Plotting in R

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Plotting is a central part of the data analysis loop. ggplot2 is a great library that works well with dplyr and the rest of the Tidyverse.

```
library(tidyverse)
```

```
## -- Attaching packages -------------------------- tidyverse
## v ggplot2 3.2.1     v purrr   0.3.2
## v tibble  2.1.3     v dplyr   0.8.3
## v tidyr   1.0.0     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.4.0
## -- Conflicts ----------------------------- tidyverse_confli
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

Example (mpg dataset)

We previously saw a small extract of this dataset data/mpg_extract.csv. The full dataset is built-in to the ggplot2 library.

```
dt <- ggplot2::mpg
dt
```

```
## # A tibble: 234 x 11
##    manufacturer model displ  year   cyl trans drv     cty
##    <chr>        <chr> <dbl> <int> <int> <chr> <chr> <int> <
##  1 audi         a4      1.8  1999     4 auto~ f        18
##  2 audi         a4      1.8  1999     4 manu~ f        21
##  3 audi         a4      2     2008     4 manu~ f        20
##  4 audi         a4      2     2008     4 auto~ f        21
##  5 audi         a4      2.8  1999     6 auto~ f        16
##  6 audi         a4      2.8  1999     6 manu~ f        18
##  7 audi         a4      3.1  2008     6 auto~ f        18
##  8 audi         a4 q~   1.8  1999     4 manu~ 4        18
##  9 audi         a4 q~   1.8  1999     4 auto~ 4        16
## 10 audi         a4 q~   2     2008     4 manu~ 4        20
```

Example (`mpg` dataset)

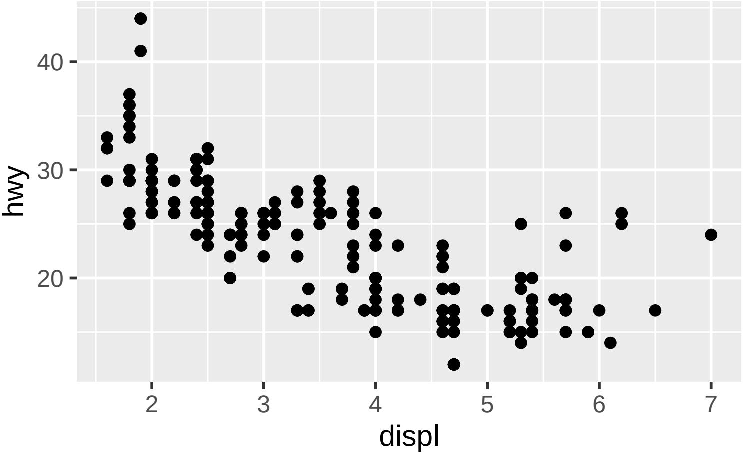
Do cars with big engines use more fuel than cars with small engines? Among the variables are:

- `displ`, a car's engine volume ("displacement") in litres
- `hwy`, a car's fuel efficiency on the highway in miles per gallon

Scatterplot using geom_point

The library is called ggplot2, but the function is called ggplot.

```
ggplot(data = dt) +
  geom_point(mapping = aes(x=displ, y=hwy))
```



Seeing/saving

- In R Studio, the plot appears in the bottom-right panel.
- If editing R Markdown, it appears inline.
- If we want to save:

```
ggsave("img/mpg_test.png")
```

```
## Saving 4 x 2.5 in image
```

General recipe for ggplot

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

The Grammar of Graphics

- Wilkinson, L. (2005), The Grammar of Graphics (2nd ed.). Statistics and Computing, New York: Springer.
- Wickham calls it "The most important modern work in graphical grammars"
- Every graph: a data set, a coordinate system, and visual marks representing data
- Wickham wrote the `ggplot2` package, an implementation of the grammar of graphics, which is used by most R practitioners.

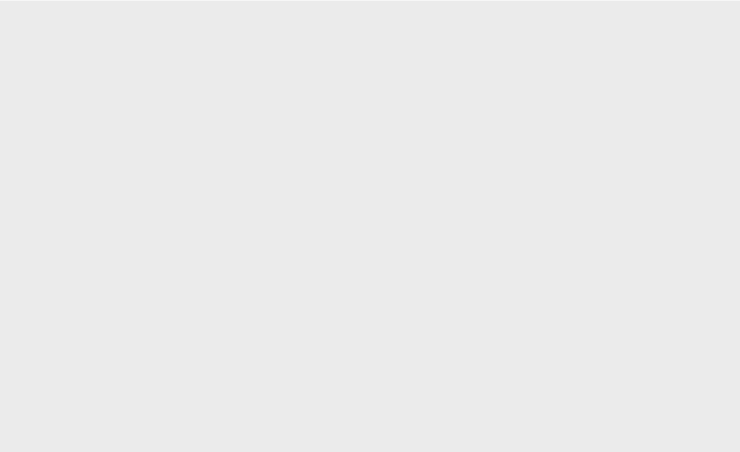
`ggplot2` concepts

- Layers
- Aesthetic mappings
- Geometric objects

Layers

We can create a blank plot with something like this.

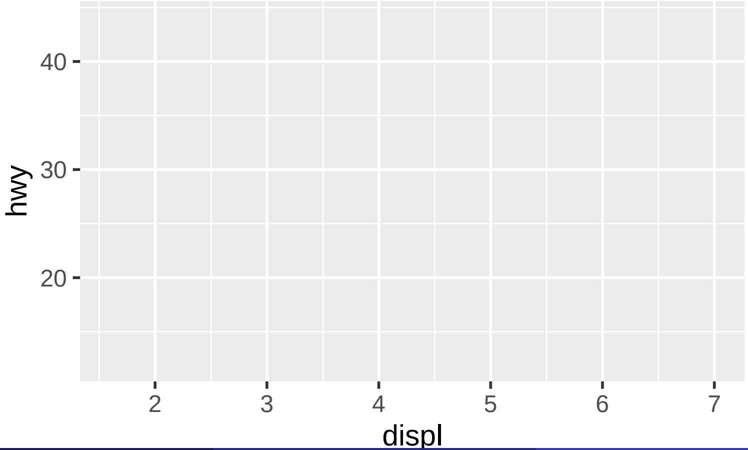
```r
ggplot(mpg)
```



Aesthetics

aes says what variable maps to what aesthetic property e.g. colour, or position on an axis. It still doesn't have any *layers*. (Notice it is allowed to put aes inside ggplot.)

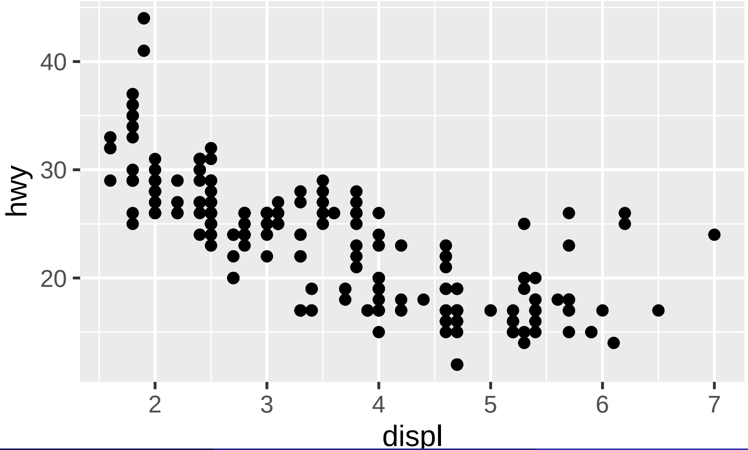
```
ggplot(mpg, aes(x=displ, y=hwy))
```



geoms

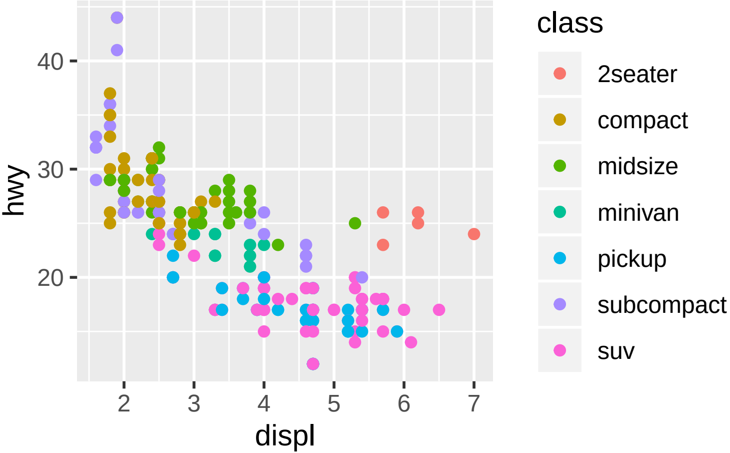
A *geom* is a way of translating a value to marks in the plot. We write + `geom`, and **that adds a layer**.

```
ggplot(data = dt) +
  geom_point(mapping = aes(x=displ, y=hwy))
```



Adding an extra aesthetic

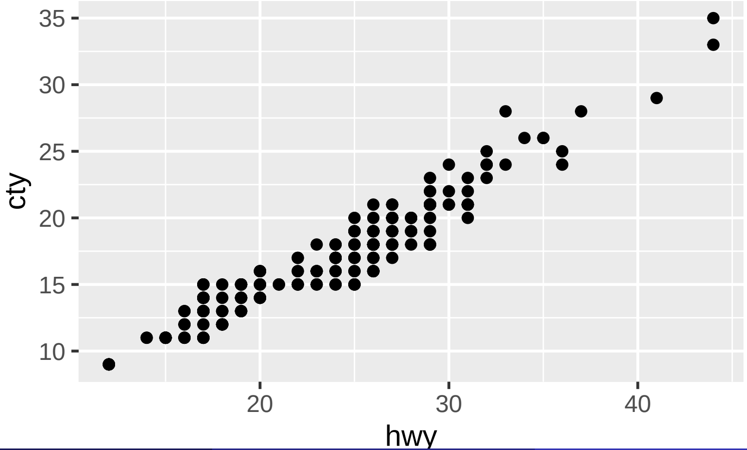
```
ggplot(data = dt) +
  geom_point(mapping = aes(x=displ, y=hwy, colour=class))
```



More geoms

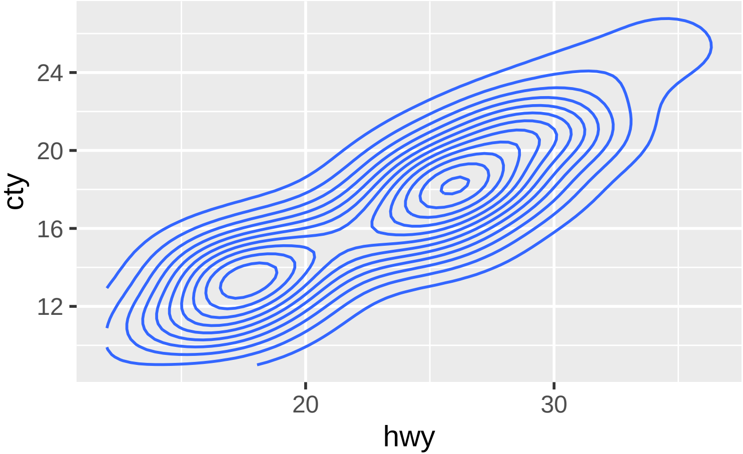
There are several different geoms. We already saw `geom_point`. Next, we'll look at how we can change appearance.

```r
ggplot(mpg, aes(x=hwy, y=cty)) +
  geom_point()
```



More geoms

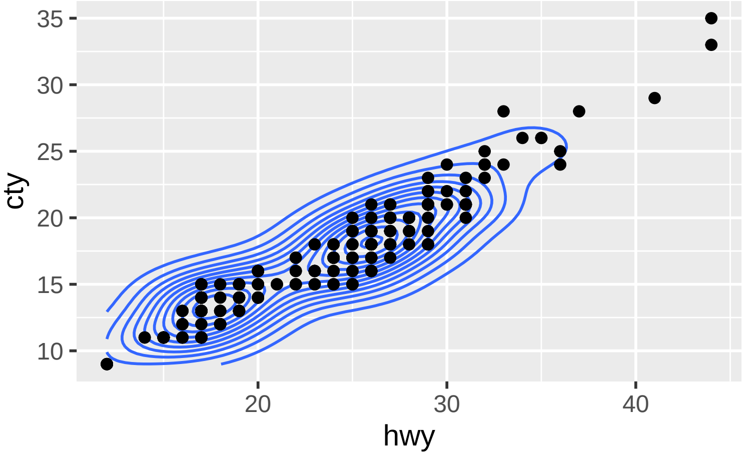
```
ggplot(mpg, aes(x=hwy, y=cty)) +
  geom_density2d()
```



Multiple geoms

We can just write + to add multiple geoms to a plot (i.e. multiple layers).

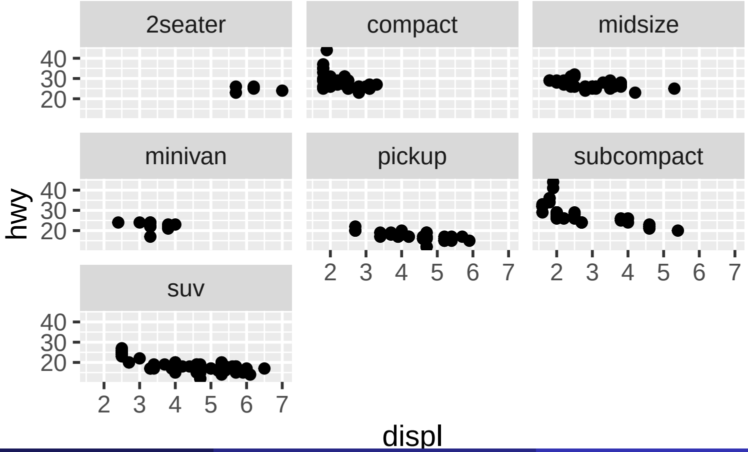
```
ggplot(mpg, aes(x=hwy, y=cty)) +
  geom_density2d() + geom_point()
```



Faceting

Maybe a nicer way is instead to split the data into one graph per class.

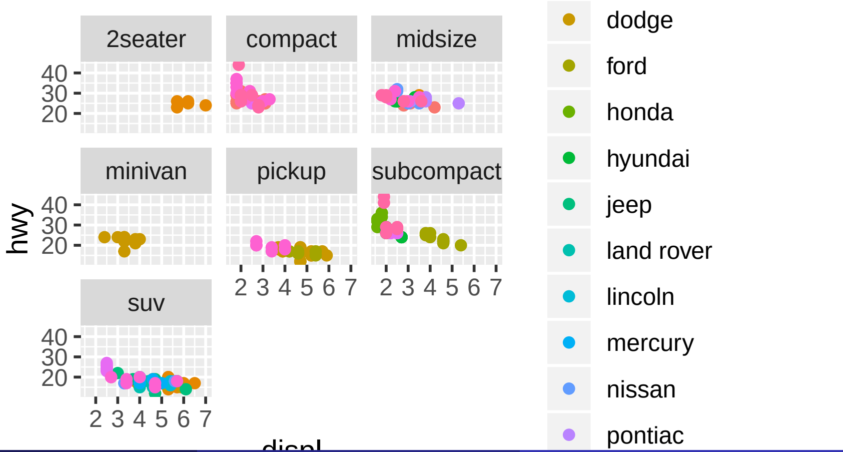
```
ggplot(data = dt) +
  geom_point(mapping = aes(x=displ, y=hwy)) +
  facet_wrap(~class) # notice tilde ~ for a *formula*
```



Adding another variable

Another variable is `manufacturer`. We are now showing 4 variables.

```
ggplot(data = dt) +
  geom_point(mapping=aes(x=displ, y=hwy, colour=manufacturer))
  facet_wrap(~class)
```



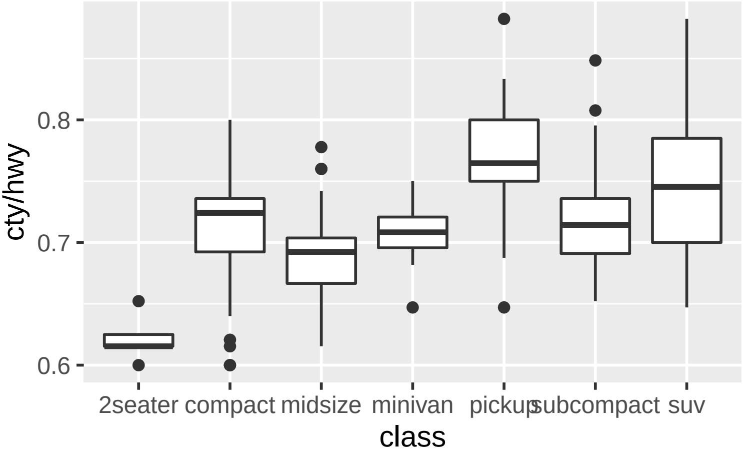
New variables

We can create a new variable inside the `aes` call.

New variables

Which car types emphasise city fuel efficiency over highway fuel efficiency?

```
ggplot(mpg, aes(x=class, y=cty/hwy)) +
  geom_boxplot()
```

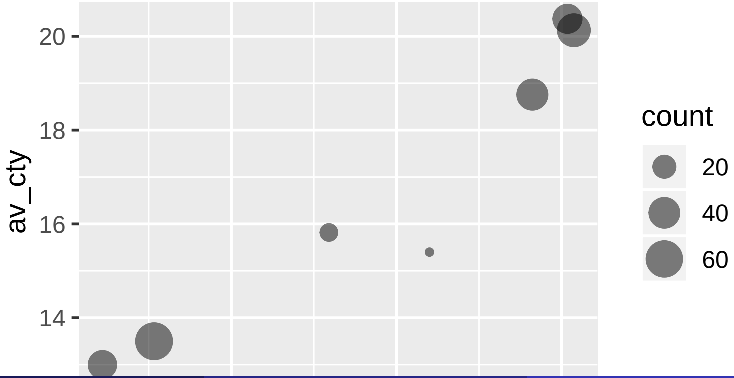


dplyr with ggplot

We can pipe the output of some dplyr manipulation straight into ggplot and then use aesthetics and geom commands to refine the plot.

dplyr with ggplot

```
mpg %>% group_by(class) %>%
  summarise(count=n(),
    av_hwy=mean(hwy),
    av_cty=mean(cty)) %>%
  ggplot(mapping = aes(x=av_hwy, y=av_cty)) +
  geom_point(aes(size=count), alpha=0.5)
```



Collision modifiers

These are methods of preventing marks (e.g. dots) from overlapping with each other.

- `dodge` (“smart” displacement of dots)
- `jitter` (random displacement of dots)
- `nudge` (manual displacement of dots)

More references

- Manual https://ggplot2.tidyverse.org/reference/
- Cheatsheet https://github.com/rstudio/cheatsheets/blob/master/data-visualization-2.1.pdf
- BBC using R for data journalism with a “house style” https://medium.com/bbc-visual-and-data-journalism/how-the-bbc-visual-and-data-journalism-team-works-with-graphics-in-r-ed0b35693535

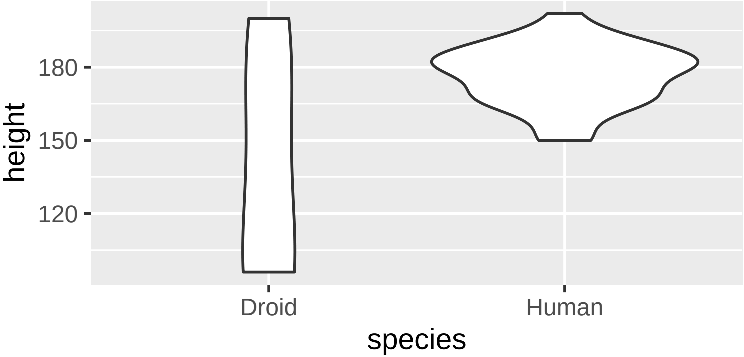
Exercises

Here are a few plots from well-known datasets. The exercise is to reproduce them using `ggplot`

Exercise 1

Character height in Star Wars using a “violin plot”. A violin plot is like a sideways, smoothed histogram, or like a box plot.

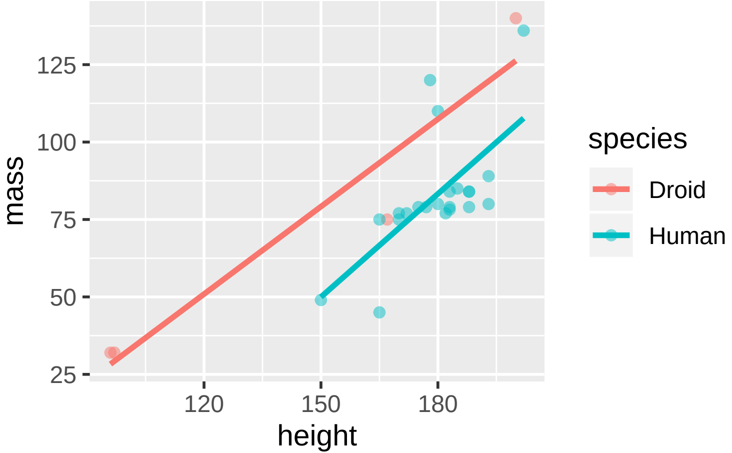
The dataset is `dplyr::starwars`.



Exercise 2

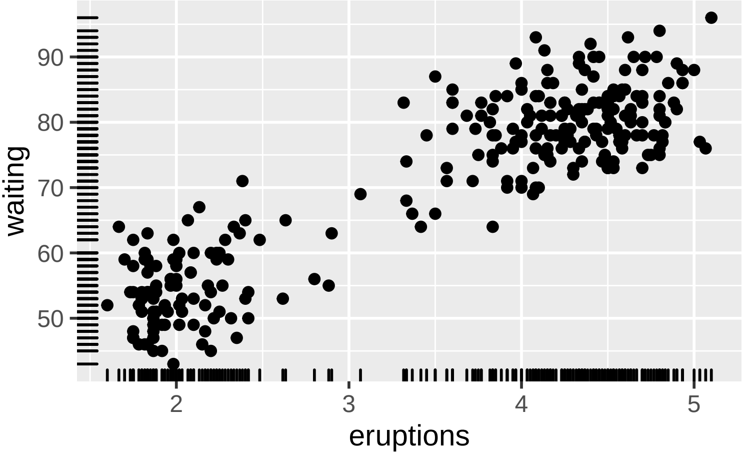
Character height and mass in Star Wars, with trendlines.

```
## Warning: Removed 14 rows containing non-finite values (stat
## Warning: Removed 14 rows containing missing values (geom_po
```



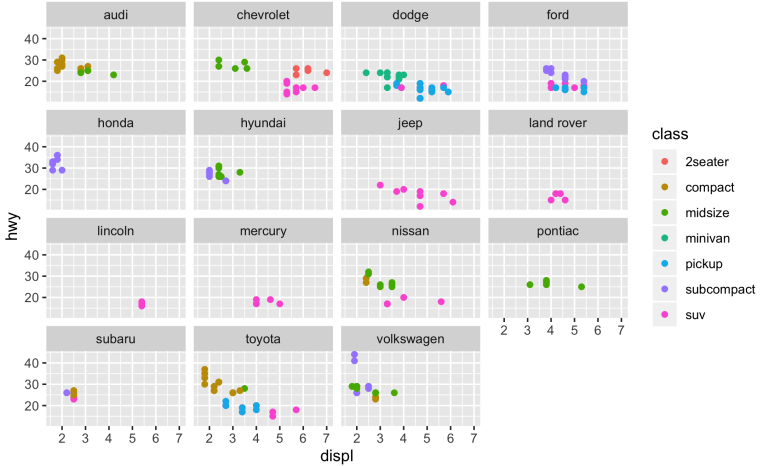
Exercise 3

Eruption length versus waiting time at the Old Faithful geyser. The dataset is `faithful`, built-in to R as a `data.frame`. Recall we can use `as_tibble` to convert to a tibble. Hint: this is called a “rug plot”.



Exercise 4

Like a previous plot, but now faceting `manufacturer` and showing `class` as colour.



Solutions

Exercise 1

```
s = dplyr::starwars
s %>% select(height, mass, species) %>%
  filter(height != "na.rm") %>%
  filter(species %in% c("Human", "Droid")) %>%
  ggplot(mapping=aes(x=species, y=height)) + geom_violin()
```

Exercise 2

```
s %>% filter(species == "Human" | species == "Droid") %>%
  ggplot(aes(x=height, y=mass, color=species)) +
  geom_point(alpha=0.5) + geom_smooth(method=lm, se=FALSE)
```

Exercise 3

```
f = as_tibble(faithful)
f %>% ggplot(aes(x=eruptions, y=waiting))
  + geom_point() + geom_rug()
```

Exercise 4

```
dt <- ggplot2::mpg
ggplot(data = dt) +
  geom_point(mapping = aes(x=displ, y=hwy, colour=class)) +
  facet_wrap(~manufacturer)
ggsave("img/R_mpg_displ_hwy_manu_class.png")
```