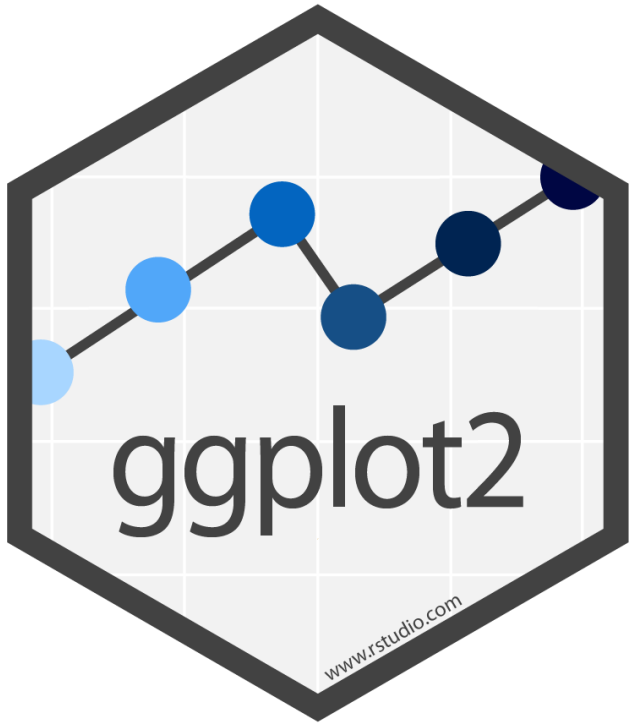
Visualising Data with



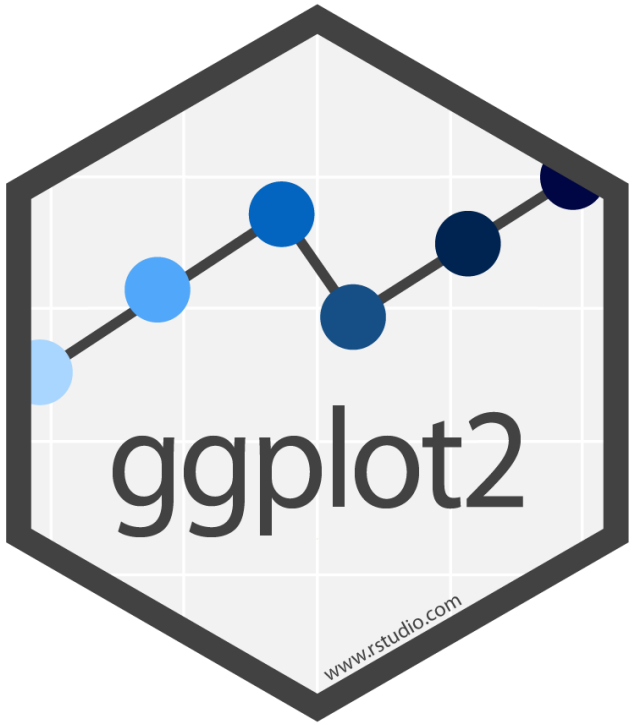
Adapted from “Explore the Tidyverse” CC by Hadley Wickham

Why Visualise?

“The simple graph has brought more information to the data analyst’s mind than any other device.”

- John Tukey

ggplot2



One of the earliest tidyverse packages.

Complex plots, by layering simple components.

Adapted from “Explore the Tidyverse” CC by Hadley Wickham

Your Turn

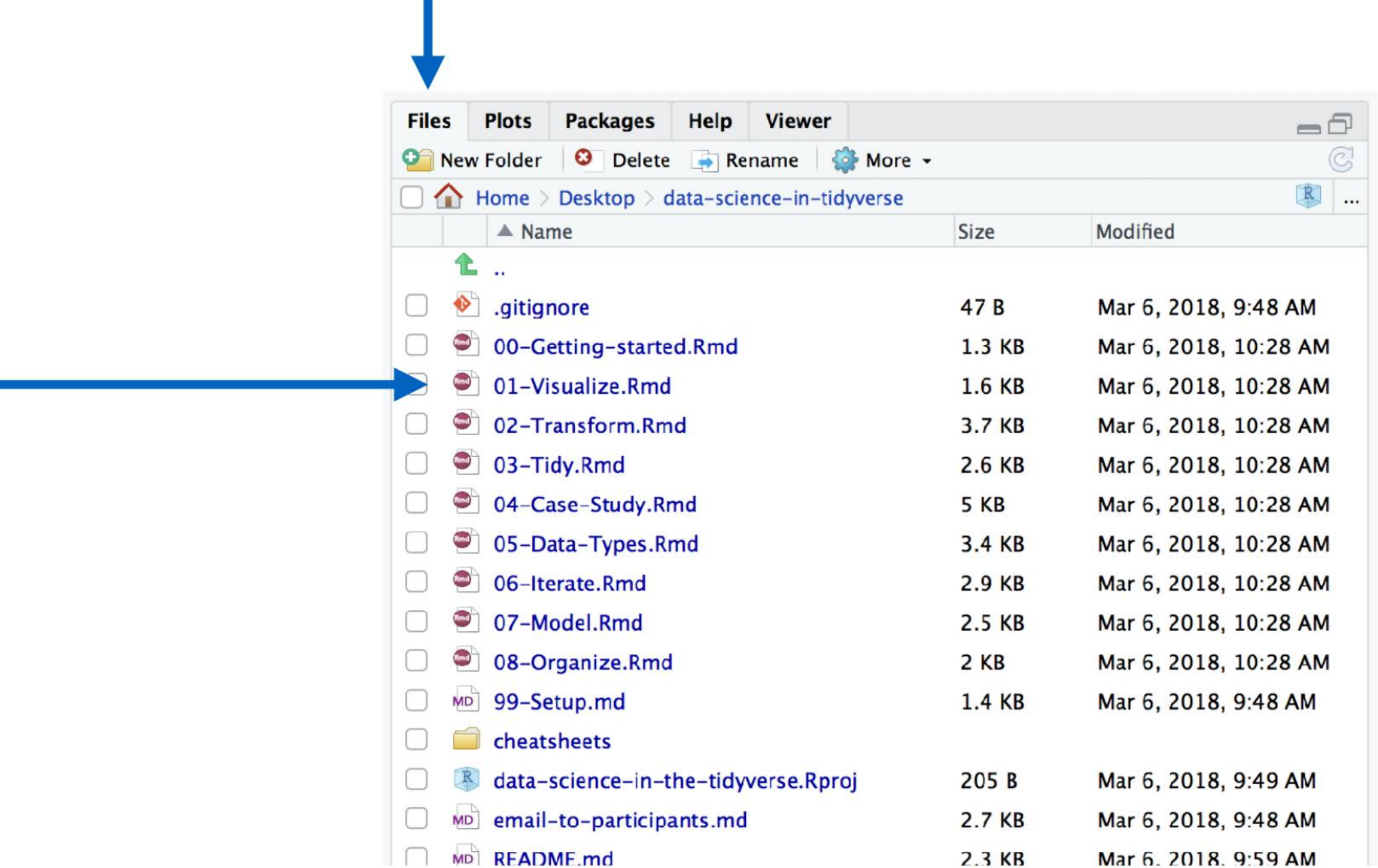
Open 01-Visualise.Rmd

I'm working on it

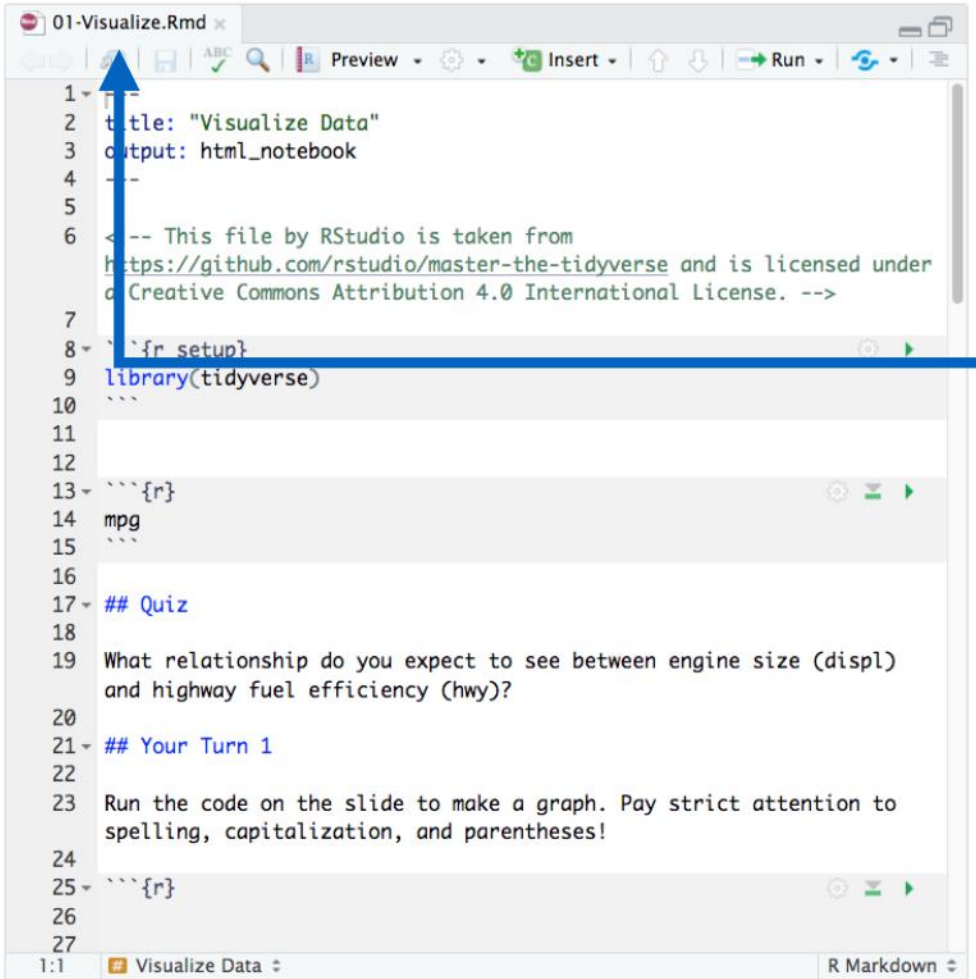
I'm stuck!

I'm done!

Adapted from “Explore the Tidyverse” CC by Hadley Wickham

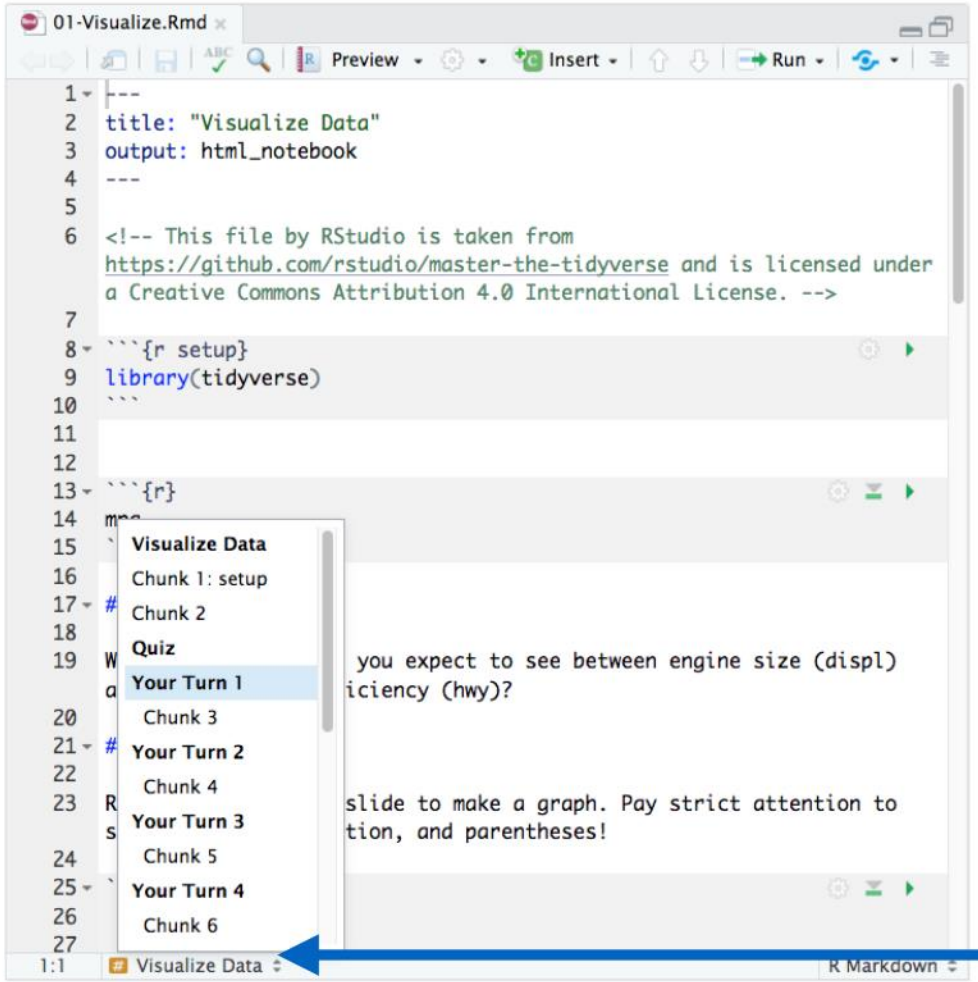


If you get lost or need to restart



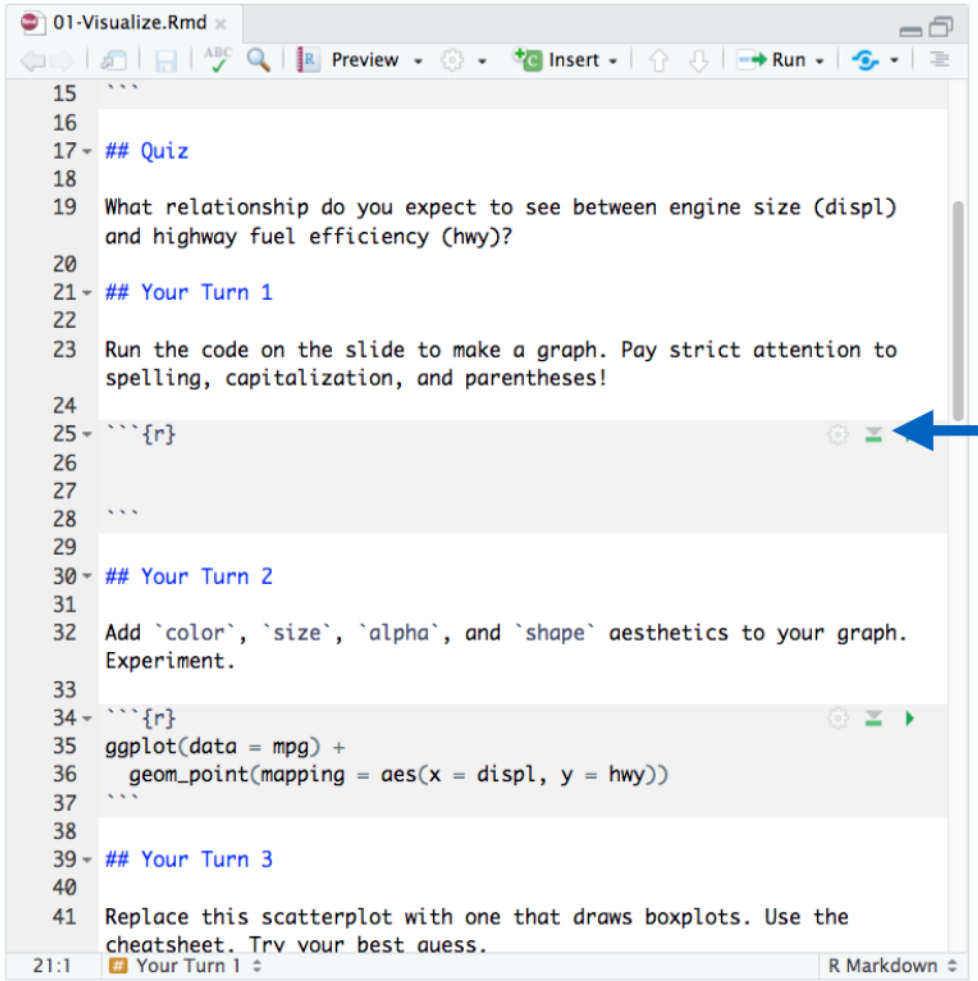
Check you are in the right file

If you get lost or need to restart



Use the section browser to quickly navigate to the right *Your Turn*

If you get lost or need to restart

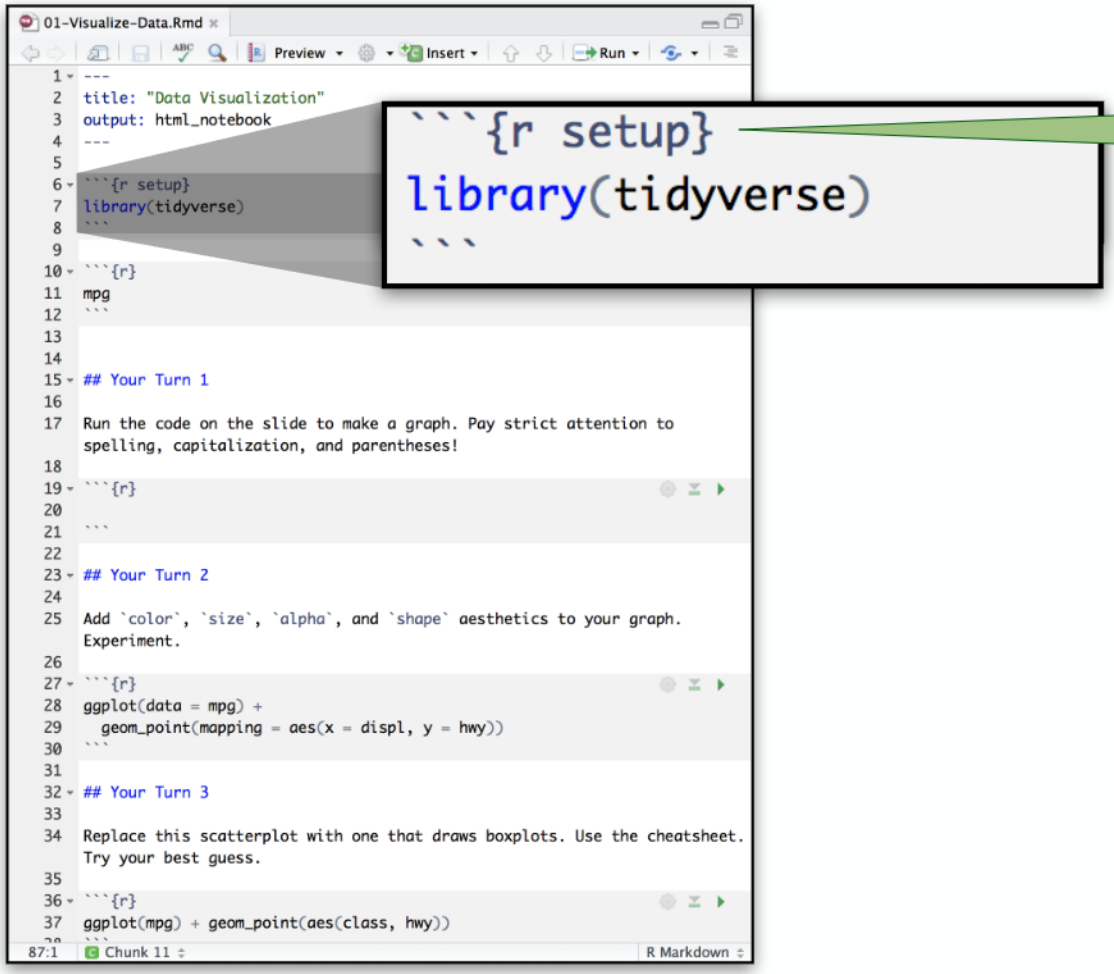


Click to run all chunks before this one.

You should be ready to go.

Setup

The setup chunk is always run once before anything else



(optional) label for chunk

ggplot2

mpg

Fuel economy data for 38 models of car.

```
mpg
?mpg
```

Quiz

Confer with your neighbours.

What relationship do you expect to see between engine size (`displ`) and highway fuel efficiency (`hwy`)?

No peeking ahead!

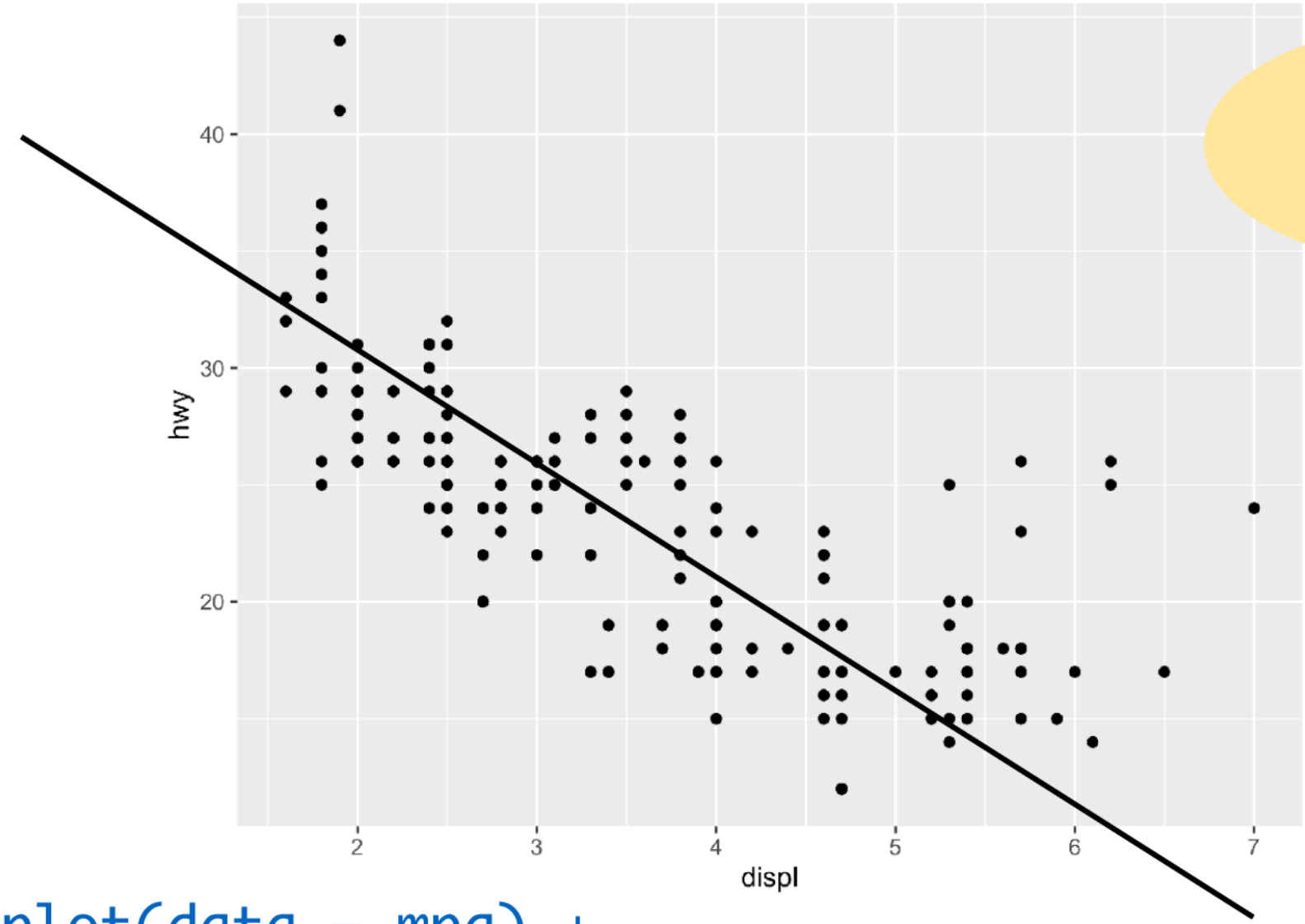
Your Turn 1

Run this code in your notebook to make a graph.

Pay strict attention to spelling, capitalization, and parentheses!

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

I'm working on it I'm stuck! I'm done!



What do you think about the line of best fit?

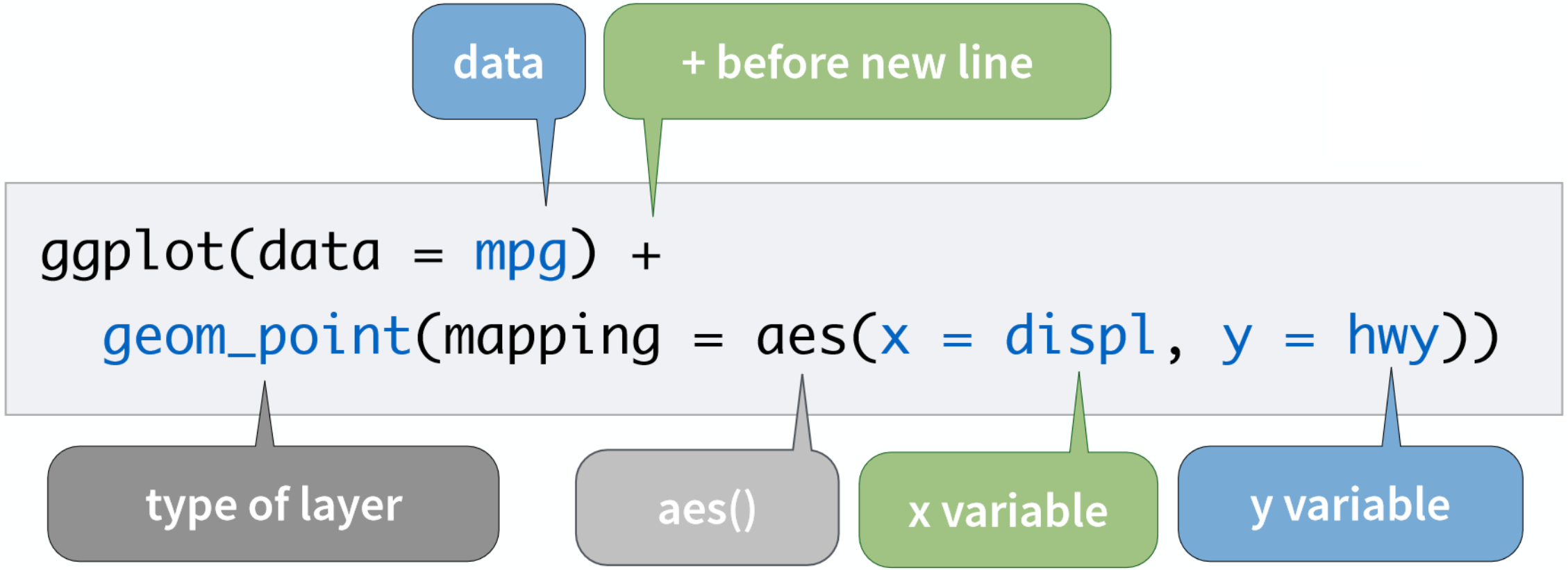
```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
```

1. "Initialize" a plot with `ggplot()`
2. Add layers with `geom_` functions

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

Pro tip: Always put the + at the end of a line, Never at the start

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

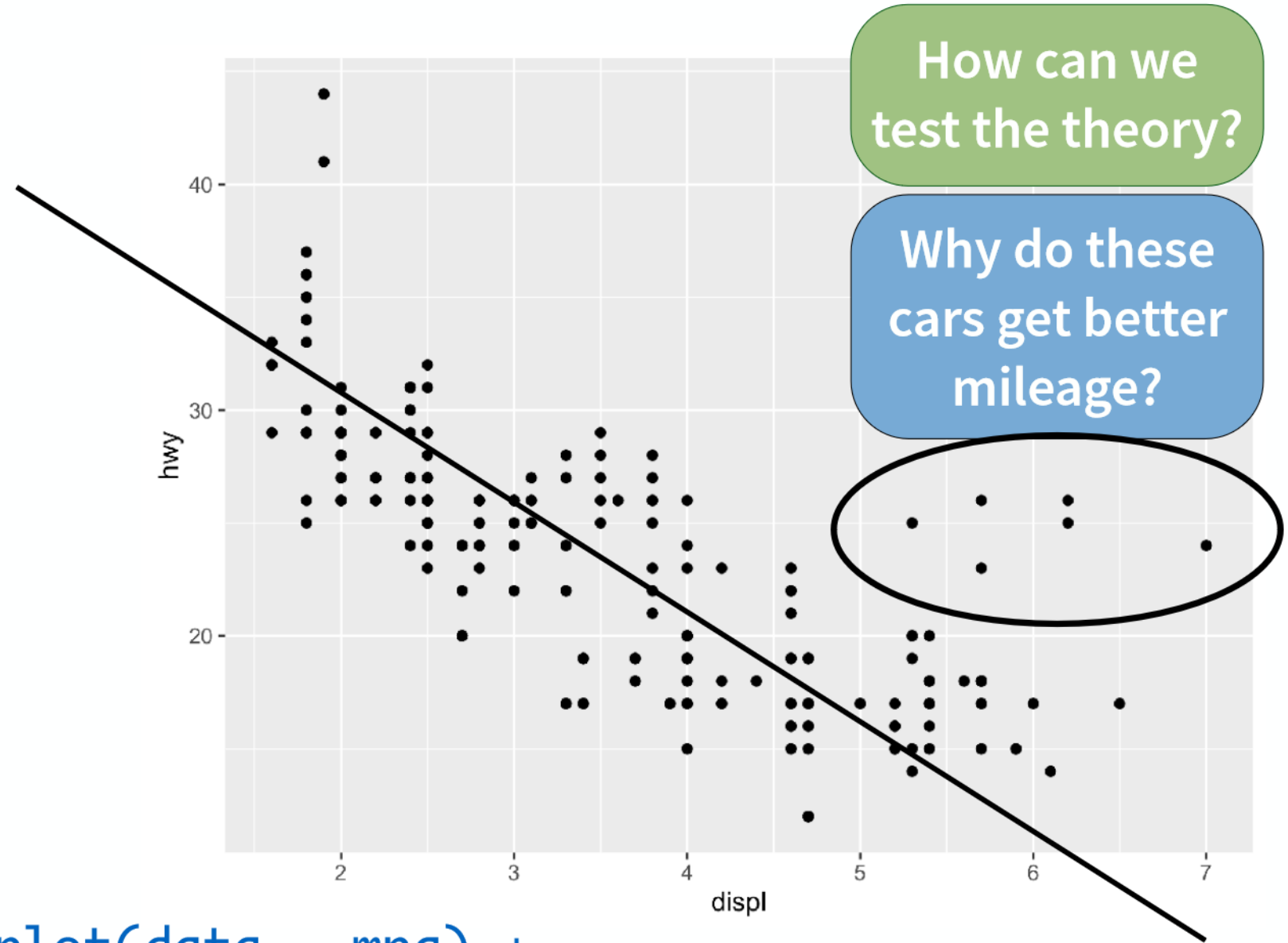


A Template

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

```
  geom_point(mapping = aes(x = displ, y = hwy))
```

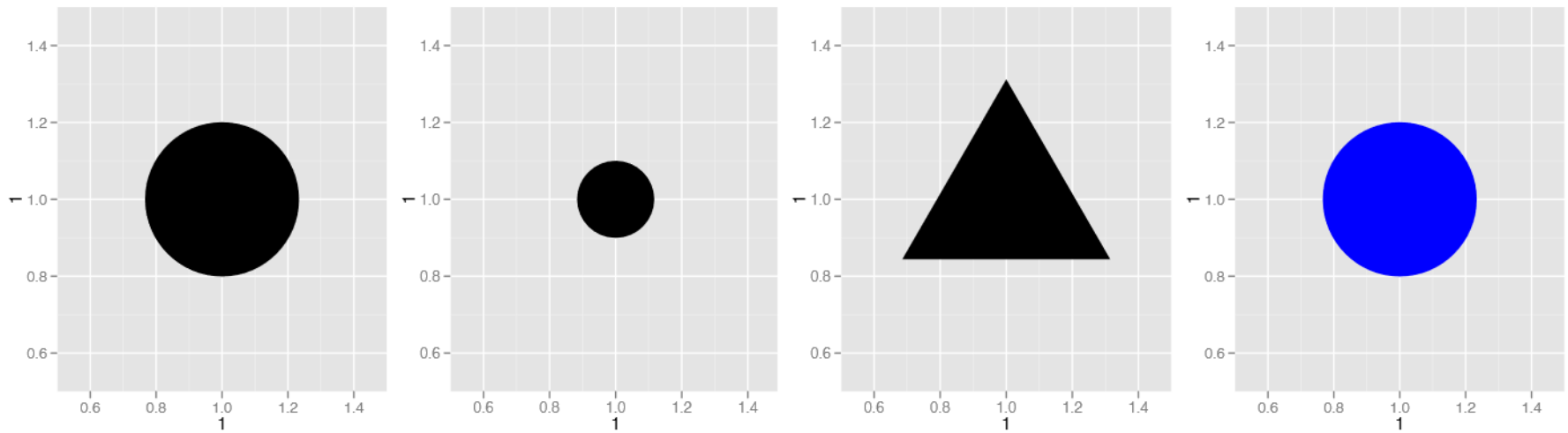

Mappings




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

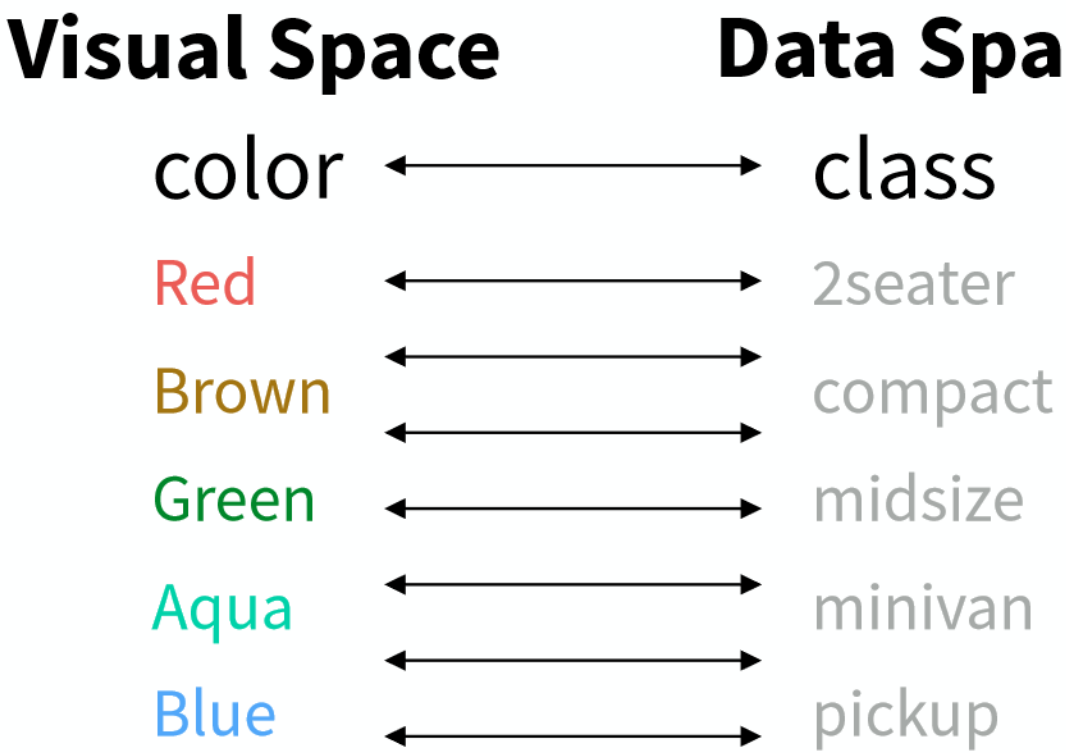
Aesthetics

Visual properties of a geometric object



How do the appearance of these points vary?

Mappings describe how aesthetics should relate to variables in the data.



Aesthetics

aesthetic property

Variable to map it to

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

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

Aesthetics

aesthetic property

Variable to map it to

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

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

Aesthetics

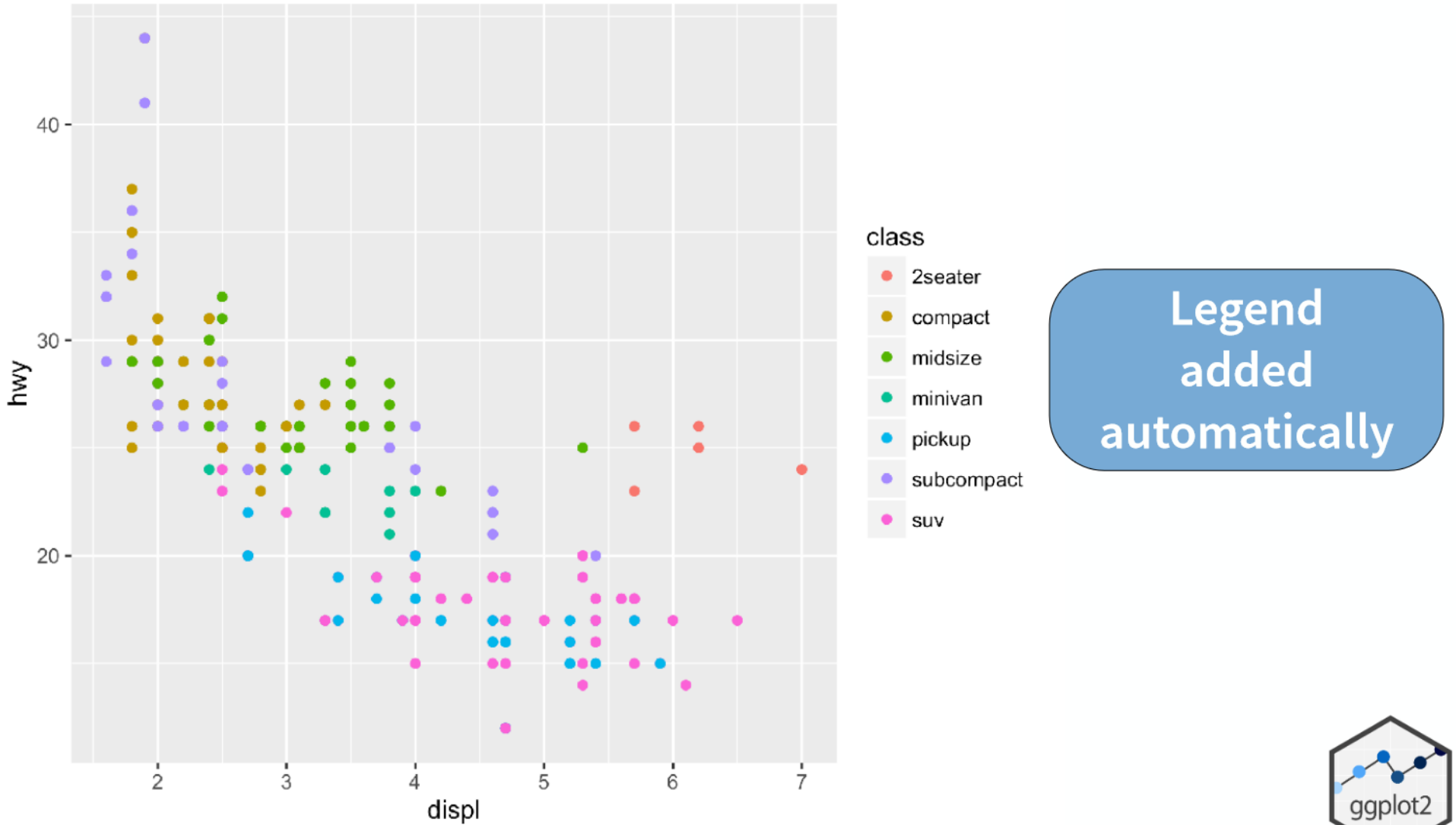
aesthetic property

Variable to map it to

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

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

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

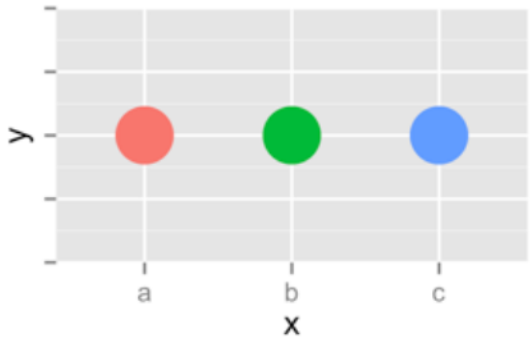
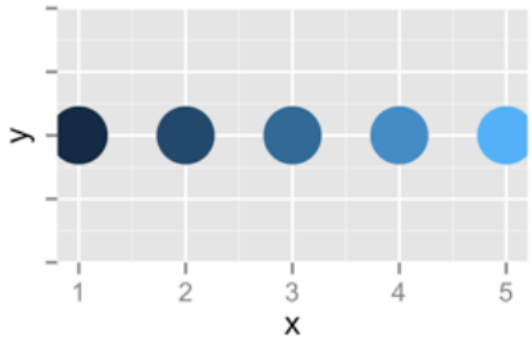
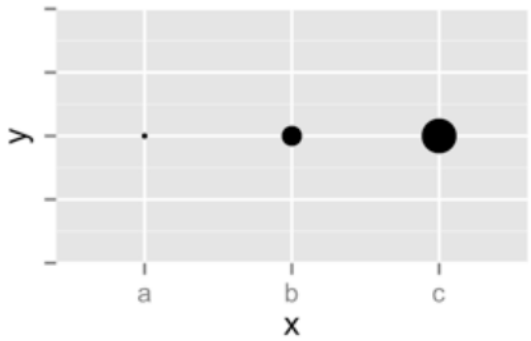
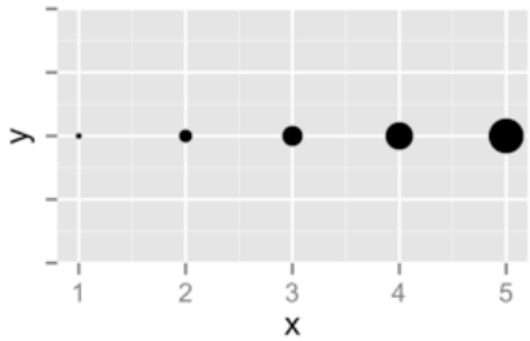
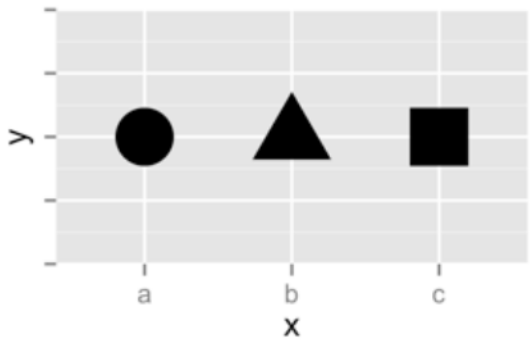


Legend added automatically

Your Turn 2

In the next chunk, add color, size, alpha, and shape aesthetics to your graph. Experiment.

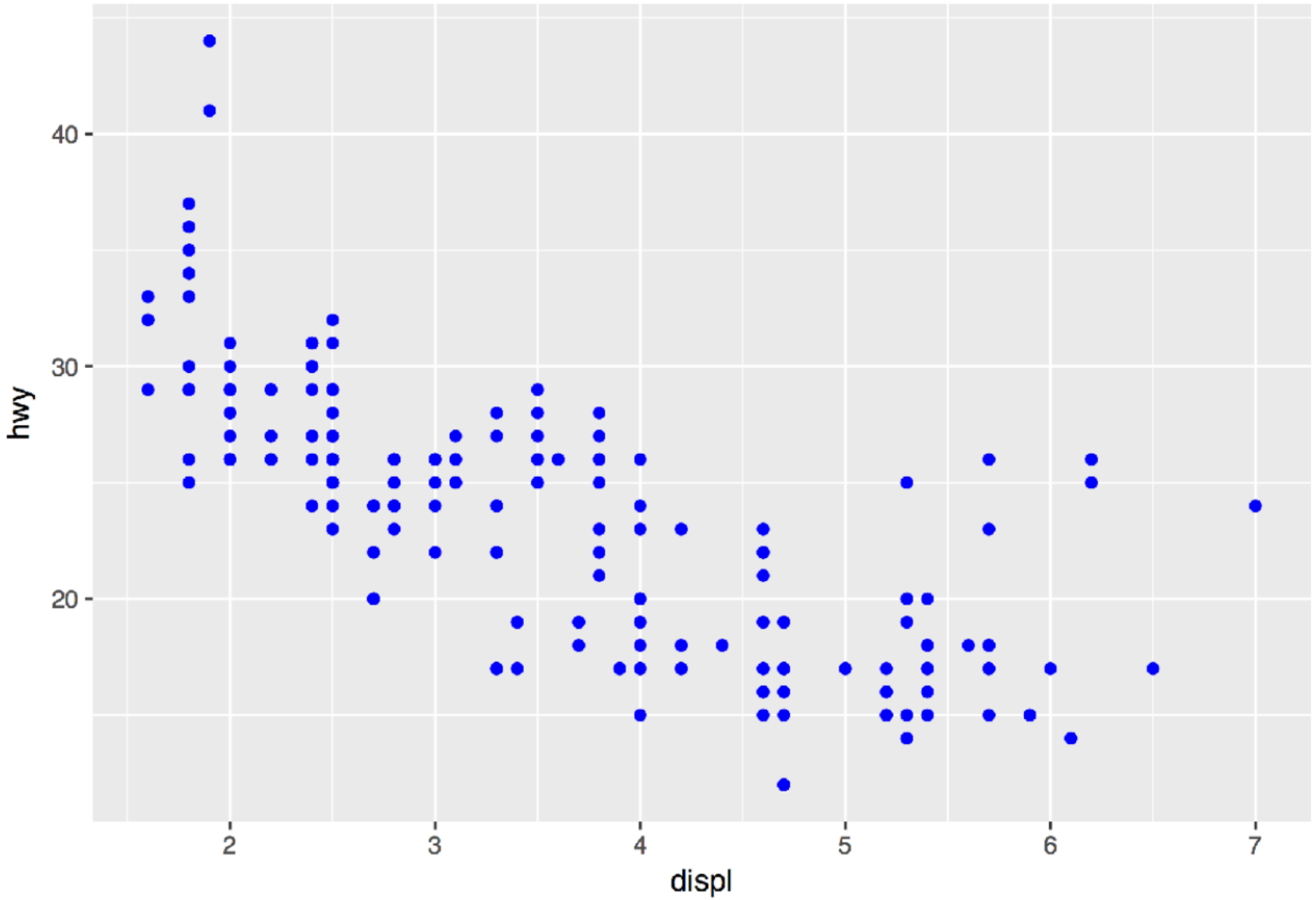
- Do different things happen when you map aesthetics to discrete and continuous variables?
- What happens when you use more than one aesthetic?

	Discrete	Continuous
Color		
Size		
Shape		

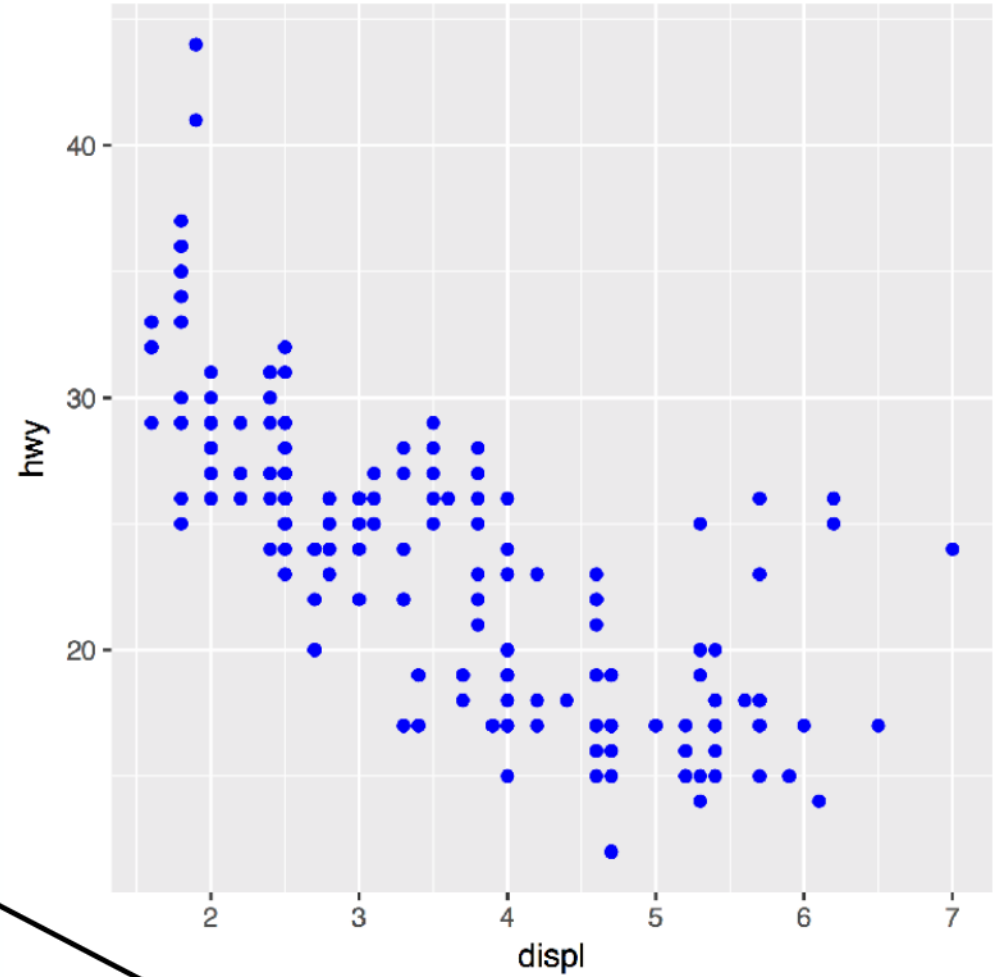
ggplot2

Setting vs. Mapping an aesthetic

How would you make this plot?

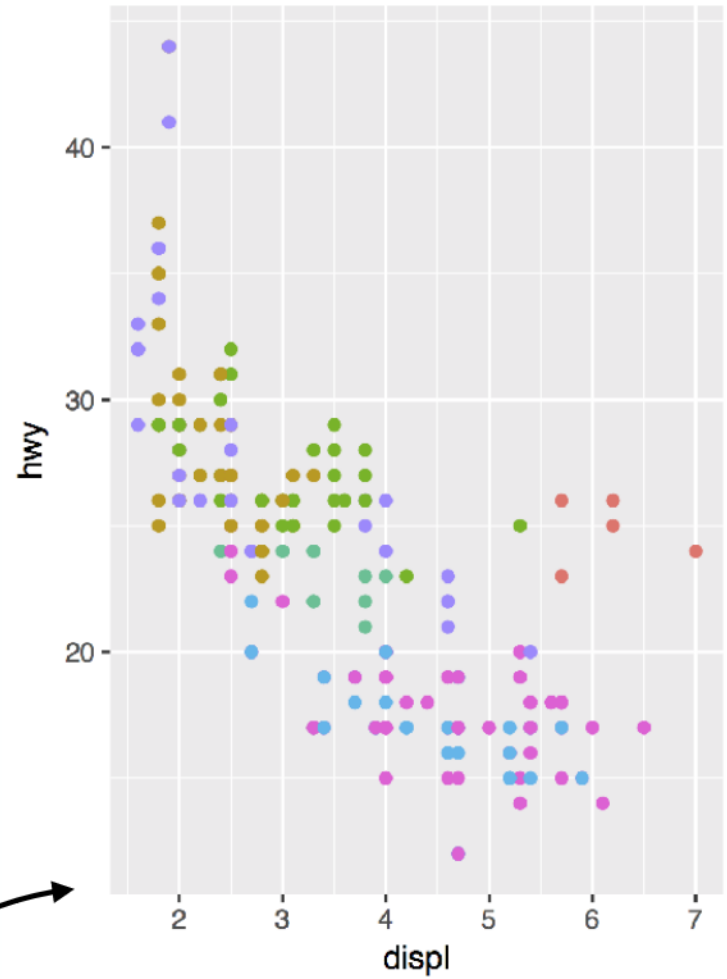


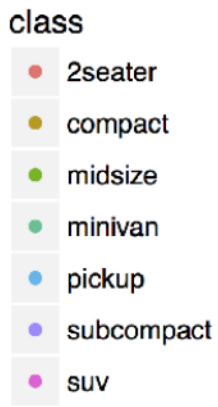
Outside of aes(): sets an aesthetic to a value

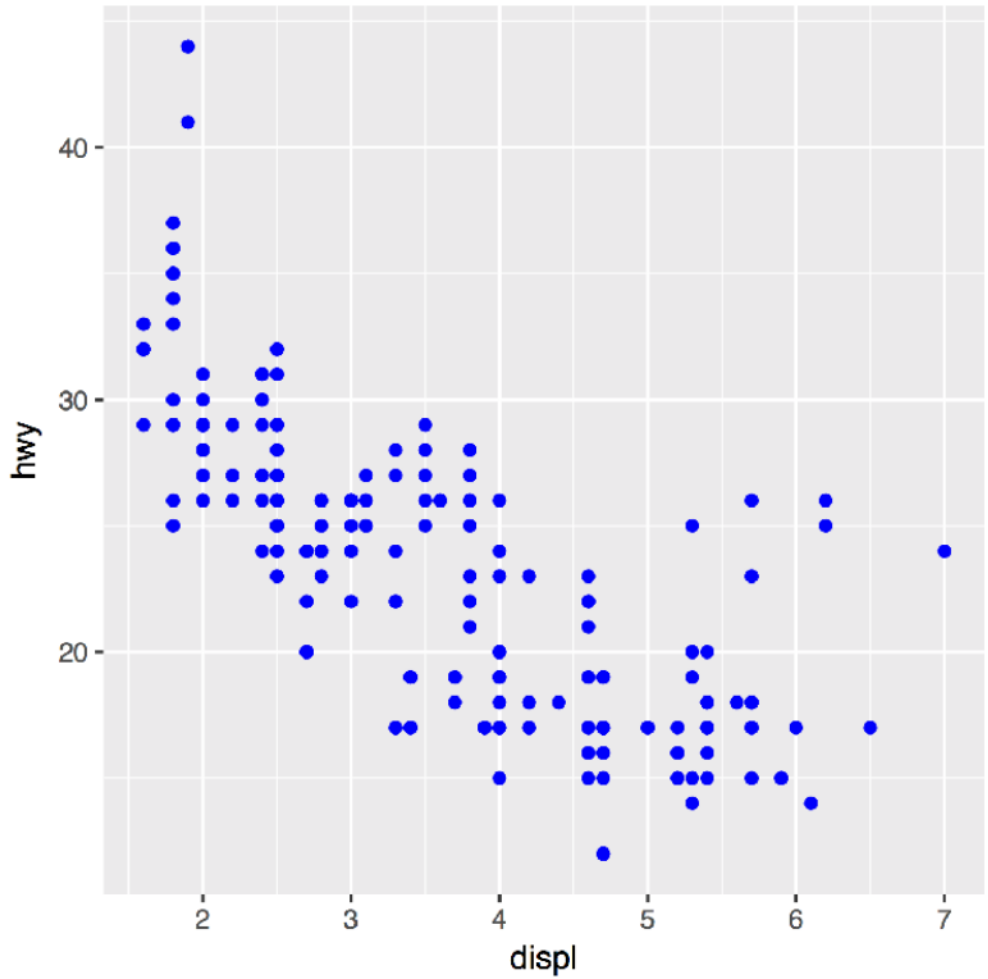



```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, color = class))
```

```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy), color = "blue")
```

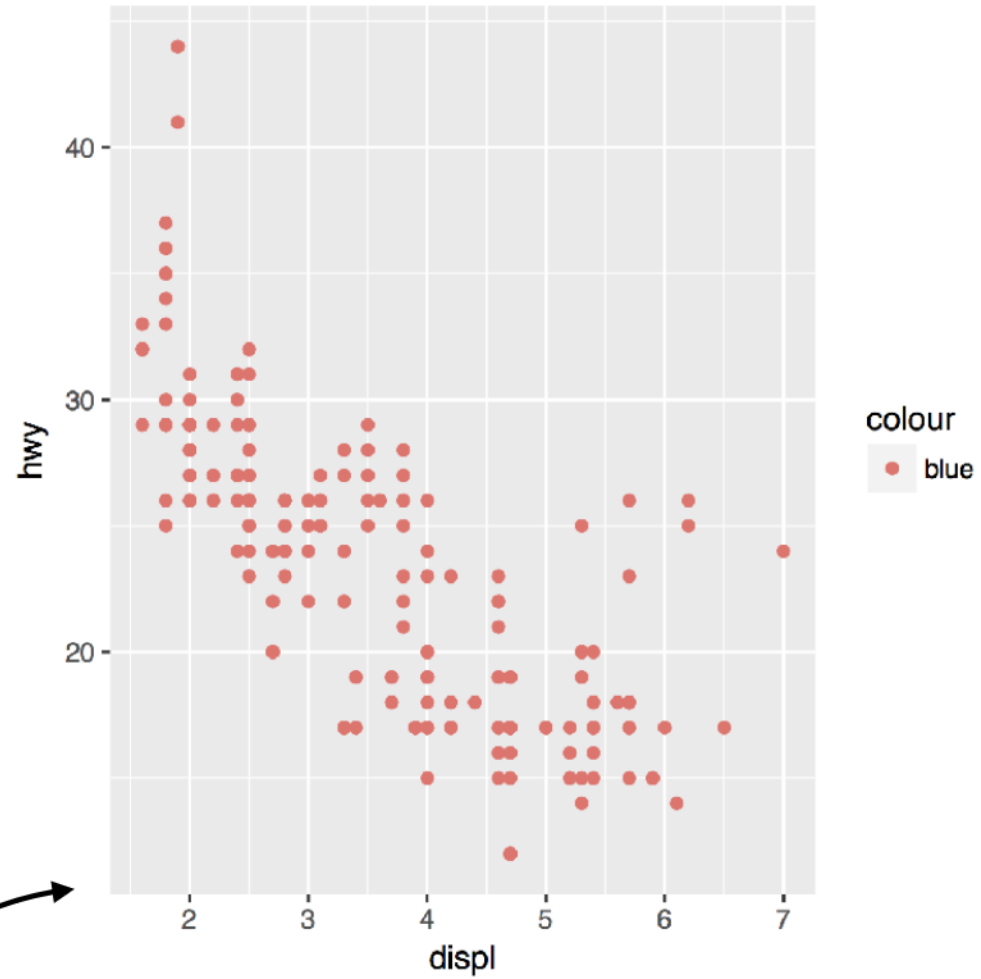


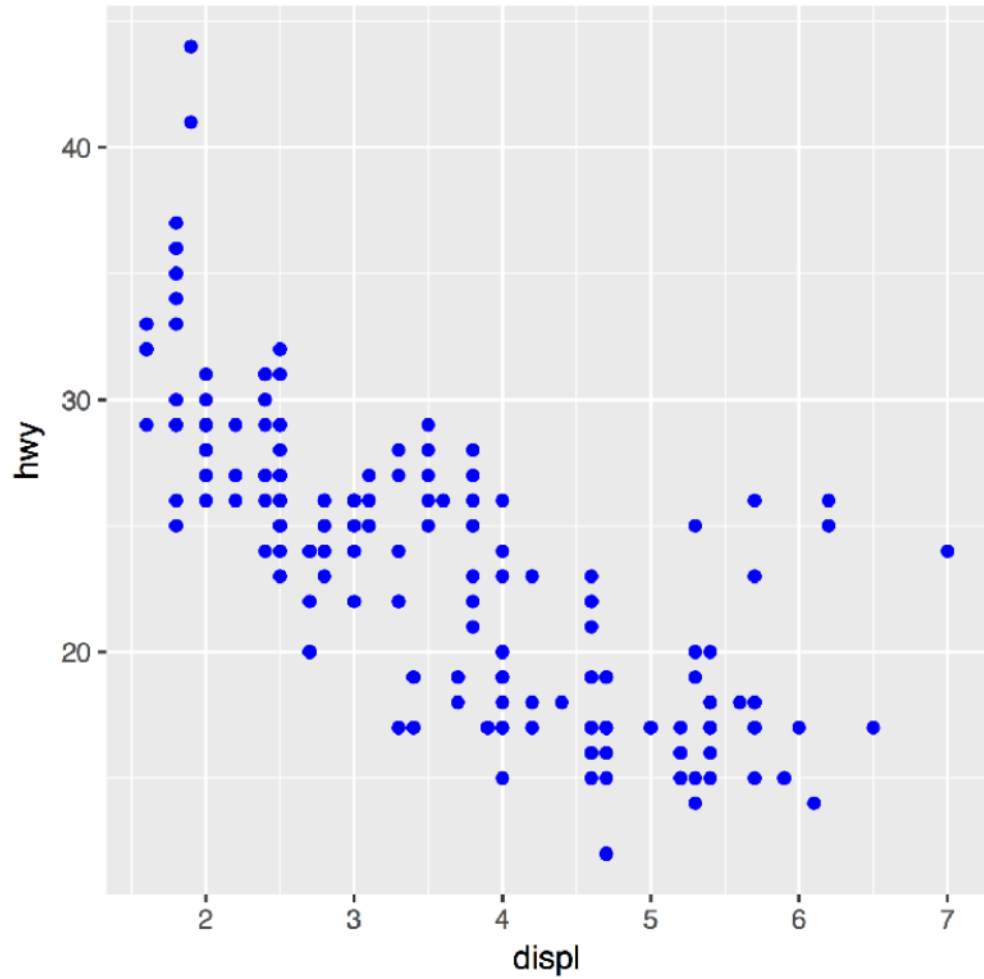





```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, color = class))
```

```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy), color = "blue")
```





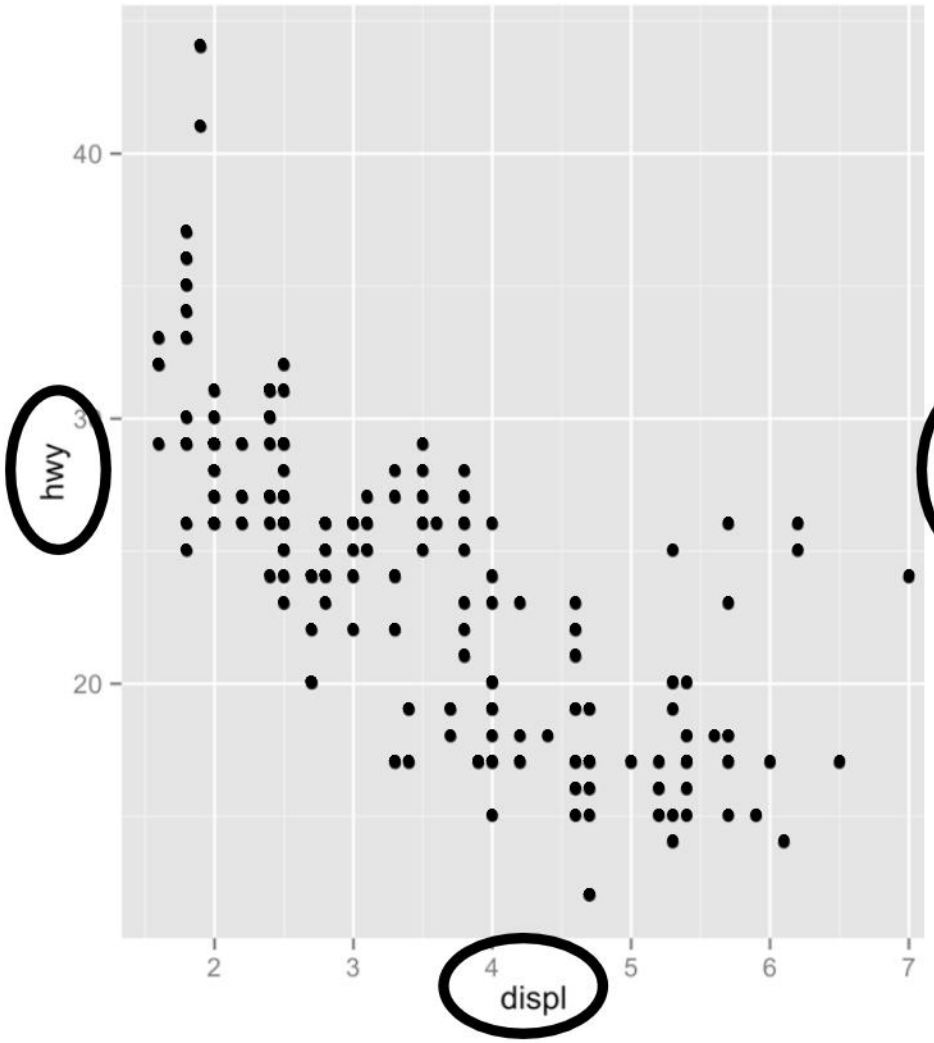

```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, color = "blue"))
```

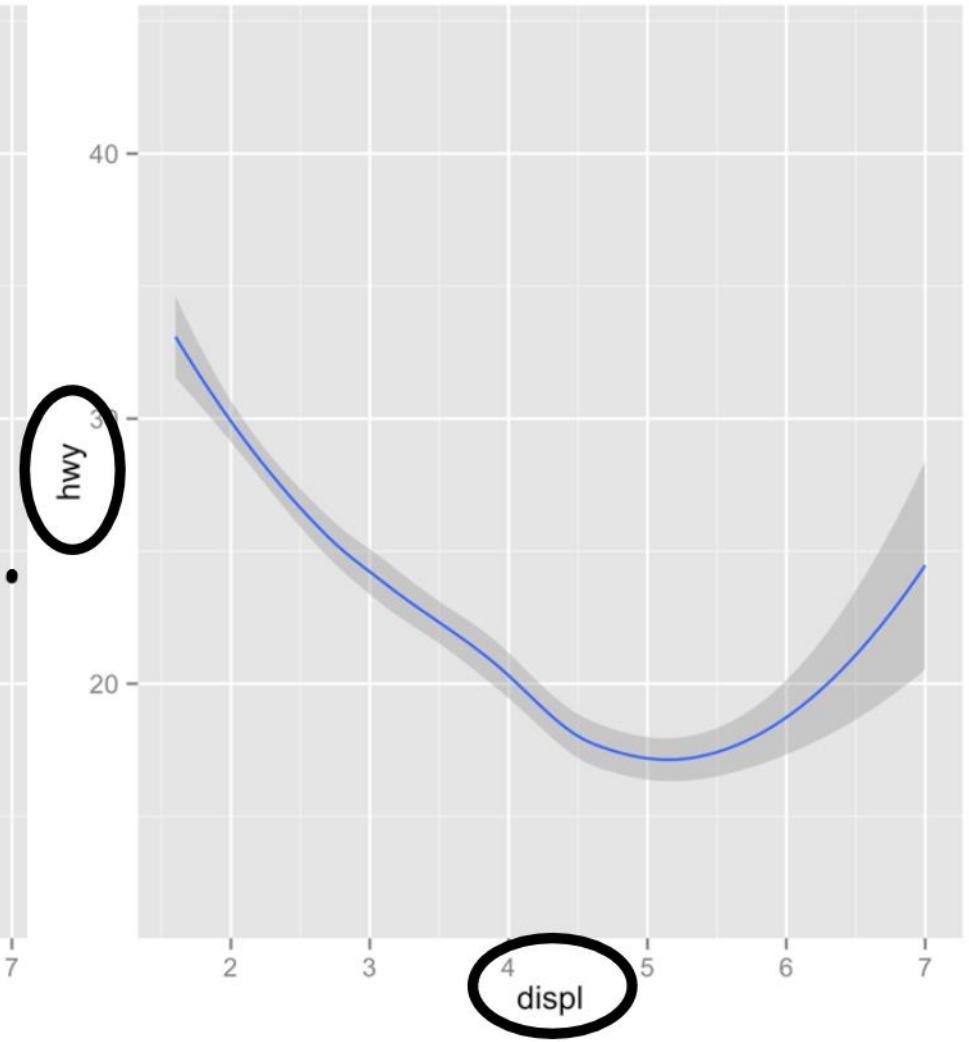
```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy), color = "blue")
```

Geoms

How are these plots similar?

How are they different?





ggplot2

geoms

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

geom_functions

Every geom requires a mapping argument.

Geoms

Use a geom function to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

ggplot2

GRAPHICAL PRIMITIVES

a <- ggplot(economics, aes(date, unemploy))
b <- ggplot(seals, aes(x = long, y = lat))

a + geom_blank()
(Useful for expanding limits)

b + geom_curve(aes(yend = lat + 1, xend=long+1,curvature=z)) - x, xend, y, yend, alpha, angle, color, curvature, linetype, size

a + geom_path(lineend="butt", linejoin="round", linemitre=1)
x, y, alpha, color, group, linetype, size

a + geom_polygon(aes(group = group))
x, y, alpha, color, fill, group, linetype, size

b + geom_rect(aes(xmin = long, ymin=lat, xmax= long + 1, ymax = lat + 1)) - xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

a + geom_ribbon(aes(ymin=unemploy - 900, ymax=unemploy + 900)) x, ymax, ymin, alpha, color, fill, group, linetype, size

LINE SEGMENTS

common aesthetics: x, y, alpha, color, linetype, size

b + geom_abline(aes(intercept=0, slope=1))
b + geom_hline(aes(yintercept = lat))
b + geom_vline(aes(xintercept = long))

b + geom_segment(aes(yend=lat+1, xend=long+1))
b + geom_spoke(aes(angle = 1:1155, radius = 1))

ONE VARIABLE continuous

c <- ggplot(mpg, aes(hwy)); c2 <- ggplot(mpg)

c + geom_area(stat = "bin")
x, y, alpha, color, fill, linetype, size

c + geom_density(kernel = "gaussian")
x, y, alpha, color, fill, group, linetype, size, weight

c + geom_dotplot()
x, y, alpha, color, fill

c + geom_freqpoly() x, y, alpha, color, group, linetype, size

c + geom_histogram(binwidth = 5) x, y, alpha, color, fill, linetype, size, weight

c2 + geom_qq(aes(sample = hwy)) x, y, alpha, color, fill, linetype, size, weight

TWO VARIABLES

continuous x , continuous y

e <- ggplot(mpg, aes(cty, hwy))

e + geom_label(aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE) x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

e + geom_jitter(height = 2, width = 2)
x, y, alpha, color, fill, shape, size

e + geom_point(), x, y, alpha, color, fill, shape, size, stroke

e + geom_quantile(), x, y, alpha, color, group, linetype, size, weight

e + geom_rug(sides = "bl"), x, y, alpha, color, linetype, size

e + geom_smooth(method = lm), x, y, alpha, color, fill, group, linetype, size, weight

e + geom_text(aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE), x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

discrete x , continuous y

f <- ggplot(mpg, aes(class, hwy))

f + geom_col(), x, y, alpha, color, fill, group, linetype, size

f + geom_boxplot(), x, y, lower, middle, upper, ymax, ymin, alpha, color, fill, group, linetype, shape, size, weight

f + geom_dotplot(binaxis = "y", stackdir = "center"), x, y, alpha, color, fill, group

f + geom_violin(scale = "area"), x, y, alpha, color, fill, group, linetype, size, weight

discrete x , discrete y

g <- ggplot(diamonds, aes(cut, color))

g + geom_count(), x, y, alpha, color, fill, shape, size, stroke

continuous bivariate distribution

h <- ggplot(diamonds, aes(carat, price))

h + geom_bin2d(binwidth = c(0.25, 500))
x, y, alpha, color, fill, linetype, size, weight

h + geom_density2d()
x, y, alpha, colour, group, linetype, size

h + geom_hex()
x, y, alpha, colour, fill, size

continuous function

i <- ggplot(economics, aes(date, unemploy))

i + geom_area()
x, y, alpha, color, fill, linetype, size

i + geom_line()
x, y, alpha, color, group, linetype, size

i + geom_step(direction = "hv")
x, y, alpha, color, group, linetype, size

visualizing error

df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
j <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))

j + geom_crossbar(fatten = 2)
x, y, ymax, ymin, alpha, color, fill, group, linetype, size

j + geom_errorbar(), x, ymax, ymin, alpha, color, group, linetype, size, width (also **geom_errorbarh()**)

j + geom_linerange()
x, ymin, ymax, alpha, color, group, linetype, size

j + geom_pointrange()
x, y, ymin, ymax, alpha, color, fill, group, linetype, shape, size

maps

data <- data.frame(murder = USArrests$Murder, state = tolower(rownames(USArrests)))
map <- map_data("state")
k <- ggplot(data, aes(fill = murder))

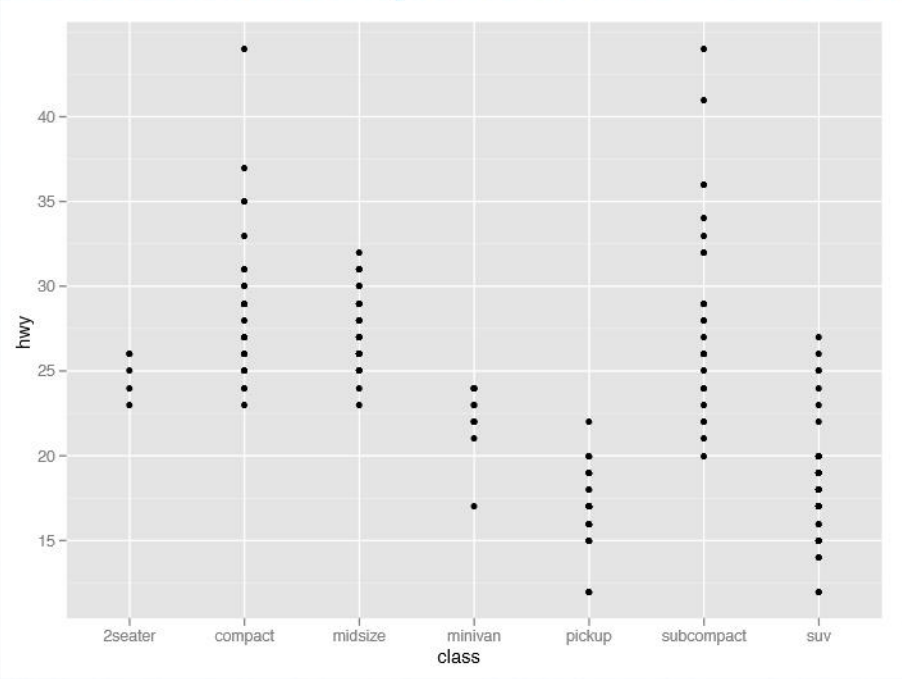
k + geom_map(aes(map_id = state), map = map) **+ expand_limits**(x = map$long, y = map$lat), map_id, alpha, color, fill, linetype, size

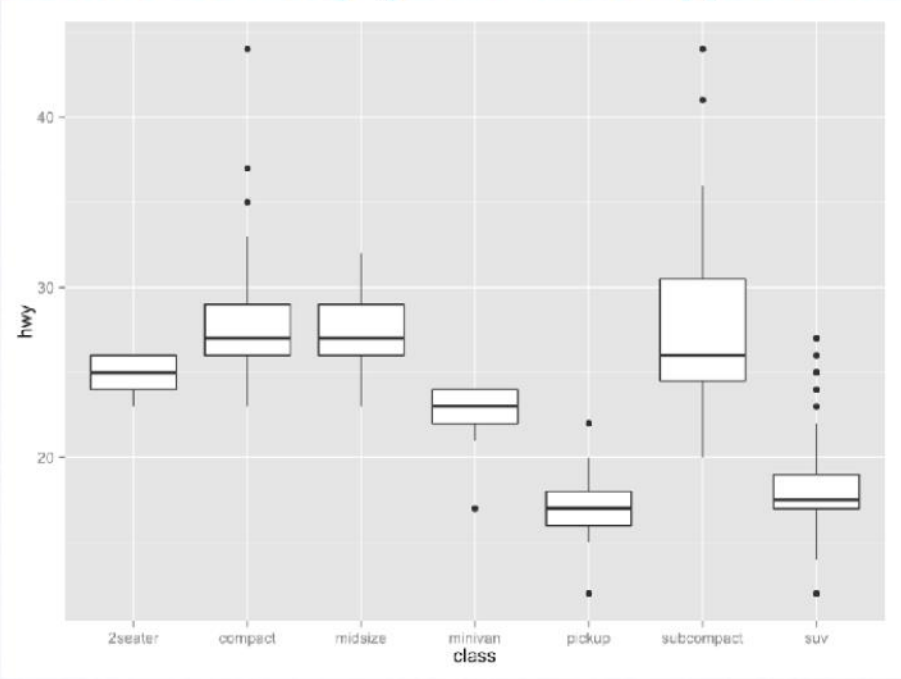
THREE VARIABLES

sealsSz <- with(seals, sqrt(delta_long^2 + delta_lat^2))l <- ggplot(seals, aes(long, lat))

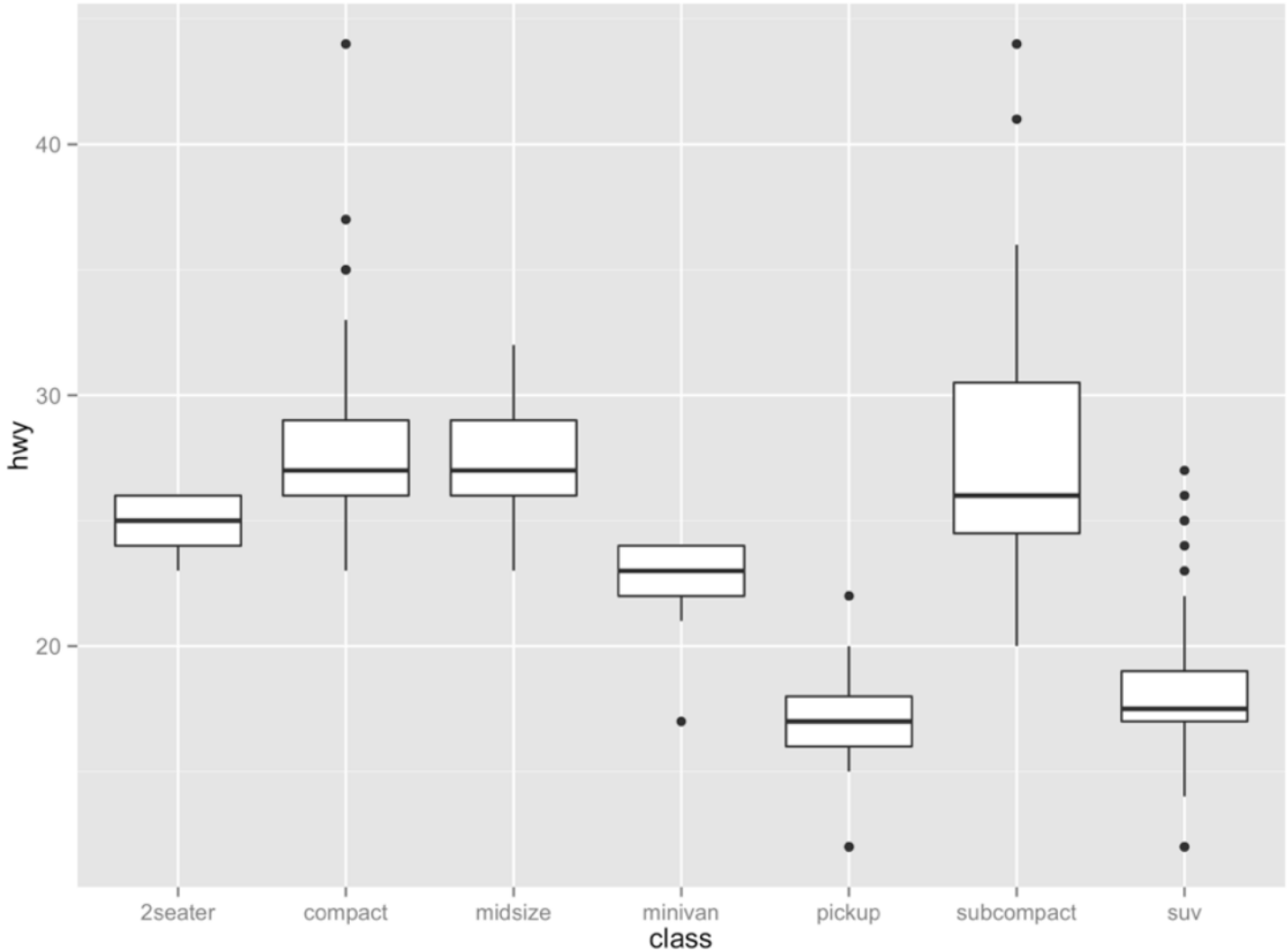
Your Turn 3

With your partner, decide how to replace this scatterplot with one that draws boxplots? Use the cheatsheet. Try your best guess.





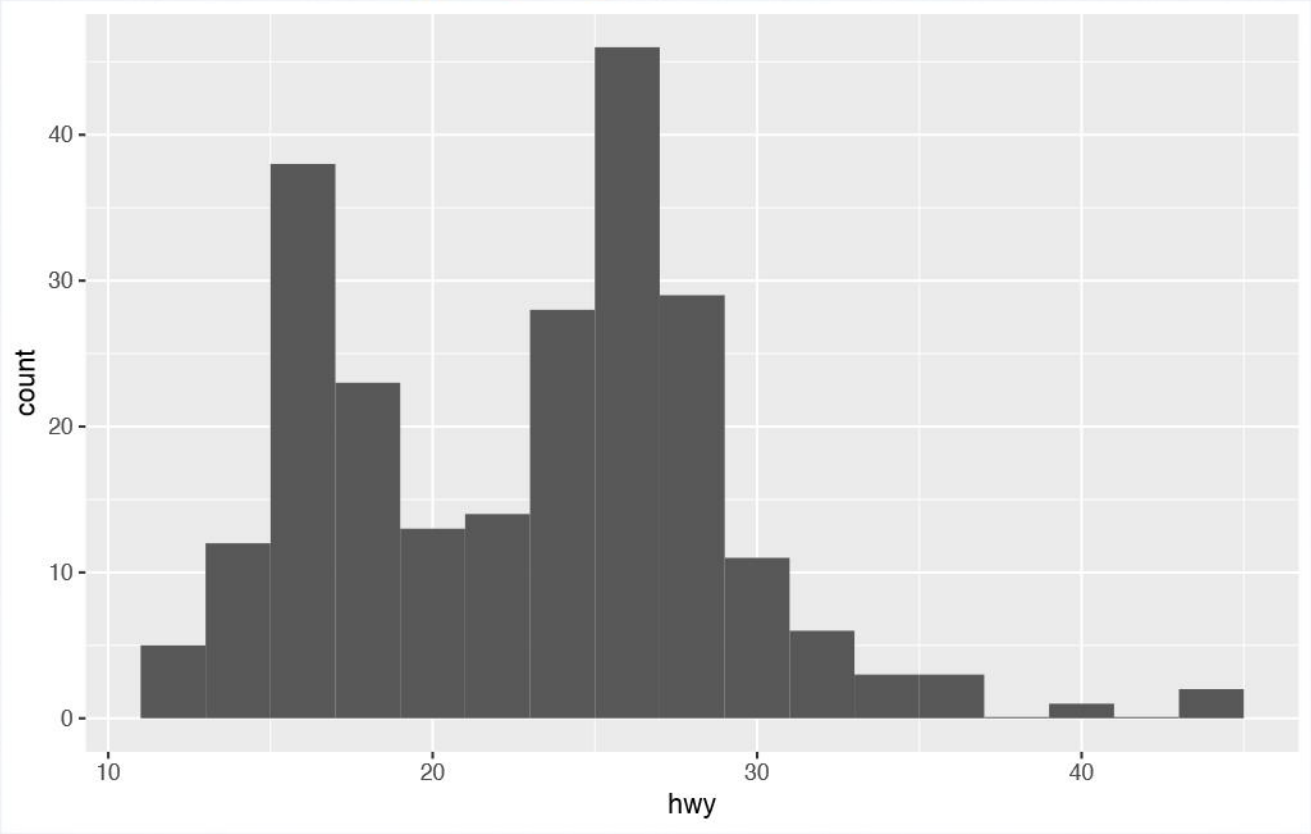

```
ggplot(mpg) + geom_point(aes(class, hwy))
```




```
ggplot(data = mpg) +
  geom_boxplot(mapping = aes(x = class, y = hwy))
```

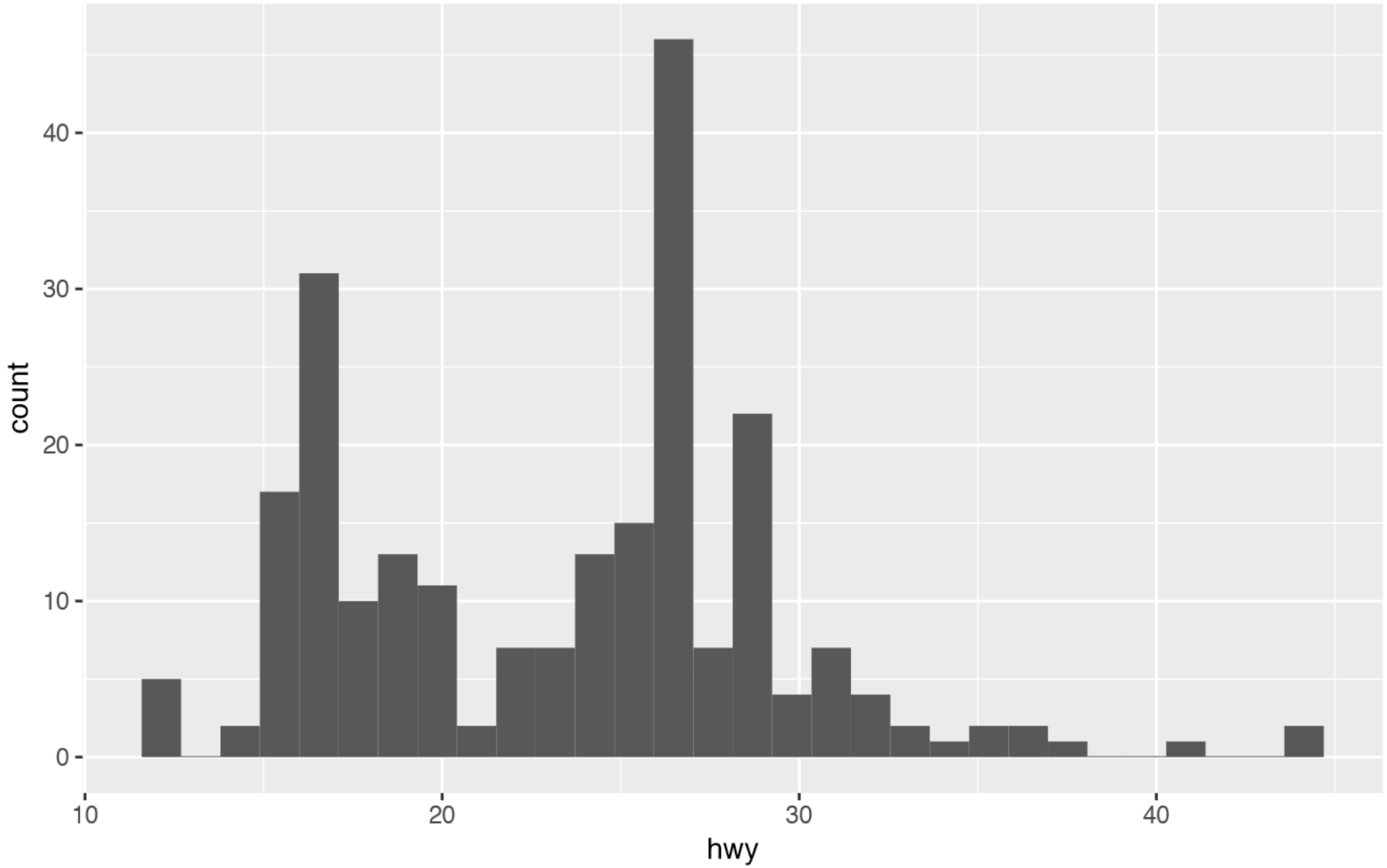
Your Turn 4

With your partner, make the **histogram** of hwy below. Use the cheatsheet. **Hint:** do not supply a y variable.



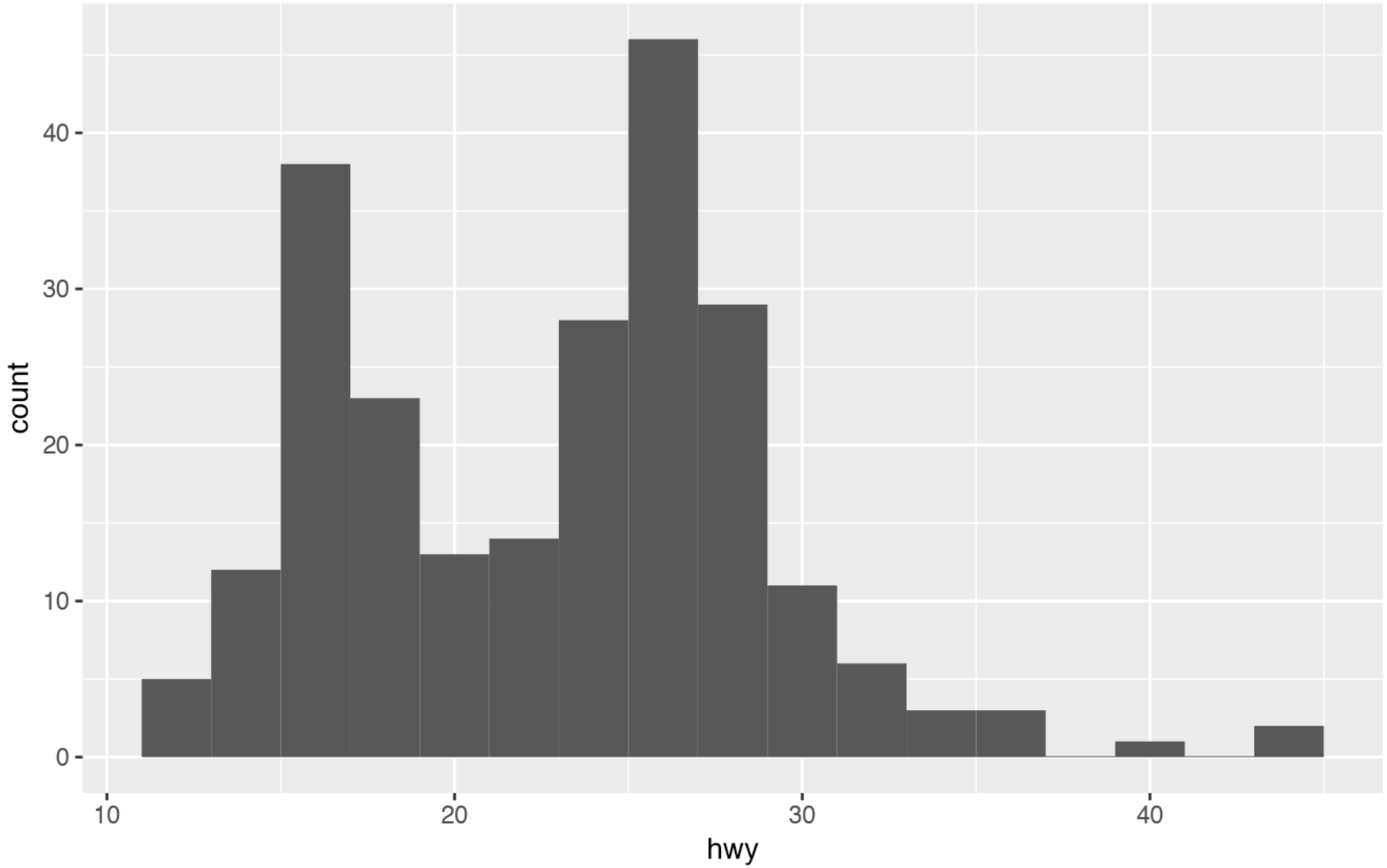
02:00

?




```
ggplot(data = mpg) +
  geom_histogram(mapping = aes(x = hwy))
```

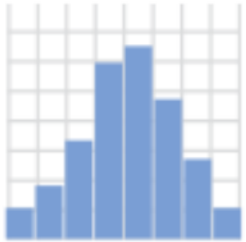
No y aesthetic




```
ggplot(data = mpg) +
  geom_histogram(mapping = aes(x = hwy), binwidth = 2)
```

On the cheatsheat:

Arguments inside (), are geom specific options

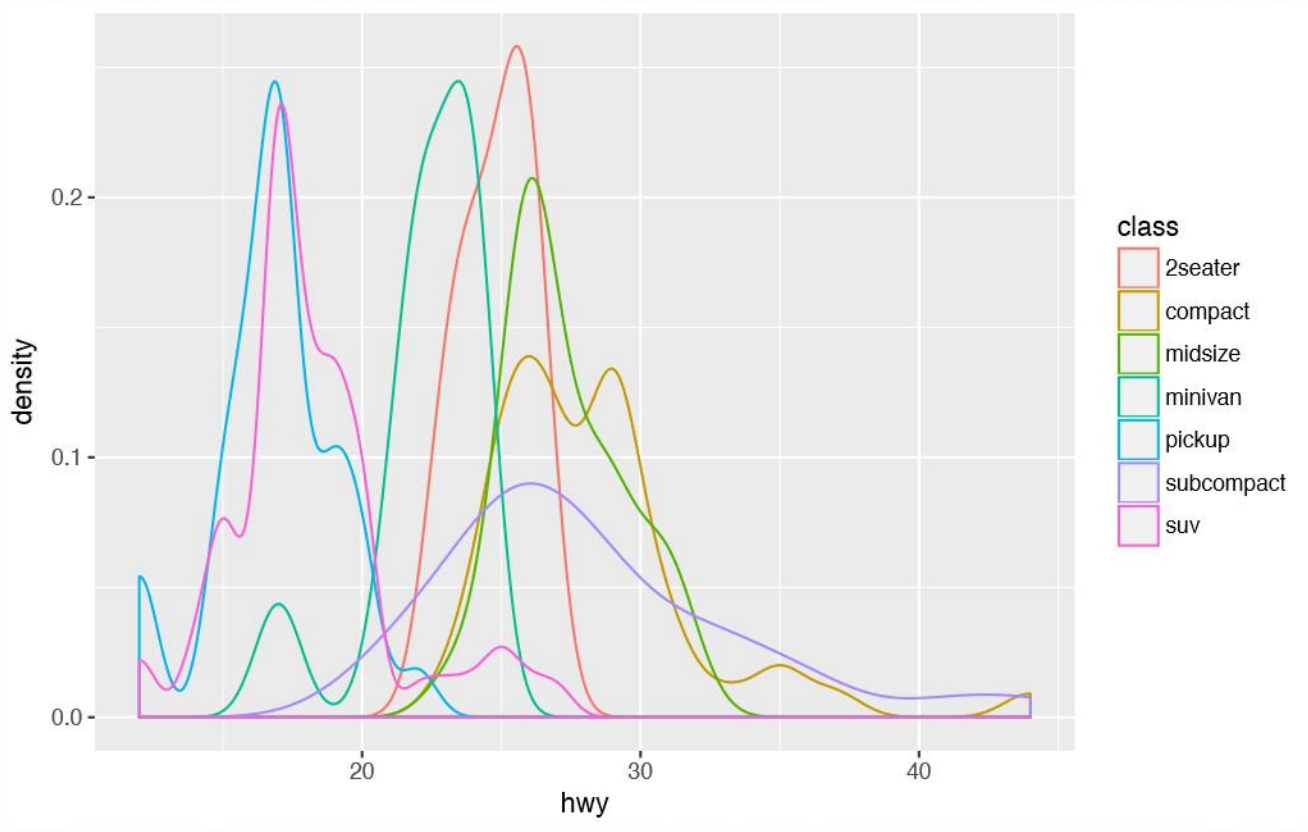


c + geom_histogram(binwidth = 5**)** x, y, alpha, color, fill, linetype, size, weight

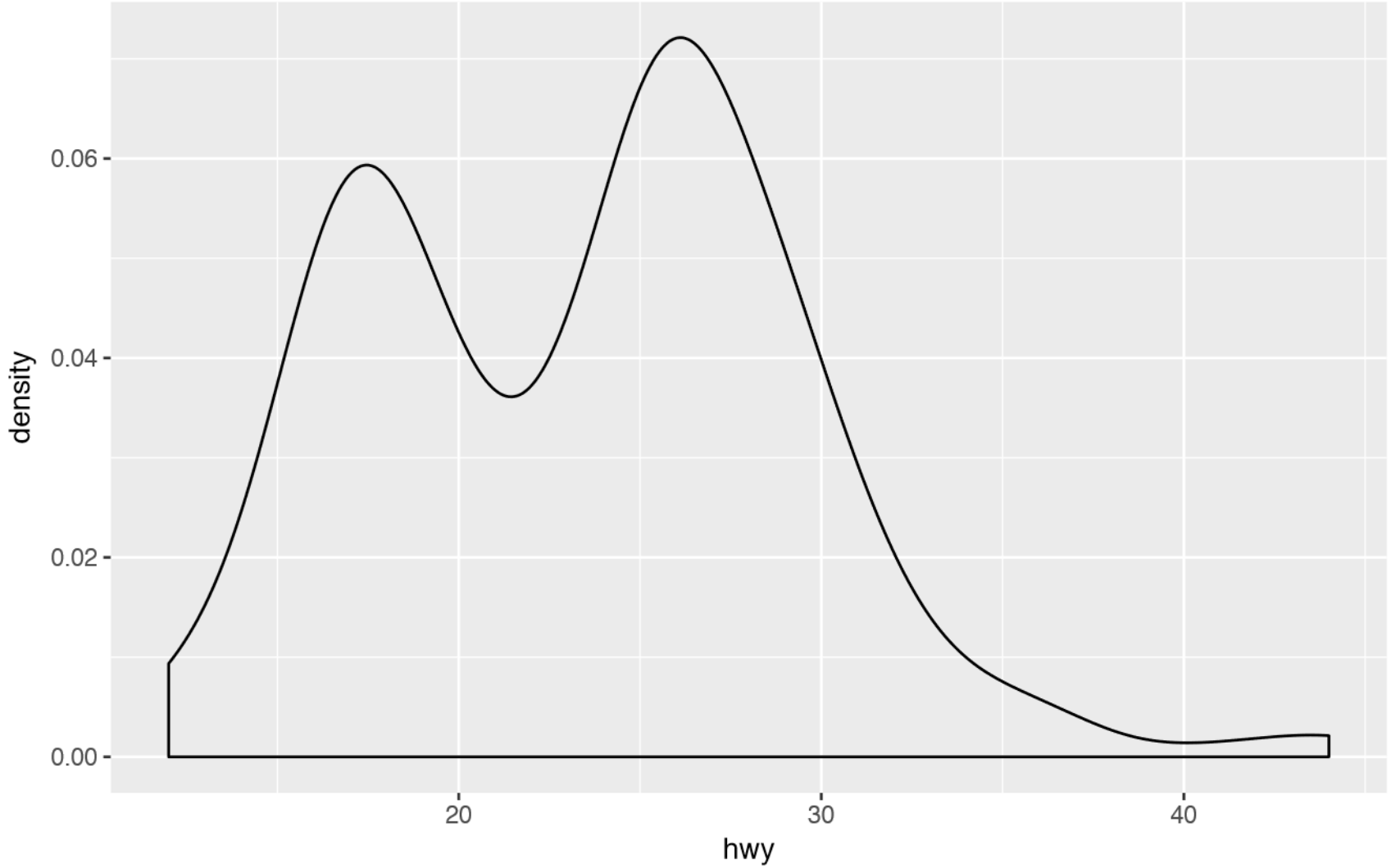
Outside the (), are aesthetics that can be mapped or set.

Your Turn 5

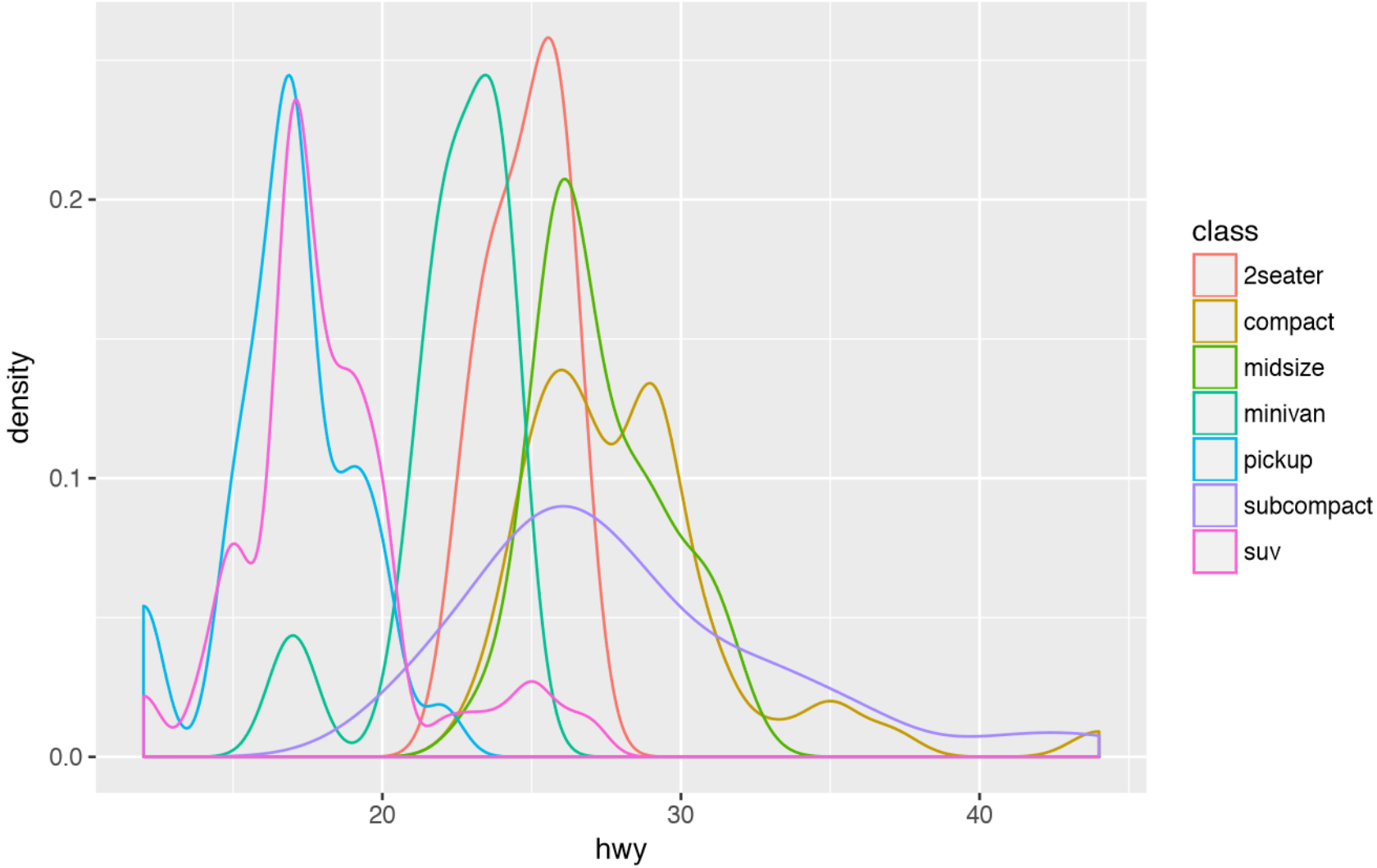
With your partner, make the density plot of hwy colored by `class` below. Use the cheatsheet. Try your best guess.



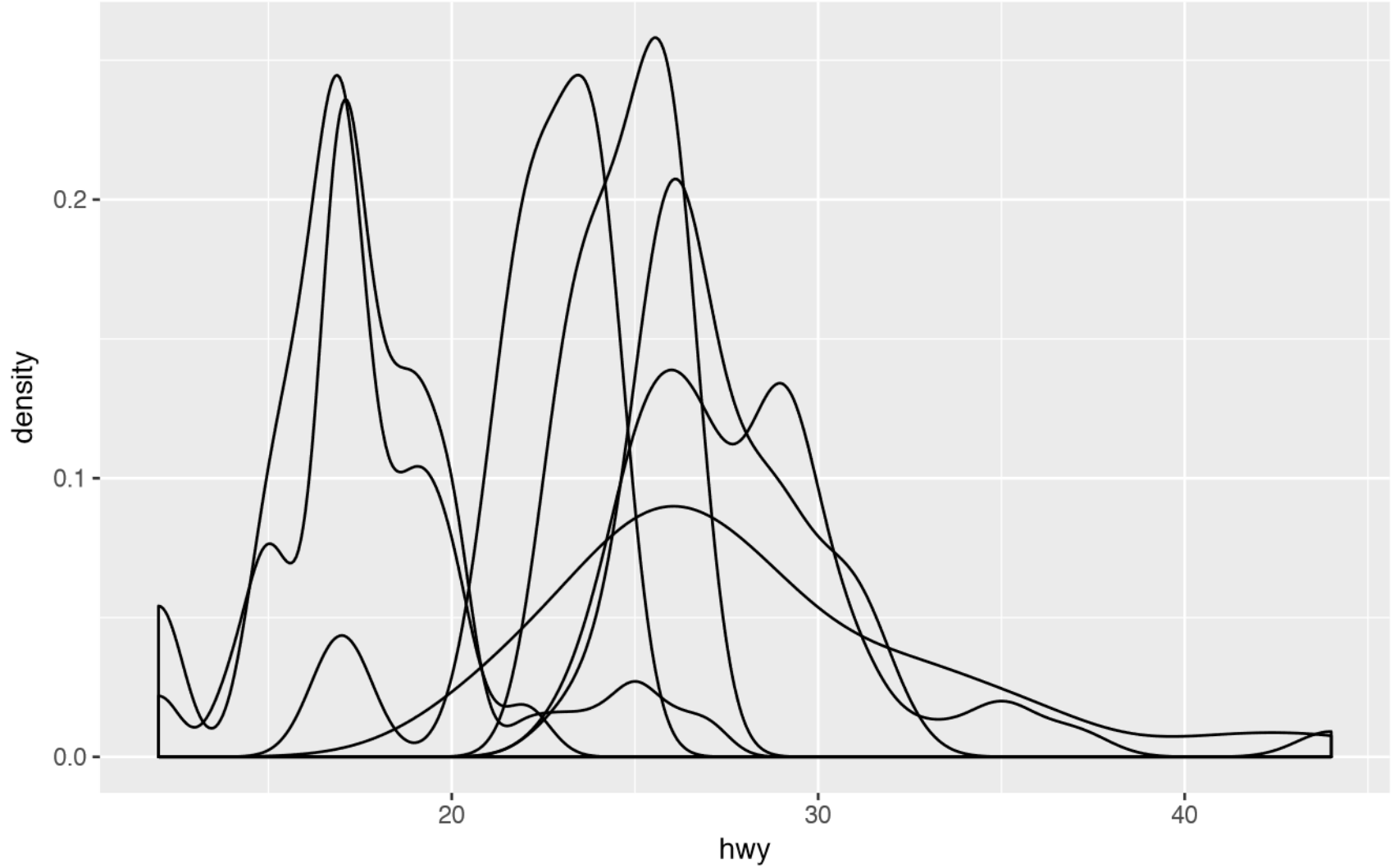
02:00




```
ggplot(data = mpg) +
  geom_density(mapping = aes(x = hwy))
```



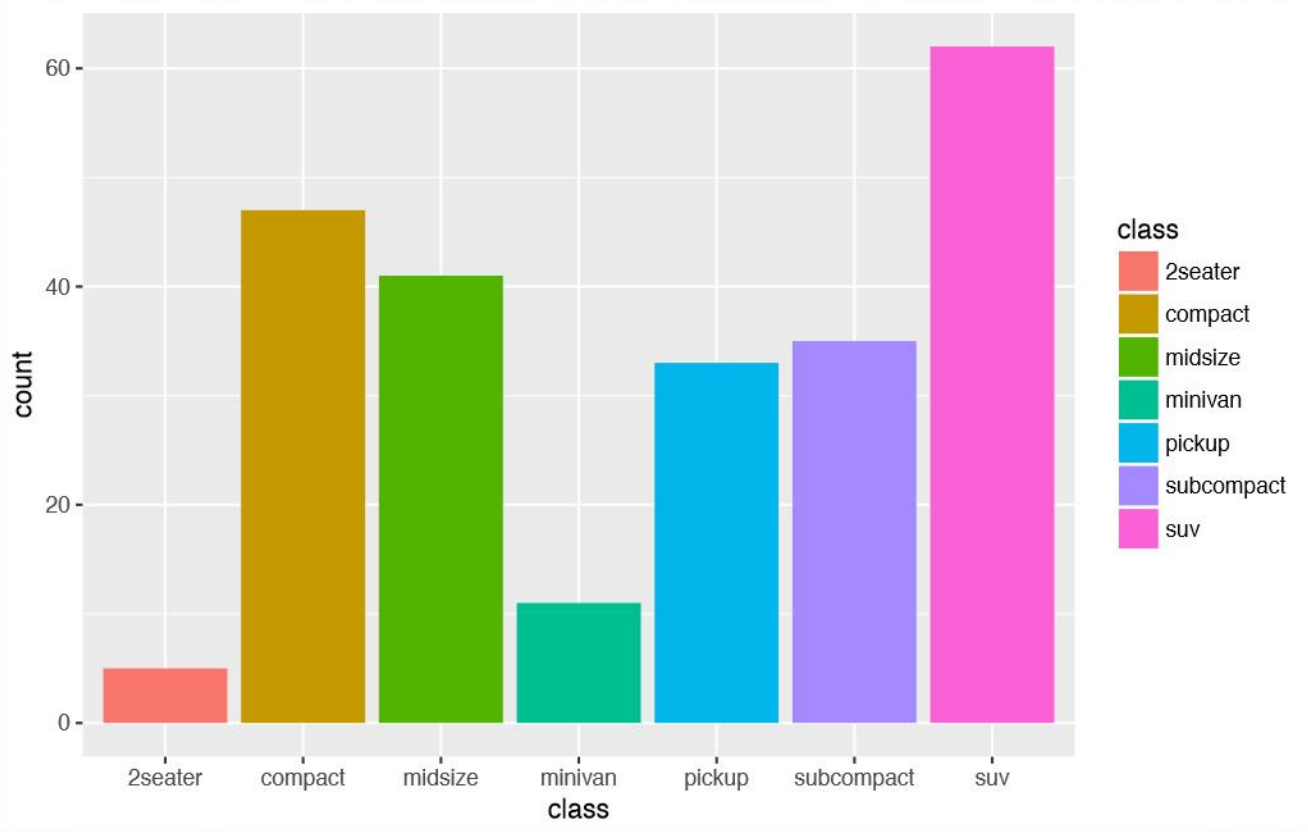

```
ggplot(data = mpg) +
  geom_density(mapping = aes(x = hwy, color = class))
```



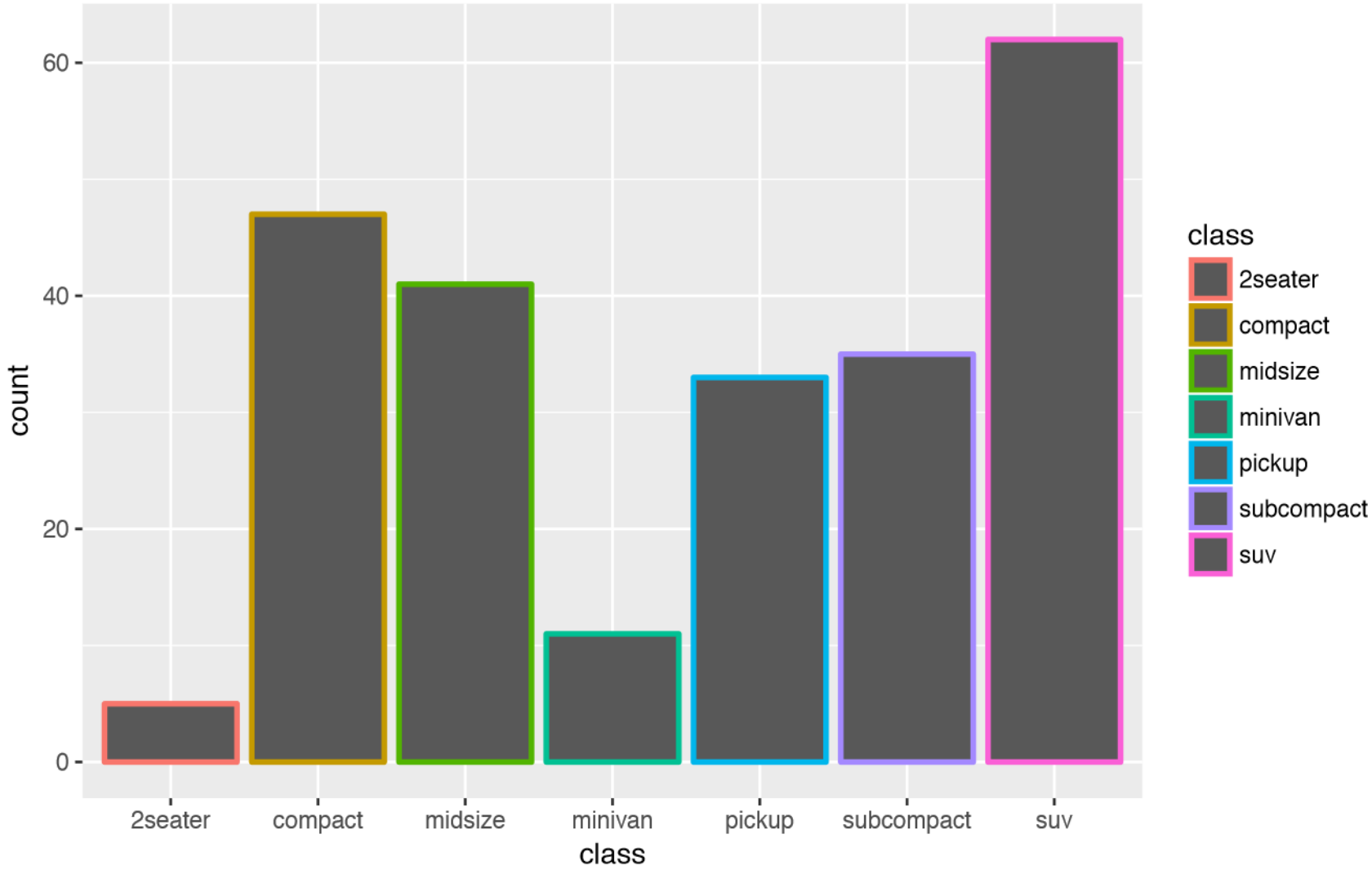

```
ggplot(data = mpg) +
  geom_density(mapping = aes(x = hwy, group = class))
```

Your Turn 6

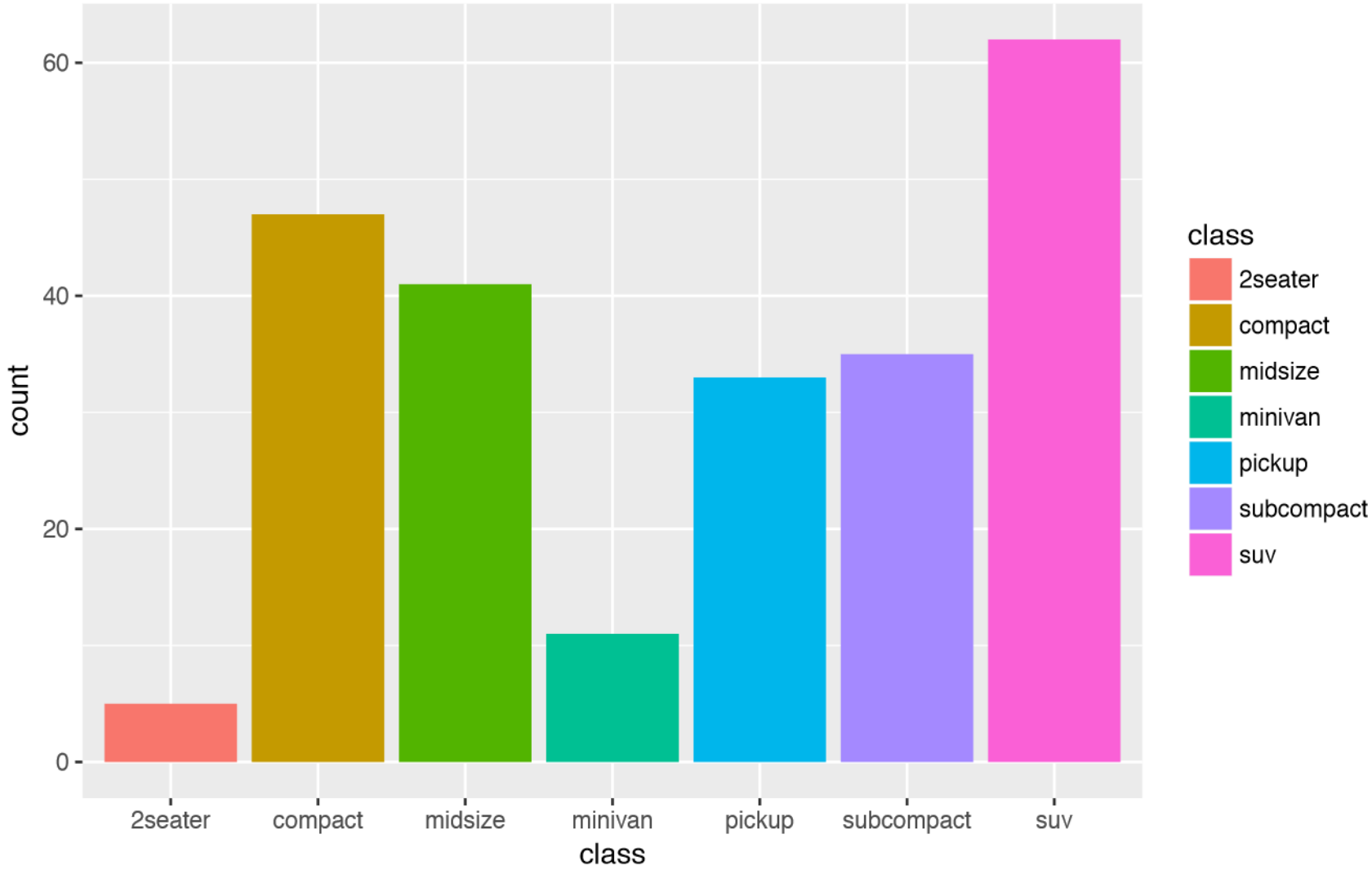
With your partner, make the **bar** chart of `class` colored by `class` below. Use the cheatsheet. Try your best guess.



02:00




```
ggplot(data = mpg) +
  geom_bar(mapping = aes(x = class, color = class))
```



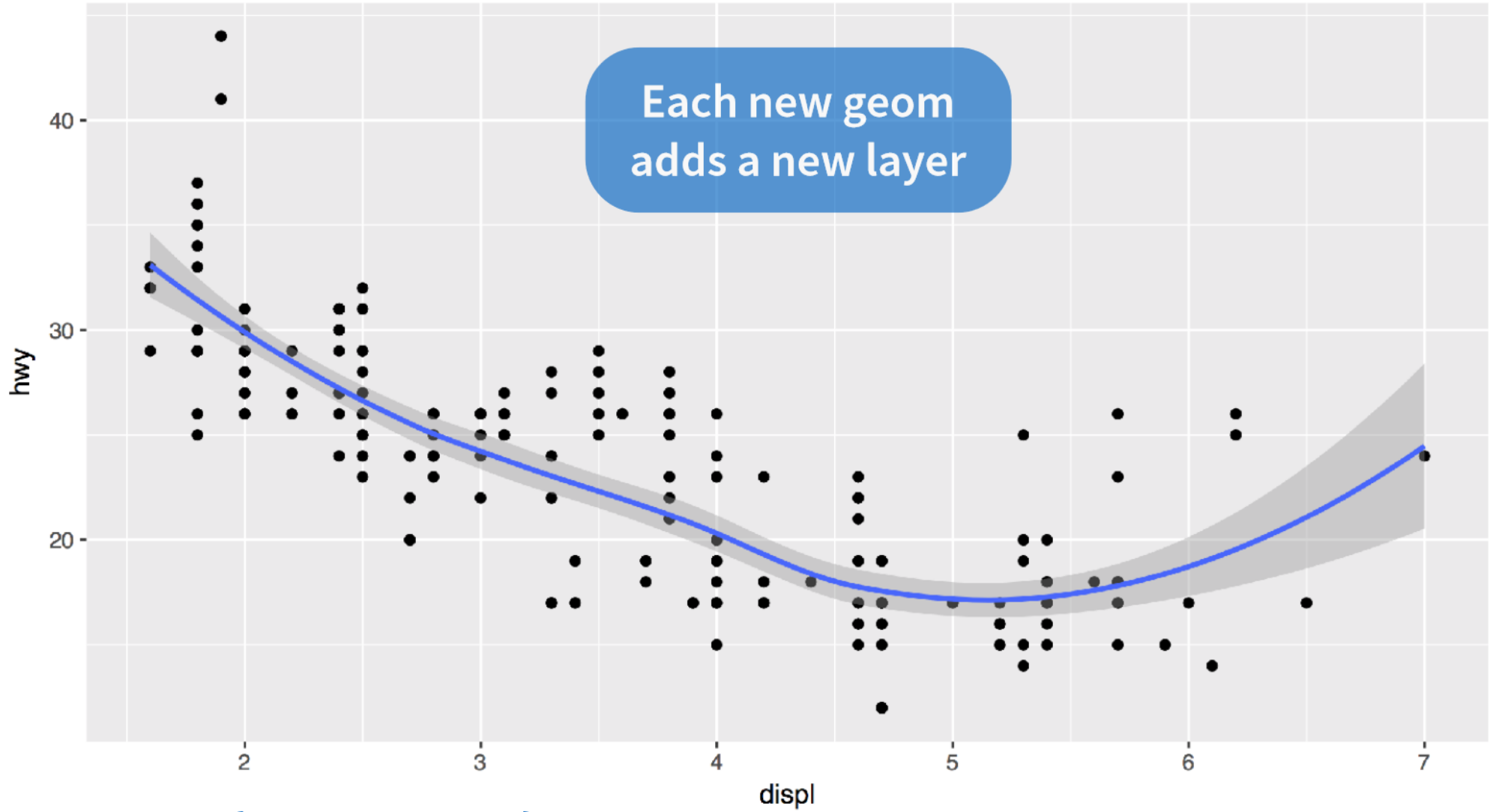

```
ggplot(data = mpg) +
  geom_bar(mapping = aes(x = class, fill = class))
```

Your Turn 7

With your partner, predict what this code will do.

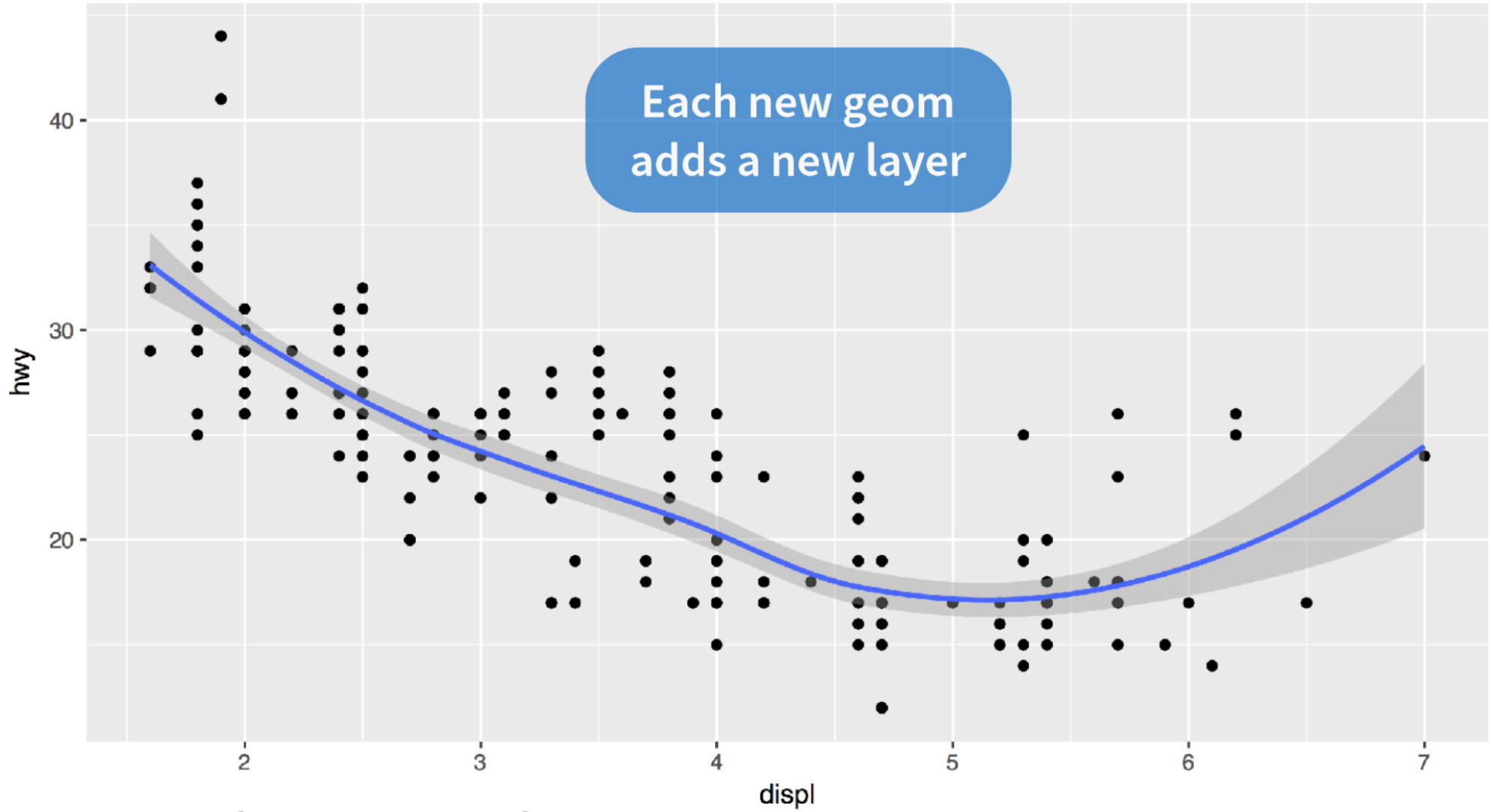
Then run it.

```
ggplot(mpg) +
  geom_point(aes(displ, hwy)) +
  geom_smooth(aes(displ, hwy))
```




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

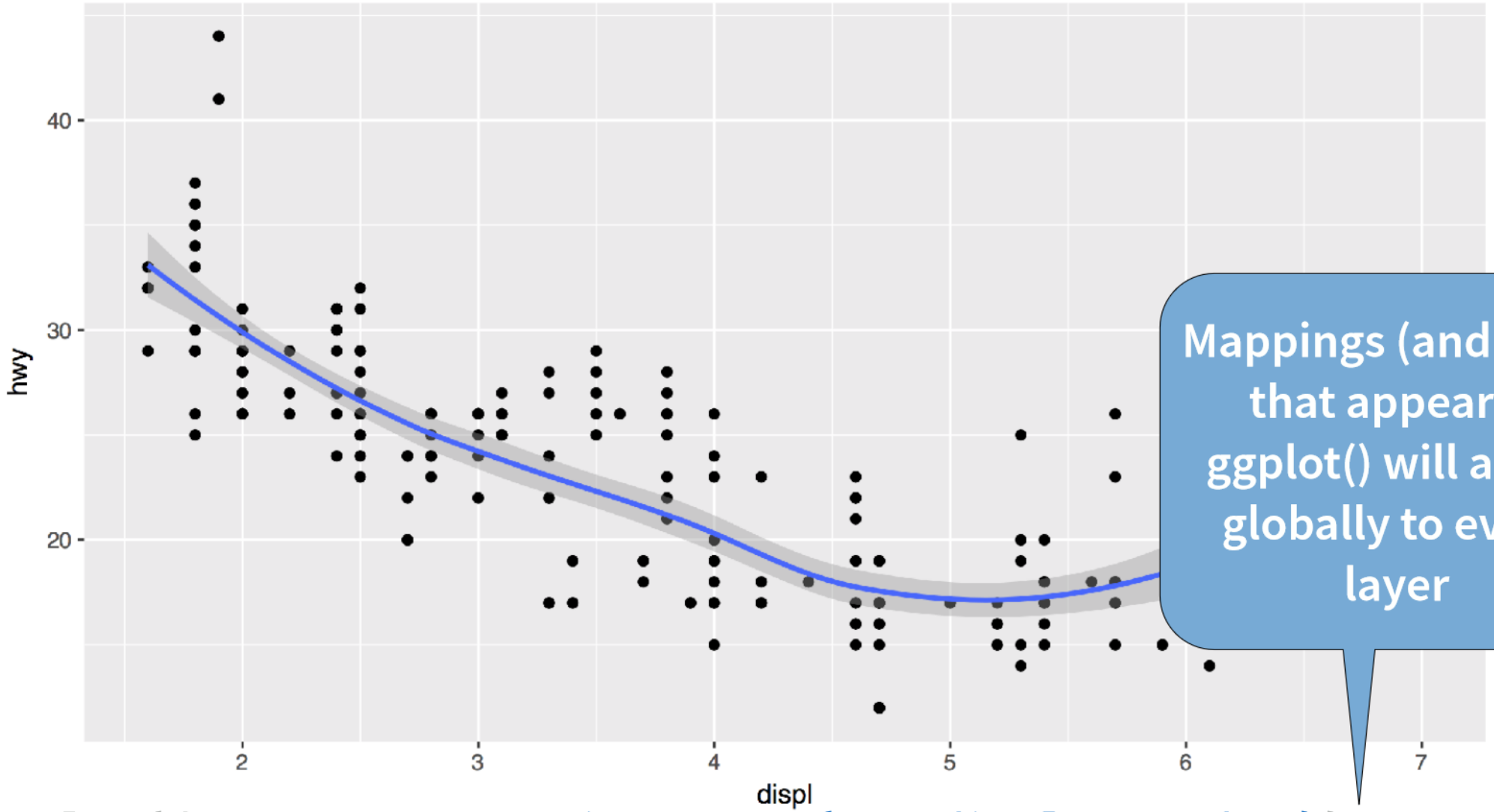

ggplot2




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

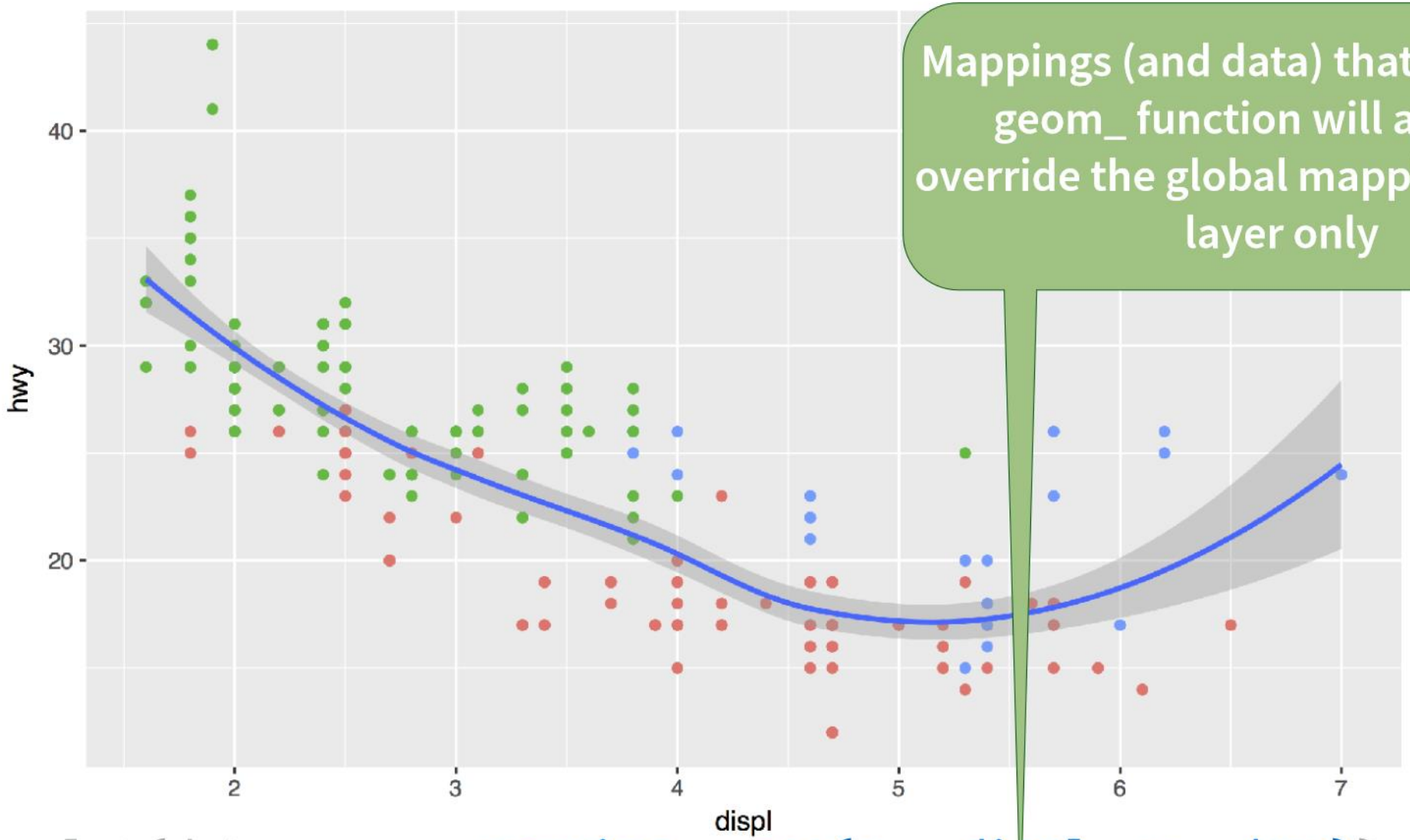

ggplot2

Global vs. Local



Mappings (and data) that appear in ggplot() will apply globally to every layer

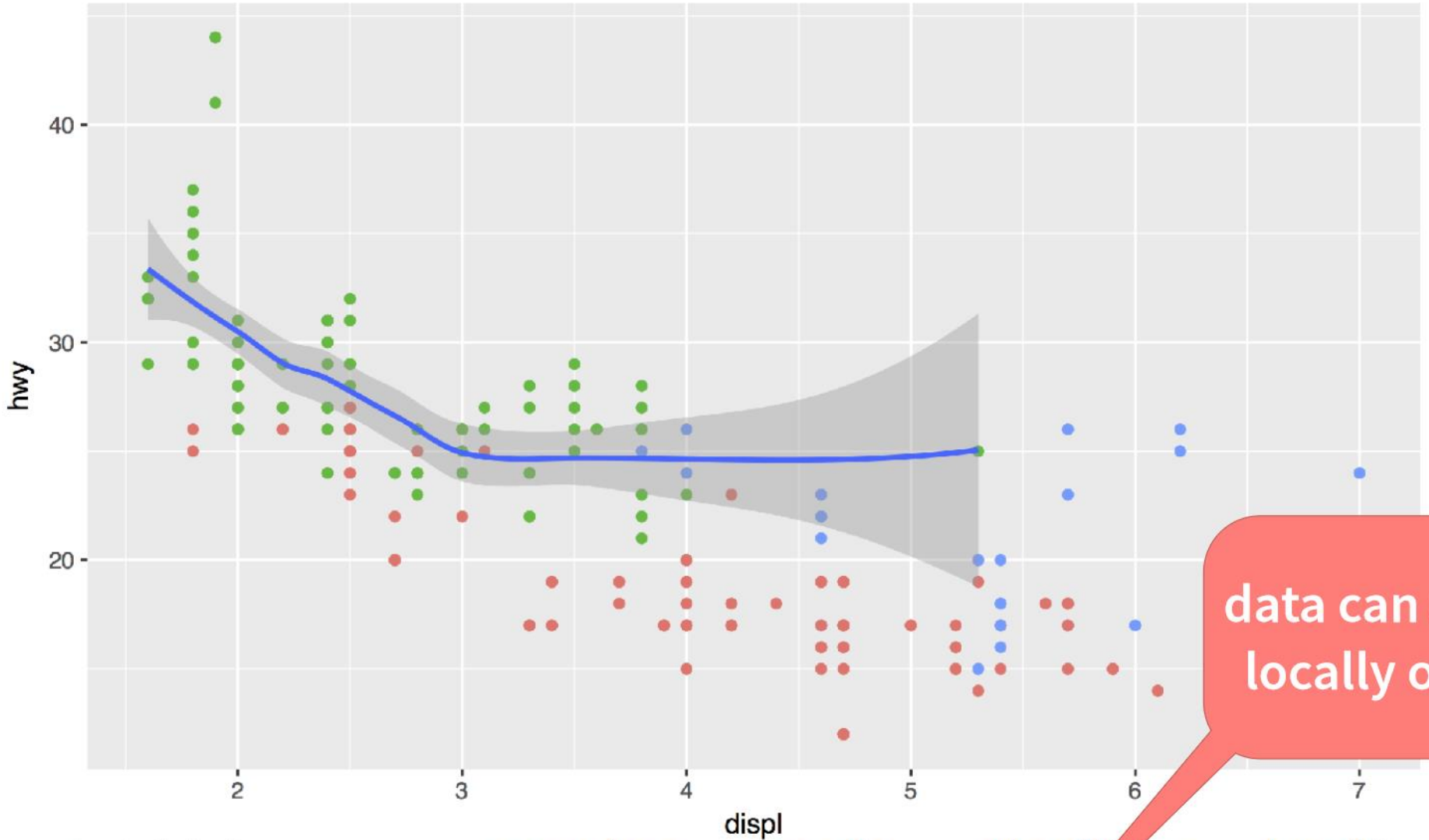
```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point() +
  geom_smooth()
```



Mappings (and data) that appear in a geom_ function will add to or override the global mappings for that layer only

```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point(mapping = aes(color = drv)) +
  geom_smooth()
```


ggplot2



data can also be set locally or globally

```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point(mapping = aes(color = drv)) +
  geom_smooth(data = filter(mpg, drv == "f"))
```


ggplot2

Exporting Graphs

Your Turn 8

What does this command return?

```
getwd()
```

Working Directory

R associates itself with a folder (i.e. directory) on your computer.

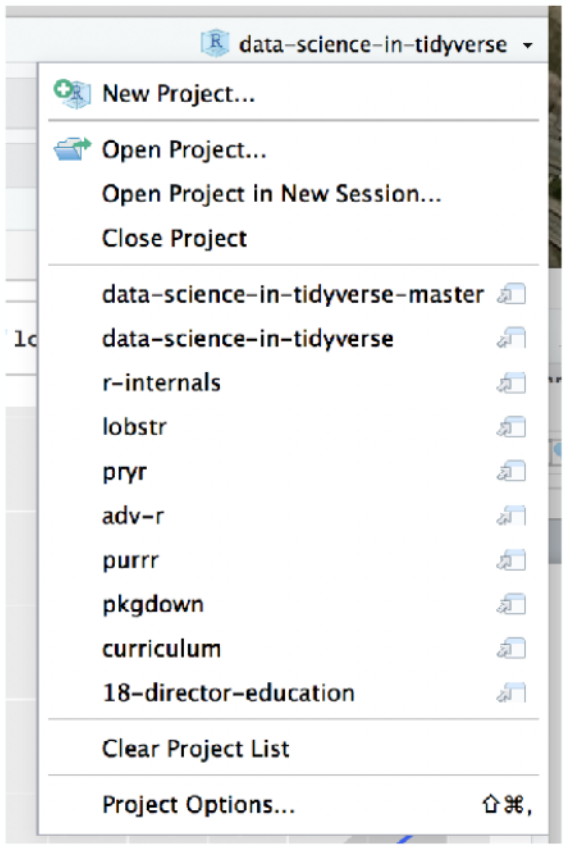
- This folder is known as your "working directory"
- When you save files, R will save them here
- When you load files, R will look for them here

Projects

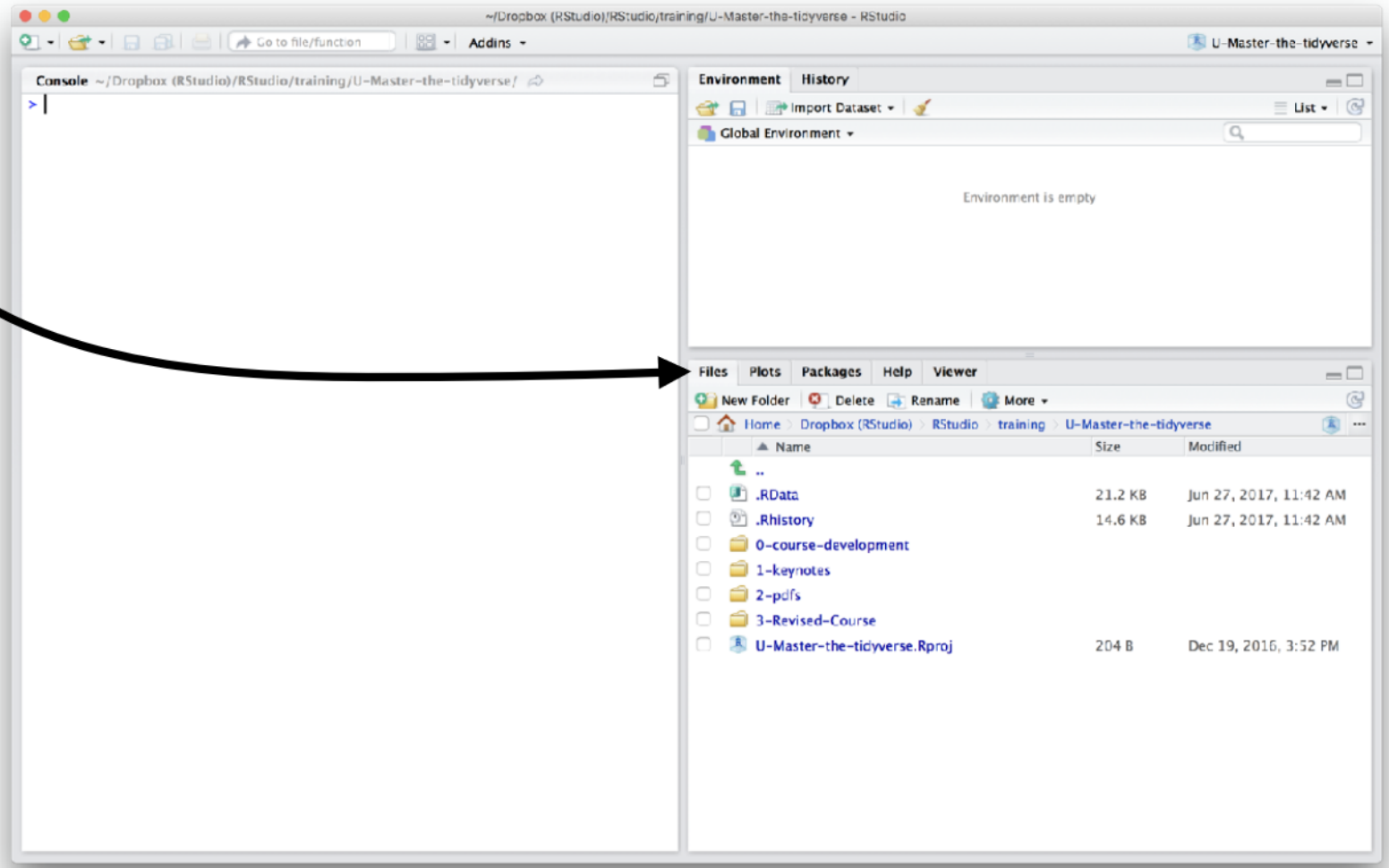
The best way of managing your working directory is with RStudio Projects.

One RStudio project = one real life project

One RStudio project = one directory



The files pane of the IDE displays the contents of your working directory



Saving plots

ggsave() saves the last plot.
Uses size on screen:

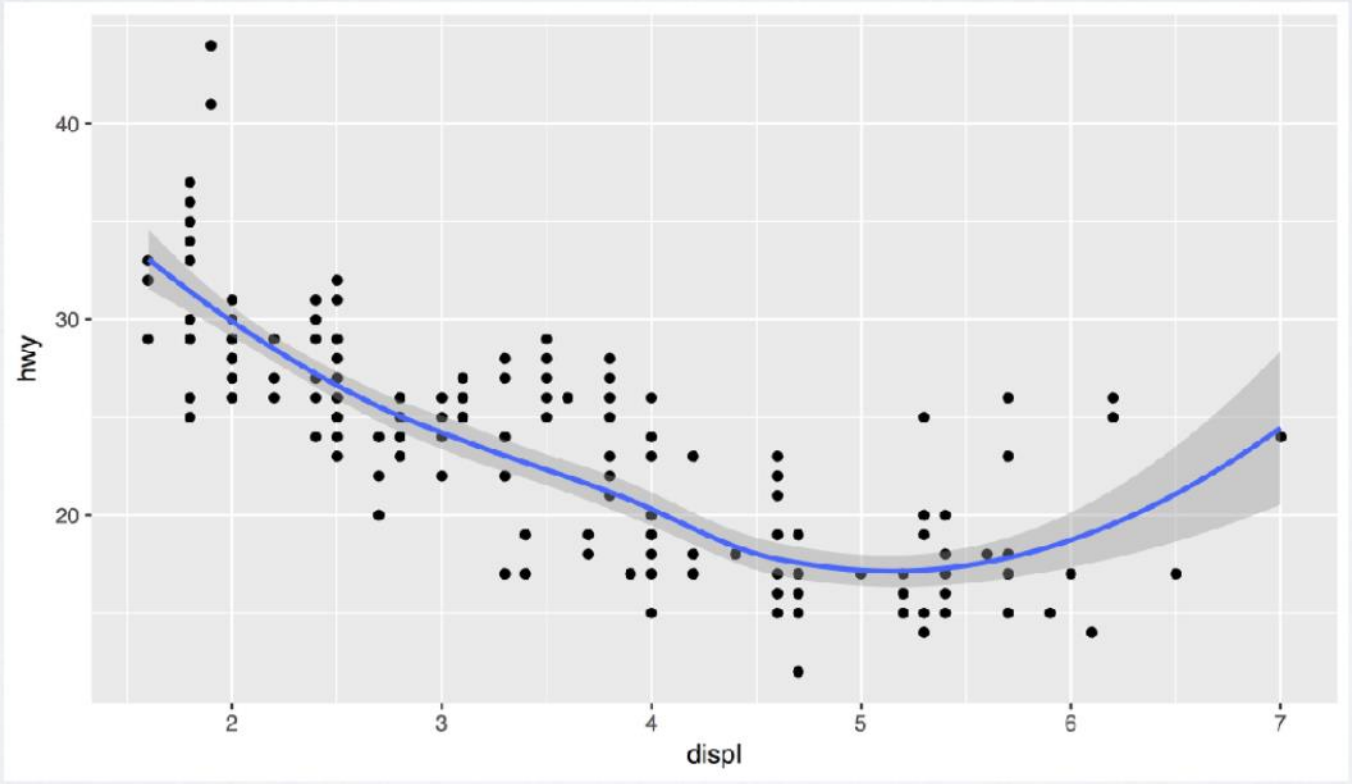
```
ggsave("my-plot.pdf")
ggsave("my-plot.png")
```

Specify size in inches

```
ggsave("my-plot.pdf", width = 6, height = 6)
```

Your Turn 9

Save your last plot and then locate it in your files pane. (You may have to refresh the files list).



The Grammar of Graphics

To make a graph

[template]

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

To make a graph

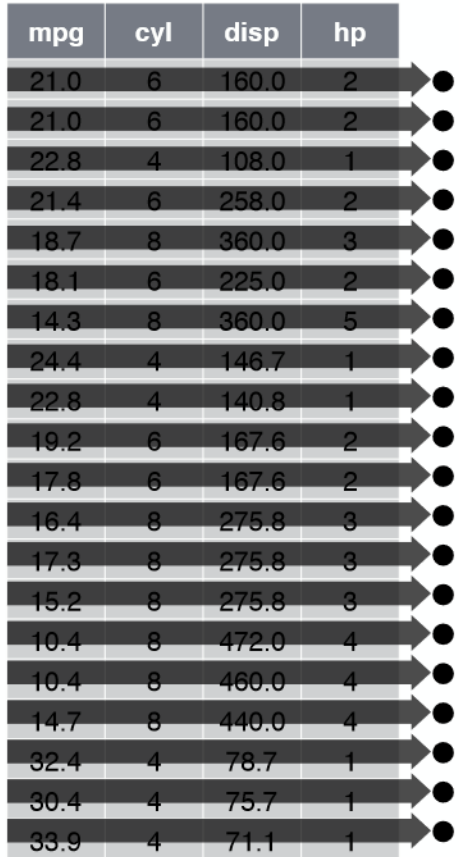
mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

data

1. Pick a **data** set

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


To make a graph



mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

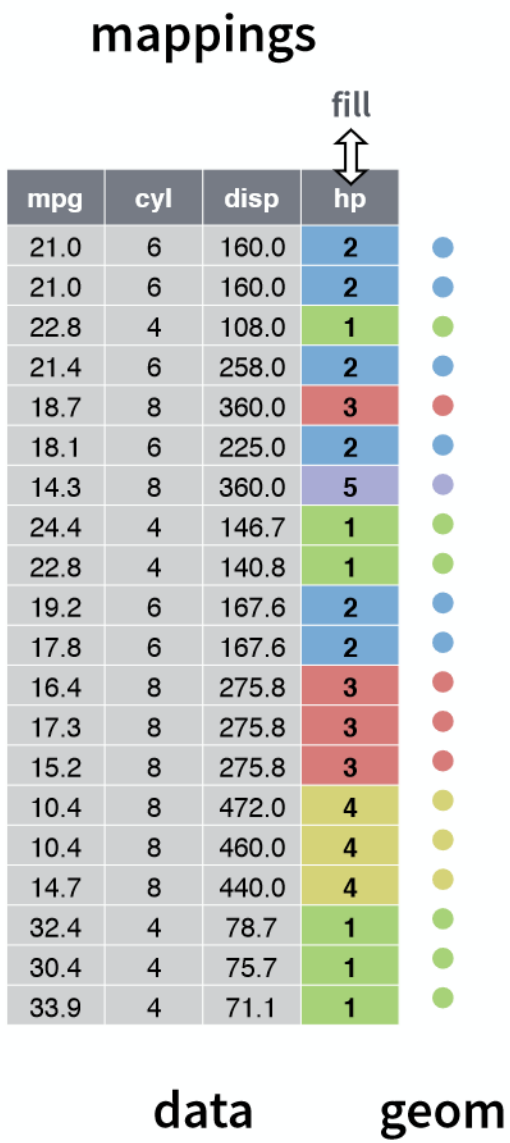
data **geom**

1. Pick a **data** set

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

2. Choose a **geom** to display cases

To make a graph



1. Pick a **data** set

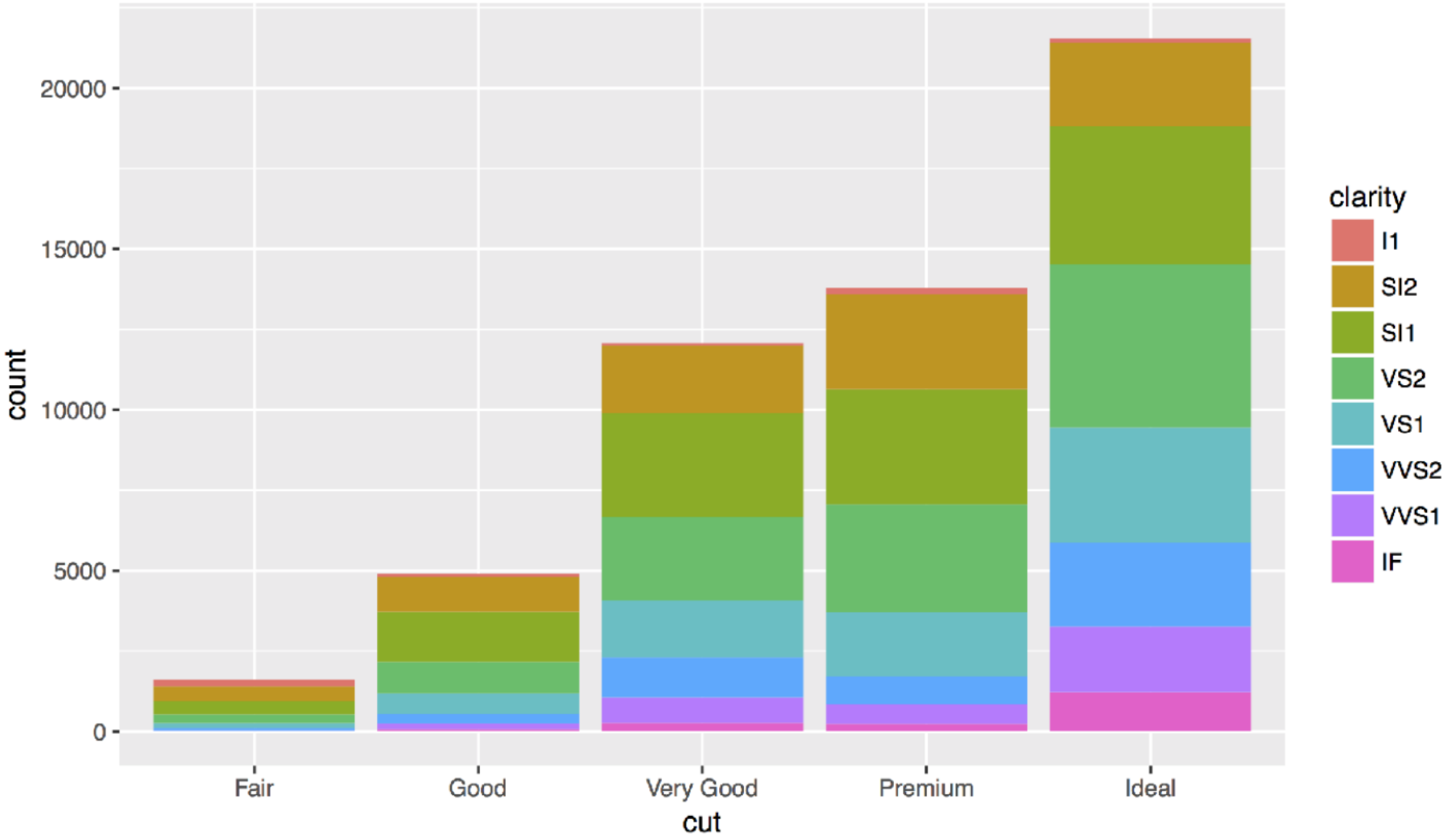
```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

2. Choose a **geom** to display cases

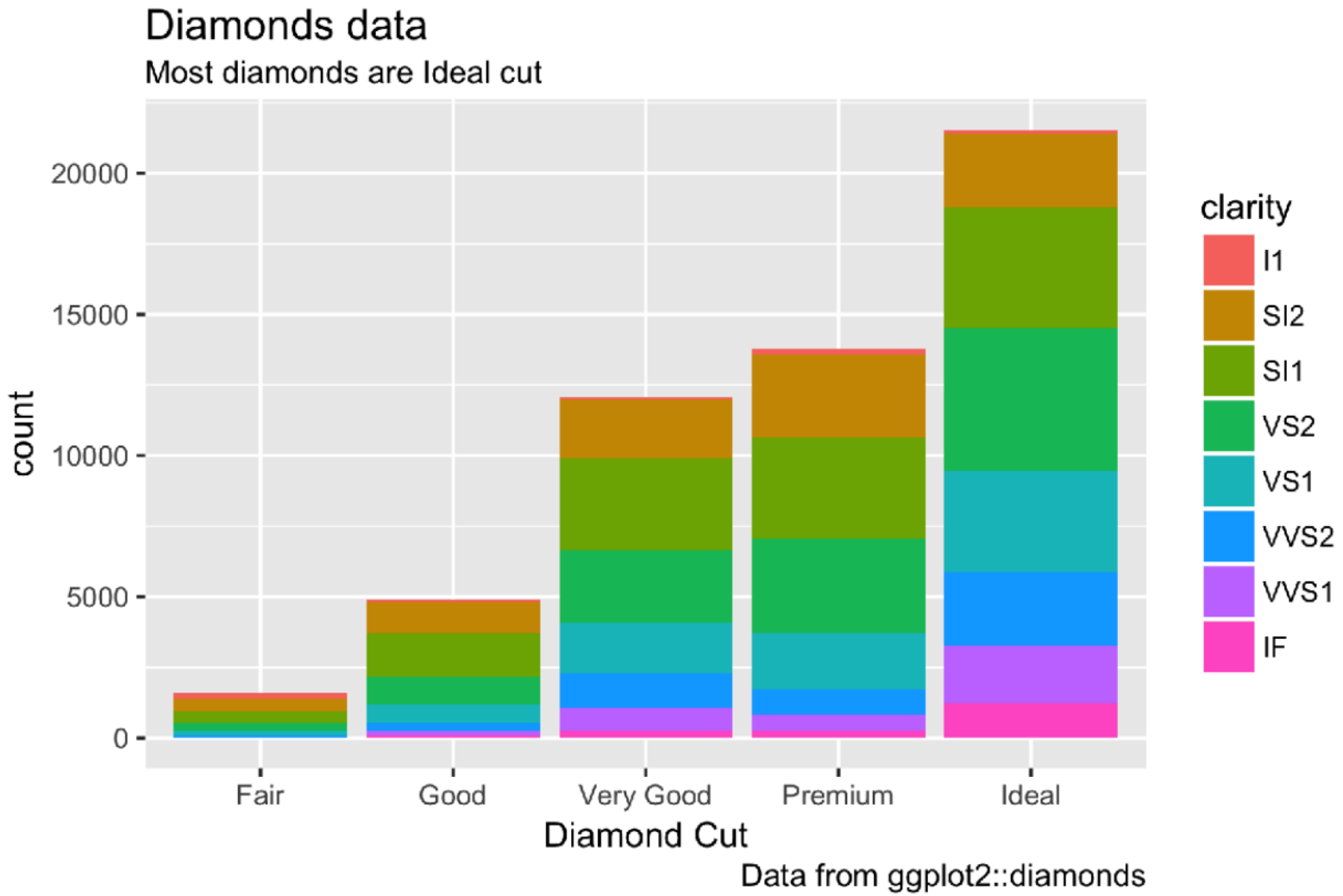
3. **Map** aesthetic properties to variables

What else?

For example:

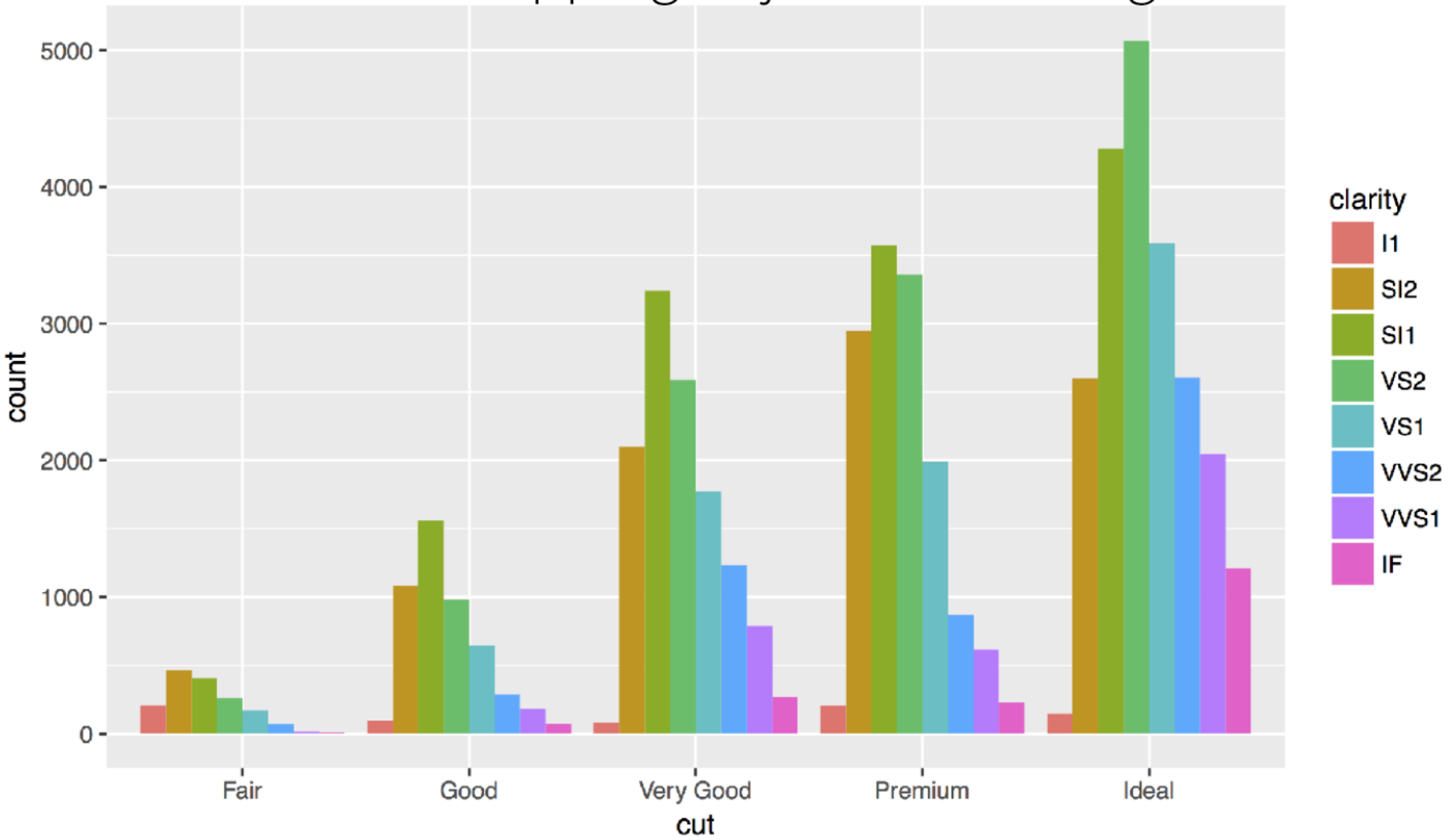


Titles and captions + labs()



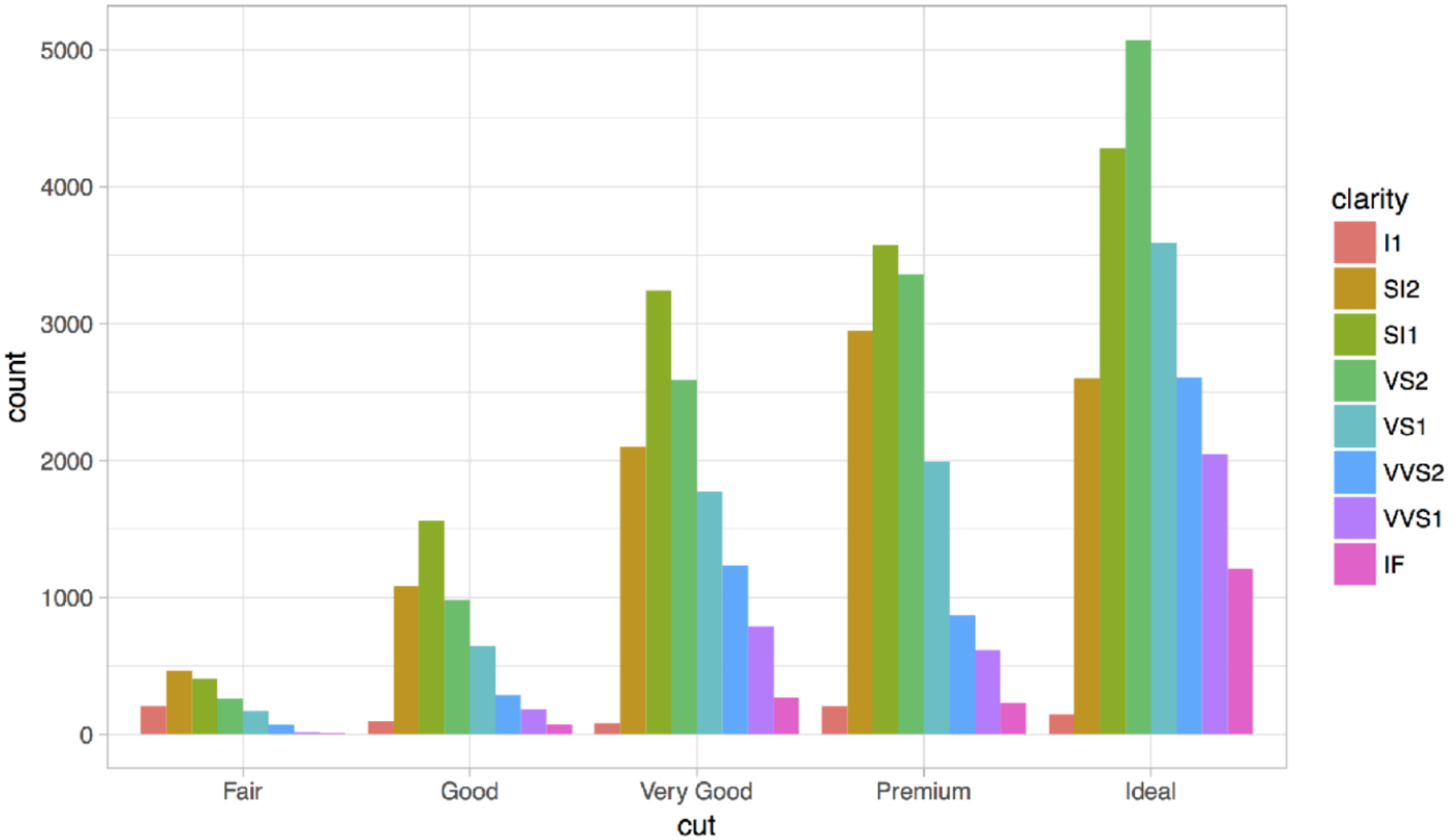
Position Adjustments

How overlapping objects are arranged



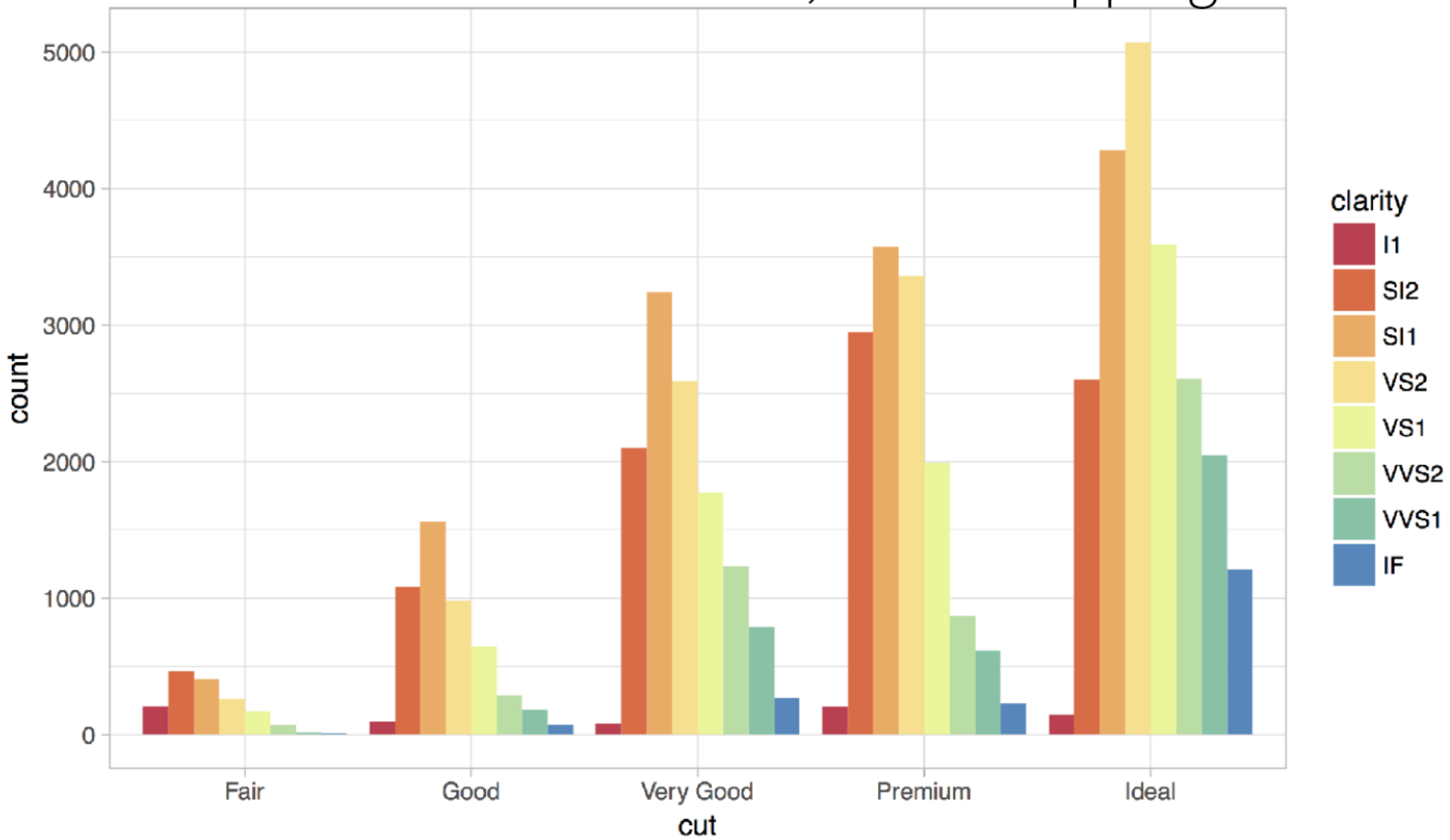
Themes

Visual appearance of non-data elements



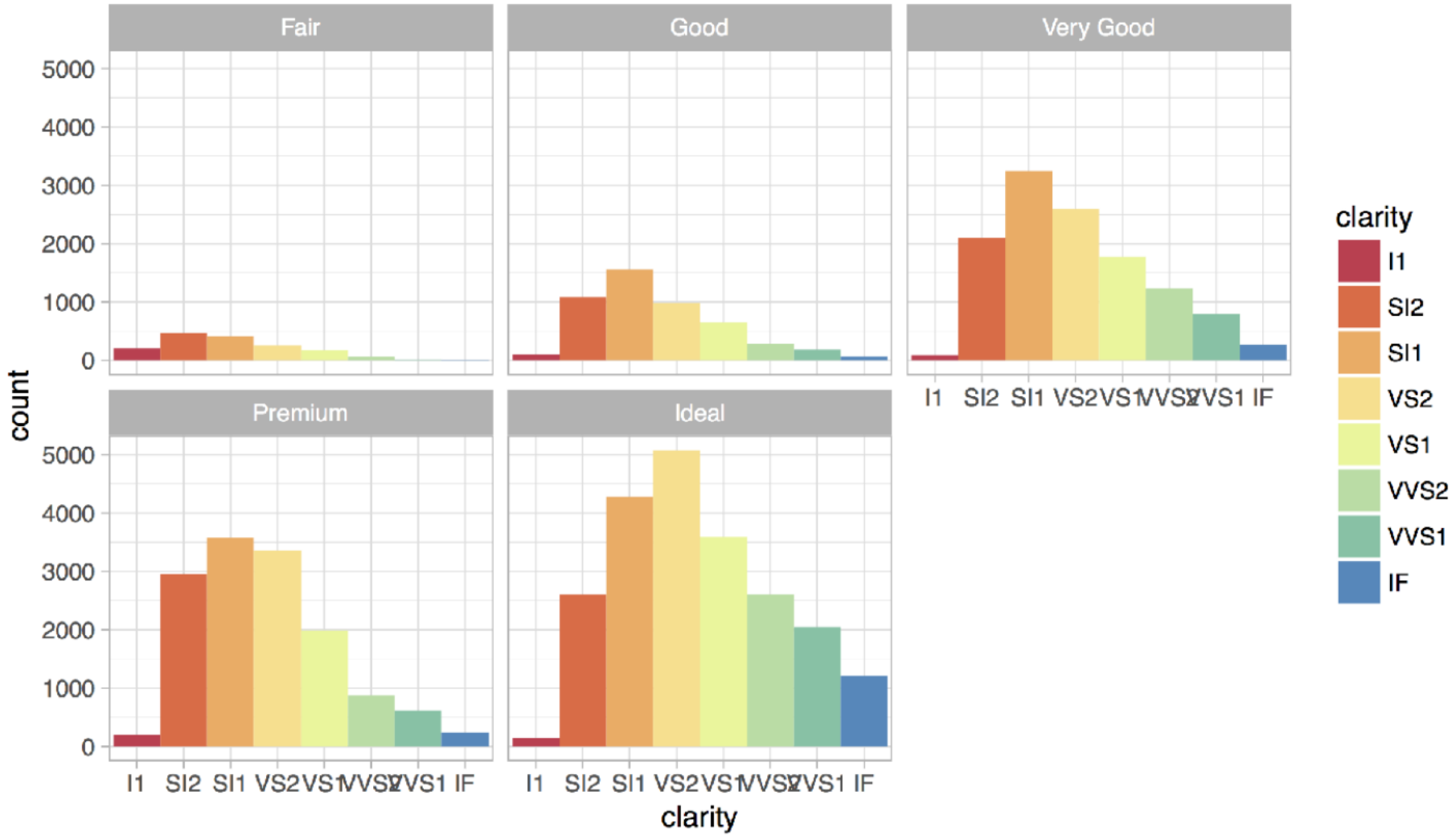
Scales

Customize color scales, other mappings

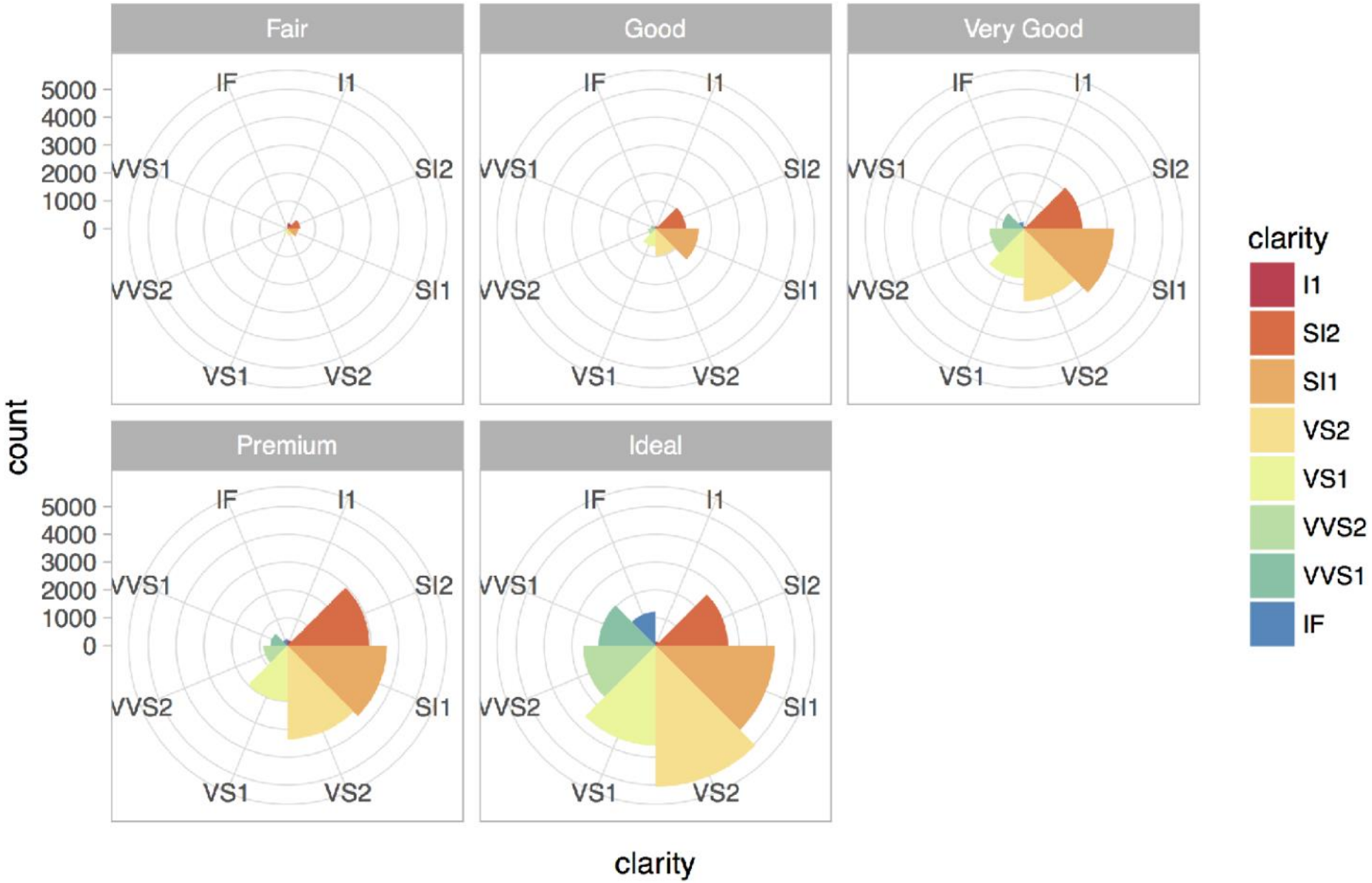


Facets

Subplots that display subsets of the data.



Coordinate systems



A ggplot2 template

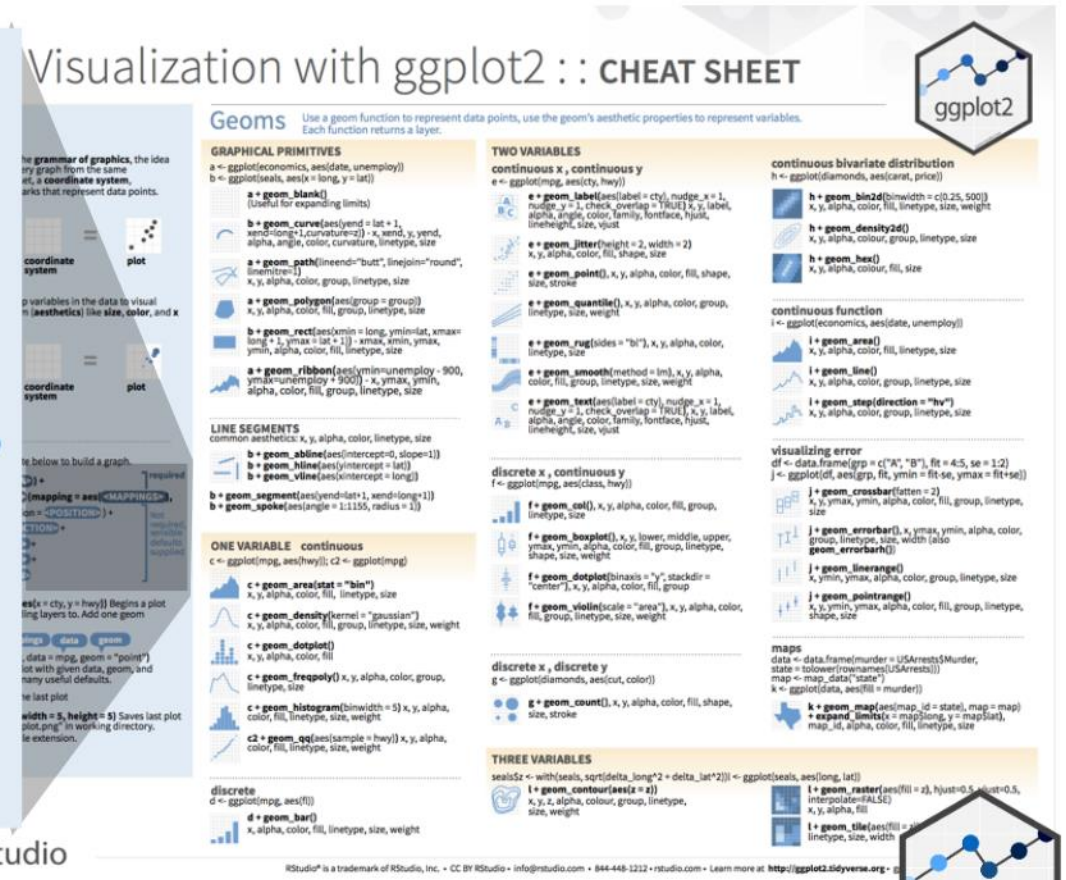
Make any plot by filling in the parameters of this template

Complete the template below to build a graph.

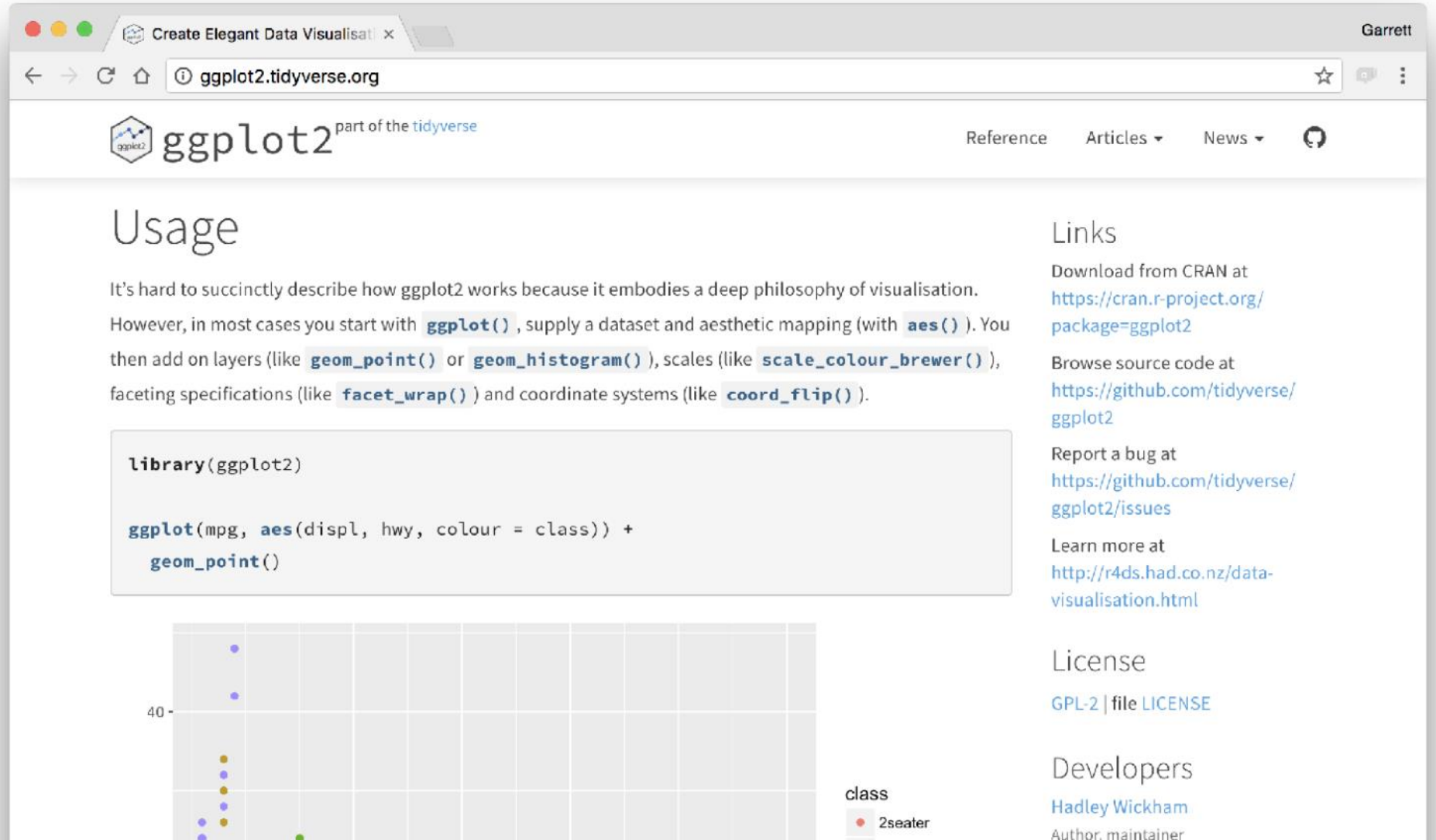
```
ggplot (data = <DATA>) +
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
 stat = <STAT> , position = <POSITION> ) +
<COORDINATE_FUNCTION> +
<FACET_FUNCTION> +
<SCALE_FUNCTION> +
<THEME_FUNCTION>
```

required

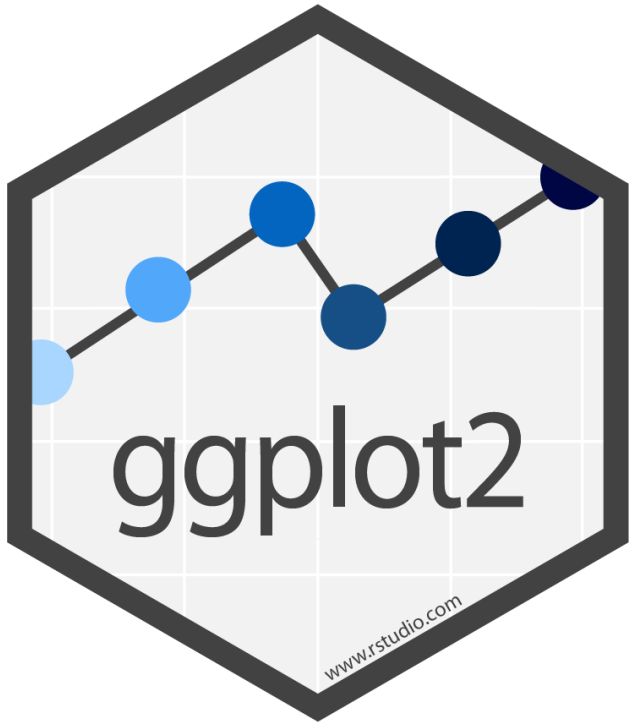
Not required, sensible defaults supplied



ggplot2.tidyverse.org



Visualising Data with



Adapted from “Explore the Tidyverse” CC by Hadley Wickham