepal.Length   5.1
## 2  setosa Sepal.Length   4.9
```

```
ggplot(df, aes(Species, value, fill = variable)) +
geom_bar(stat = "identity", position = "dodge")
```



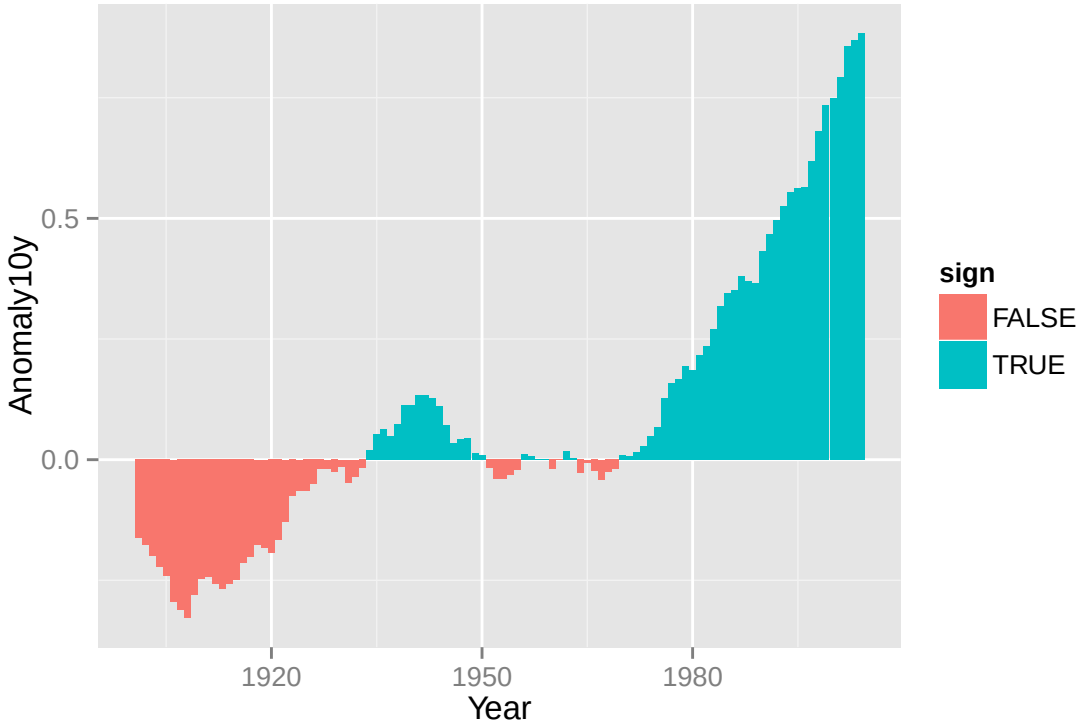
Exercise 3

Using the d2 dataset you created earlier, generate this plot below. Take a quick look at the data first to see if it needs to be binned.



Exercise 4

- Using the climate dataset, create a new variable called sign. Make it logical (true/false) based on the sign of Anomaly10y.
- Plot a bar plot and use `sign` variable as the fill.

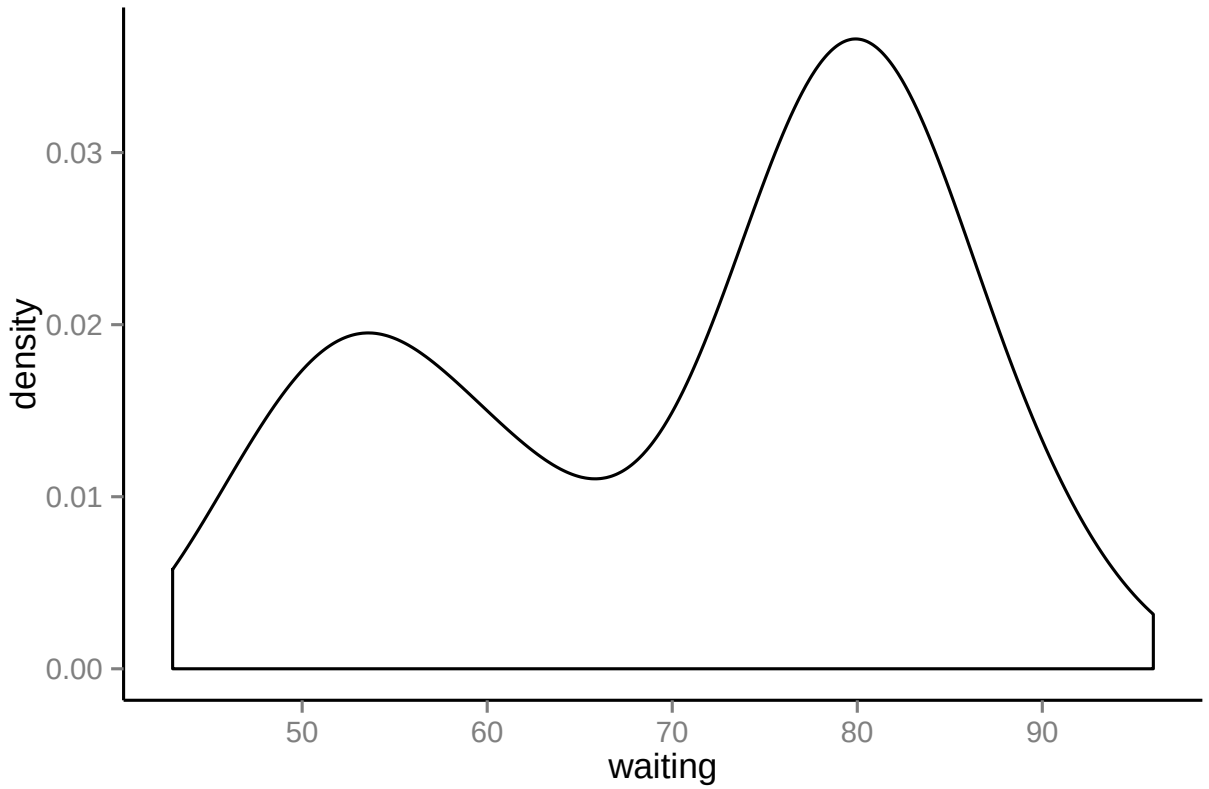


Section 8

Density Plots

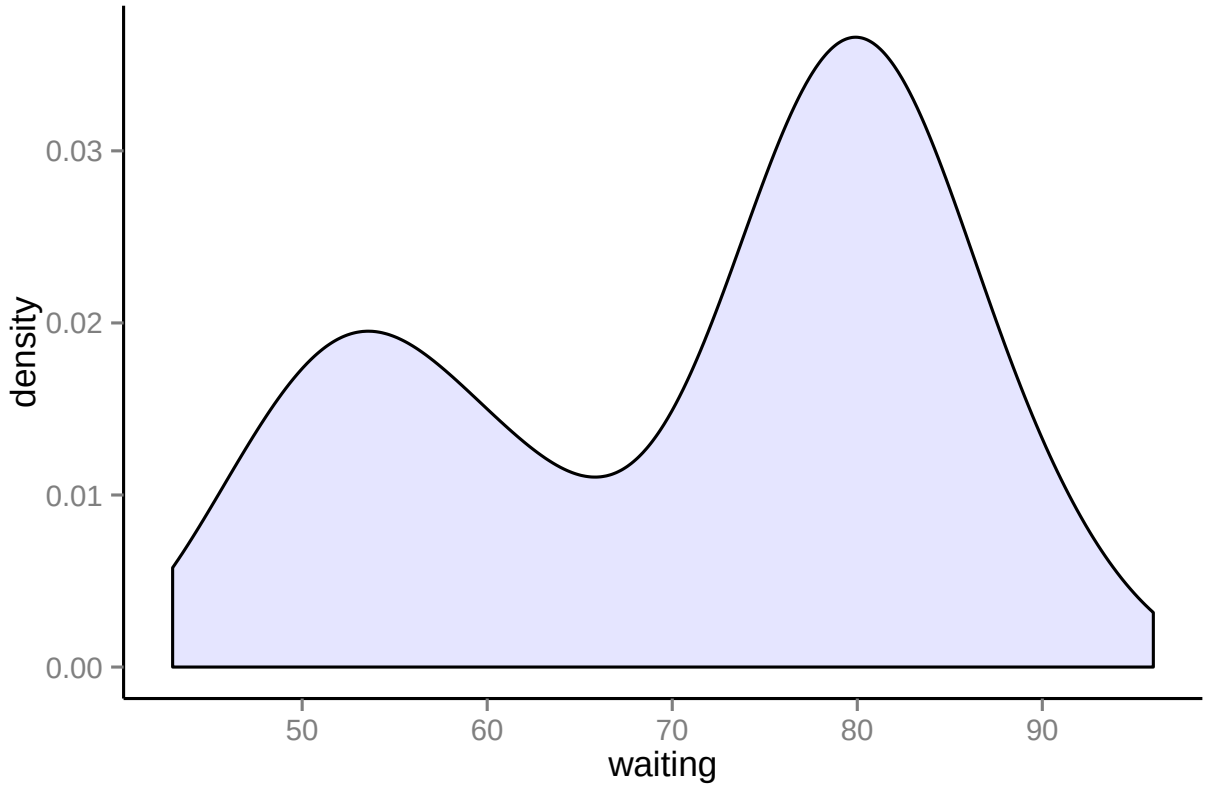
Density plots

```
ggplot(faithful, aes(waiting)) + geom_density()
```

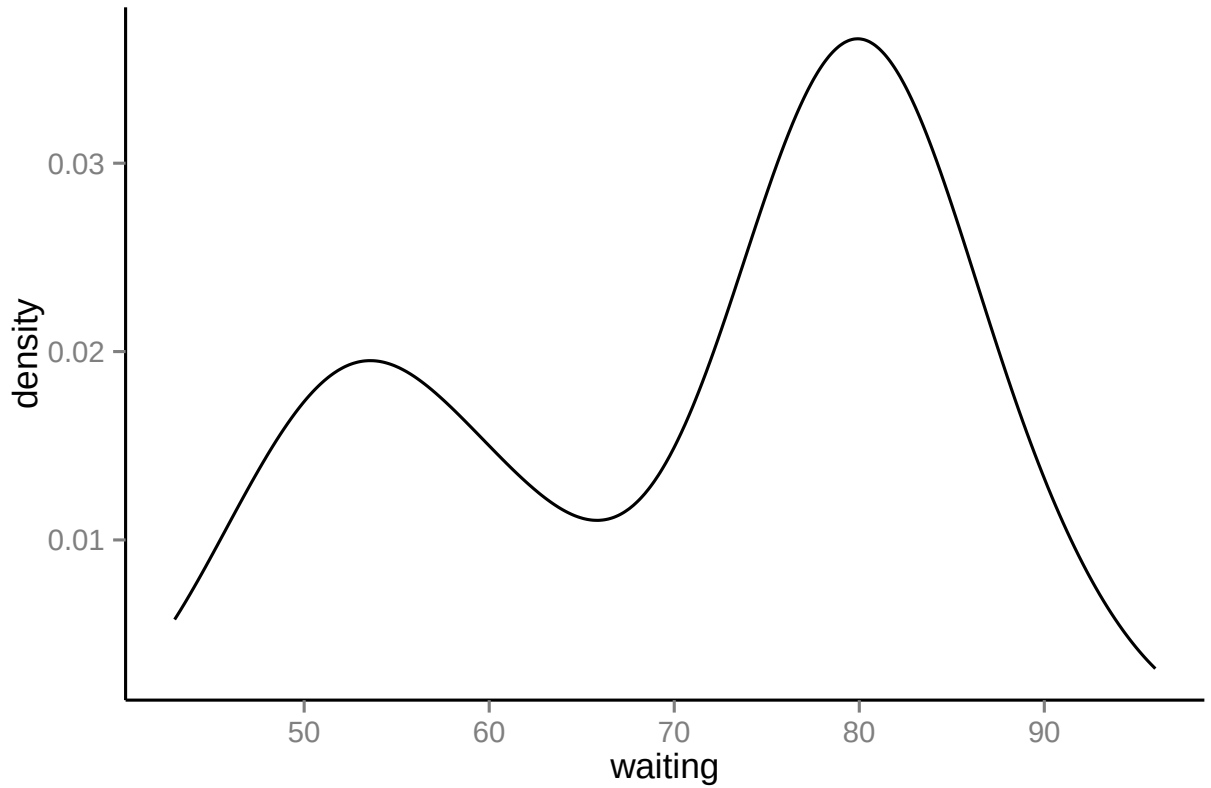


Density plots

```
ggplot(faithful, aes(waiting)) +
geom_density(fill = "blue", alpha = 0.1)
```



```
ggplot(faithful, aes(waiting)) +
geom_line(stat = "density")
```



Section 9

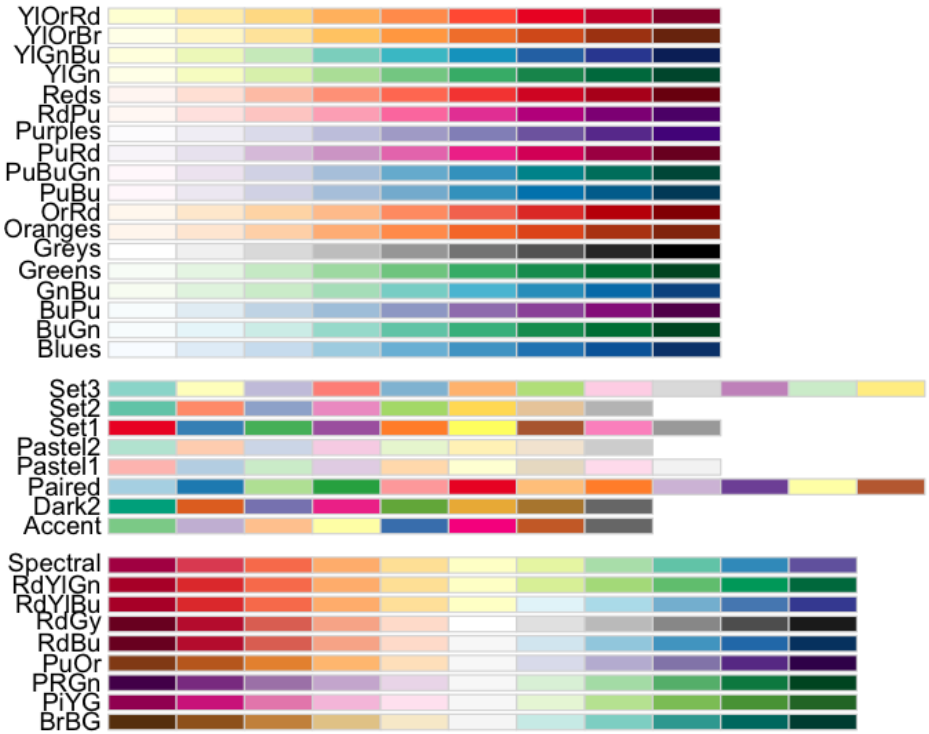
Mapping Variables to colors

Colors

```
# Map all points to one color
aes(color = "black")
# Or map the points to a variavble
aes(color = variable)
# Then add a scale for the colors.  Below we manually
# define colors but there are other ways (see next slide)
scale_fill_manual(values = c("color1", "color2"))
```

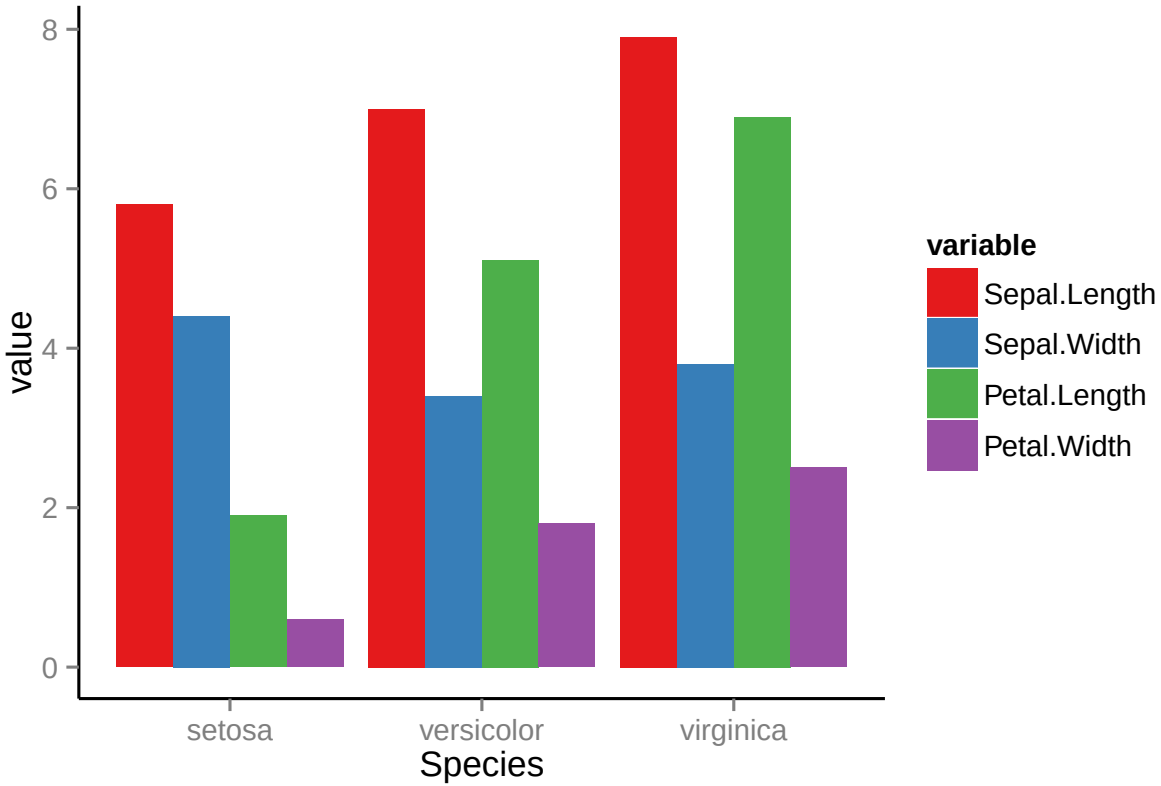
The RColorBrewer package

```
library(RColorBrewer)
display.brewer.all()
```



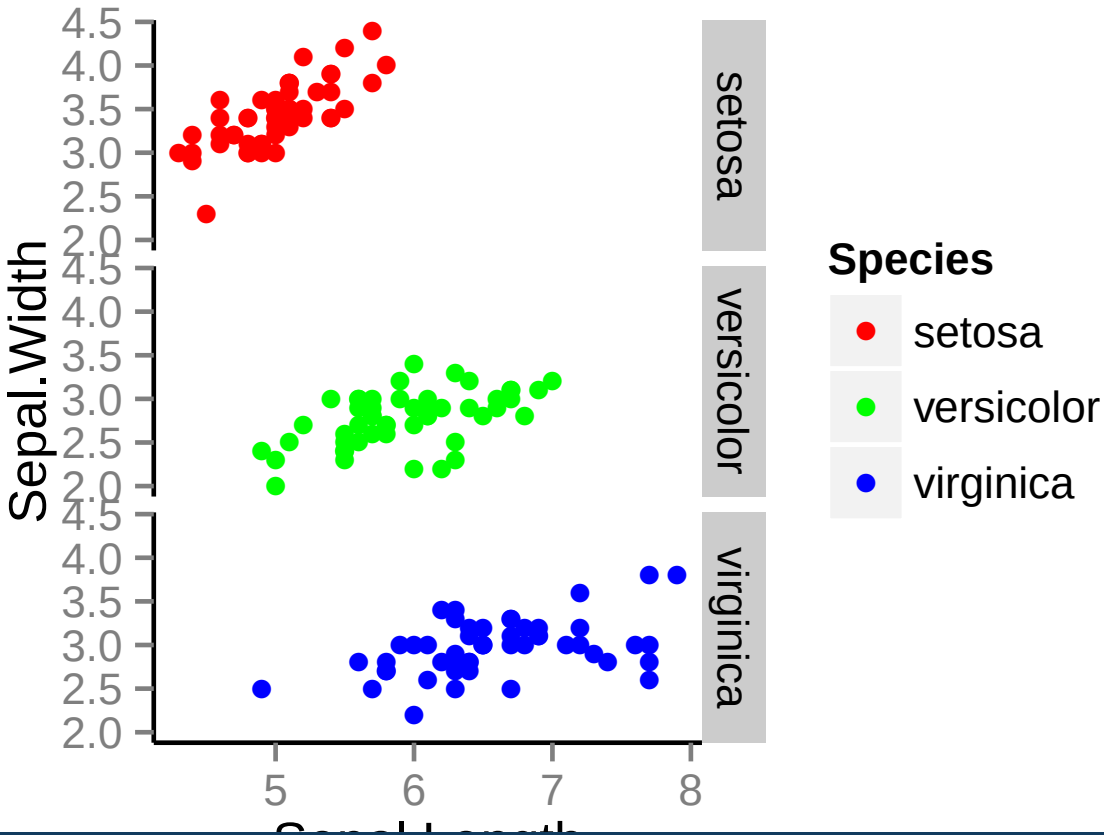
Using a color brewer palette

```
df  <- melt(iris, id.vars = "Species")
ggplot(df, aes(Species, value, fill = variable)) +
geom_bar(stat = "identity", position = "dodge") +
scale_fill_brewer(palette = "Set1")
```



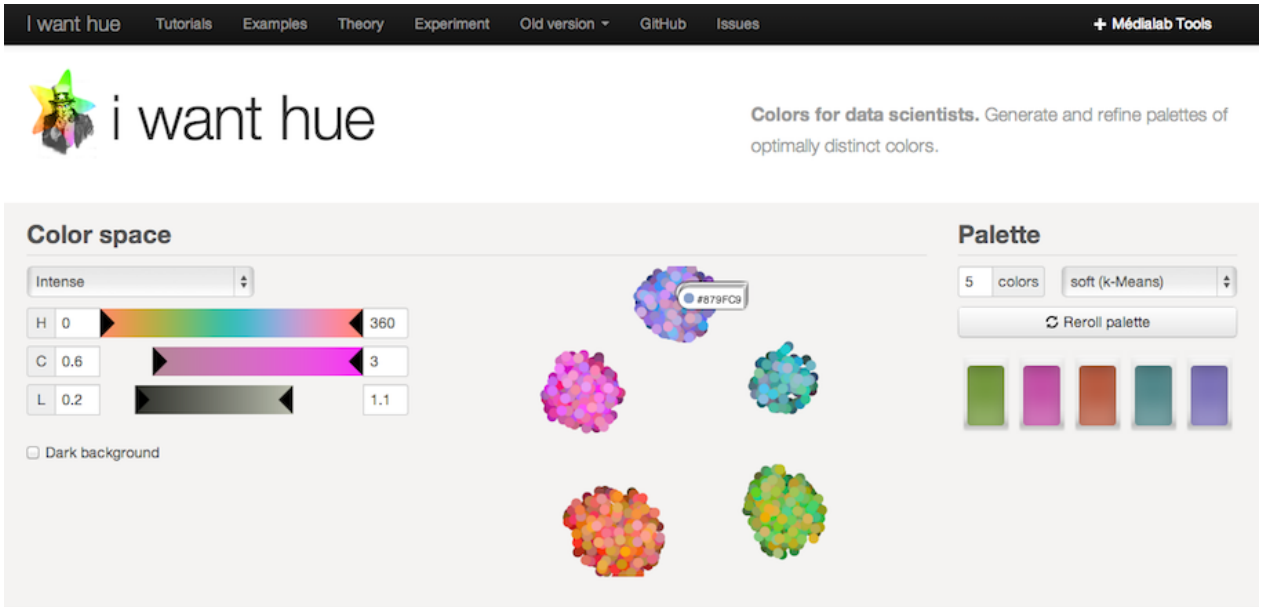
Manual color scale

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point() +
facet_grid(Species ~ .) +
scale_color_manual(values = c("red", "green", "blue"))
```



Refer to a color chart for beautiful visualizations

http://tools.medialab.sciences-po.fr/iwanthue/

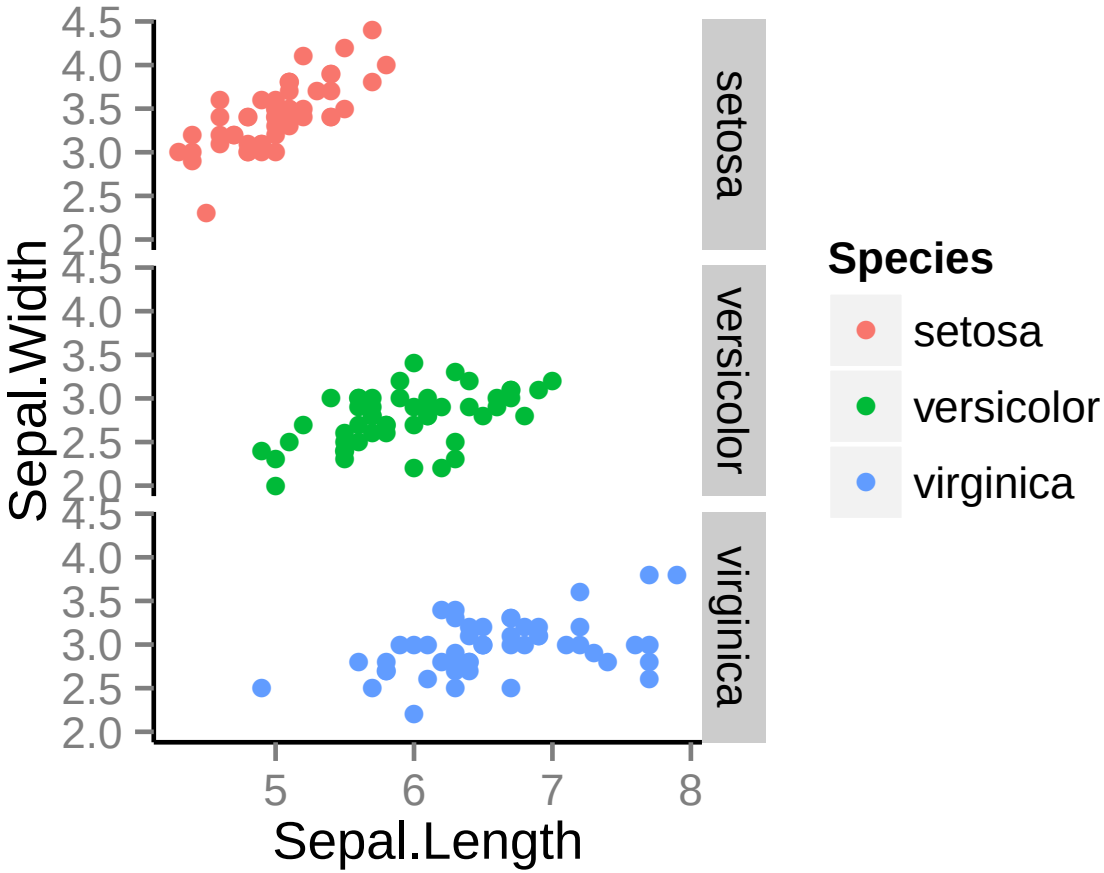


Section 10

Faceting

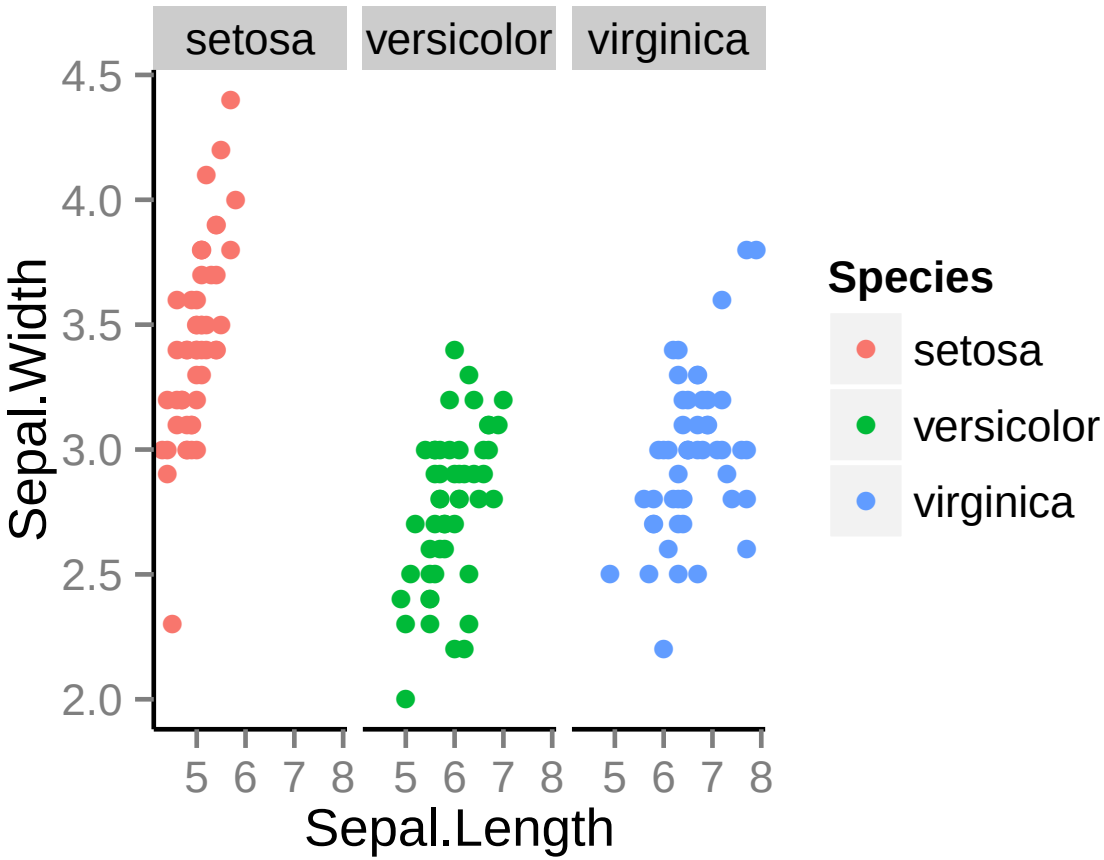
Faceting along columns

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point() +
facet_grid(Species ~ .)
```



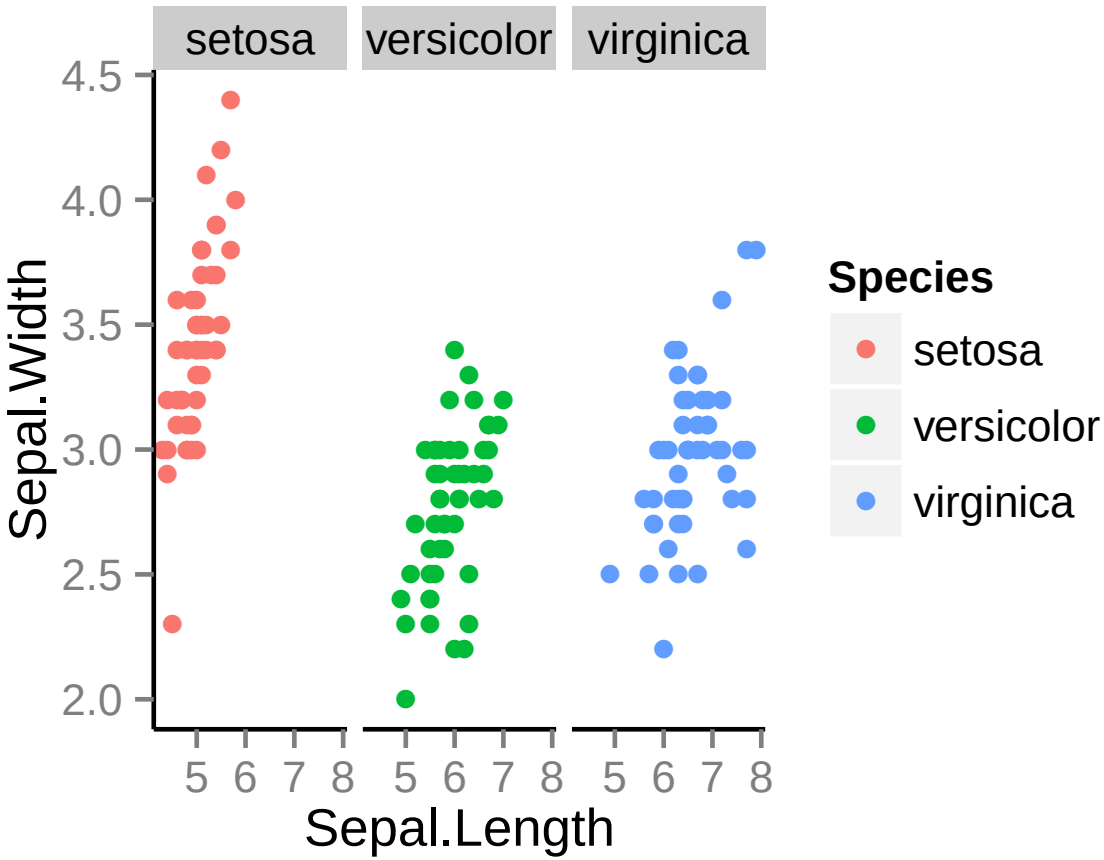
and along rows

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point() +
facet_grid(. ~ Species)
```



or just wrap your panels

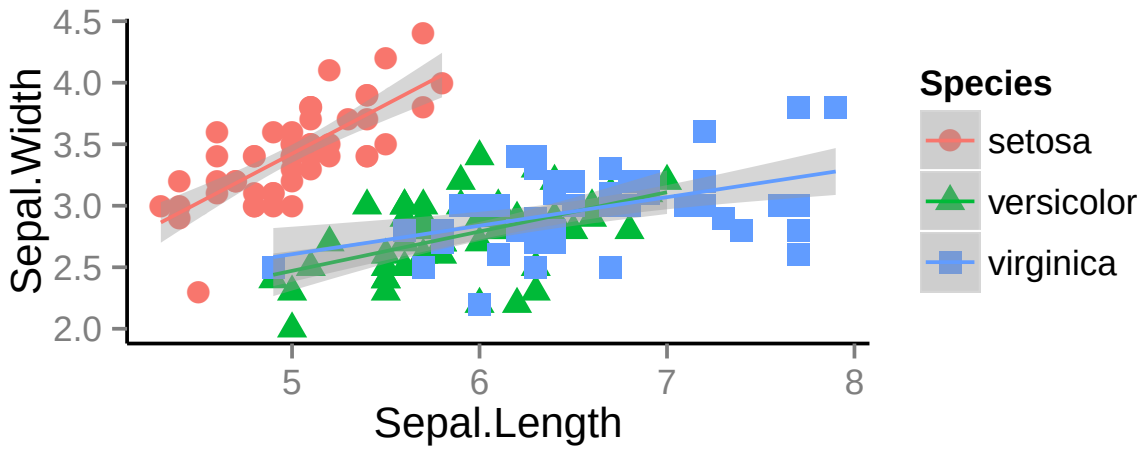
```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point() +
facet_wrap( ~ Species)
```



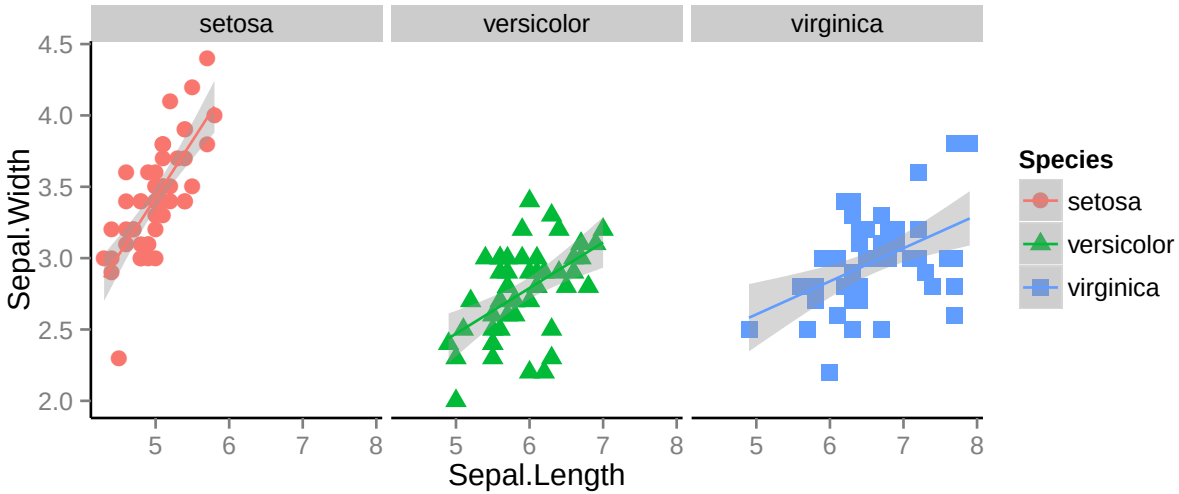
Section 11

Adding smoothers

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(aes(shape = Species), size = 3) +
geom_smooth(method = "lm")
```



```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(aes(shape = Species), size = 3) +
geom_smooth(method = "lm") +
facet_grid(. ~ Species)
```



Section 12

Themes

Adding themes

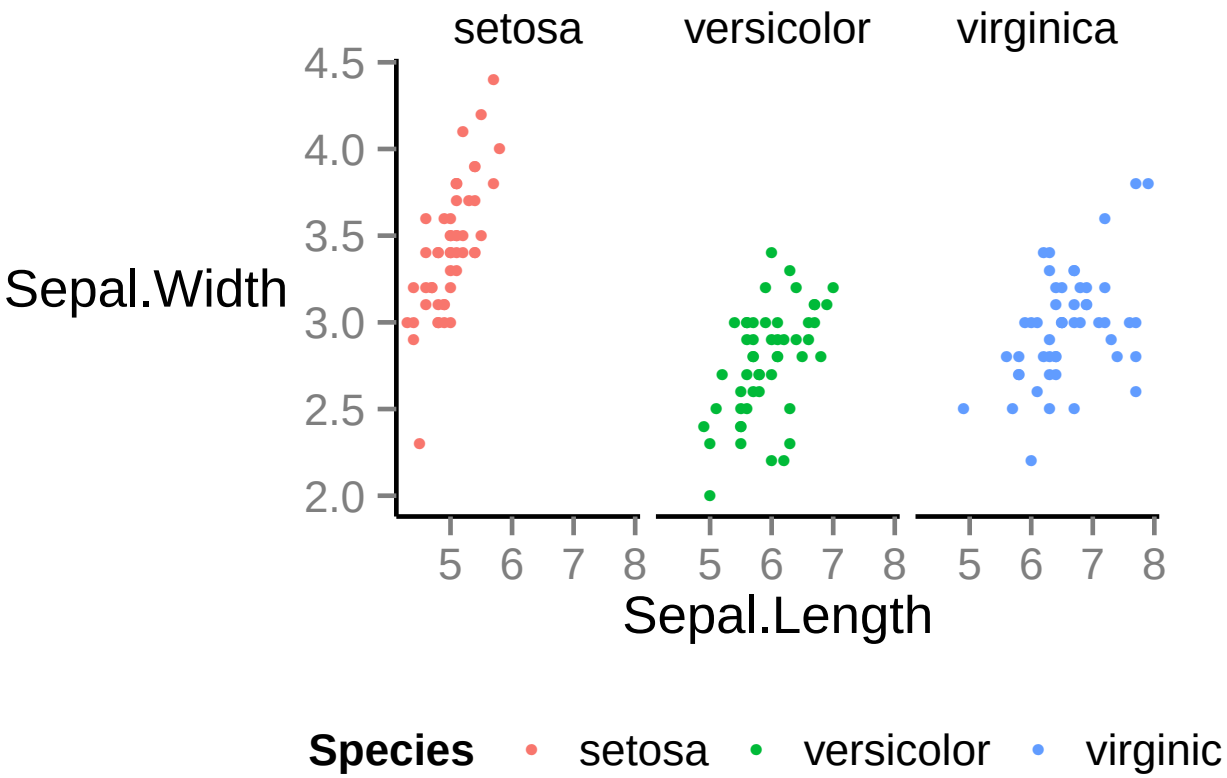
Themes are a great way to define custom plots.

```
+theme()
# see ?theme() for more options
```

A themed plot

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(size = 1.2, shape = 16) +
facet_wrap( ~ Species) +
theme(legend.key = element_rect(fill = NA),
legend.position = "bottom",
strip.background = element_rect(fill = NA),
axis.title.y = element_text(angle = 0))
```

Adding themes



ggthemes library

```
install.packages("ggthemes")
library(ggthemes)
# Then add one of these themes to your plot
+theme_stata()
+theme_excel()
+theme_wsj()
+theme_solarized()
```

Section 13

Create functions to automate your plotting

Write functions for day to day plots

```
my_custom_plot <- function(df, title = "", ...) {
    ggplot(df, ...) +
    ggtitle(title) +
    whatever geoms() +
    theme(...)
}
```

Then just call your function to generate a plot. It's a lot easier to fix one function that do it over and over for many plots

```
plot1 <- my_custom_plot(dataset1, title = "Figure 1")
```

Section 14

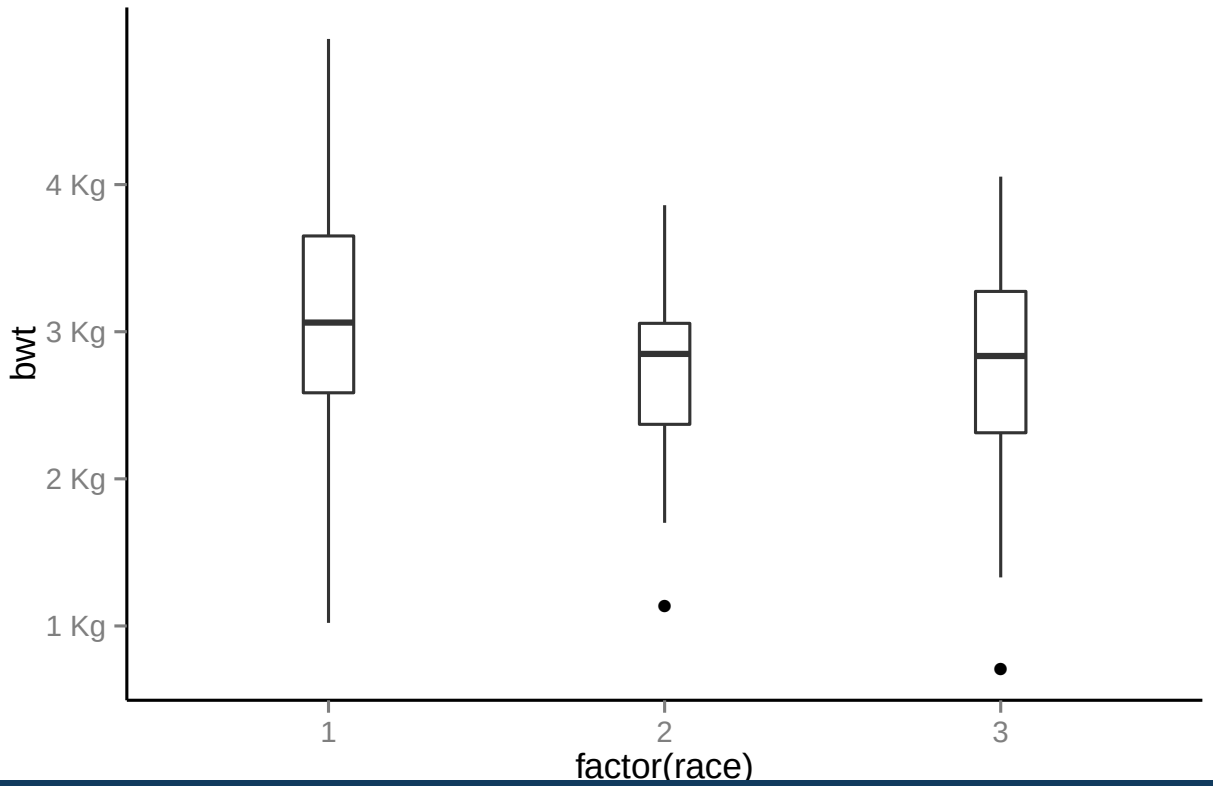
Scales

Commonly used scales

```
scale_fill_discrete(), scale_colour_discrete()
scale_fill_hue(), scale_color_hue()
scale_fill_manual(),  scale_color_manual()
scale_fill_brewer(), scale_color_brewer()
scale_linetype(), scale_shape_manual()
```

Adding a continuous scale

```
library(MASS)
ggplot(birthwt, aes(factor(race), bwt)) +
geom_boxplot(width = .2) +
scale_y_continuous(labels = (paste0(1:4, " Kg")),
breaks = seq(1000, 4000, by = 1000))
```

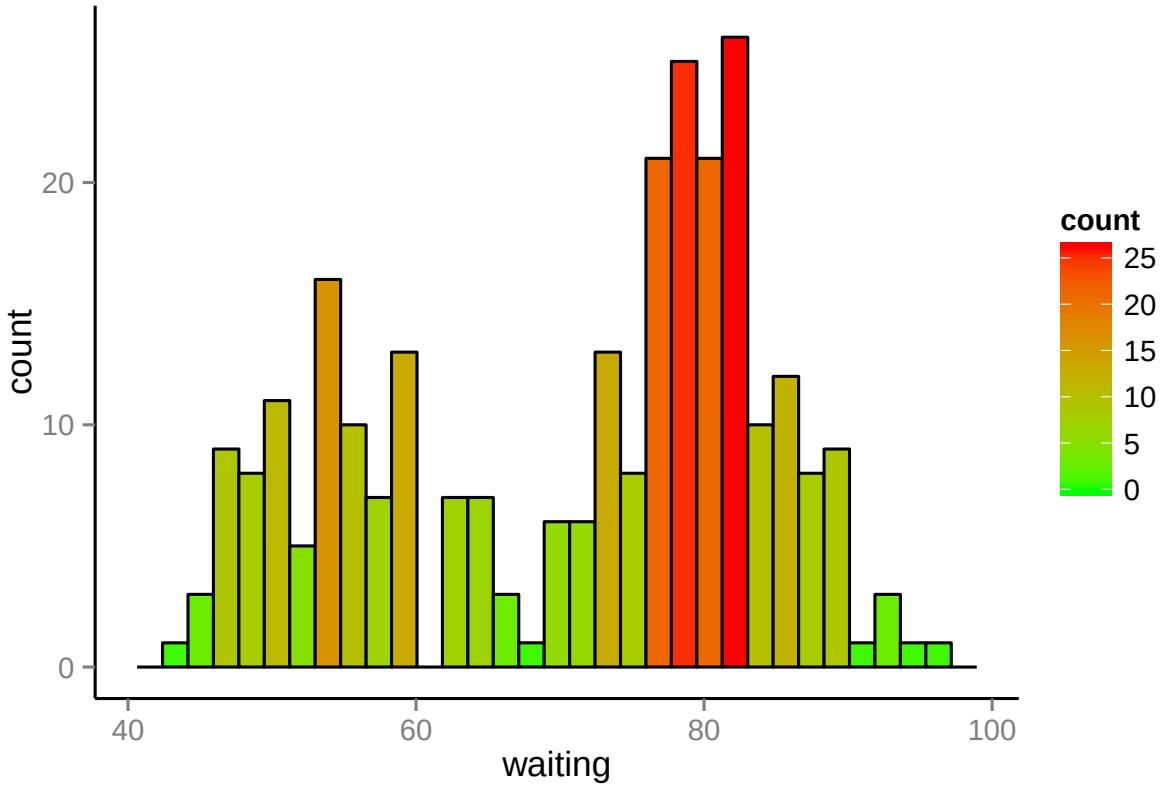


Another continuous scale with custom labels

```
# Assign the plot to an object
dd <- ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(size = 4, shape = 16) +
facet_grid(. ~Species)
# Now add a scale
dd +
scale_y_continuous(breaks = seq(2, 8, by = 1),
labels = paste0(2:8, " cm"))
```

gradients

```
h + geom_histogram( aes(fill = ..count..), color="black") +
scale_fill_gradient(low="green", high="red")
```



Section 15

Publication quality figures

- If the plot is on your screen

```
ggsave("~/path/to/figure/filename.png")
```

- If your plot is assigned to an object

```
ggsave(plot1, file = "~/path/to/figure/filename.png")
```

- Specify a size

```
ggsave(file = "/path/to/figure/filename.png", width = 6,
height =4)
```

- or any format (pdf, png, eps, svg, jpg)

```
ggsave(file = "/path/to/figure/filename.eps")
ggsave(file = "/path/to/figure/filename.jpg")
ggsave(file = "/path/to/figure/filename.pdf")
```

Further help

- You've just scratched the surface with ggplot2.
- Practice
- Read the docs (either locally in `R` or at `http://docs.ggplot2.org/current/`)
- Work together