Data Visualization Using R & ggplot2

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Some housekeeping

Install some packages

```
install.packages("ggplot2”, dependencies = TRUE)
install.packages("plyr”)
install.packages("ggthemes”)
install.packages("reshape2”)
install.packages("gridExtra”)
```

Section 1

Why ggplot2?

Why ggplot2?

- More elegant & compact code than with base graphics
- More aesthetically pleasing defaults than lattice
- Very powerful for exploratory data analysis

Why `ggplot2`?

- ‘gg’ is for ‘grammar of graphics’ (term by Lee Wilkinson)
- A set of terms that defines the basic components of a plot
- Used to produce figures using coherant, consistant syntax

Why ggplot2?

- Supports a continuum of expertise:
- Easy to get started, plenty of power for complex figures

Section 2

The Grammar

Some terminology

- **data**

- Must be a data.frame
- Gets pulled into the ggplot() object

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
```

plyr and reshape are key for using R

These two packages are the swiss army knives of R.

- plyr
    1. ddply (data frame to data frame ply)
        1.1 split
        1.2 apply
        1.3 combine
    2. llply (list to list ply)
    3. join

plyr

```
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

# Note the use of the . function to allow Species to be used
# without quoting
ddply(iris, .(Species), summarize,
      mean.Sep.Wid = mean(Sepal.Width, na.rm = TRUE))

##      Species mean.Sep.Wid
## 1     setosa        3.428
## 2 versicolor        2.770
## 3  virginica        2.974
```

plyr and reshape are key for using R

These two packages are the swiss army knives of R.

- reshape
  1. melt
  2. dcast (data frame output)
  3. acast (vector/matrix/array output)

reshape2

```
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

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

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

reshape2

```
df[1:2, ]

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

dcast(df, Species ~ variable, mean)

##      Species Sepal.Length Sepal.Width Petal.Length
## 1     setosa        5.006       3.428        1.462
## 2 versicolor        5.936       2.770        4.260
## 3  virginica        6.588       2.974        5.552
##   Petal.Width
## 1       0.246
## 2       1.326
## 3       2.026
```

Section 3

Aesthetics

Some terminology

- **data**
- **aes**thetics

- **How your data are represented visually**
    - *a.k.a. mapping*
- which data on the x
- which data on the y
- but also: color, size, shape, transparency

Let's try an example

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

## data: Sepal.Length, Sepal.Width, Petal.Length,
##   Petal.Width, Species [150x5]
## mapping:  x = Sepal.Length, y = Sepal.Width
## faceting: facet_null()
```

Section 4

Geoms

Some terminology

- **data**
- **aesthetics**
- **geom**etry

- **The geometric objects in the plot**
- points, lines, polygons, etc
- shortcut functions: geom_point(), geom_bar(), geom_line()

Basic structure

```r
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()
```

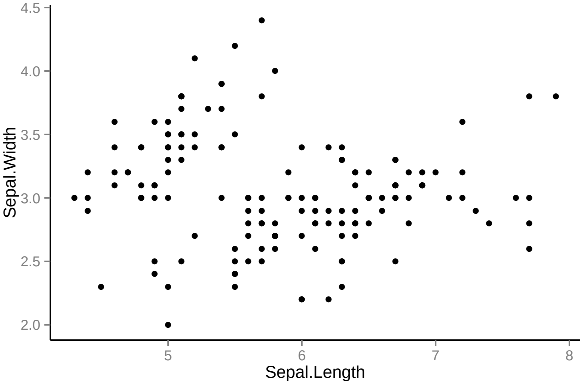
- Specify the data and variables inside the ggplot function.
- Anything else that goes in here becomes a global setting.
- Then add layers: geometric objects, statistical models, and facets.

Quick note

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

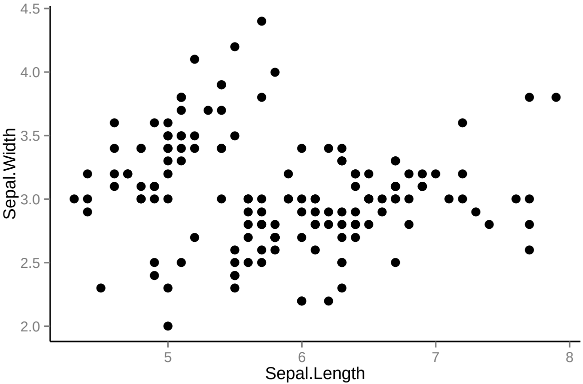
Let's try an example

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



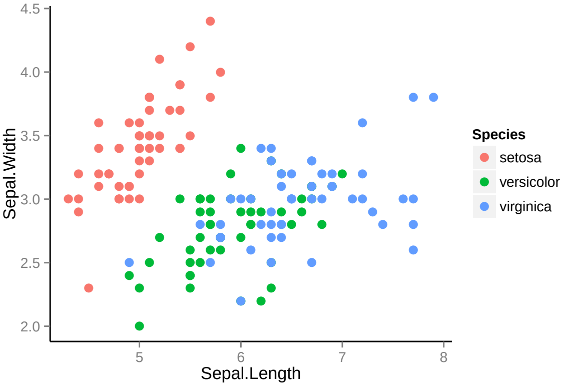
Changing the aesthetics of a geom: Increase the size of points

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



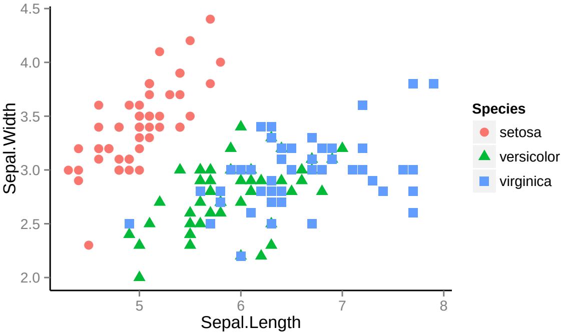
Changing the aesthetics of a geom: Add some color

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



Changing the aesthetics of a geom: Differentiate points by shape

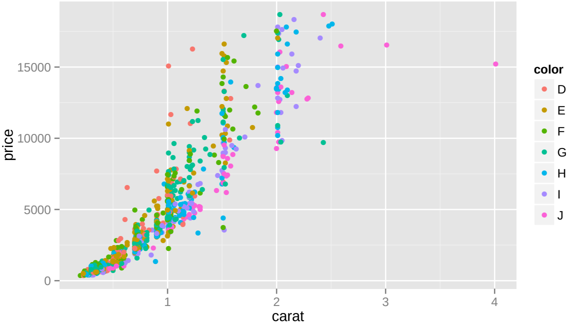
```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point(aes(shape = Species), size = 3)
# Why aes(shape = Species)?
```



Exercise 1

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

Then generate this plot below.



Section 5

Stats

Some terminology

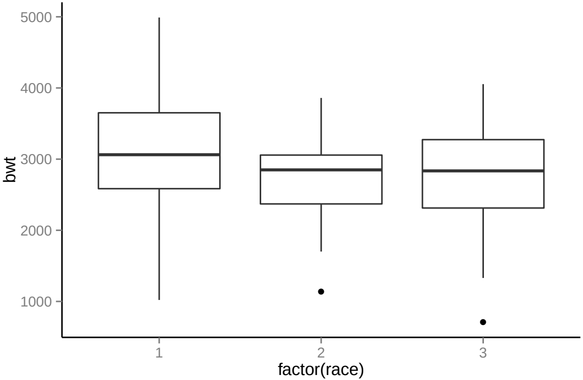
- data
- aesthetics
- geometry
- **stat**s

- **Statistical transformations and data summary**
- All geoms have associated default stats, and vice versa
- e.g. binning for a histogram or fitting a linear model

Built-in stat example: Boxplots

See ?geom_boxplot for list of options

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



Built-in stat example: Boxplots

```
myplot <- ggplot(birthwt, aes(factor(race), bwt)) + geom_boxplot()
summary(myplot)

## data: low, age, lwt, race, smoke, ptl, ht, ui, ftv,
##   bwt [189x10]
## mapping:  x = factor(race), y = bwt
## faceting: facet_null()
## -----------------------------------
## geom_boxplot: outlier.colour = black, outlier.shape = 16, outlier.size =
## stat_boxplot:
## position_dodge: (width = NULL, height = NULL)
```

Section 6

Facets

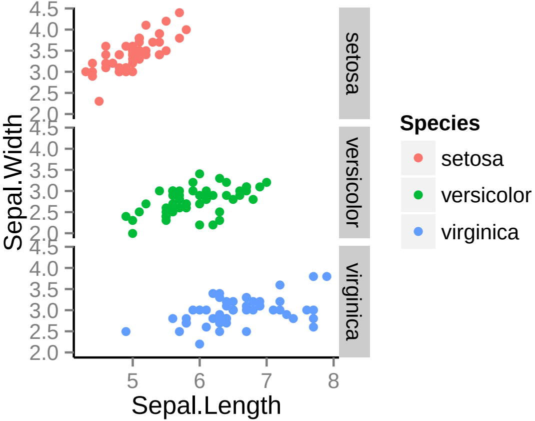
Some terminology

- **data**
- **aesthetics**
- **geometry**
- **stats**
- **facets**

- **Subsetting data to make lattice plots**
- Really powerful

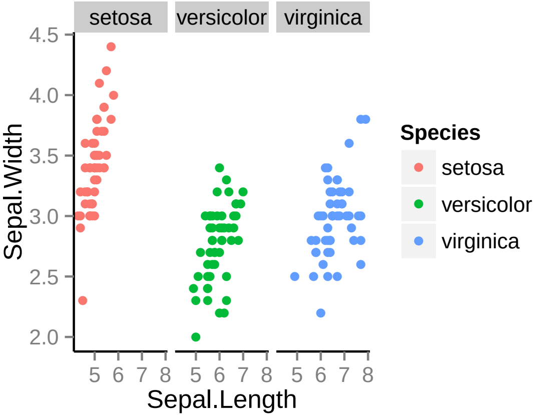
Faceting: single column, multiple rows

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



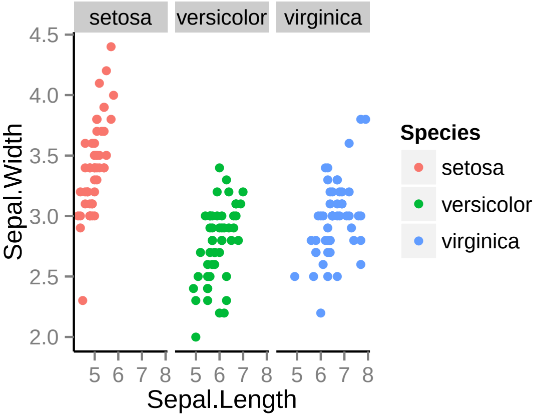
Faceting: single row, multiple columns

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



or just wrap your facets

```
ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) +
geom_point() +
facet_wrap( ˜ Species) # notice lack of .
```



Section 7

Scales

Some terminology

- data
- aesthetics
- geometry
- stats
- facets
- **scale**s

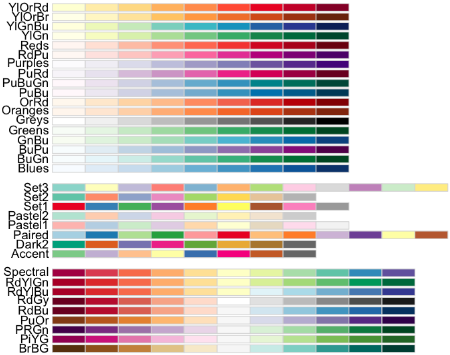
- **Control the mapping from data to aesthetics**
- Often used for adjusting color mapping

Colors

```
aes(color = variable)  # mapping
color <- "black"  # setting
# Or add it as a scale
scale_fill_manual(values = c("color1", "color2"))
```

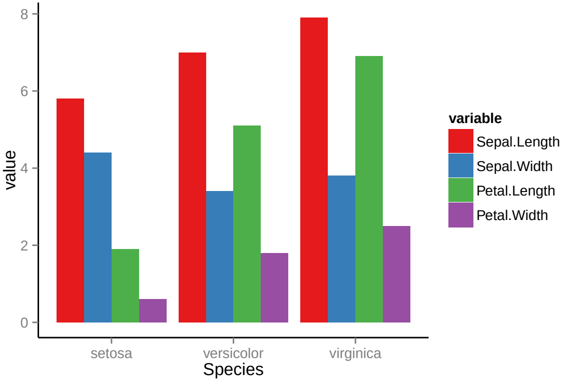
The RColorBrewer package

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



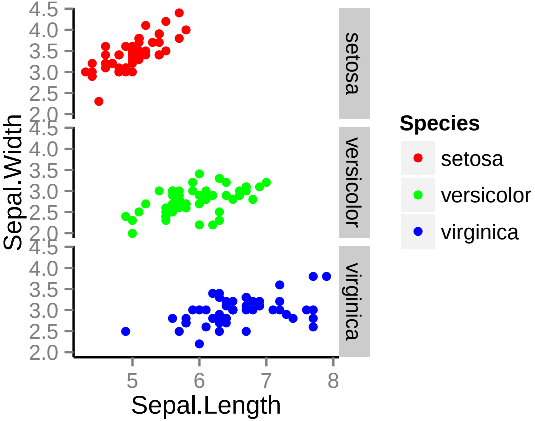
Using a color brewer palette

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



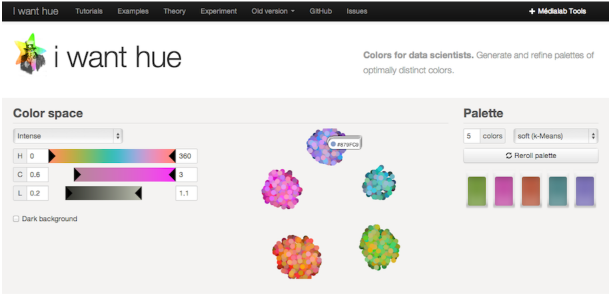
Manual color scale

```
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 beautful visualizations

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



i want hue

Colors for data scientists. Generate and refine palettes of optimally distinct colors.

Color space

Intense

H 0 360

C 0.6 3

L 0.2 1.1

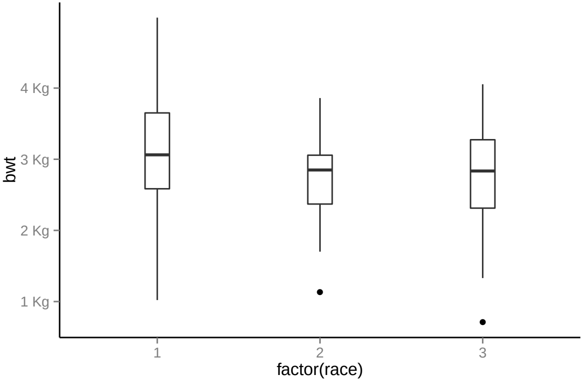
□ Dark background

Palette

5 colors soft (k-Means)

Adding a continuous scale to an axis

```
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))
```



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()
```

Section 8

Coordinates

Some terminology

- **data**
- **aesthetics**
- **geometry**
- **stats**
- **facets**
- **scales**
- **coord**inates

- Not going to cover this in detail
- e.g. polar coordinate plots

Section 9

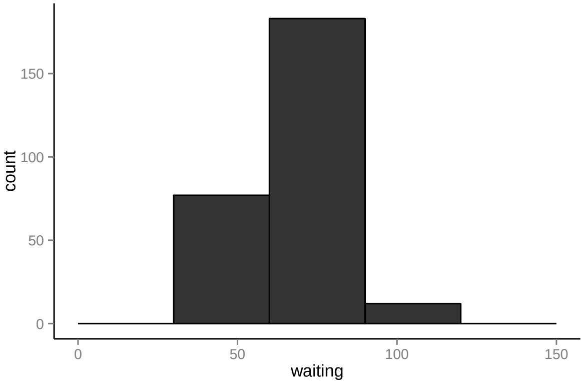
Putting it all together with more examples

Section 10

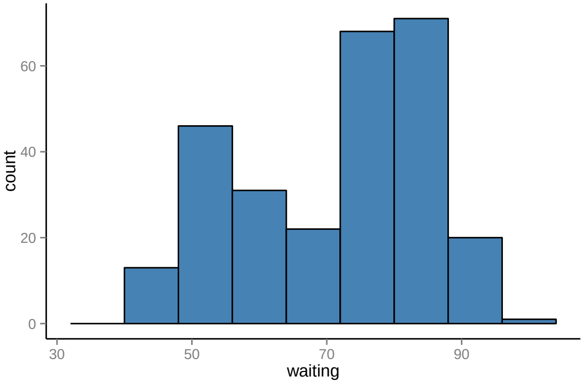
Histograms

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")
```

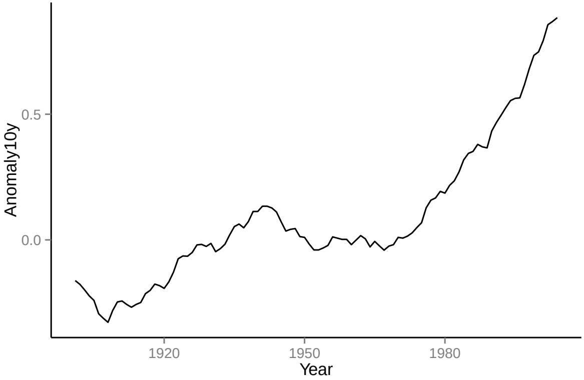


Section 11

Line plots

```
## Error:  cannot change working directory
```

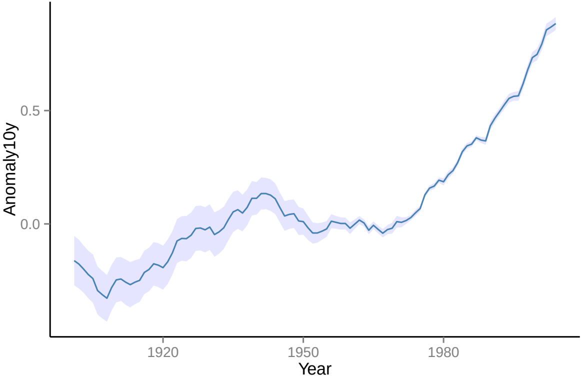
```
climate <- read.csv("data/climate.csv", header = T)
ggplot(climate, aes(Year, Anomaly10y)) +
geom_line()
```



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

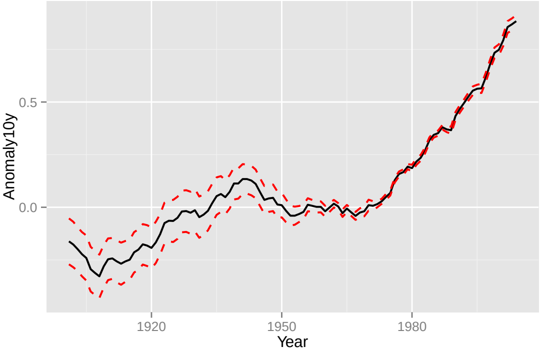
We can also plot confidence regions

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



Exercise 2

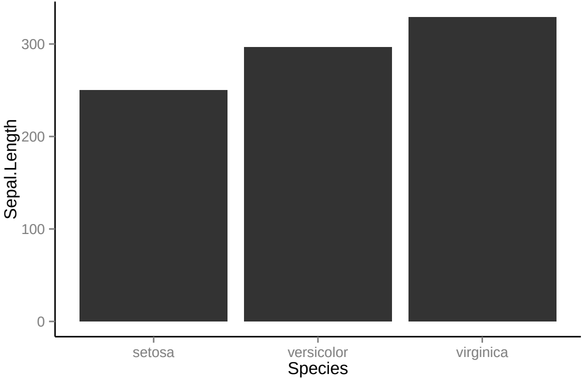
- Modify the previous plot and change it such that there are three lines instead of one with a confidence band.



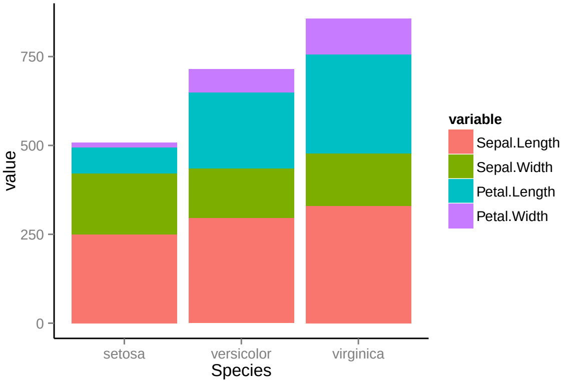
Section 12

Bar plots

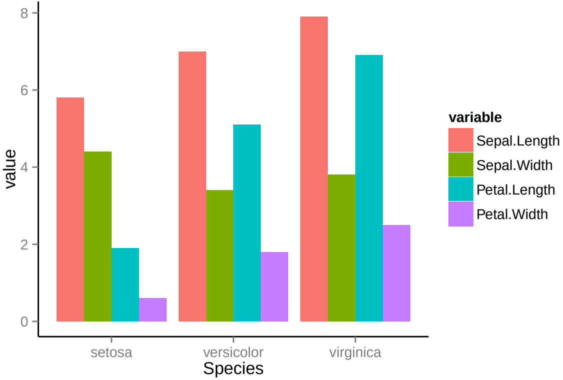
```
ggplot(iris, aes(Species, Sepal.Length)) +
geom_bar(stat = "identity")
```



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

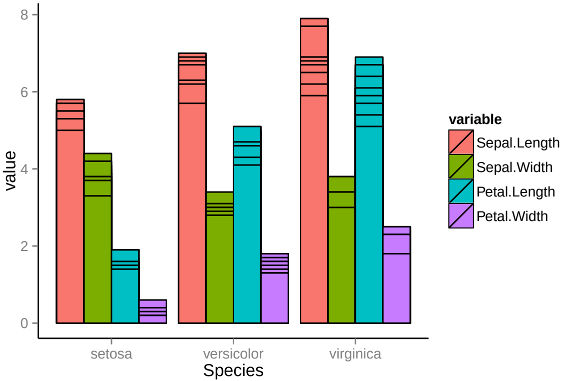


```
ggplot(df, aes(Species, value, fill = variable)) +
geom_bar(stat = "identity", position = "dodge")
```



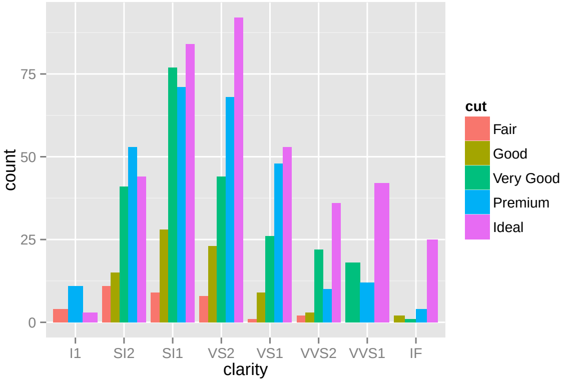
What's going on with the y axis?

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



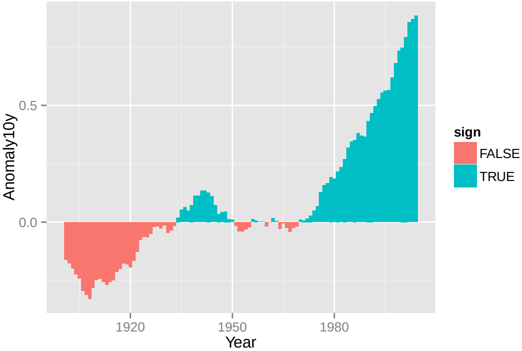
Exercise 3

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.

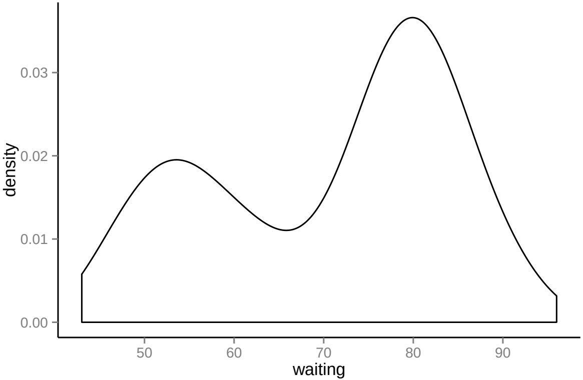


Section 13

Density Plots

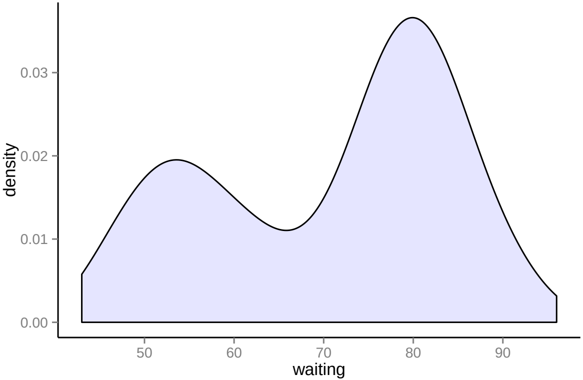
Density plots

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

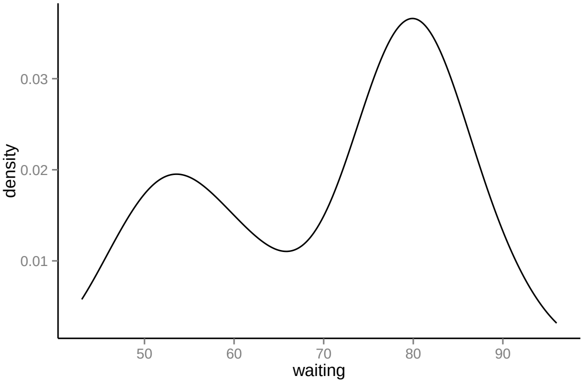


Density plots

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



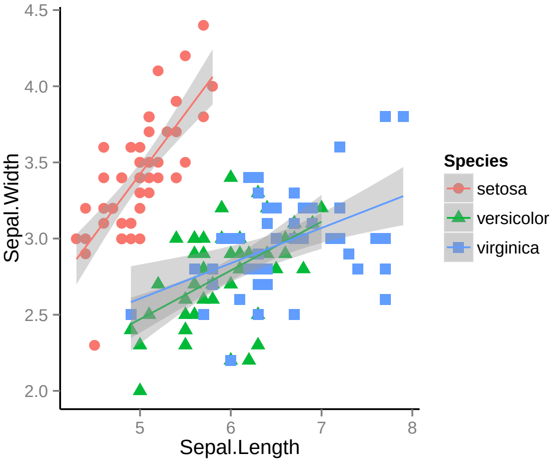
```r
ggplot(faithful, aes(waiting)) +
geom_line(stat = "density")
```



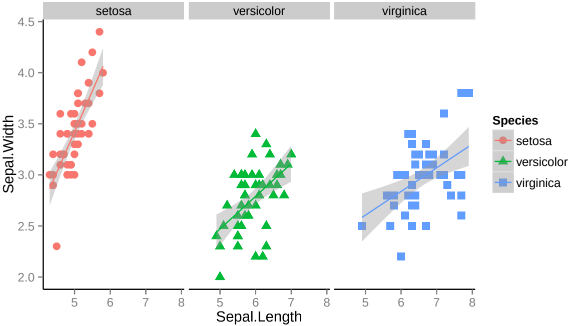
Section 14

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 15

Themes

Adding themes

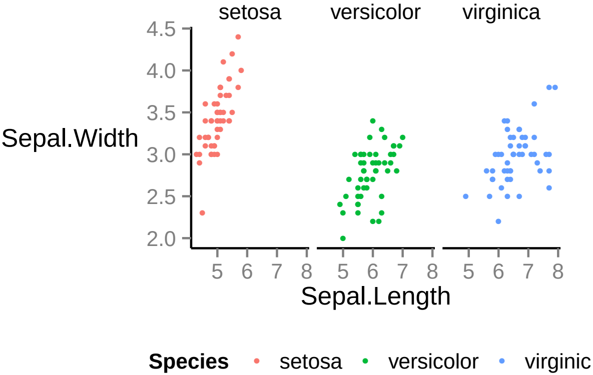
Themes are a great way to define custom plots.

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

A themed plot

```r
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

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

Section 16

Create functions to automate your plotting

Write functions for day to day plots

```r
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

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

Section 17

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