Visualising data with ggplot2

Some guiding principles...

1. You should visualise your data early and often.

2. Visualising = understanding.

This session focuses on the ggplot2 package

There are several other ways of creating plots in R.

- Base graphics e.g. `plot(...)`
- The `lattice` package
- The `vcd` package

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- Base graphics e.g. `plot(...)`
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- The `vcd` package

They are all ~~terrible~~ *different*.

Histograms

Description

The generic function `hist` computes a histogram of the given data values. If `plot = TRUE`, the resulting object of class `"histogram"` is plotted by `plot.histogram`, before returned.

Usage

```
hist(x, ...)

## Default S3 method:
hist(x, breaks = "Sturges",
     freq = NULL, probability = !freq,
     include.lowest = TRUE, right = TRUE,
     density = NULL, angle = 45, col = NULL, border = NULL,
     main = paste("Histogram of" , xname),
     xlim = range(breaks), ylim = NULL,
     xlab = xname, ylab,
     axes = TRUE, plot = TRUE, labels = FALSE,
     nclass = NULL, warn.unused = TRUE, ...)
```

Forest plot to display the result of a meta-analysis

Description

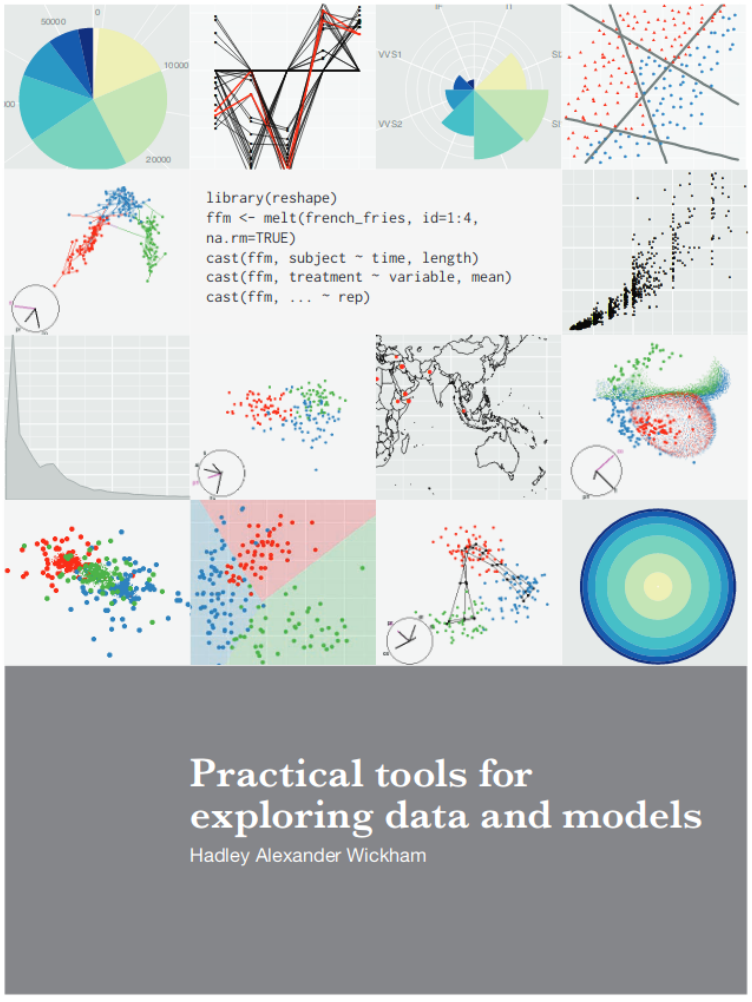
Draws a forest plot in the active graphics window (using grid graphics system).

Usage

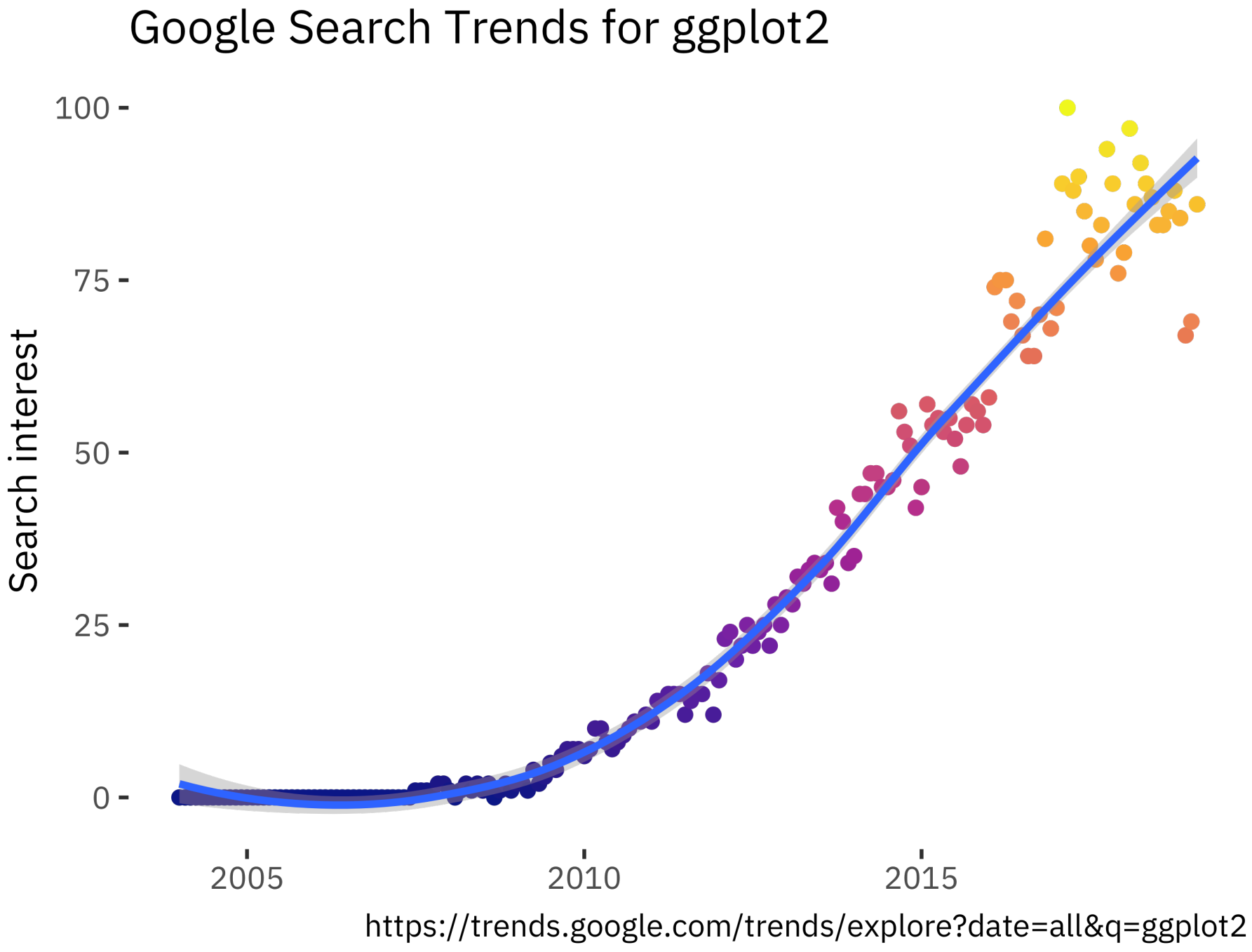
```
forest(x, ...)

## S3 method for class 'meta'
forest(x, sortvar, studlab=TRUE,
       layout=gs("layout"),
       comb.fixed=x$comb.fixed, comb.random=x$comb.random,
       overall=TRUE,
       text.fixed=NULL,
       text.random=NULL,
       lty.fixed=2, lty.random=3, col.fixed="black", col.random="black",
       prediction=x$prediction,
       text.predict=NULL,
       subgroup=TRUE,
       print.subgroup.labels=TRUE,
       bylab=x$bylab, print.byvar=x$print.byvar,
       byseparator=x$byseparator,
       text.fixed.w=text.fixed, text.random.w=text.random, bysort=FALSE,
       pooled.totals=comb.fixed|comb.random, pooled.events=FALSE,
       pooled.times=FALSE, study.results=TRUE,
       xlab="", xlab.pos,
       smlab=NULL, smlab.pos, xlim="symmetric",
       allstudies=TRUE,
       weight.study, weight.subgroup,
       pscale=x$pscale, irscale=x$irscale, irunit=x$irunit,
       ref=ifelse(backtransf & is.relative.effect(x$sm), 1, 0),
       leftcols=NULL, rightcols=NULL,
```

The origins of ggplot2



Hadley Wickham (2008)


Google Search Trends for ggplot2
Search interest
100
75
50
25
0
2005
2010
2015
https://trends.google.com/trends/explore?date=all&q=ggplot2

Where to learn more

1. The ggplot2 website

   `https://ggplot2.tidyverse.org`

2. “ggplot2: elegant graphics for data analysis”

   `https://ggplot2-book.org`

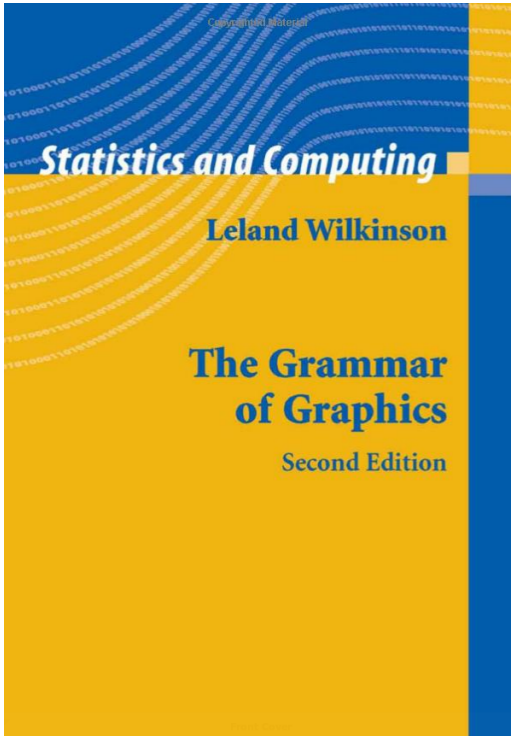
ggplot2 is now over 10 years old and is used by hundreds of thousands of people to make millions of plots.

That means, by-and-large, ggplot2 itself changes relatively little. When we do make changes, they will be generally to add new functions or arguments rather than changing the behaviour of existing functions, and if we do make changes to existing behaviour we will do them for compelling reasons.

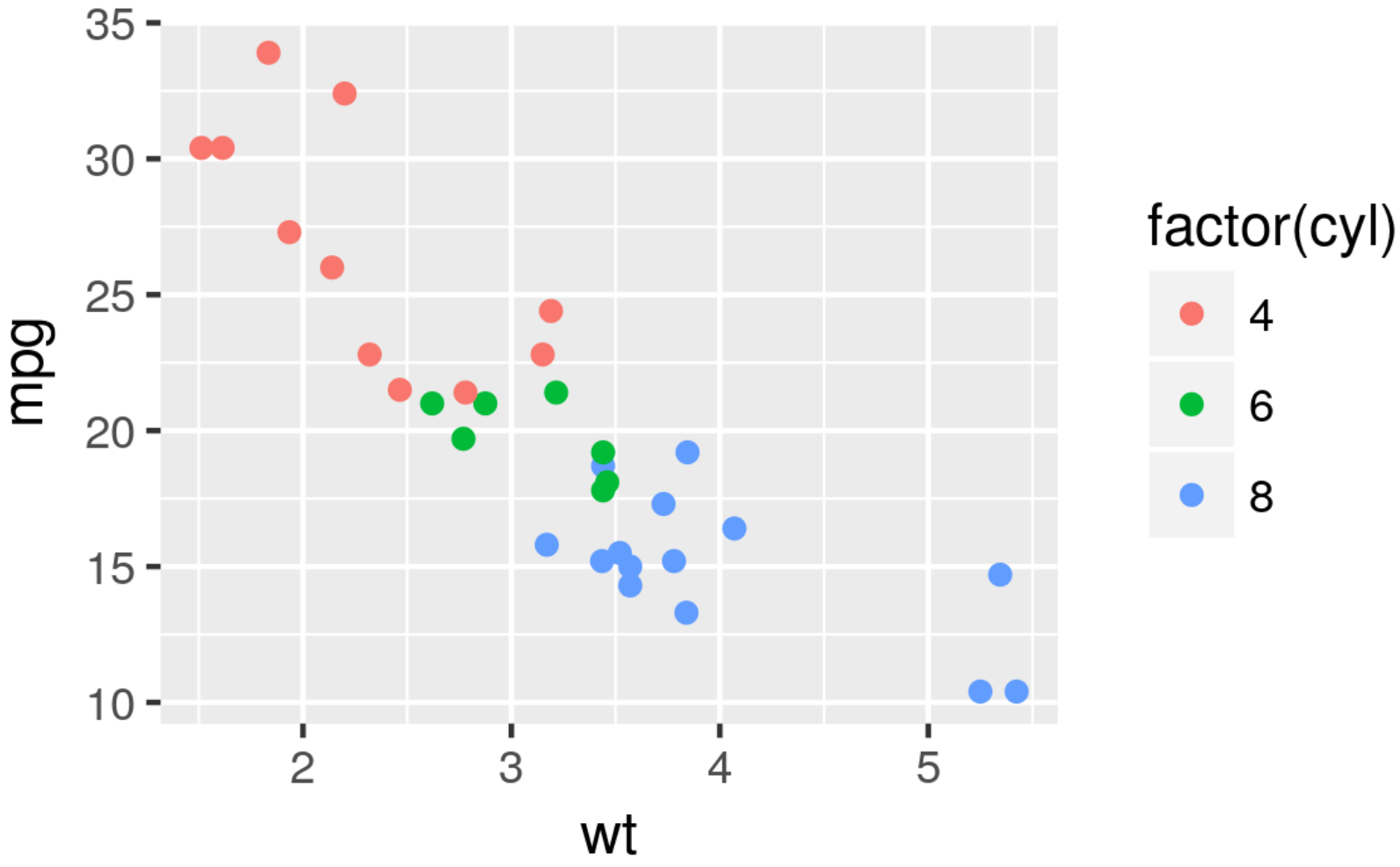
What is ggplot2?

"ggplot2 is a system for declaratively creating graphics, based on The Grammar of Graphics. You provide the data, tell ggplot2 how to map variables to aesthetics, what graphical primitives to use, and it takes care of the details".

ggplot2.tidyverse.org



A simple plot



What are the different components of this graph?

Essential components of a `ggplot2` plot

1. Data

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   How are the data plotted? Points, lines, bars?

Essential components of a `ggplot2` plot

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2. Aesthetics (or mappings)

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   How are the data plotted? Points, lines, bars?

4. Facets

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   Titles, labels, colors, etc.

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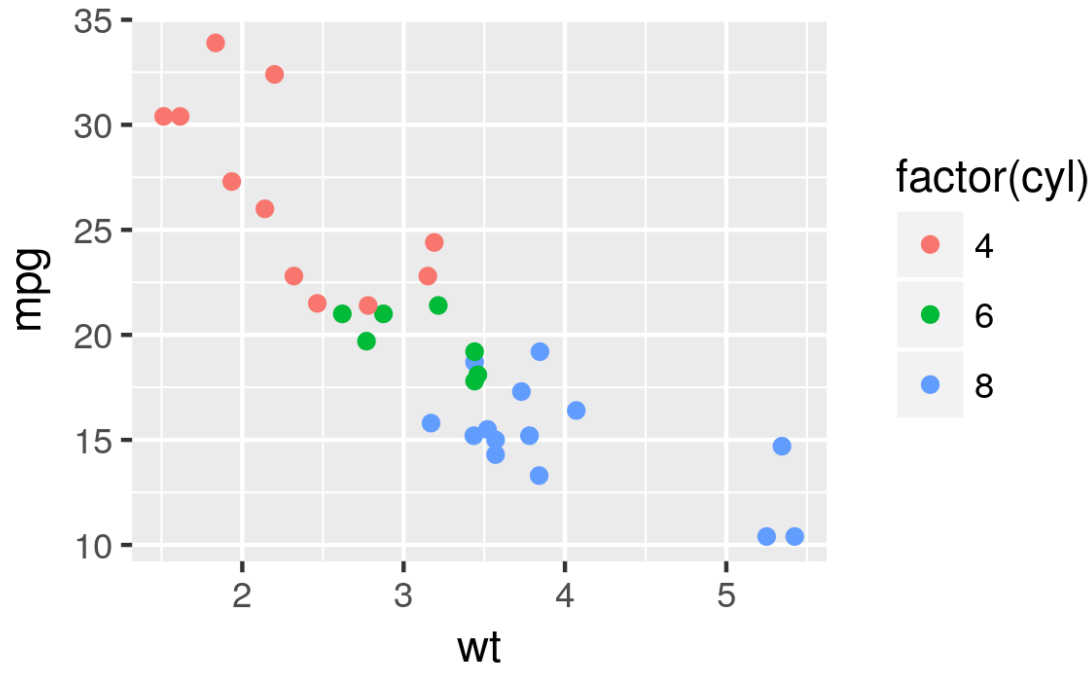
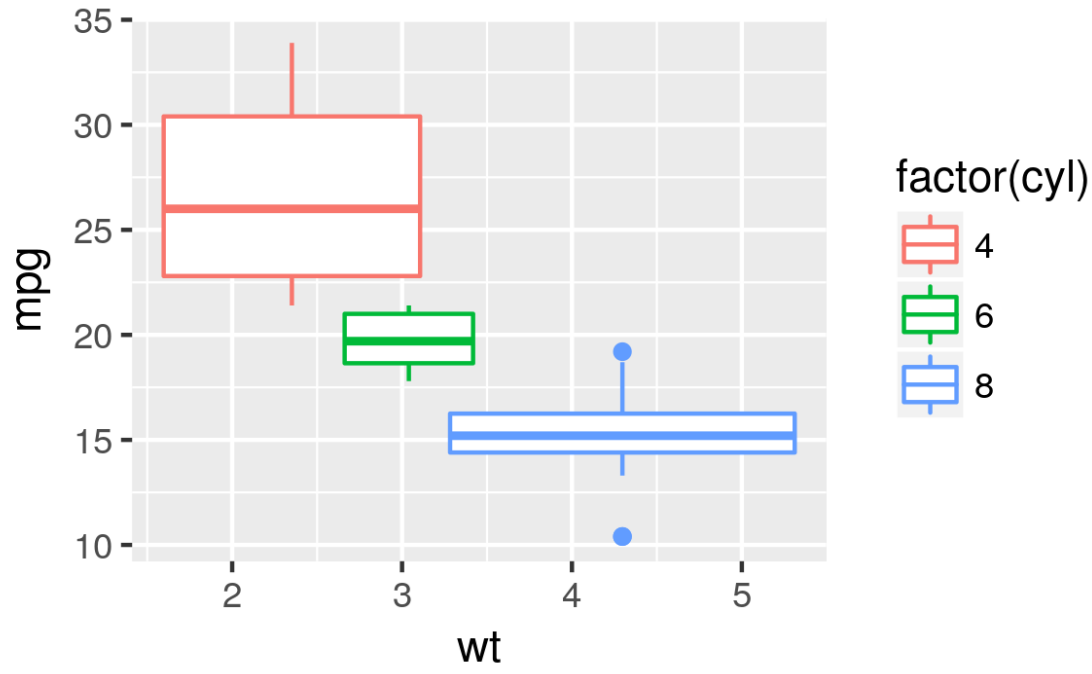
   Titles, labels, colors, etc.

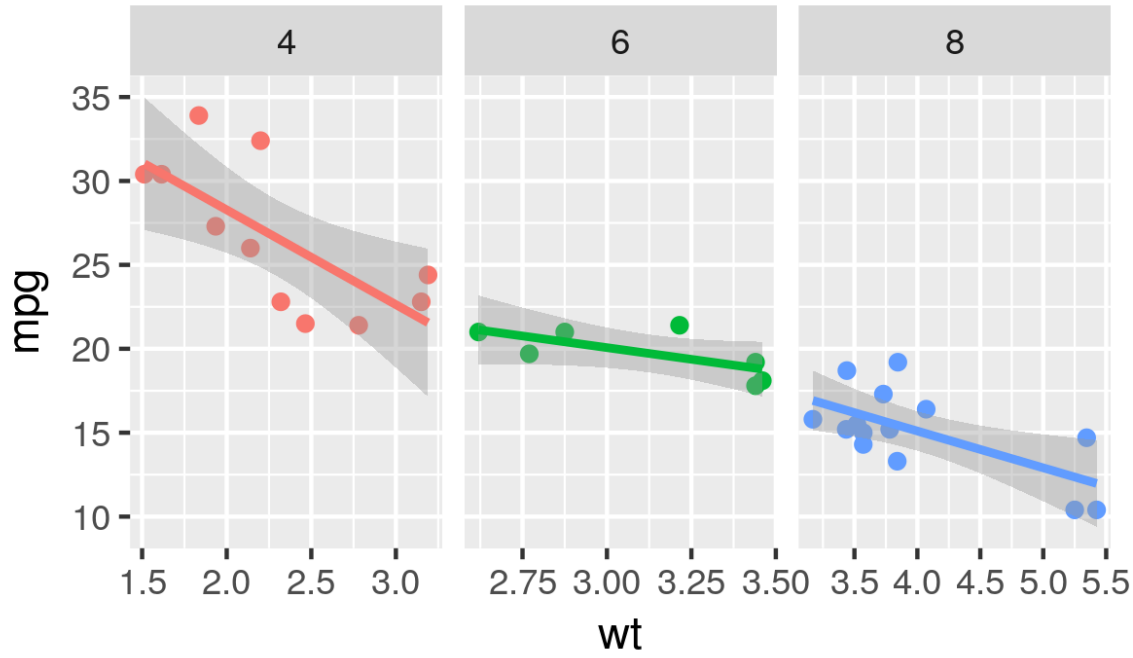
```
ggplot(mtcars,
       aes(x = wt,
           y = mpg,
           color = factor(cyl))) +
       geom_point()
```



```
ggplot(mtcars,
       aes(x = wt,
           y = mpg,
           color = factor(cyl))) +
       geom_boxplot()
```



```
ggplot(mtcars,
       aes(x = wt,
           y = mpg,
           color = factor(cyl))) +
  geom_point() +
  geom_smooth(method = "lm") +
  facet_wrap(~ cyl, scale = "free_x")
```



Why do we care?

1. Consistency
2. Flexibility

Also nice to have:

- Widely used, well supported, big and friendly community.
- Better defaults, themes, extensibility.

So far we've covered:

- `ggplot2` and how it compares to 'base' R.
- The core components of a `ggplot2` plot.

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- `ggplot2` and how it compares to 'base' R.
- The core components of a `ggplot2` plot.

The remainder of this session...

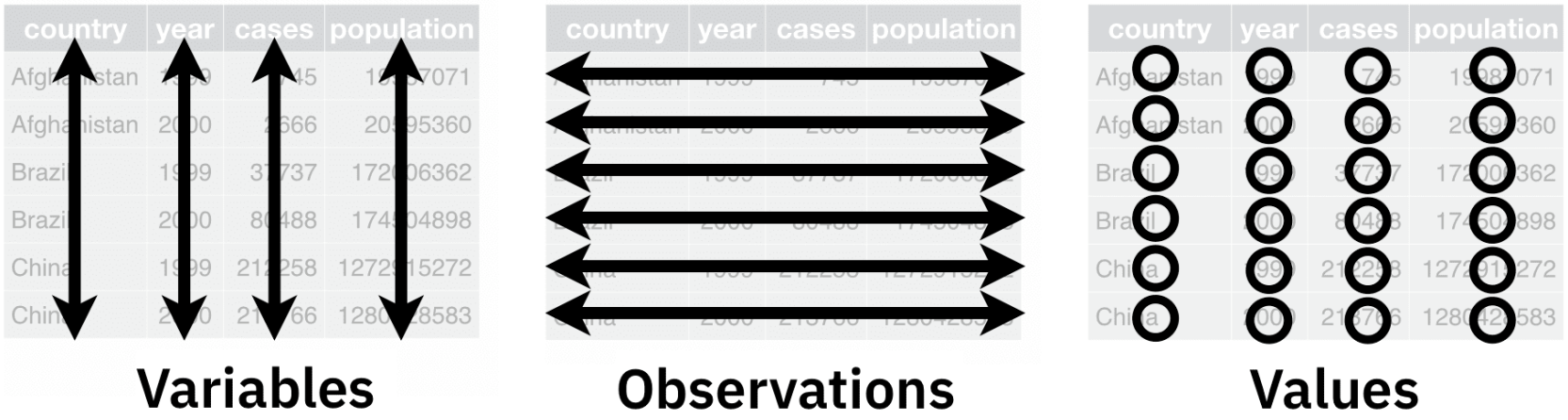
1. The different components of a `ggplot2` plot.
    1. Data
    2. Aesthetics (or mappings)
    3. Coordinates (or geoms)
    4. Facets
    5. Theme
2. Some examples (scatterplot, histogram, bar plots)...
3. Things you should know.
4. PRACTICE.

Preparing your data
for plotting...

1. Data

More important than it sounds...

- Most difficulties with `ggplot2` arise because the source data are not in the correct format.
- Your data should be tidy.



1. Each variable forms a column.
2. Each observation forms a row.
3. Each type of observational unit forms a table.

Once your data are tidy, they are added to the plot as the first argument.

```
ggplot(data, ...)
```

Alternatively, using the pipe...

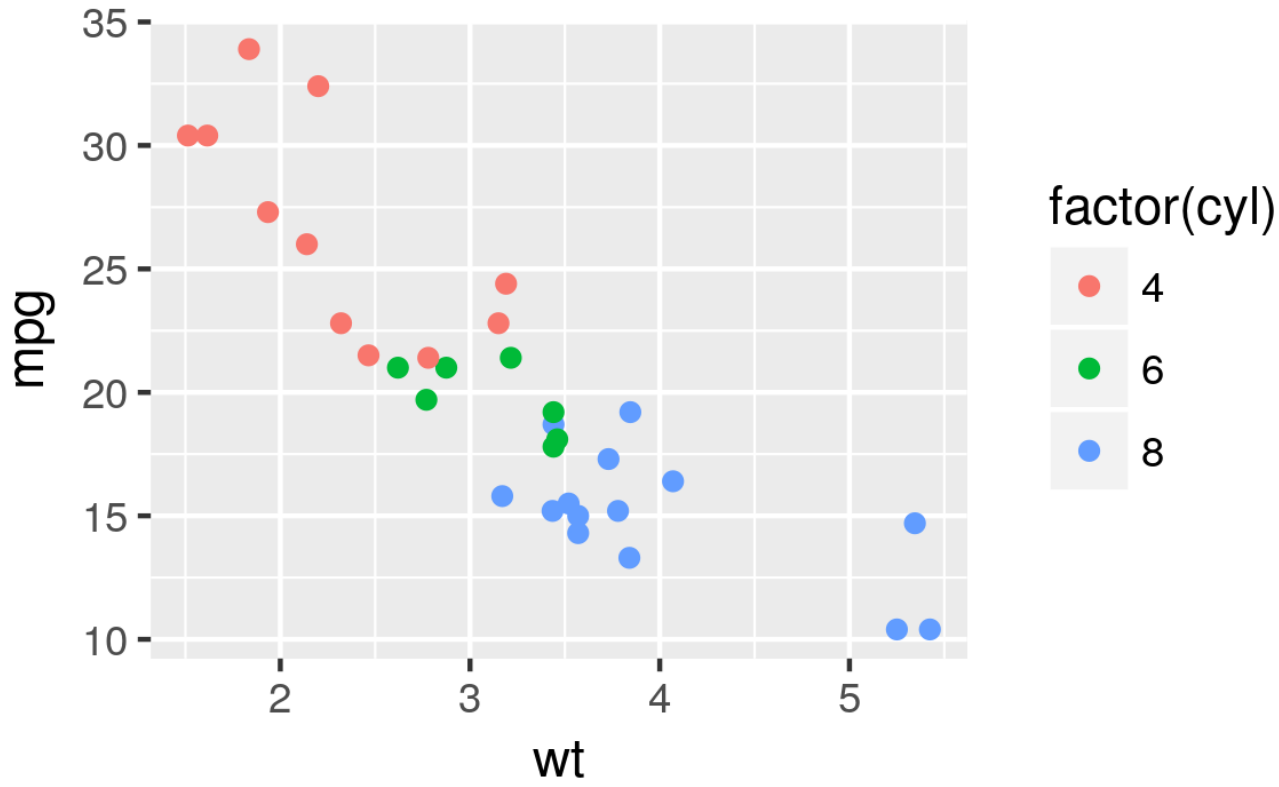
```
data |>
  ggplot(...)
```

Mapping data onto components of your plot...

Aesthetics (or mappings)

These describe how your data map onto different components of the plot.

- Which variable goes on the x-axis?
- Should the points be grouped?
- Which variable should determine the colour of the points?



- The required aesthetics depend on the type of plot.
- Some are essential; others are optional.
- They are specified using `aes`.

```
data |>
    ggplot() +
    aes(x = weight,
        y = height)
```

NOTE: We're 'adding' components; no pipes here.

Geoms

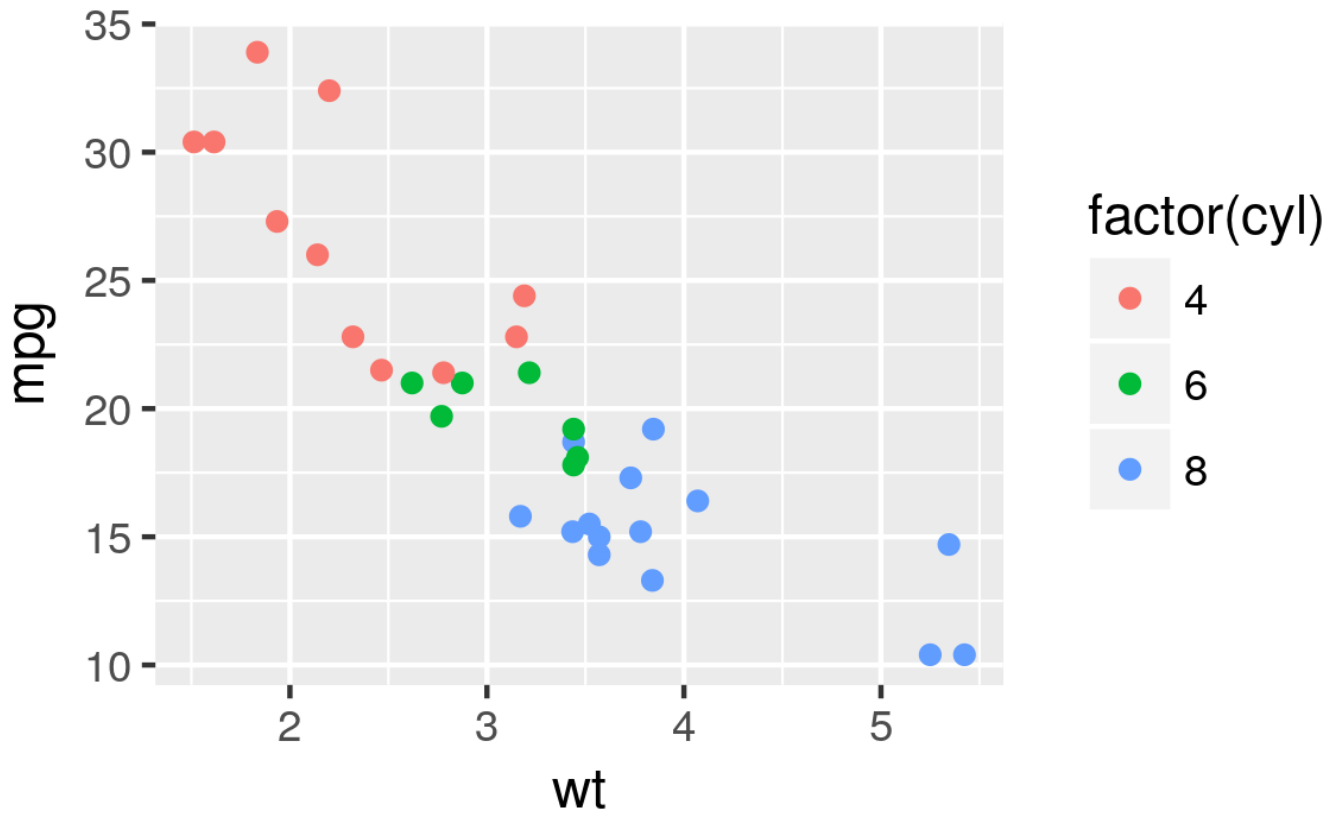
- Geoms specify how the data should be plotted.

  Do we want a point, a line, a histogram?

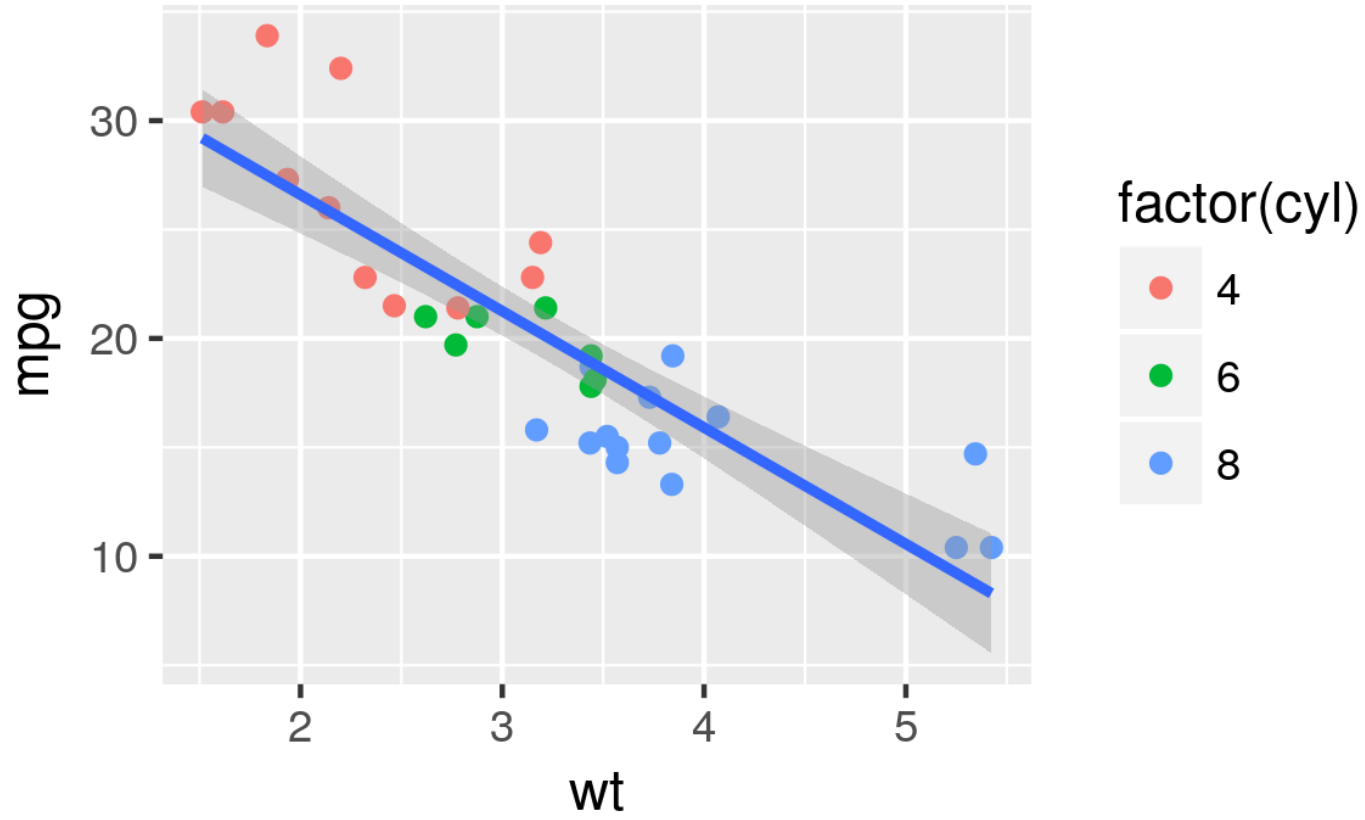
- There are some basic geoms that you'll use regularly.
  - `geom_point()`
  - `geom_line()`
  - `geom_histogram()`

```
mtcars |>
  ggplot() +
    aes(x = wt, y = mpg)) +
    geom_point()
```

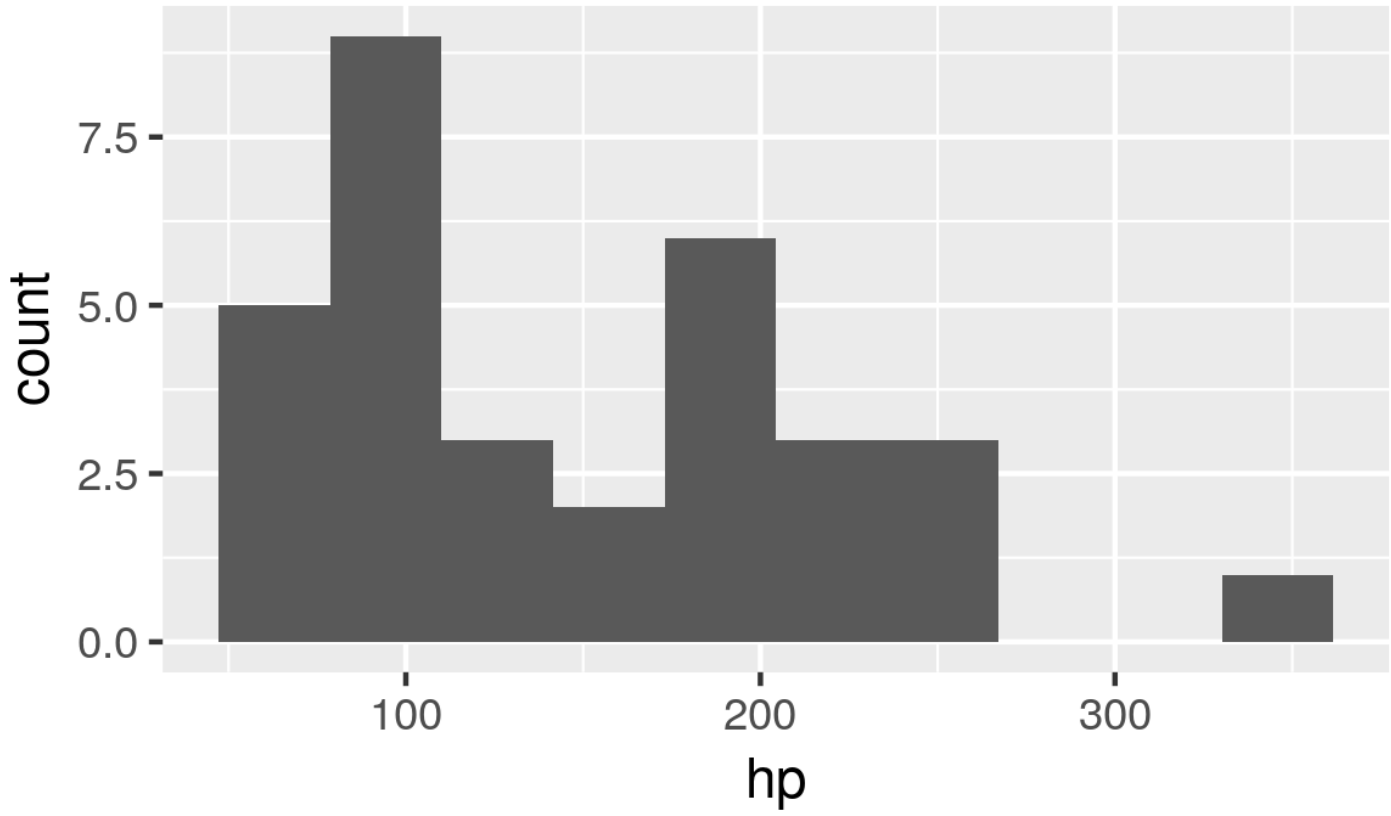
```r
mtcars |>
    ggplot() +
      aes(x = wt,
          y = mpg,
          color = factor(cyl)) +
      geom_point()
```



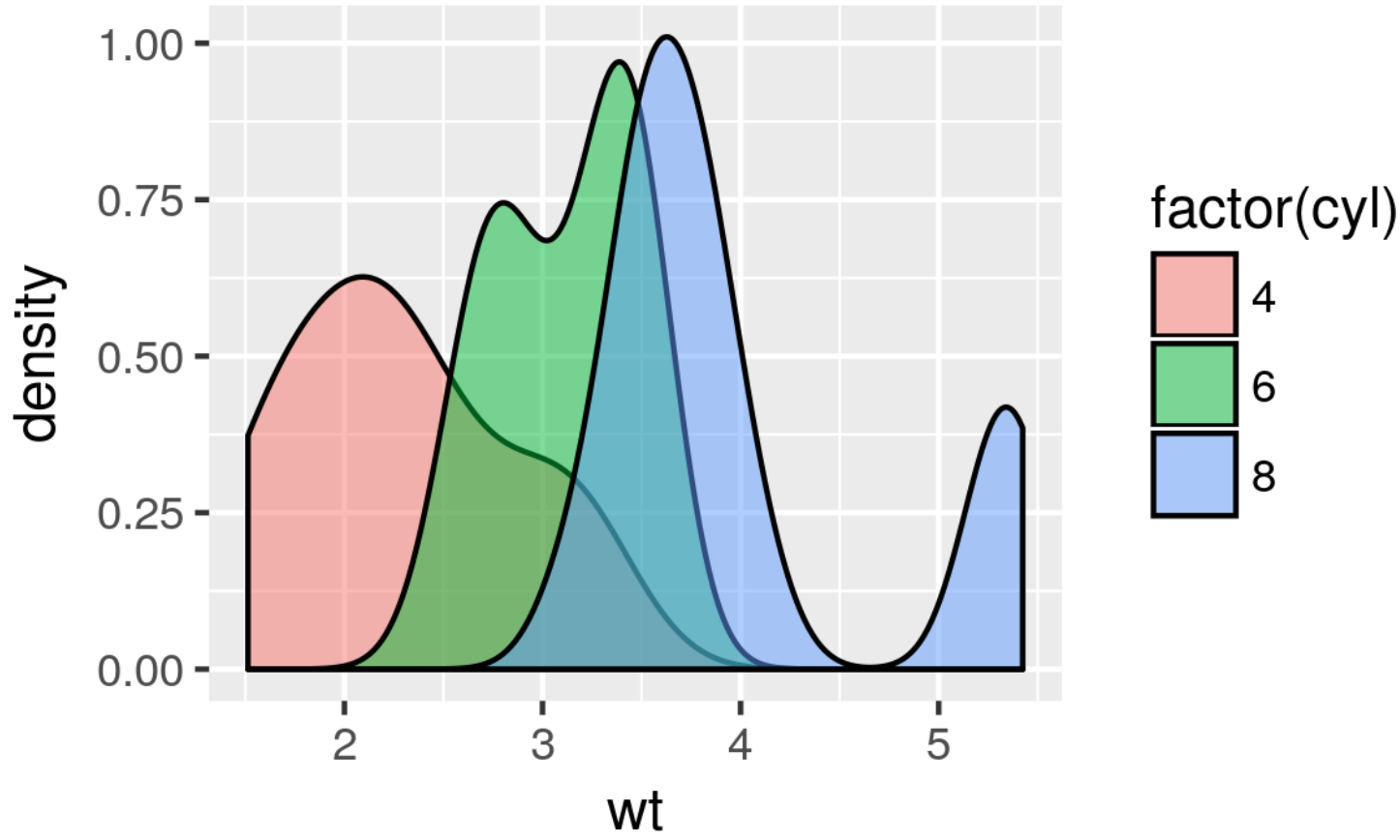
```r
mtcars |>
  ggplot() +
    aes(x = wt,
        y = mpg) +
    geom_point(aes(color = factor(cyl))) +
    geom_smooth(method = "lm")
```



```r
mtcars |>
  ggplot() +
      aes(x = hp) +
      geom_histogram(bins = 10)
```



```r
mtcars |>
    ggplot() +
      aes(x = wt,
          fill = factor(cyl)) +
      geom_density(alpha = 0.5)
```




LIGHTYEAR

geom_abline
geom_bar
geom_bin2d
geom_boxplot
geom_col
geom_contour
geom_count
geom_crossbar
geom_curve
geom_density
geom_density_2d
geom_dotplot
geom_errorbar
geom_errorbarh
geom_histogram
geom_hline
geom_jitter
geom_label
geom_line
geom_linerange
geom_map
geom_path
geom_point
geom_pointrange
geom_polygon
geom_qq
geom_quantile
geom_raster
geom_segment
geom_smooth
geom_spoke
geom_step
geom_text
geom_tile
geom_violin
geom_vline
geom_freqpoly
geom_hex
geom_histogram
geom_rect
geom_ribbon
geom_rug

And more... ggplot2-exts.org

Remember

- You can store plots as objects.

```
p <- ggplot(...)
```

- You will find it easier to write `ggplot2` code in the script editor, not the console.

Practical: scatterplots with `ggplot2`

1. Load the `tidyverse` package and the `starwars` dataset. `data(starwars)`
2. Create a scatterplot of `mass` (x-axis) against `height` (y-axis).

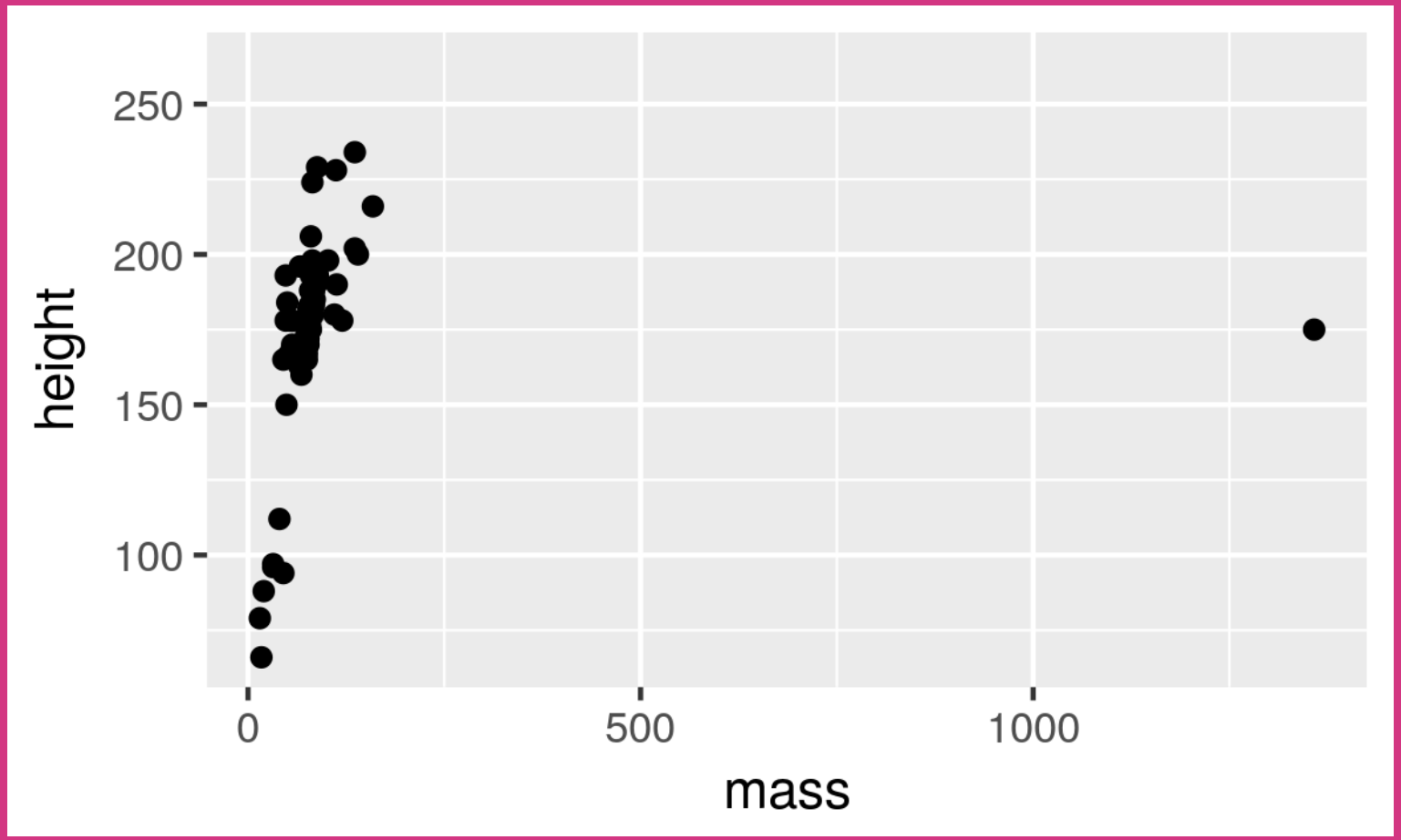
   Hint: `geom_point()`
3. Remove the outlying point and redraw the plot.

   Hint: `filter(...)`
4. Color the points by `homeworld`.

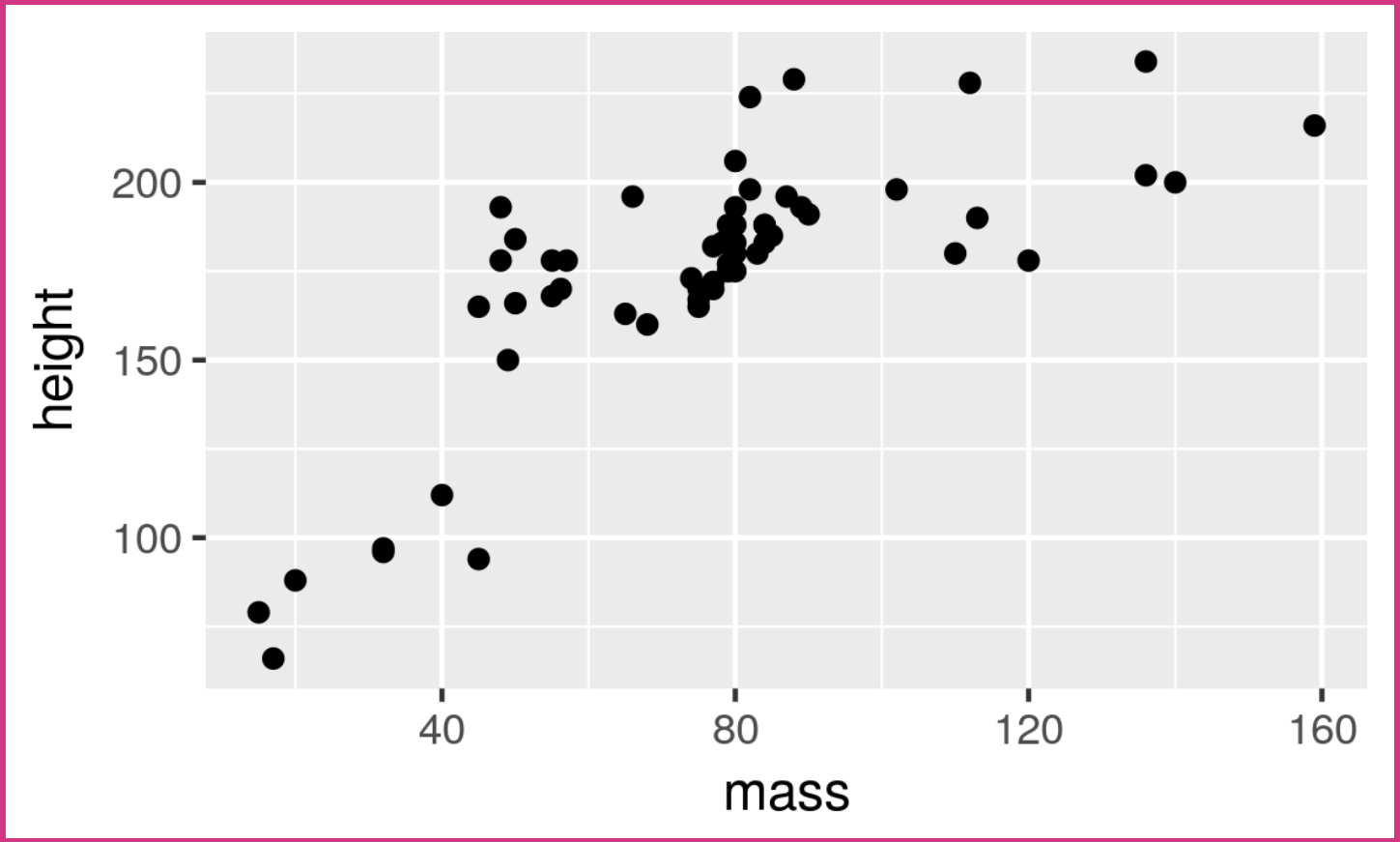
   Hint: `aes(color = ...)`
5. Add a line-of-best-fit.

   Hint: `geom_smooth(method = "lm")`

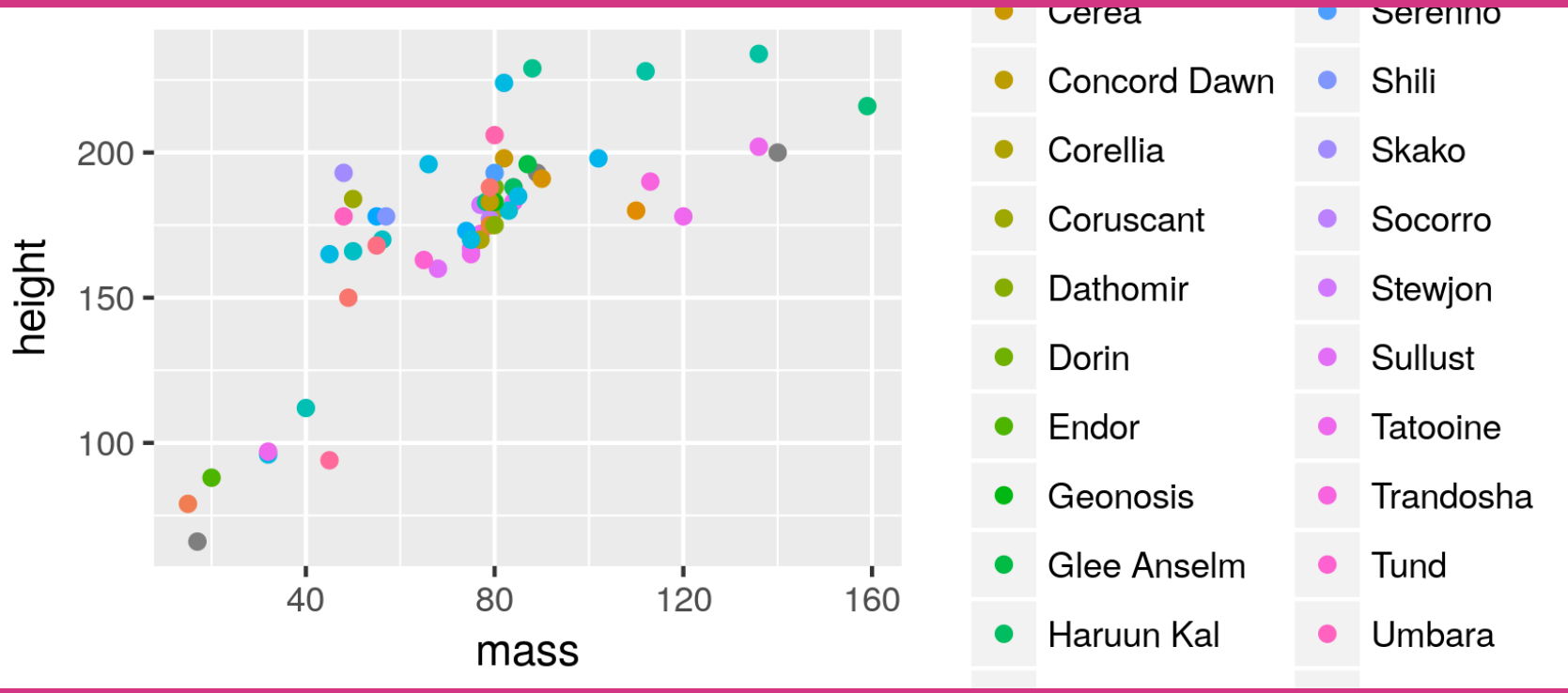
```
starwars |>
    ggplot() +
        aes(x = mass,
            y = height) +
        geom_point()
```



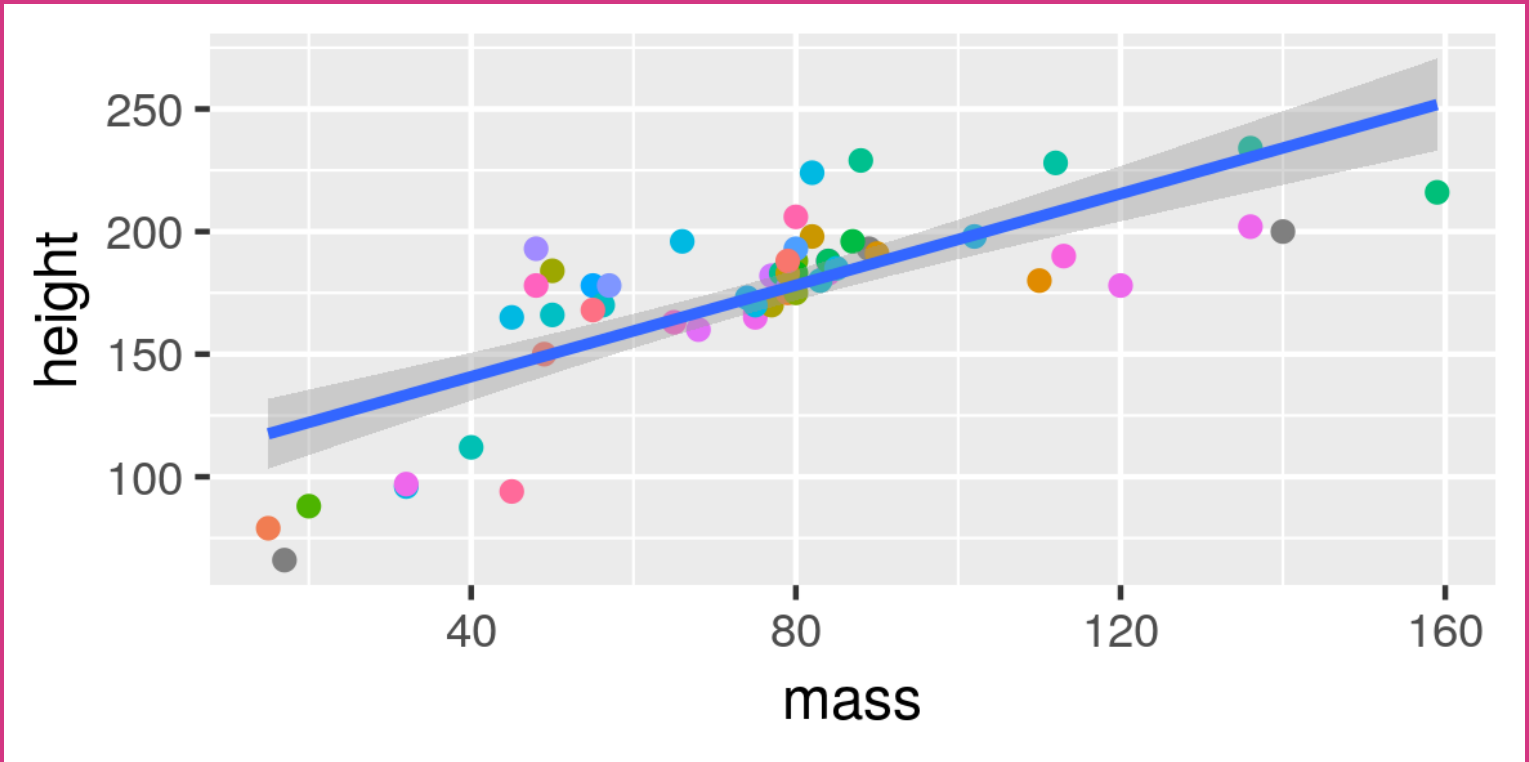
```
starwars |>
    filter(mass < 1000) |>
    ggplot() +
      aes(x = mass,
          y = height) +
      geom_point()
```



```r
starwars |>
    filter(mass < 1000) |>
    ggplot() +
      aes(x = mass,
          y = height) +
      geom_point(aes(color = homeworld))
```



```r
starwars |>
    filter(mass < 1000) |>
    ggplot() +
      aes(x = mass, y = height) +
    geom_point(aes(color = homeworld)) +
    geom_smooth(method = "lm") +
    theme(legend.position = "none")
```



Dividing the plot into subplots...

Facets

Facets divide a plot into subplots based on the values of one or more discrete variables.

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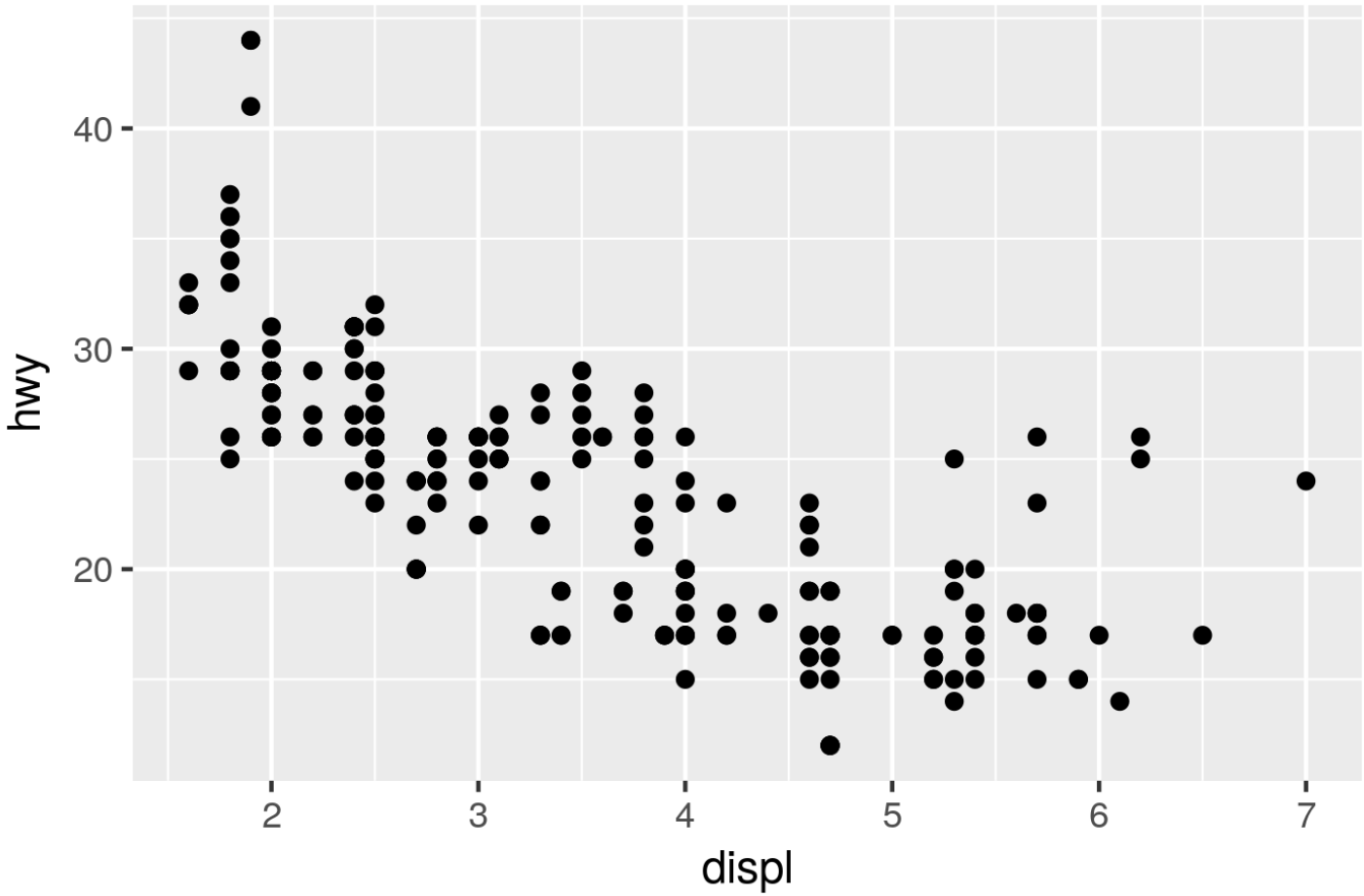

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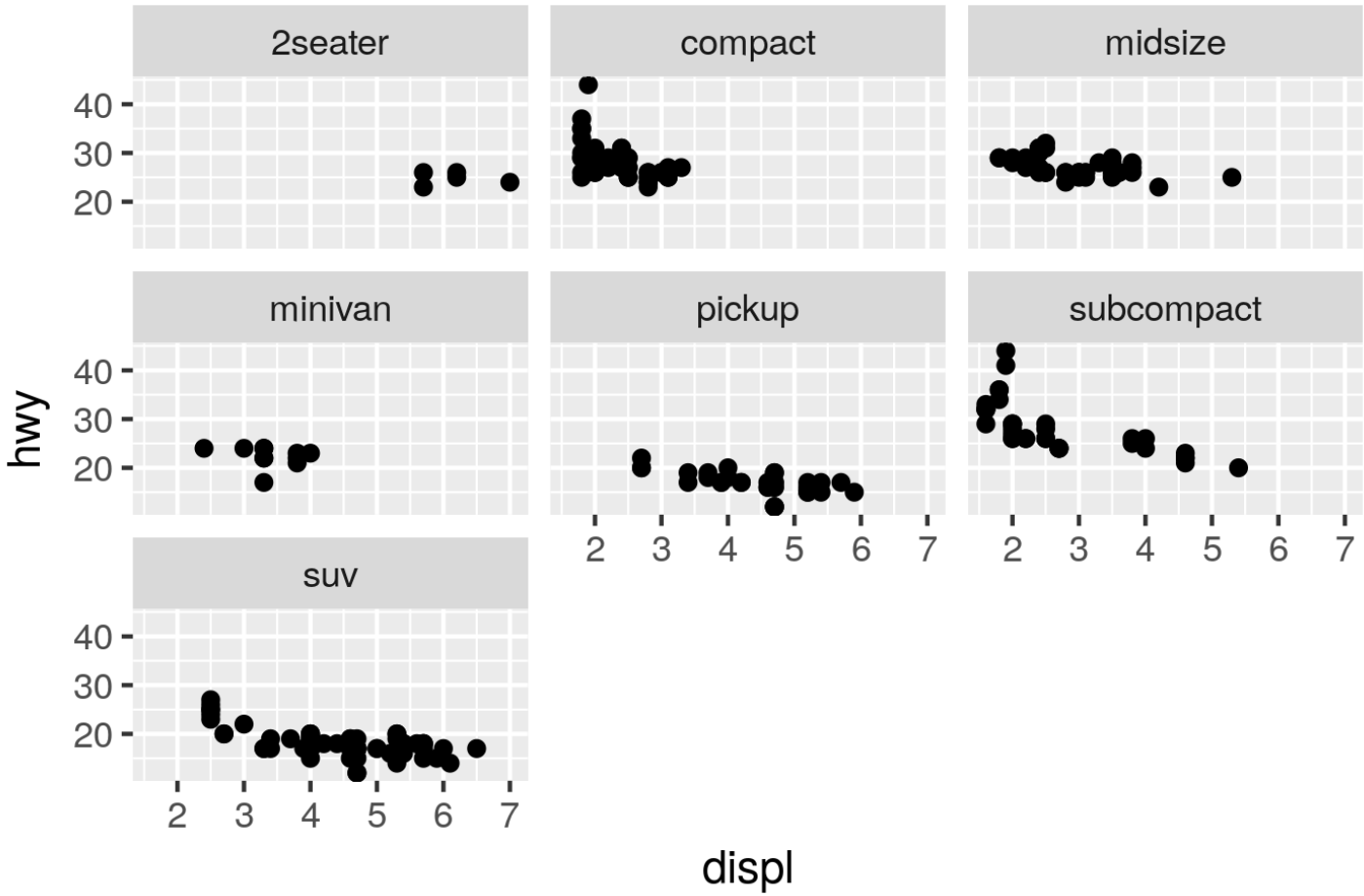
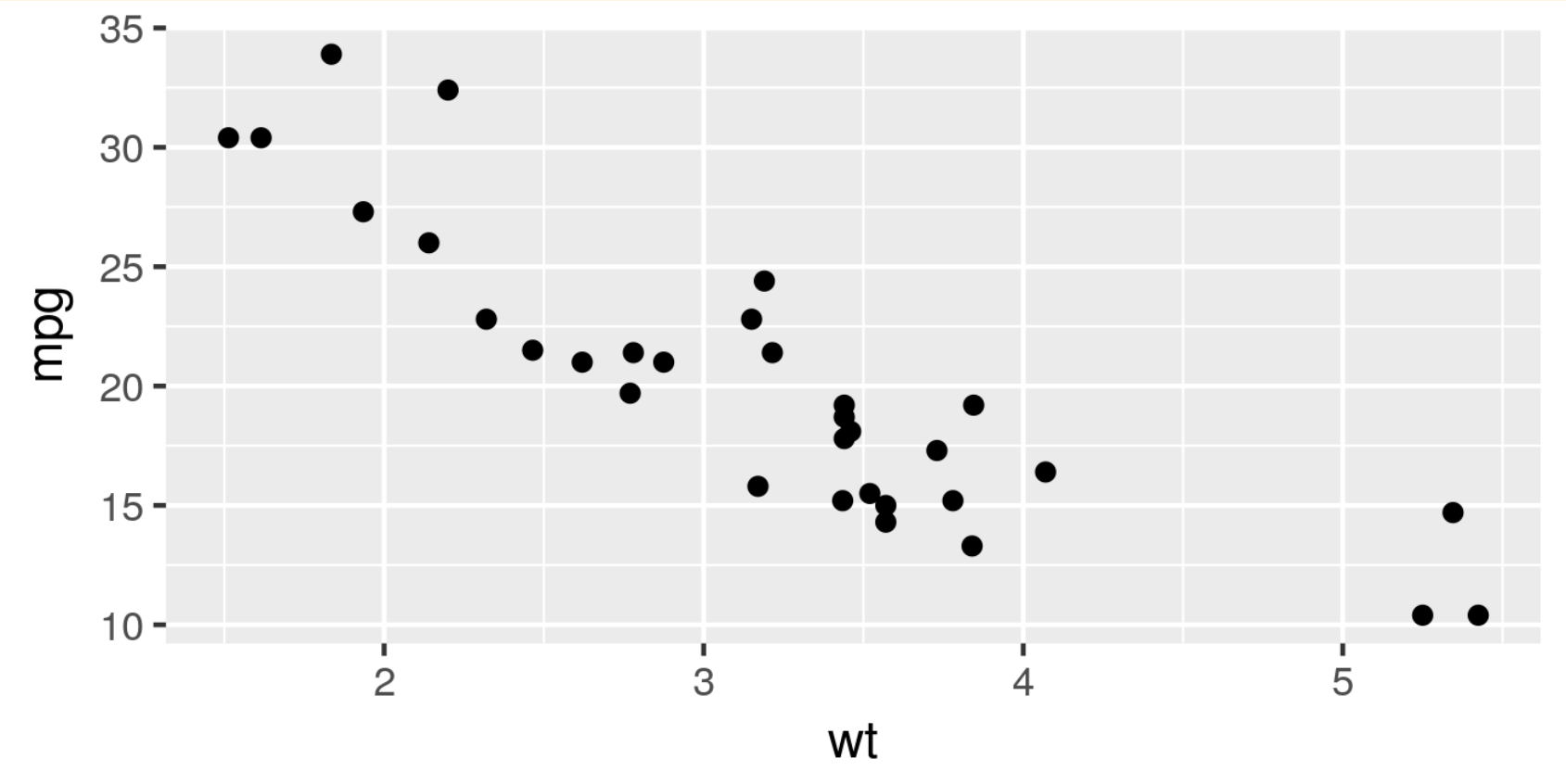
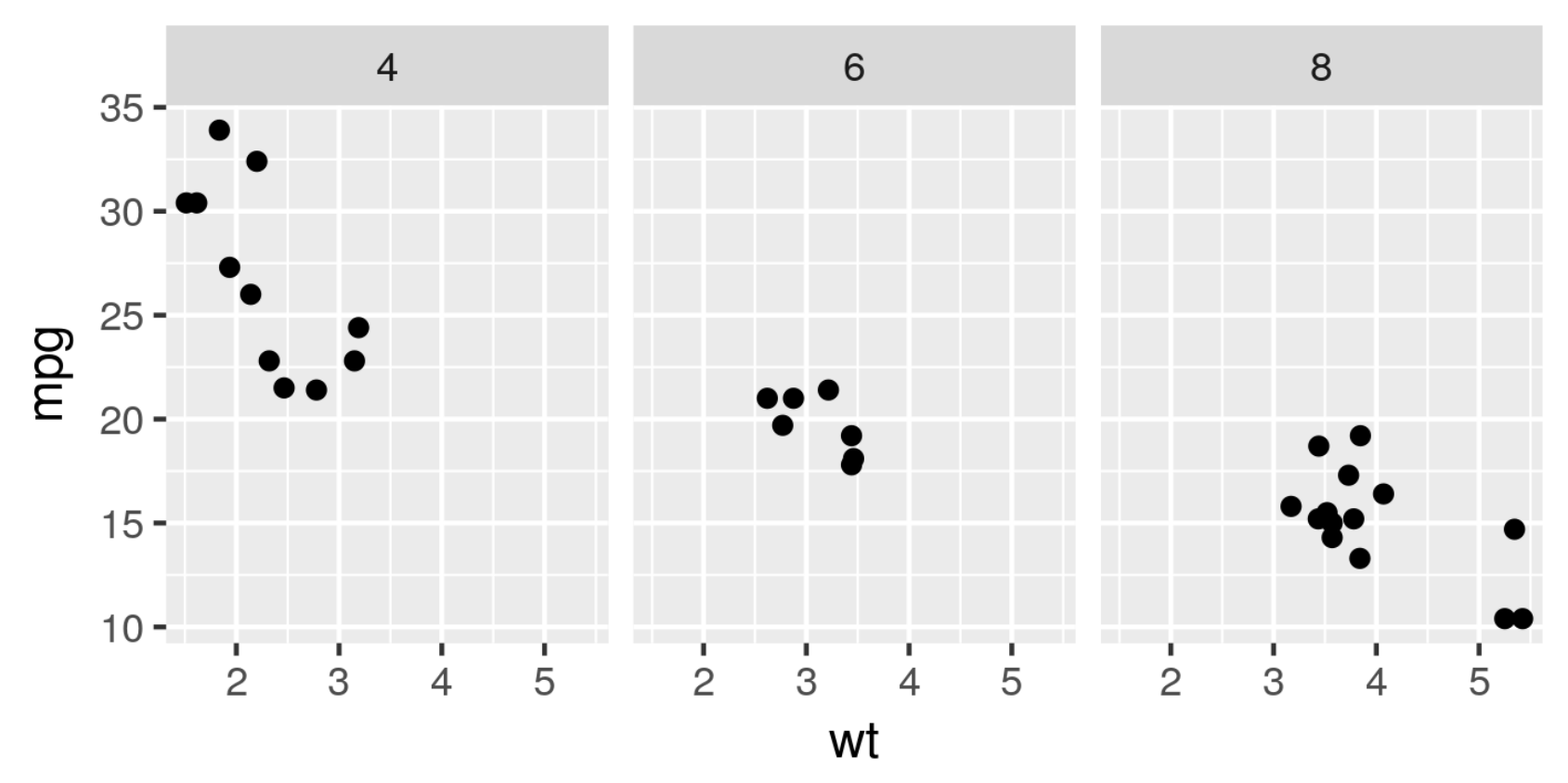


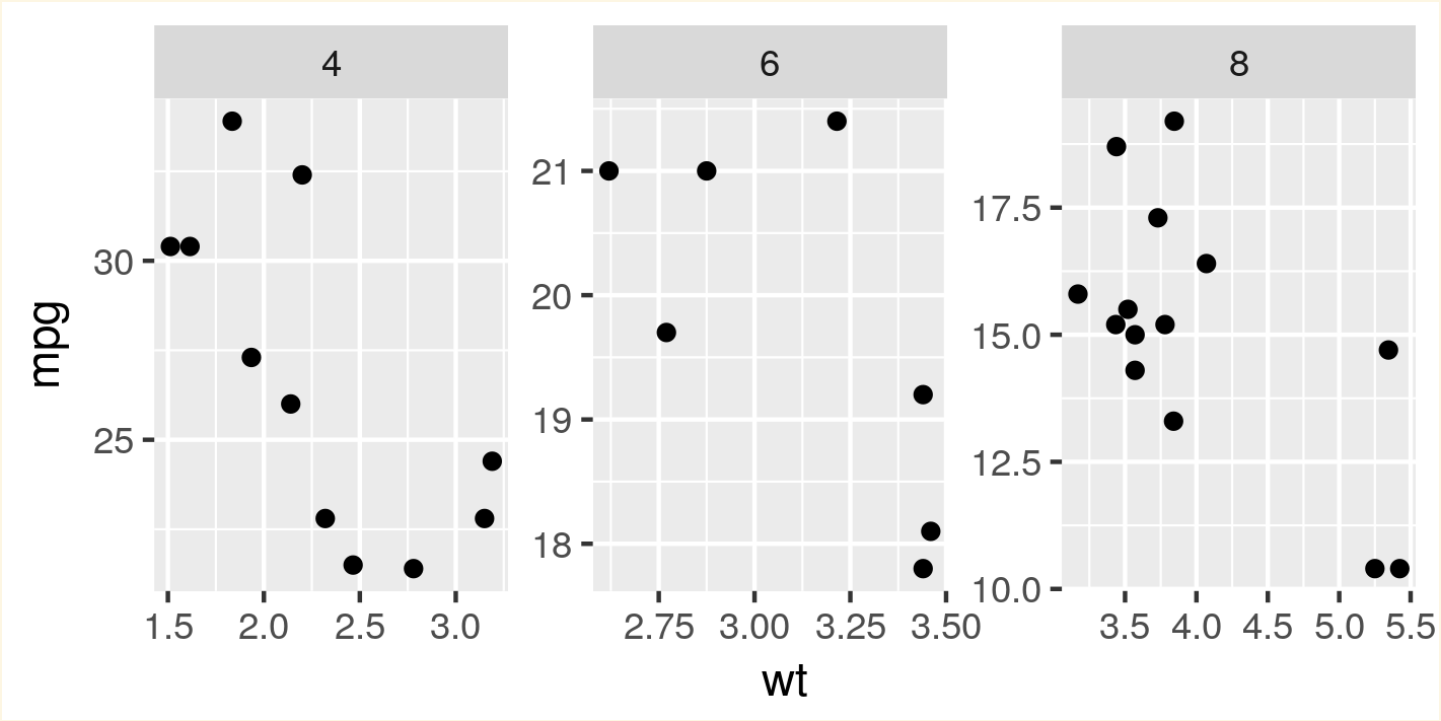
```
ggplot(mtcars,
       aes(x = wt, y = mp)) +
       geom_point()
```



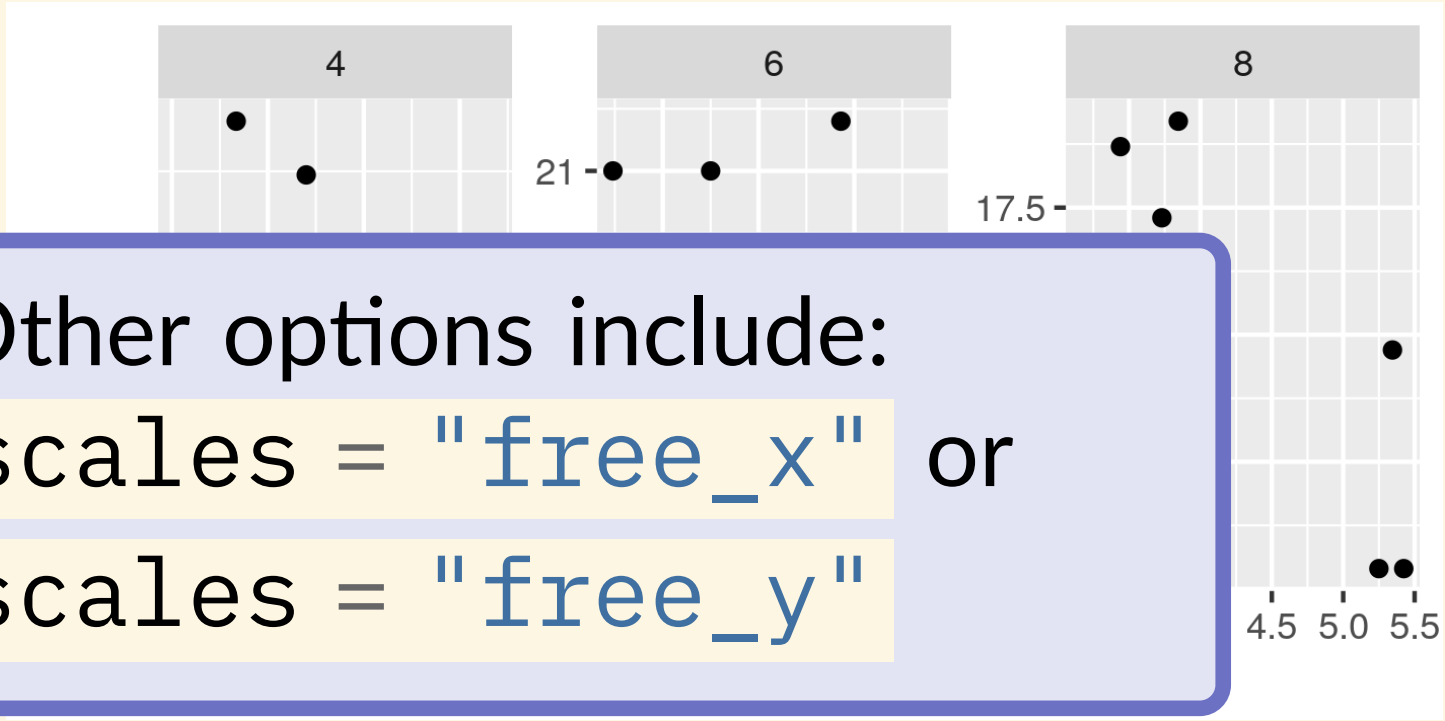
```r
mtcars |>
  ggplot() +
    aes(x = wt, y = mp) +
    geom_point() +
    facet_wrap(~ cyl)
```



```
mtcars |>
  ggplot() +
    aes(x = wt, y = mp) +
    geom_point() +
    facet_wrap(~ cyl)
                scales = "free")
```



```
mtcars |>
  ggplot() +
    aes(x = wt, y = mp) +
    geom_point() +
    facet_wrap(~ cyl)
                  scales = "free")
```



Other options include:

`scales = "free_x"` or

`scales = "free_y"`

Practical: adding subplots with `facet_grid`

1. Load the `mtcars` dataset.

   `data(mtcars)`

2. Create a scatterplot of `wt` against `mpg`.

   Hint: `geom_point()`

3. Color the points by `cyl`

   Hint: `aes(color = ...)`

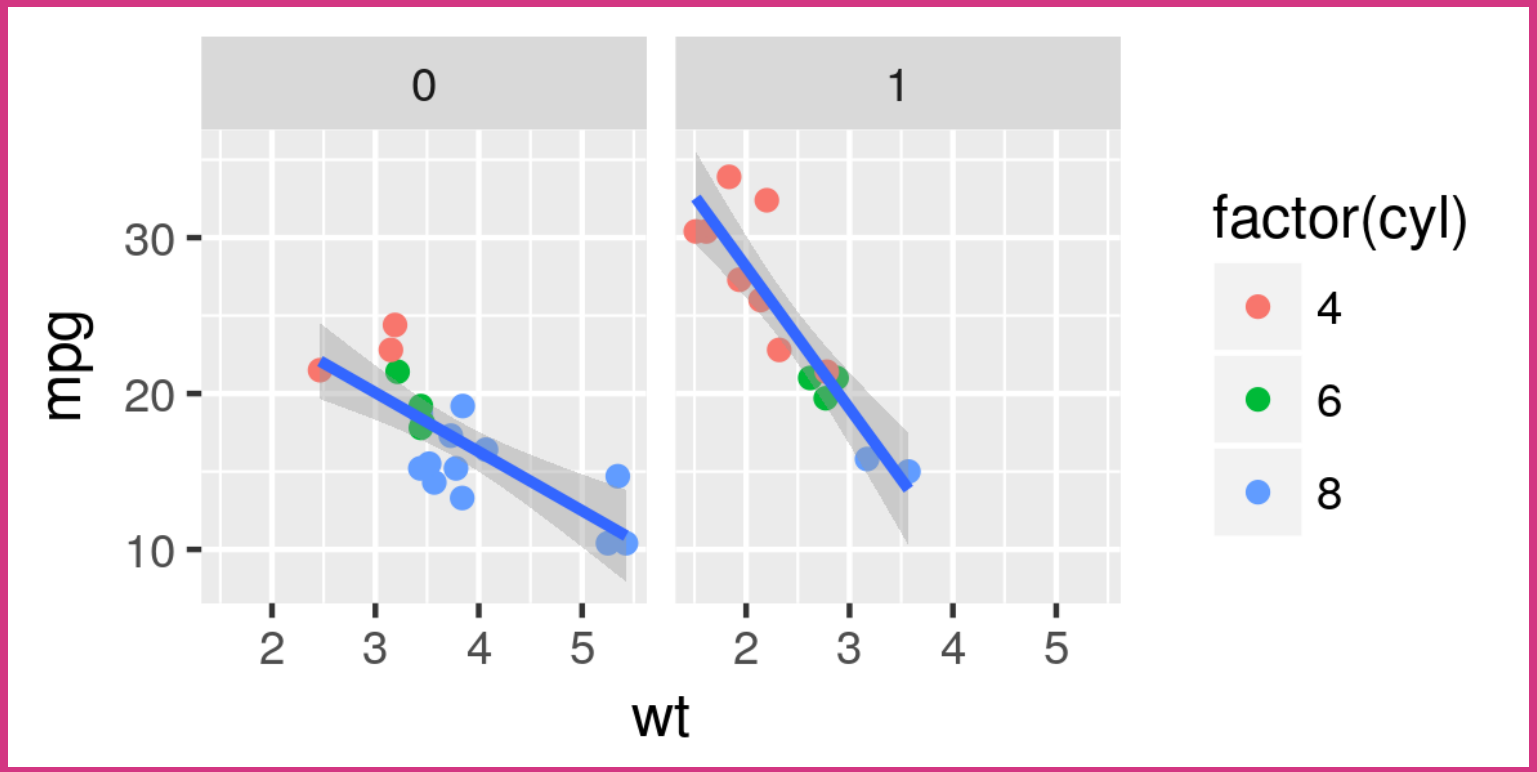
4. Add a line-of-best-fit.

   Hint: `geom_smooth(method = "lm")`

5. Produce a grid with separate plots for automatic and manual cars (`am`).

   Hint: `facet_wrap(...)`

```
mtcars |>
   ggplot() +
    aes(x = wt, y = mpg) +
    geom_point(aes(color = factor(cyl))) +
    geom_smooth(method = "lm") +
    facet_wrap(~ am)
```



Things you should know…

You can save plots with `ggsave`.

```
# Create a plot, store as an object 'p'
p <- ggplot(df) +
       aes(x = weight,
           y = height) +
       geom_point()

# Save as a PNG image
ggsave(p,
       filename = "scatterplot.png"
       dev = "png",
       dpi = "300",
       width = 7,
       heigth = 5)
```

You can label plots with `labs()`.

```
ggplot(df) +
  aes(x = weight,
      y = height) +
  geom_point() +
  labs(title = "My plot title",
       x = "A label for the x-axis",
       y = "A label for the y-axis")
```

See `?labs` for more.

You can adjust the axis range with `coord_cartesian`.

```
ggplot(df) +
  aes(x = weight,
      y = height) +
  geom_point() +
  coord_cartesian(xlim = c(0, 100),
                  ylim = c(10, 20))
```

Read this section of the ggplot2 book to learn more:

https://ggplot2-book.org/scales-guides.html

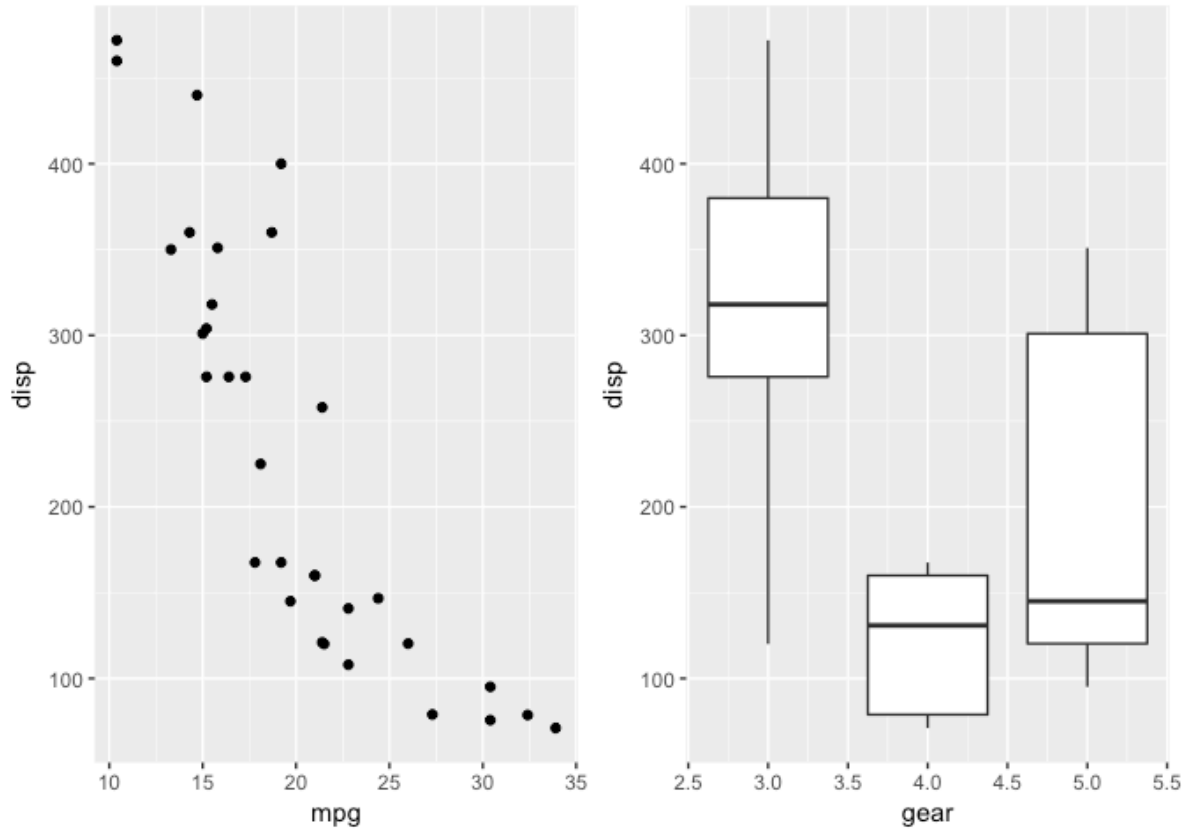
You can write functions that create plots.

Suppose we have 10 datasets; we want a plot for each one.

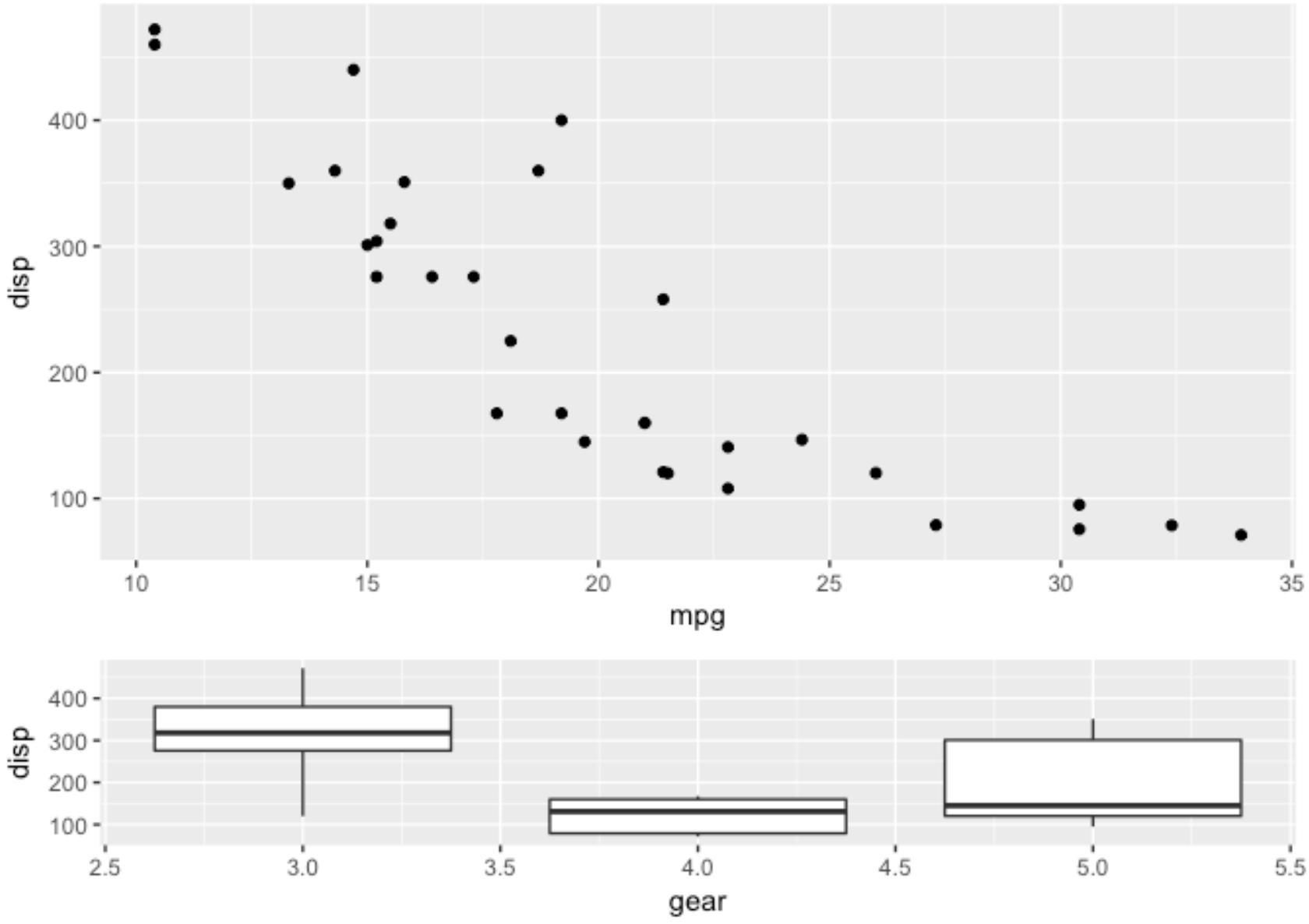
```
# A function to plot a single dataset
draw_the_plot <- function(data) {
   data |>
     ggplot() +
     aes(x = weight,
         y = height) +
     geom_point()
 }

for (d in many_datasets) {
  p <- draw_plot(d)
  ggsave(p, ...)
}
```

Combine multiple plots with patchwork

```
library(patchwork)
p1 <- ggplot(mtcars) + ... + geom_point()
p2 <- ggplot(mtcars) + ... + geom_boxplot()
p1 + p2
```



```
p1 + p2 + plot_layout(ncol = 1, heights = c(3, 1))
```



https://patchwork.data-imaginist.com

Wrapping up

- Build a plot by combining different components.
    1. Data
    2. Aesthetics
    3. Coordinates
    4. Facets
    5. Theme
- Make sure your data are tidy first.
- Save with `ggsave`.

Have fun!


ggplot2:
Build a data
MASTERPIECE
THEMES
GEOMS
aes
fill
color
ganimate
plotly
HORST '18