# Tidyverse Workshop

## Data visualisation with ggplot2


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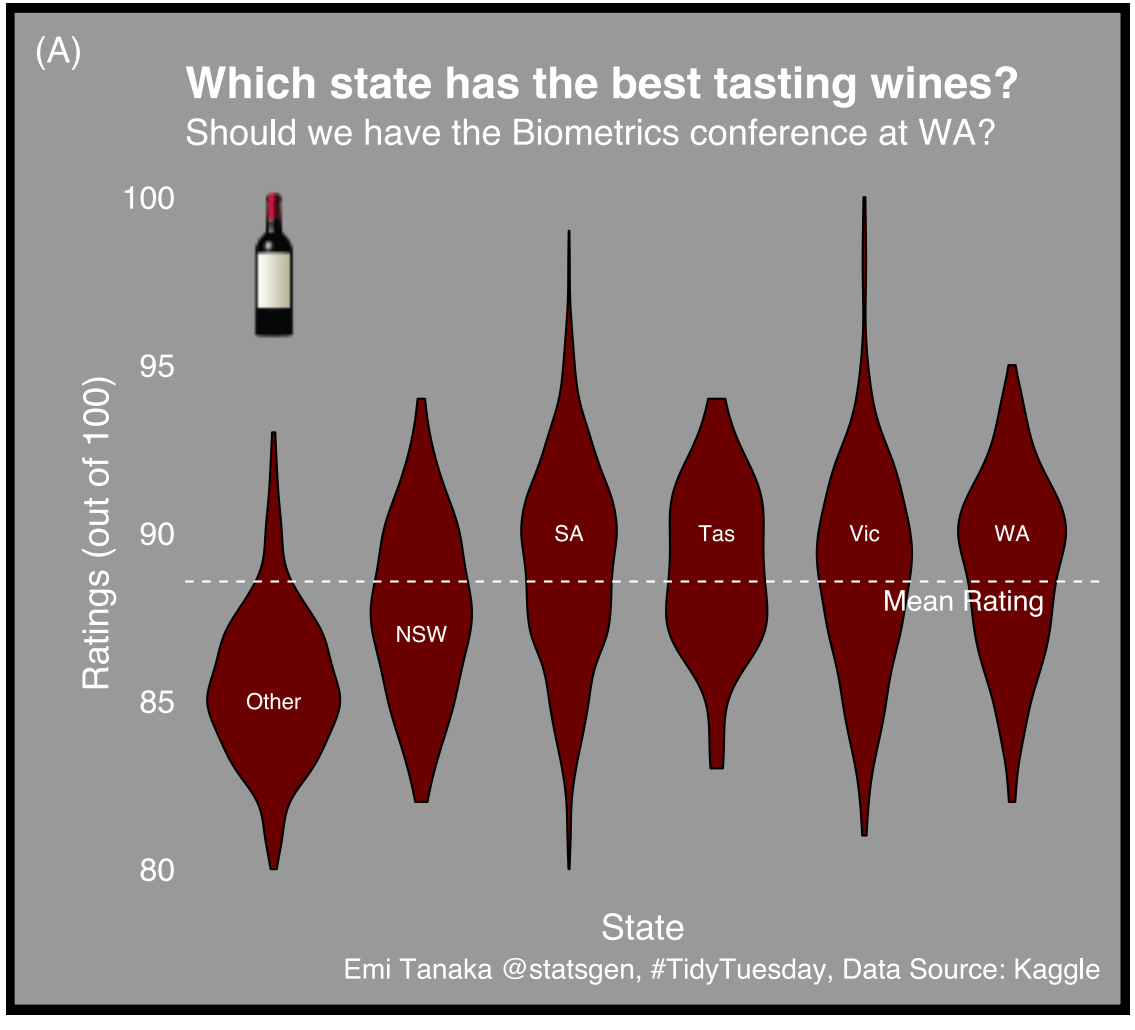
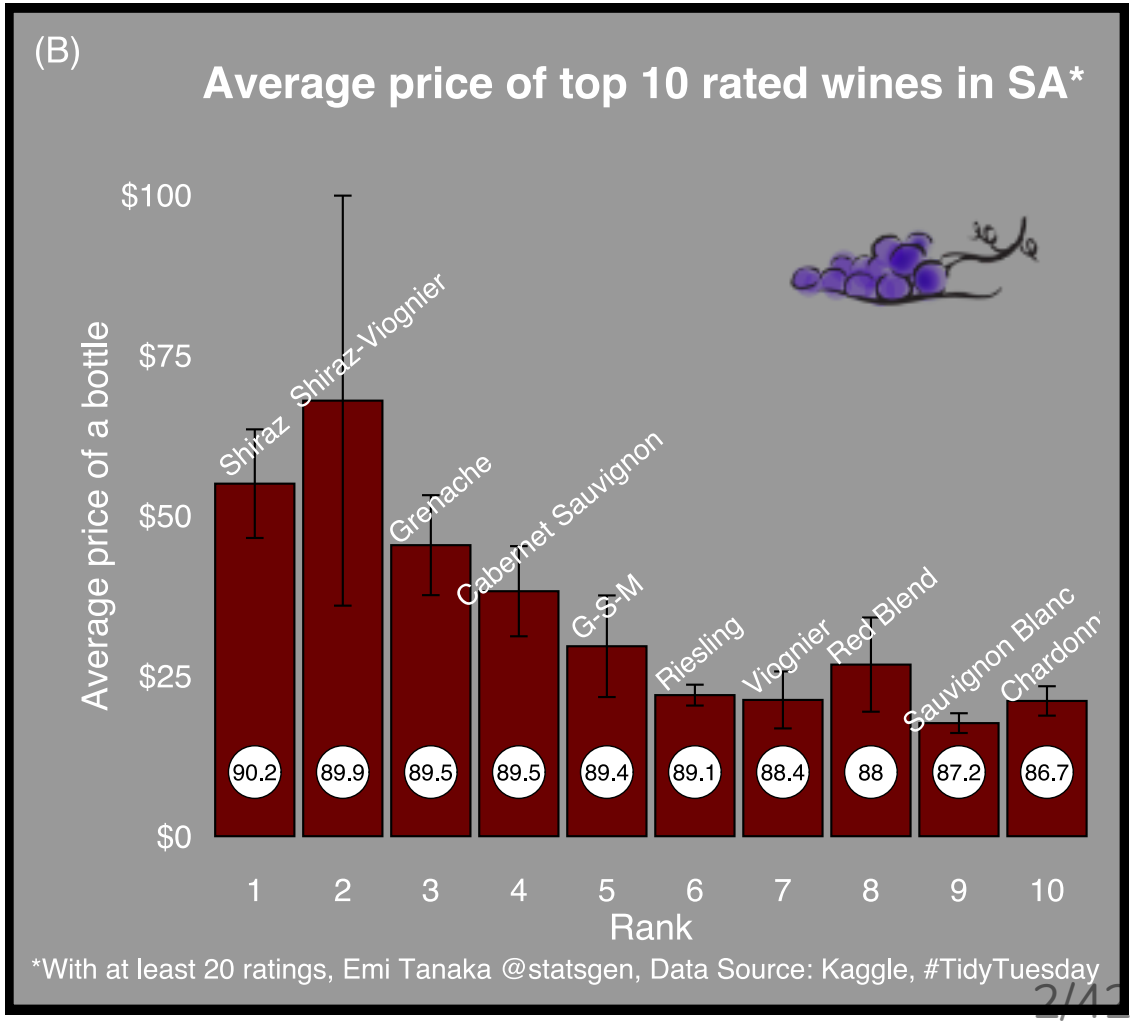
1st Dec 2019 @ Biometrics by the Botanic Gardens | Adelaide, Australia

# 🎯 Aim: draw beautiful plots like this using (layered) grammar of graphics



# Basic structure of ggplot: 3 🔑 components

```
ggplot(data = <data>, mapping = aes(<mappings>)) +
    <layer>()
```

1. **data**,
2. a set of **aesthetic** mappings between variables in the data and visual properties, and
3. at least one **layer** which describes how to render each observation.

# Data: Classic iris dataset

`iris` is a built-in dataset in R - type `iris` to your console and press **`Enter`**.

Image source: suruchifialoke.com

```
skimr::skim(iris)
```

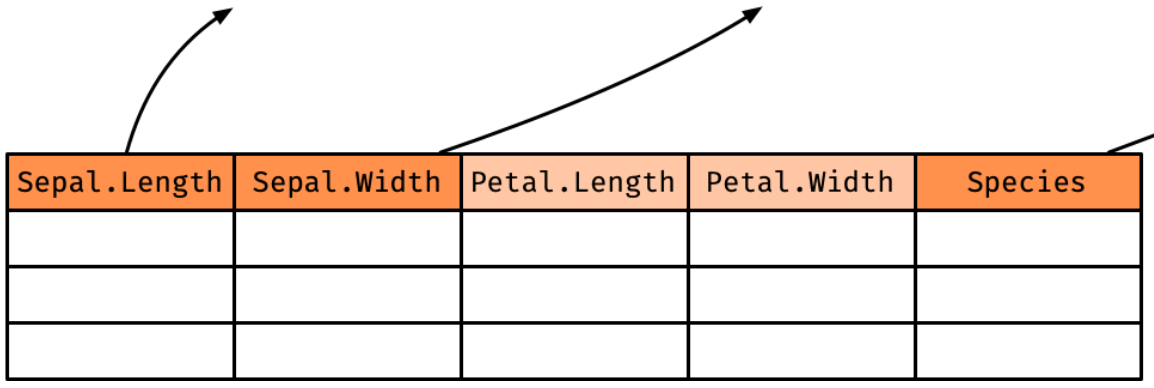
```
  Skim summary statistics
   n obs: 150
   n variables: 5

  ── Variable type:factor ──────────────────────────────────────────────────────
   variable missing complete   n n_unique                       top_counts ordered
    Species       0      150 150        3 set: 50, ver: 50, vir: 50, NA: 0   FALSE

  ── Variable type:numeric ─────────────────────────────────────────────────────
      variable missing complete   n mean   sd  p0 p25  p50 p75 p100     hist
  Petal.Length       0      150 150 3.76 1.77 1   1.6 4.35 5.1  6.9 ▁▁▂▅▇
   Petal.Width       0      150 150 1.2  0.76 0.1 0.3 1.3  1.8  2.5 ▁▂▅▃▃
  Sepal.Length       0      150 150 5.84 0.83 4.3 5.1 5.8  6.4  7.9 ▂▅▇▆▃
   Sepal.Width       0      150 150 3.06 0.44 2   2.8 3    3.3  4.4 ▁▃▇▃▁
```

# Aesthetic mappings: `aesthetic = column`

```
aes(x = Sepal.Length, y = Sepal.Width, color = Species)
```




- `Sepal.Length` is mapped to the `x` coordinate
- `Sepal.Width` is mapped to the `y` coordinate
- `Species` is mapped to the `color`

# Layer

Each layer has a

- `geom` - the geometric object to use display the data,
- `stat` - statisitcal transformations to use on the data,
- `data` and `mapping` which is usually inherited from `ggplot` object,

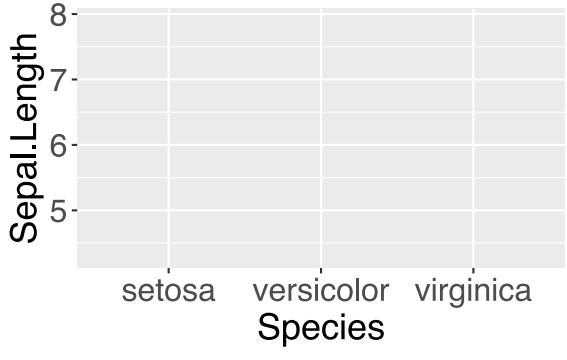
Further specifications are provided by `position` adjustment, `show_legend` and so on.

# Hidden argument names in ggplot

```
ggplot(data = <data>, mapping = aes(x = <x>, y = <y>, <other mappings>))
```

```
ggplot(iris, aes(Species))
```


```
ggplot(iris, aes(Species, Sepal.Length))
```




- No need to write explicitly write out `data =`, `mapping =`, `x =`, and `y =` each time in `ggplot`.
- `ggplot` code in the wild often omit these argument names.
- But position needs to be correct if argument name not specified!
- If no layer is specified, then plot is `geom_blank()`.

# Example layer: geom_point()

The <layer> is usually created by a function preceded by geom_ in its name.

```
ggplot(iris, aes(Species, Sepal.Length)) +
  geom_point()
```

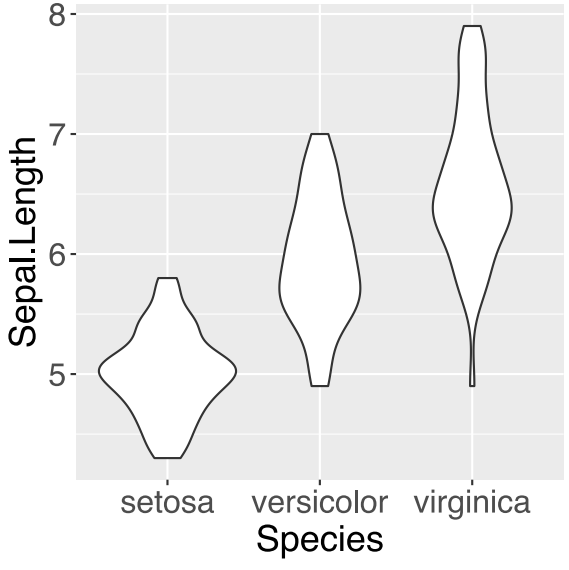
is a shorthand for

```
ggplot(iris, aes(Species, Sepal.Length)) +
  layer(geom = "point",
        stat = "identity", position = "identity",
        params = list(na.rm = FALSE))
```

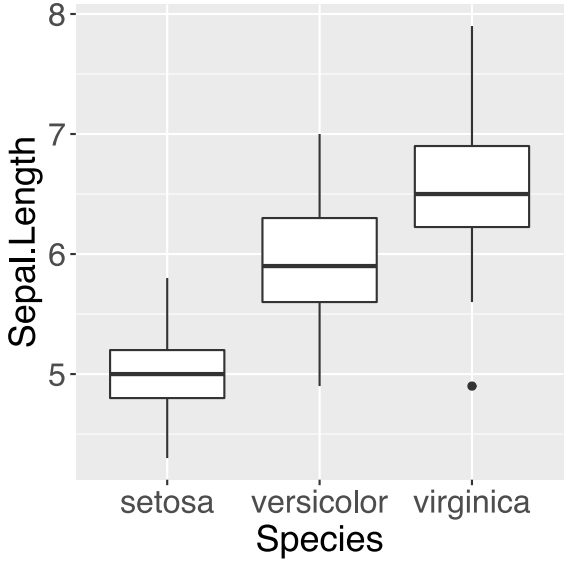
# Different geometric objects

```
p <- ggplot(iris, aes(Species, Sepal.Length))
```

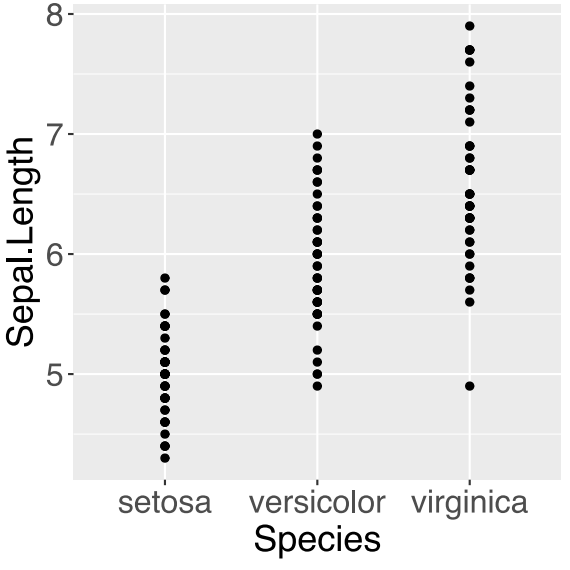
```
p + geom_violin()
```




```
p + geom_boxplot()
```




```
p + geom_point()
```

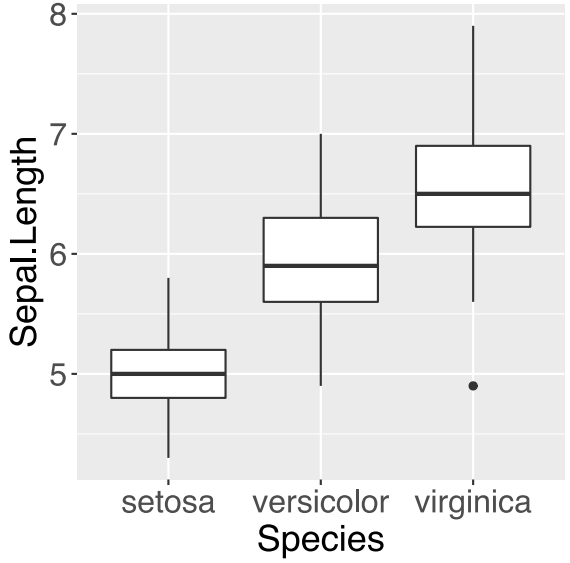


# geom

| geom | Description |
|---|---|
| geom_abline, geom_hline, geom_vline | Reference lines: horizontal, vertical, and diagonal |
| geom_bar, geom_col | Bar charts |
| geom_bin2d | Heatmap of 2d bin counts |
| geom_blank | Draw nothing |
| geom_boxplot | A box and whiskers plot (in the style of Tukey) |
| geom_contour | 2d contours of a 3d surface |
| geom_count | Count overlapping points |
| geom_density | Smoothed density estimates |
| geom_density_2d, geom_density2d | Contours of a 2d density estimate |
| geom_dotplot | Dot plot |

# Statistical transformation

```
g <- ggplot(iris, aes(Species, Sepal.Length)) + geom_boxplot()
```




- The y-axis is not the raw data!
- It is plotting a statistical transformation of the y-values.
- Under the hood, data is transformed (including x factor input to numerical values).

```
layer_data(g, 1)
```

```
  ymin lower middle upper ymax outliers notchupper notchlower x |
1  4.3 4.800    5.0   5.2  5.8             5.089378   4.910622 1
2  4.9 5.600    5.9   6.3  7.0             6.056412   5.743588 2
3  5.6 6.225    6.5   6.9  7.9      4.9    6.650826   6.349174 3
```

# Statistical transformation: stat_bin

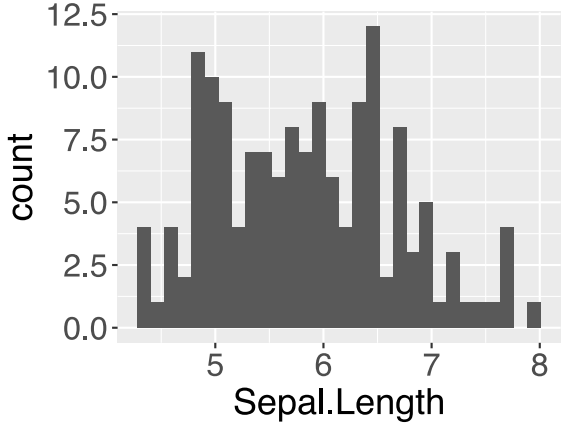
For `geom_histogram`, default is `stat = "bin"`.

For `stat_bin`, default is `geom = "bar"`.

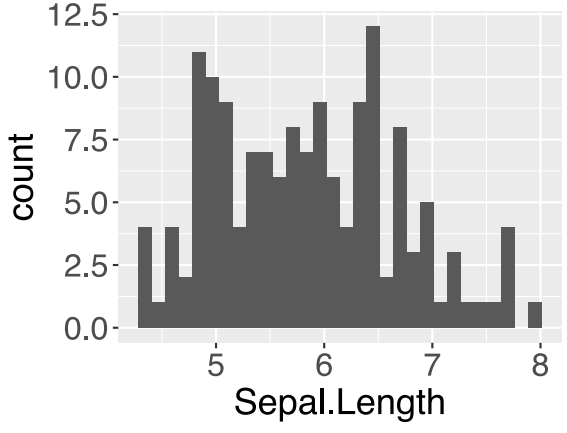
Every `geom` has a `stat` and vice versa.

```
p <- ggplot(iris, aes(Sepal.Length))
```

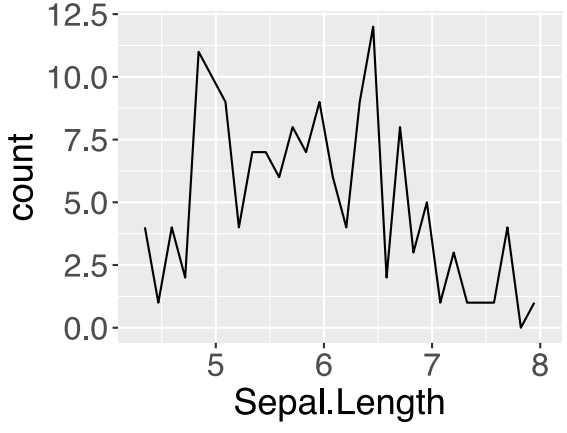
```
p + geom_histogram()
```




```
p + stat_bin(geom = "bar")
```




```
p + stat_bin(geom = "line")
```



# Using statistical transformations

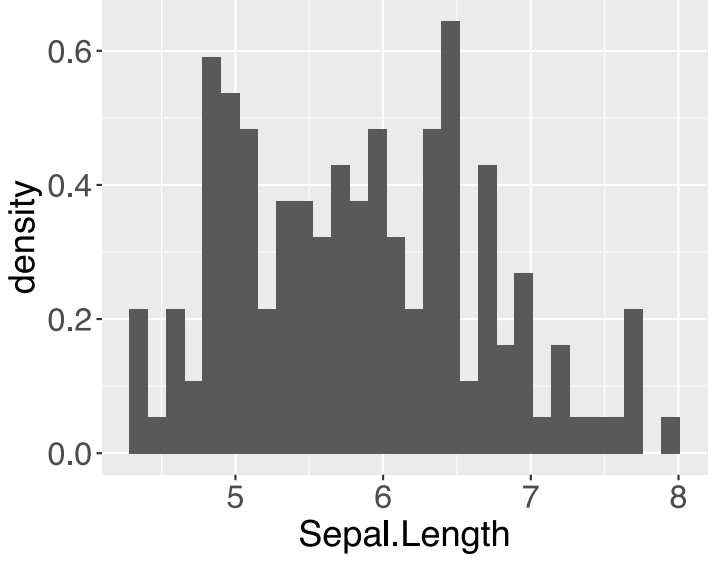
To map an aesthestic to computed statistical variable (say called `var`), you can refer to it by either `stat(var)` or `..var..`.

---

`stat = "bin"`

| | x | count | density |
|---|---|---|---|
| 1 | 4.344828 | 4 | 0.2148148 |
| 2 | 4.468966 | 1 | 0.0537037 |
| 3 | 4.593103 | 4 | 0.2148148 |
| 4 | 4.717241 | 2 | 0.1074074 |
| 5 | 4.841379 | 11 | 0.5907407 |
| 6 | 4.965517 | 10 | 0.5370370 |
| 7 | 5.089655 | 9 | 0.4833333 |
| 8 | 5.213793 | 4 | 0.2148148 |
| 9 | 5.337931 | 7 | 0.3759259 |
| 10 | 5.462069 | 7 | 0.3759259 |
| 11 | 5.586207 | 6 | 0.3222222 |

```
p + geom_histogram(aes(y = stat(density) ))
```




```
p + geom_histogram(aes(y = ..density.. ))
```

# stat

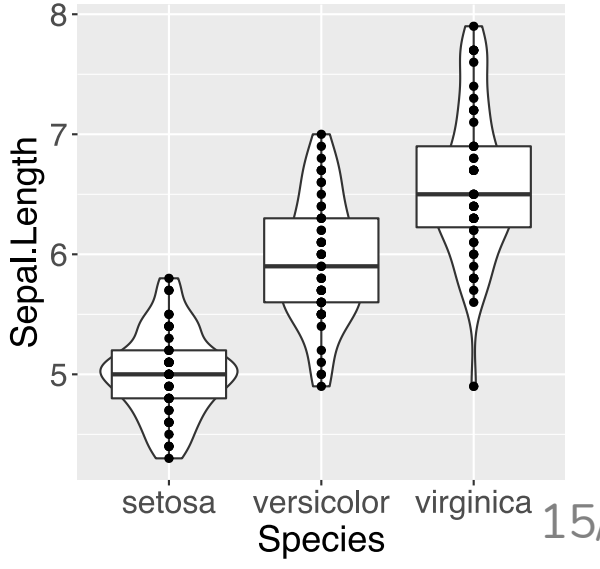
| stat | Description |
|---|---|
| stat_count | Bar charts |
| stat_bin_2d, stat_bin2d | Heatmap of 2d bin counts |
| stat_boxplot | A box and whiskers plot (in the style of Tukey) |
| stat_contour | 2d contours of a 3d surface |
| stat_sum | Count overlapping points |
| stat_density | Smoothed density estimates |
| stat_density_2d, stat_density2d | Contours of a 2d density estimate |
| stat_bin_hex, stat_binhex | Hexagonal heatmap of 2d bin counts |
| stat_bin | Histograms and frequency polygons |
| stat_qq_line, stat_qq | A quantile-quantile plot |

# Add multiple layers

```
ggplot(<data>, aes(<mappings>)) +
  <layer>() +
  <layer>() +
  <layer>()
```

Each layer inherits mapping and data from `ggplot` by default.

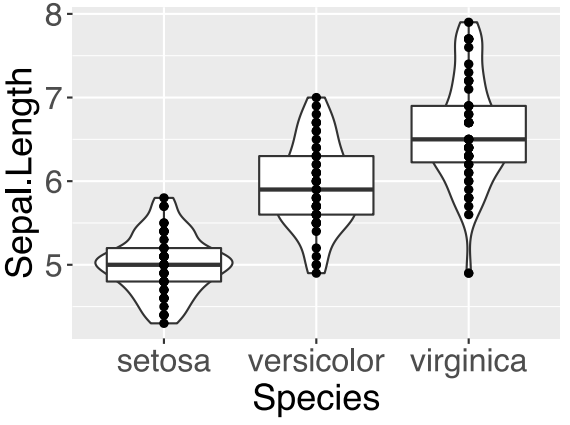
```
ggplot(data = iris, aes(x = Species, y = Sepal.Length)) +
  geom_violin() +
  geom_boxplot() +
  geom_point()
```



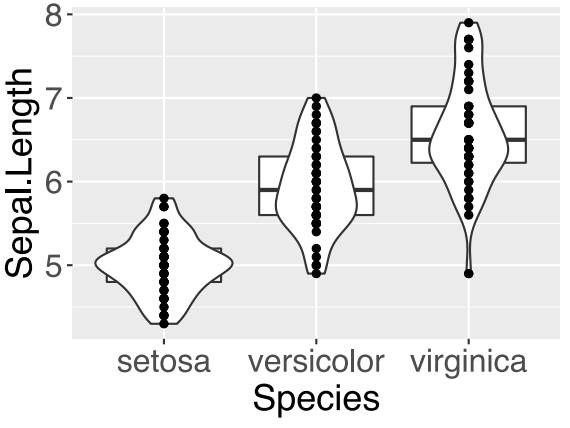
# Order of the layers matters!

Boxplot and violin plot order are switched around.

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




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

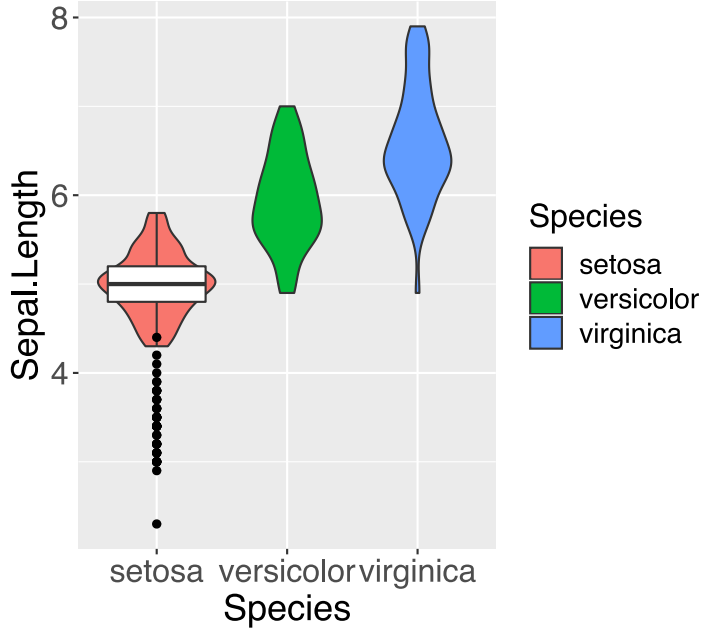


# Layer-specific data and aesthetic mappings

```
ggplot(<data>, aes(<mappings>)) +
  <layer>(aes(<mappings>)) +
  <layer>(data = <data>) +
  <layer>(aes(<mappings>), <data>)
```

For each layer, aesthetic and/or data can be overwritten.

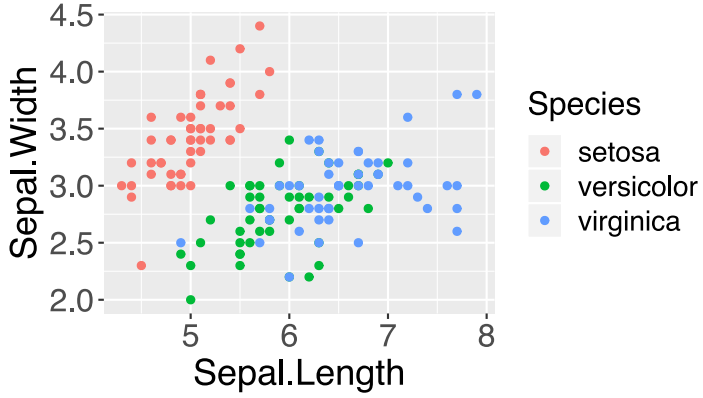
```
ggplot(iris, aes(Species, Sepal.Length)) +
  geom_violin(aes(fill = Species)) +
  geom_boxplot(data = filter(iris, Species=="setosa")) +
  geom_point(data = filter(iris, Species=="setosa"),
             aes(y = Sepal.Width))
```



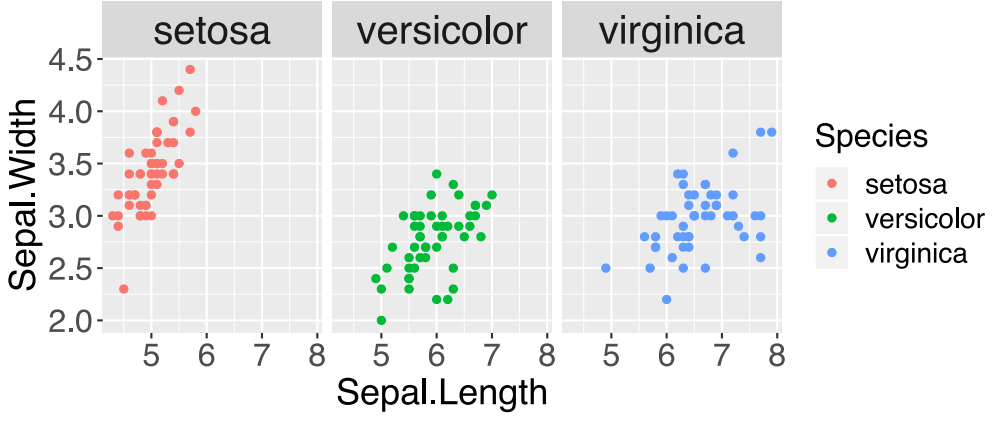
# Facetting

```
g <- ggplot(iris, aes(Sepal.Length, Sepal.Width, color = Species)) + geom_point()
```

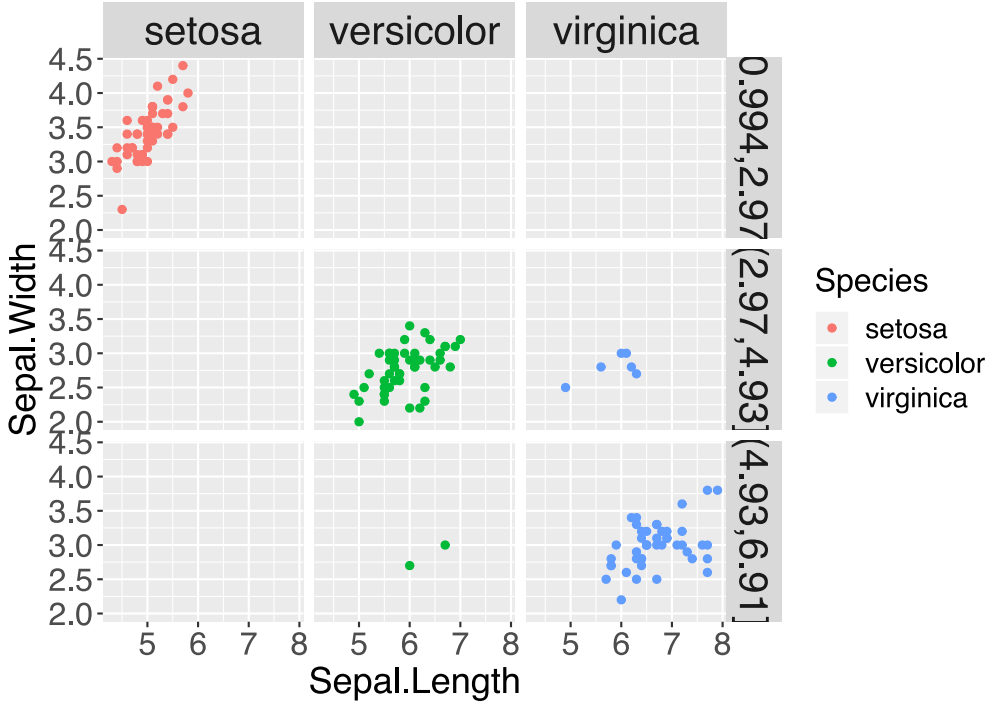
```
g
```

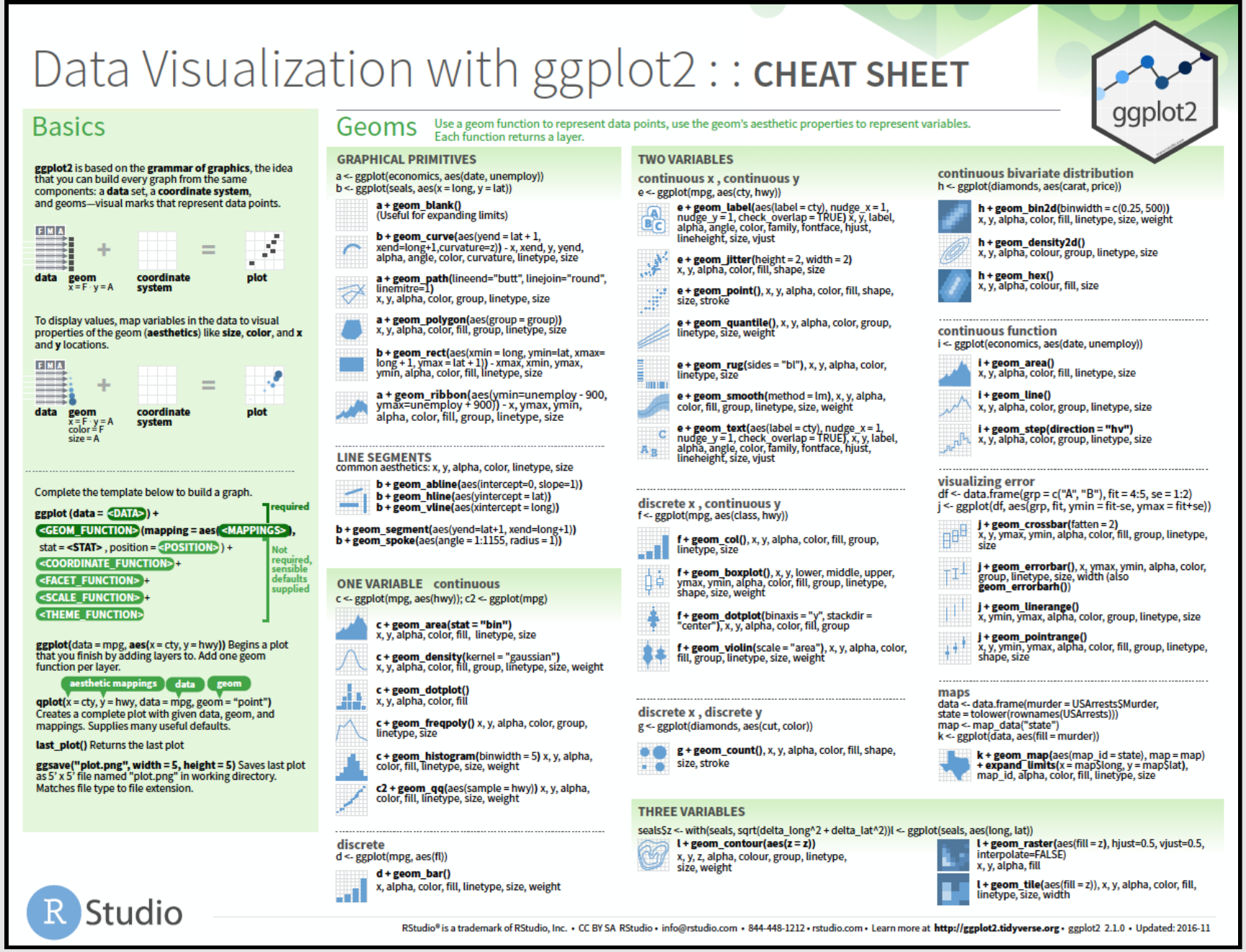



```
g + facet_wrap(~Species)
```




```
g + facet_grid(cut(Petal.Length, 3) ~ Species)
```





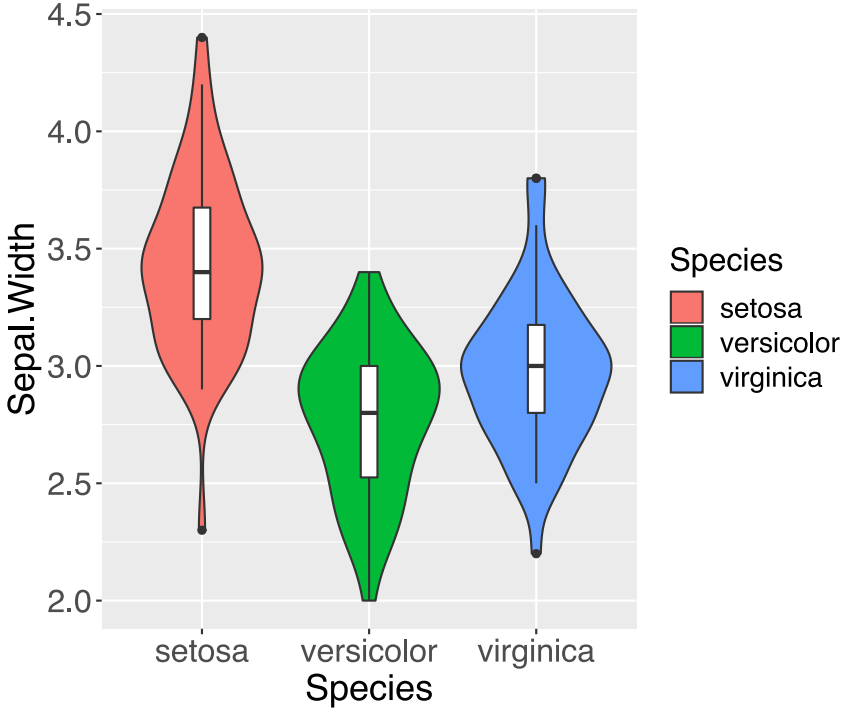

HELP!

- RStudio > Help > Cheatsheets
- R4DS Community Slack
- Twitter with hastag #rstats
- RStudio Community
- Stackoverflow

# Recreate-the-plot Game

```
colnames(iris)
```

```
[1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Width"  "Species"
```




What are the `mappings` and `geoms`?

- `x = ?`
- `y = ?`
- `color = ?`
- `fill = ?`
- `geom_???`
- other?

Open and go through:

`challenge-01-recreate-ggplot.Rmd`

For answers go to (but don't look until trying!):

`challenge-01-recreate-ggplot-solution.Rmd`

20:00

# Diamonds data

```
skimr::skim(diamonds)
```

```
  Skim summary statistics
   n obs: 53940
   n variables: 10

  ── Variable type:factor ──────────────────────────────────────────────────────
   variable missing complete     n n_unique                                 top_counts ordered
    clarity       0    53940 53940        8  SI1: 13065, VS2: 12258, SI2: 9194, VS1: 8171    TRUE
      color       0    53940 53940        7           G: 11292, E: 9797, F: 9542, H: 8304    TRUE
        cut       0    53940 53940        5 Ide: 21551, Pre: 13791, Ver: 12082, Goo: 4906    TRUE

  ── Variable type:integer ─────────────────────────────────────────────────────
   variable missing complete     n    mean      sd  p0 p25  p50     p75  p100     hist
      price       0    53940 53940 3932.8 3989.44 326 950 2401 5324.25 18823 ▇▂▁▁▁

  ── Variable type:numeric ─────────────────────────────────────────────────────
   variable missing complete     n  mean   sd   p0   p25   p50   p75  p100     hist
      carat       0    53940 53940  0.8  0.47  0.2  0.4   0.7   1.04  5.01 ▇▃▁▁▁
      depth       0    53940 53940 61.75 1.43 43   61    61.8  62.5  79   ▁▁▂▇▁
      table       0    53940 53940 57.46 2.23 43   56    57    59    95   ▁▇▇▁▁
          x       0    53940 53940  5.73 1.12  0    4.71  5.7   6.54 10.74 ▁▂▇▇▃
          y       0    53940 53940  5.73 1.14  0    4.72  5.71  6.54 58.9  ▇▁▁▁▁
          z       0    53940 53940  3.54 0.71  0    2.91  3.53  4.04 31.8  ▇▃▁▁▁
```

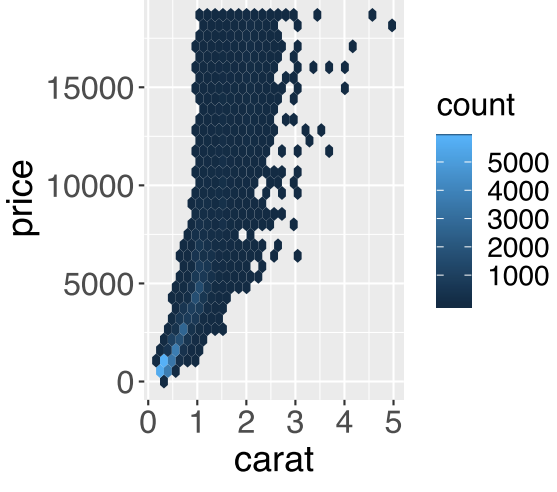
# Scales

Scales control the mapping from data to aesthetics.

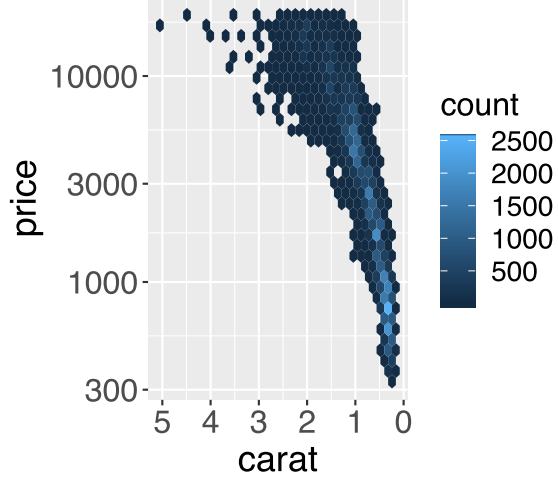
```
scale_<aesthestic>_<type>
```

```
g <- ggplot(diamonds, aes(carat, price) ) + geom_hex()
```

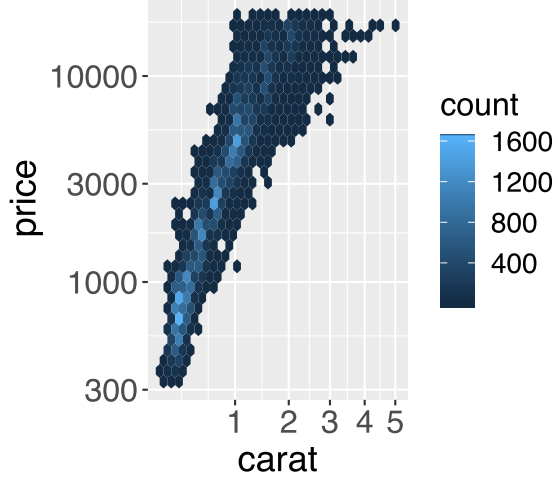
```
g + scale_y_continuous() +
  scale_x_continuous()
```




```
g + scale_x_reverse() +
  scale_y_continuous(trans="log10")
```




```
g + scale_y_log10() +
  scale_x_sqrt()
```



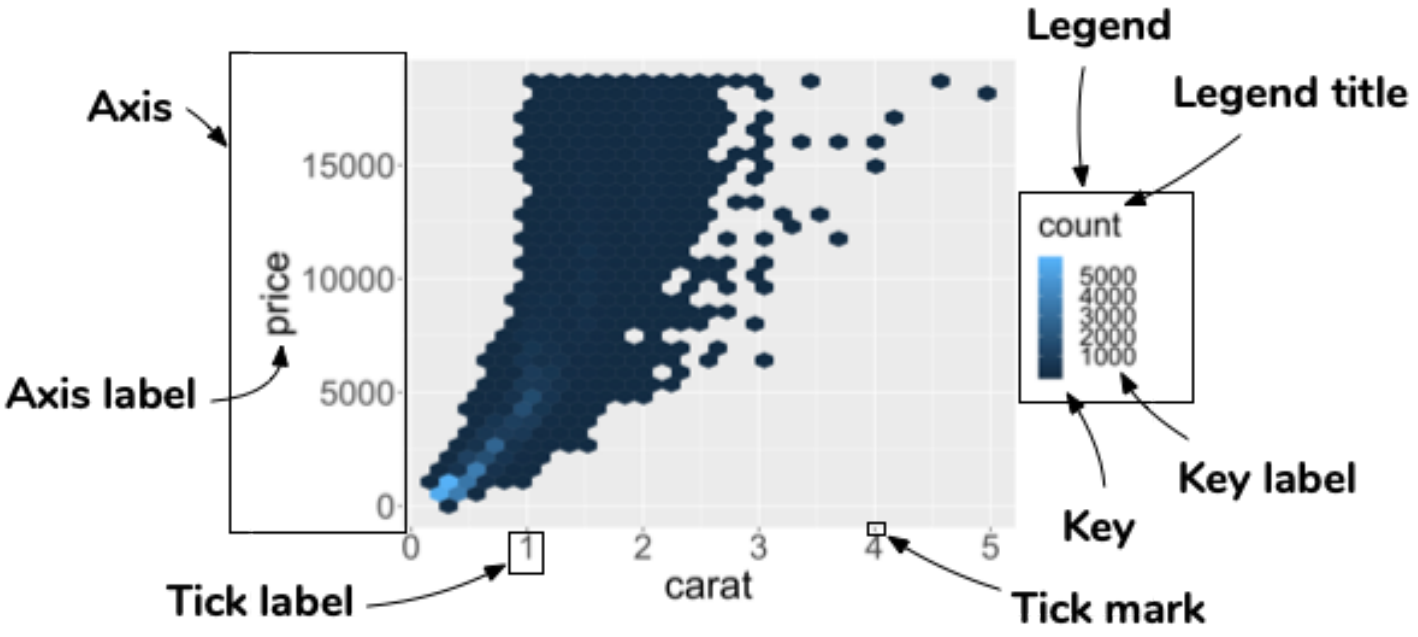
# scale

| scales | Description |
| --- | --- |
| scale_alpha, scale_alpha_continuous, scale_alpha_discrete, scale_alpha_ordinal, scale_alpha_datetime, scale_alpha_date | Alpha transparency scales |
| scale_colour_brewer, scale_fill_brewer, scale_colour_distiller, scale_fill_distiller, scale_color_brewer, scale_color_distiller | Sequential, diverging and qualitative colour scales from colorbrewer.org |
| scale_colour_continuous, scale_fill_continuous | Continuous colour scales |
| scale_x_continuous, scale_y_continuous, scale_x_log10, scale_y_log10, scale_x_reverse, scale_y_reverse, scale_x_sqrt, scale_y_sqrt | Position scales for continuous data (x & y) |

# Guide: an axis or a legend

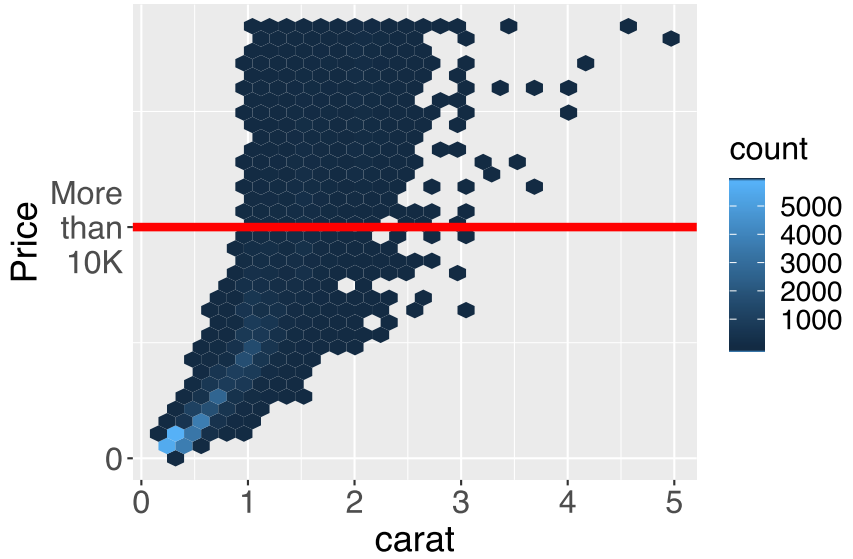
The scale creates a guide: an axis or legend.

So to modify these you generally use `scale_*` or other handy functions (`guides`, `labs`, `xlab`, `ylab` and so on).



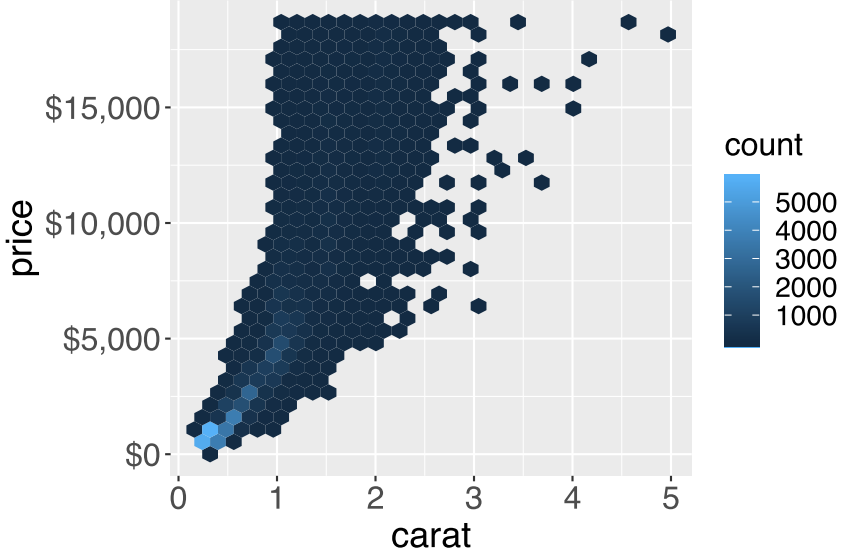
# Modify axis

```
g +
  scale_y_continuous(name = "Price",
                     breaks = c(0, 10000),
                     labels = c("0", "More\n than\n 10K")) +
  geom_hline(yintercept = 10000, color = "red", size = 2)
```



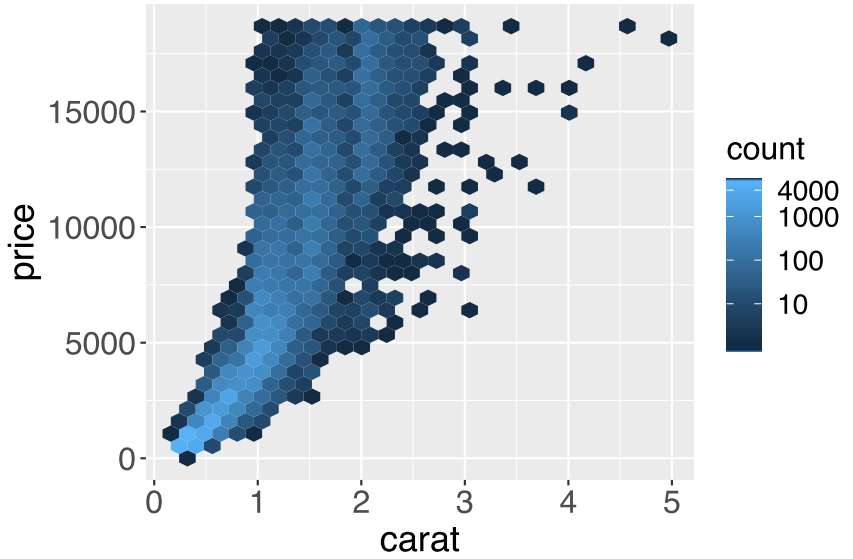
# Nicer formatting functions in scales 📦

```
g +
  scale_y_continuous(
    label = scales::dollar_format()
  )
```



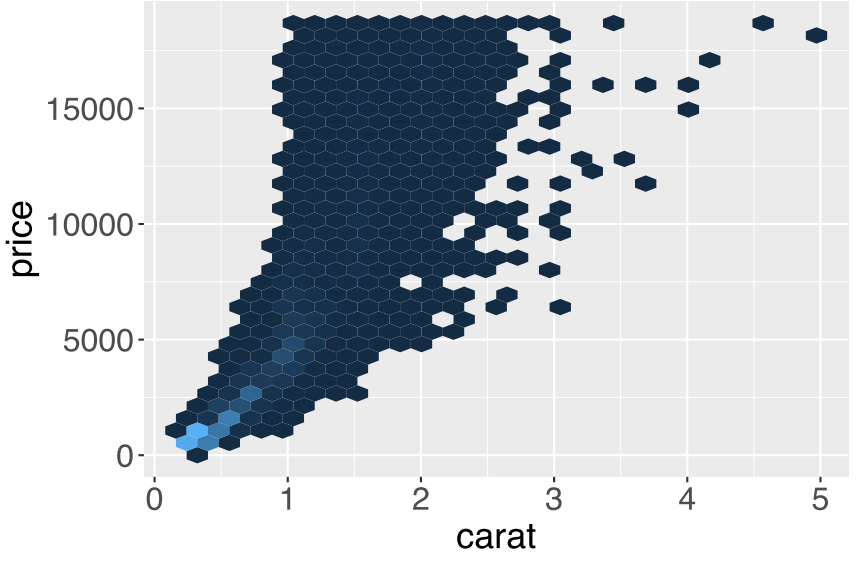
# Modifying legend

```
g +
  scale_fill_continuous(
    breaks = c(0, 10, 100, 1000, 4000),
    trans = "log10"
  )
```



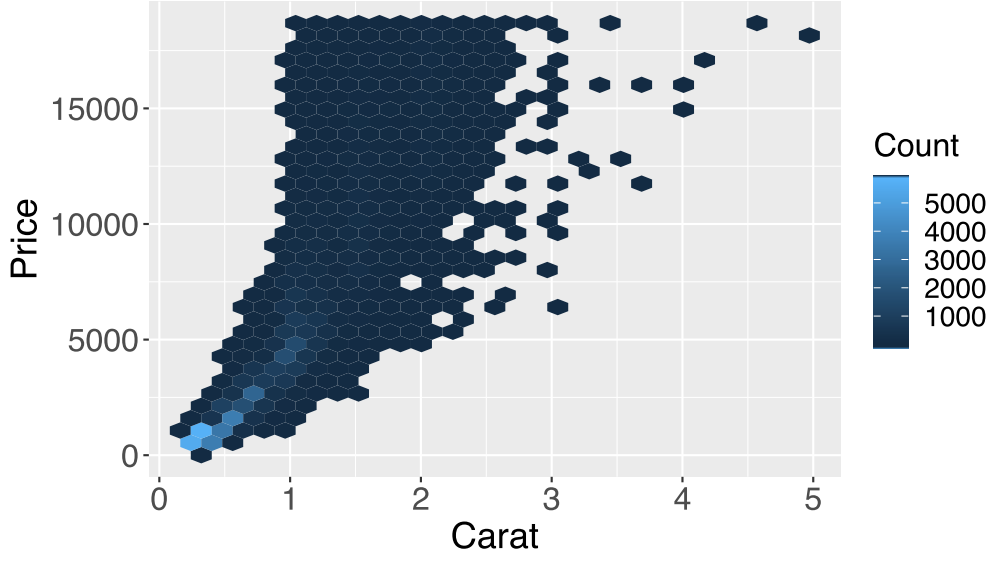
# Removing legend

```
g +
  scale_fill_continuous(
    guide = "none"
  )
```



# Alternative control of guides

```
g +
  ylab("Price") + # Changes the y axis label
  labs(x = "Carat", # Changes the x axis label
       fill = "Count") # Changes the legend name
```




```
g + guides(fill = "none") # remove the legend
```

Open and go through:

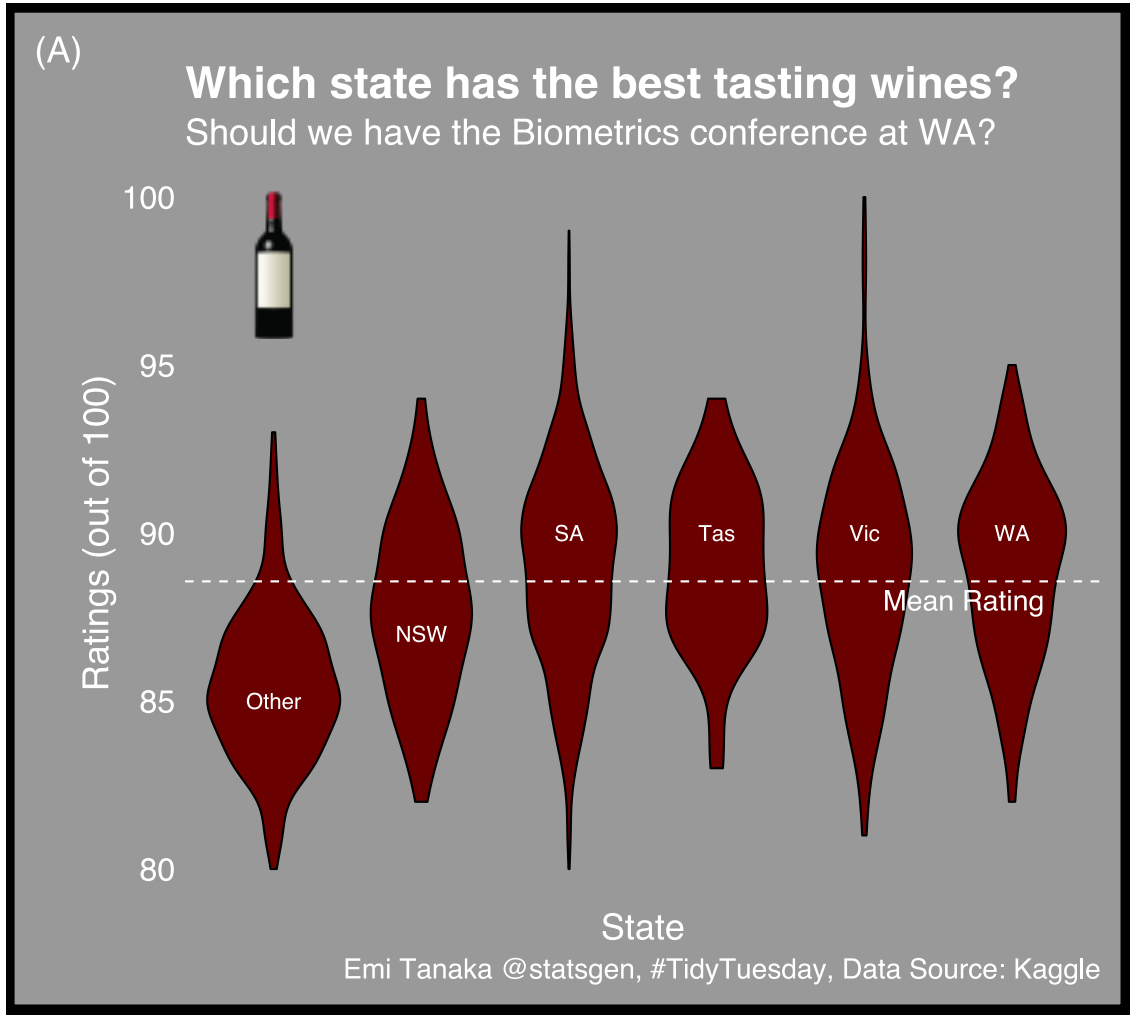
`challenge-02-ggplot-scales.Rmd`

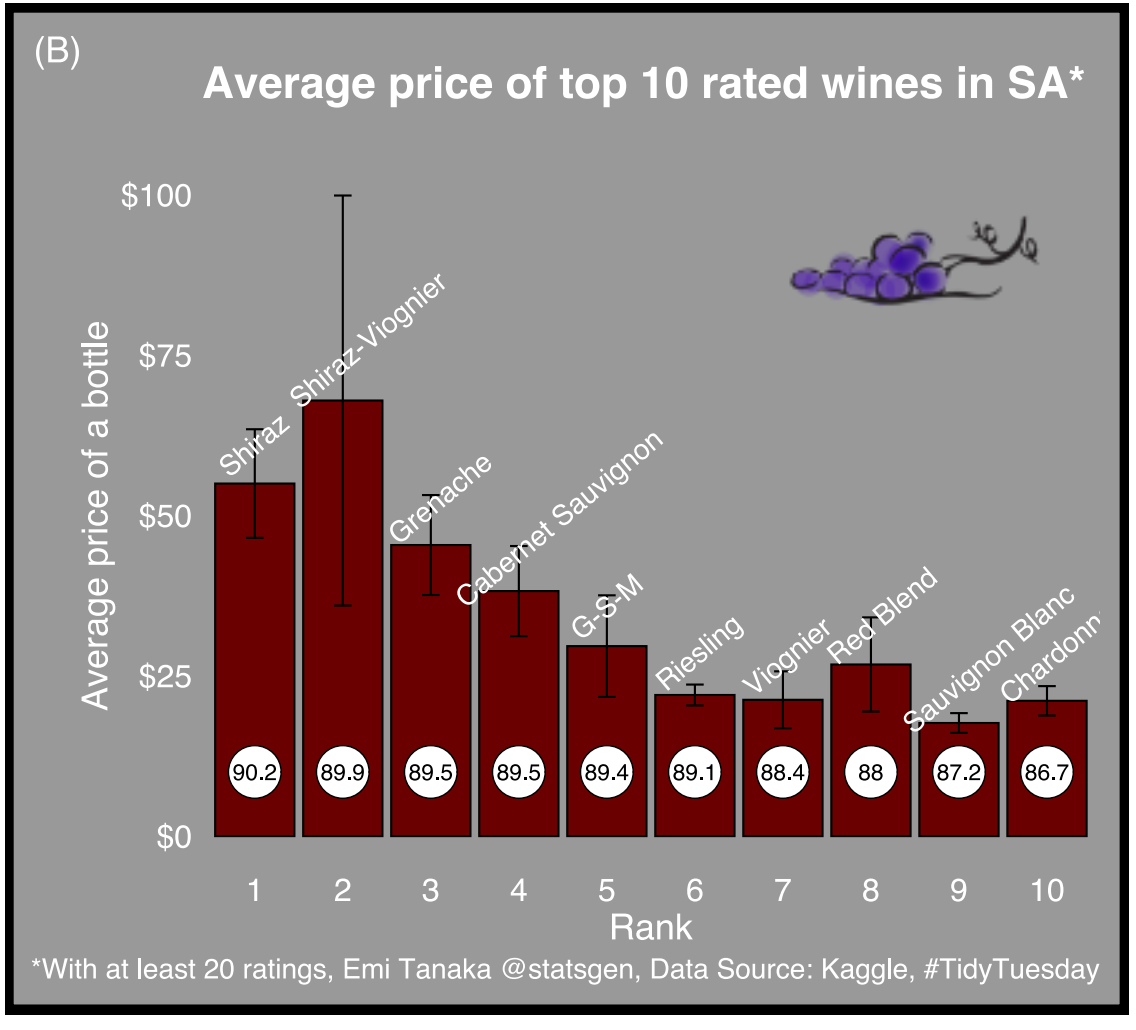
For answers go to (but again don't look until trying!):

`challenge-02-ggplot-scales-solution.Rmd`

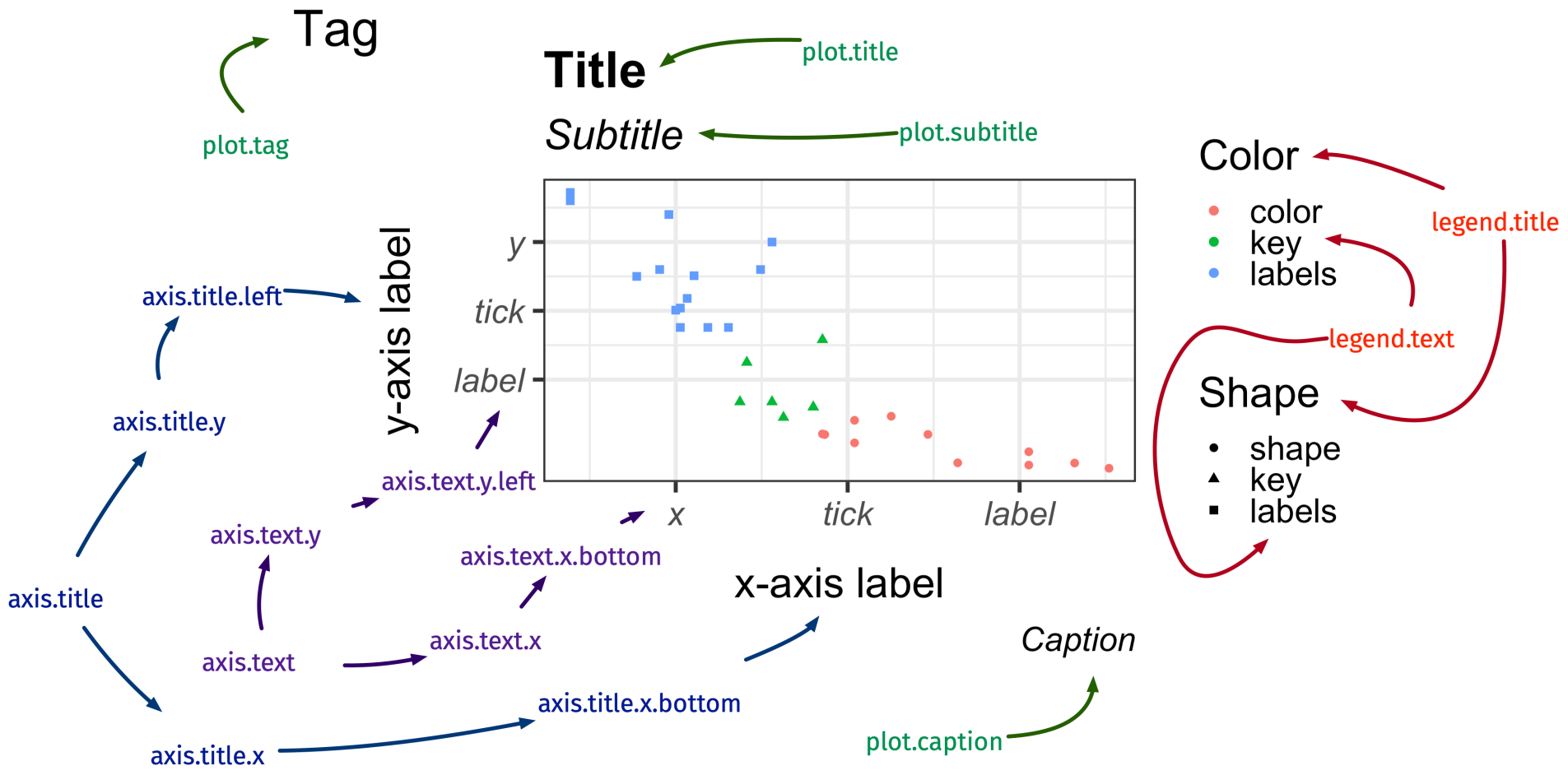
15:00

# How to change the look?



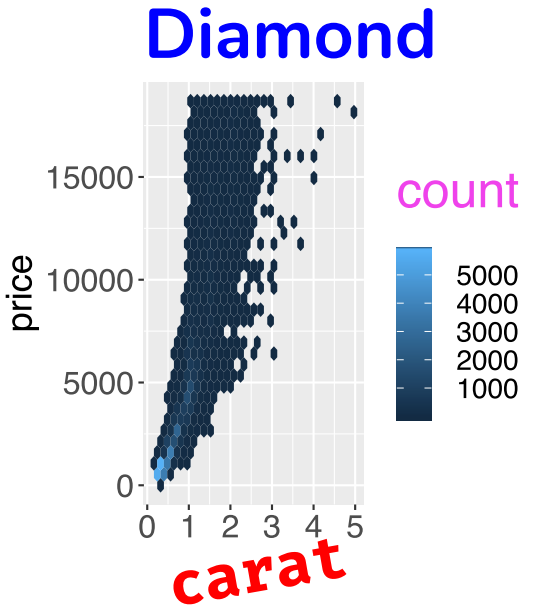
# theme: modify the *look* of texts



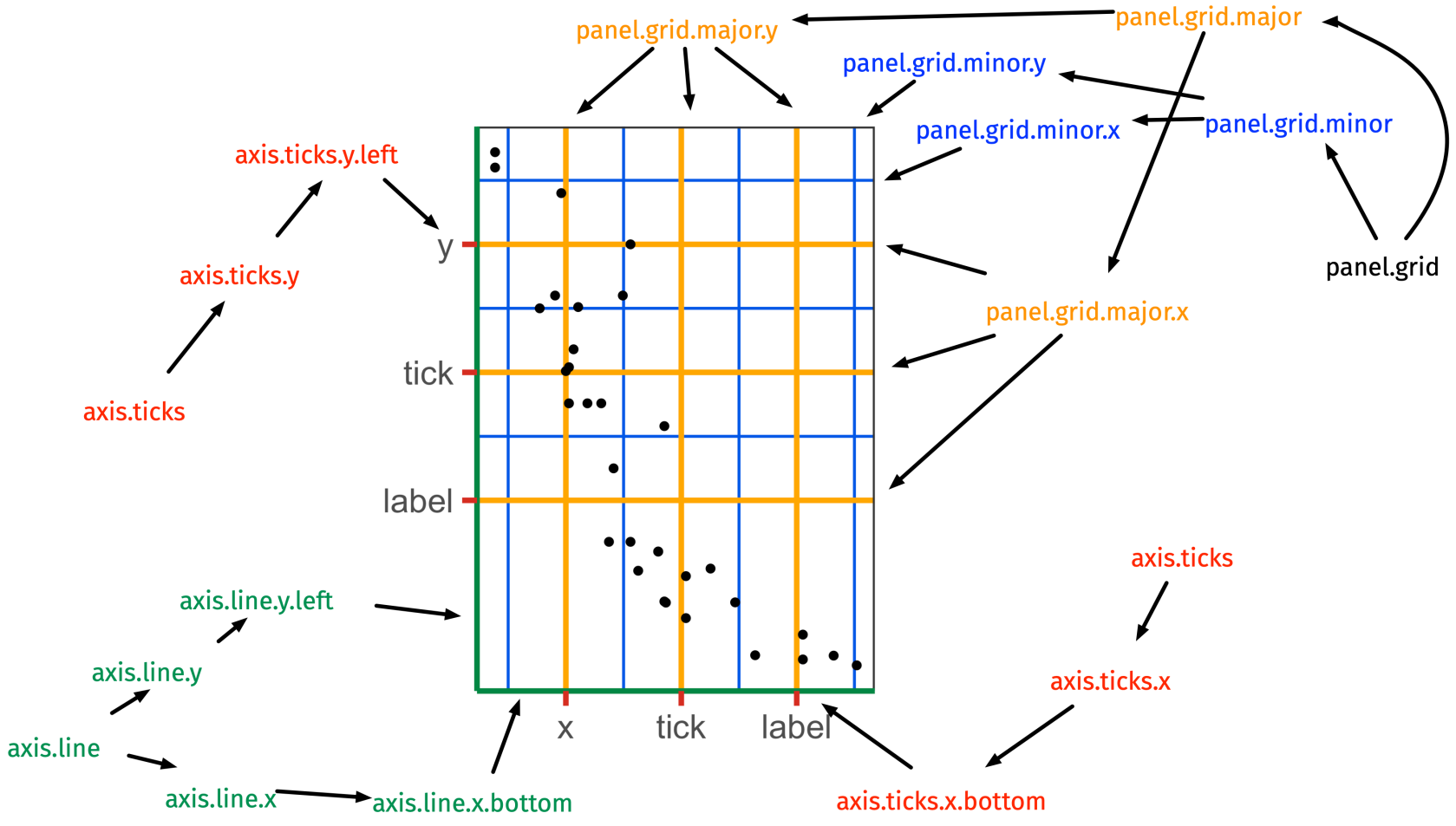

`element_text()`

# element_text()

```
ggplot(diamonds, aes(carat, price)) + geom_hex() +
 labs(title = "Diamond") +
 theme(axis.title.x = element_text(size = 30,
                                   color = "red",
                                   face = "bold",
                                   angle = 10,
                                   family = "Fira Code"),
       legend.title = element_text(size = 25,
                                   color = "#ef42eb",
                                   margin = margin(b = 5)),
       plot.title = element_text(size = 35,
                                 face = "bold",
                                 family = "Nunito",
                                 color = "blue"
                                ))
```



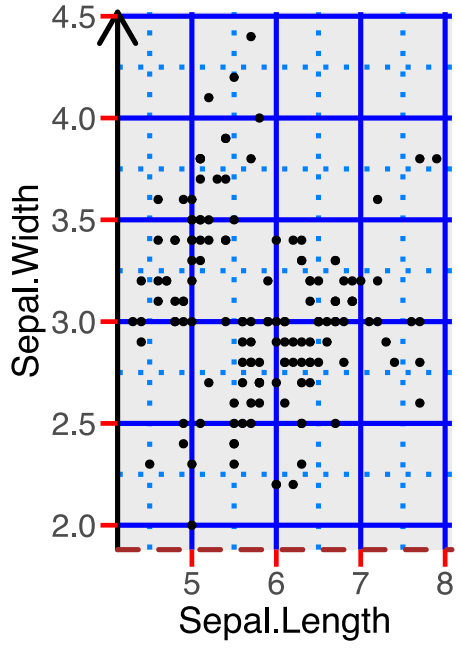
# theme: modify the *look* of the lines



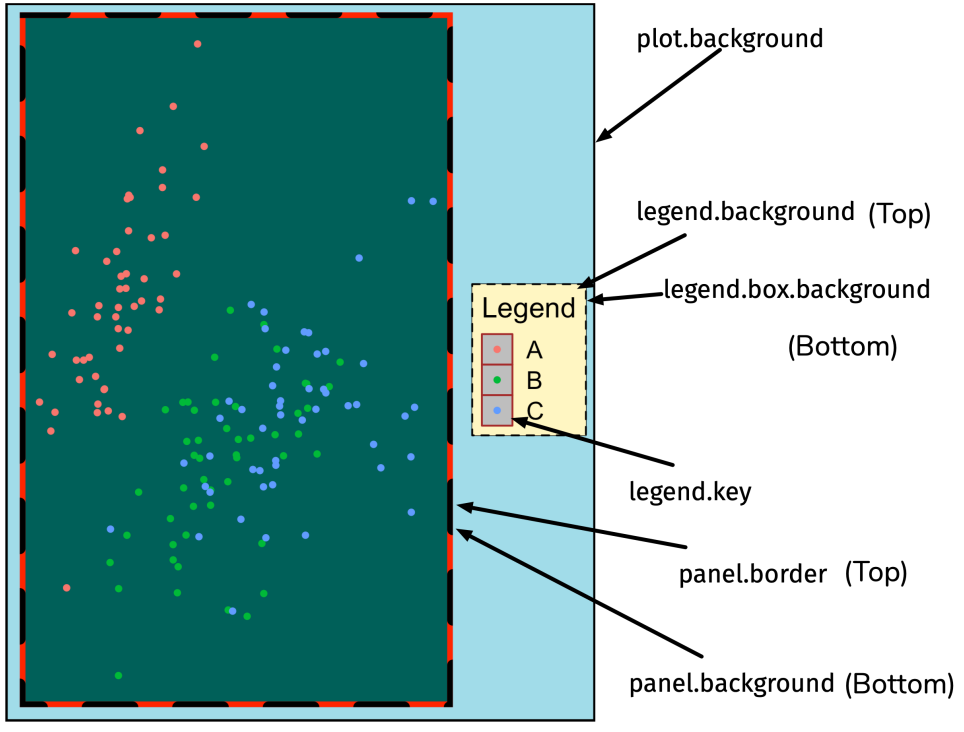

`element_line()`

# element_line()

```
ggplot(iris, aes(Sepal.Length, Sepal.Width)) + geom_point() +
 theme(axis.line.y = element_line(color = "black",
                                  size = 1.2,
                                  arrow = grid::arrow()),
       axis.line.x = element_line(linetype = "dashed",
                                  color = "brown",
                                  size = 1.2),
       axis.ticks = element_line(color = "red", size = 1.1),
       axis.ticks.length = unit(3, "mm"),
       panel.grid.major = element_line(color = "blue",
                                       size = 1.2),
       panel.grid.minor = element_line(color = "#0080ff",
                                       size = 1.2,
                                       linetype = "dotted"))
```



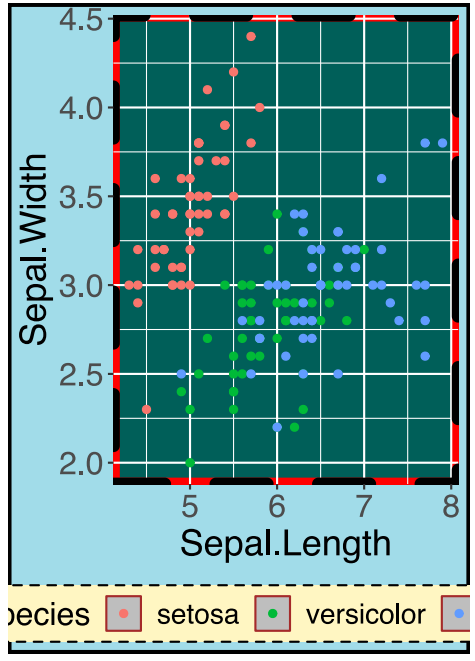
# theme: modify the *look* of the rectangular regions




`element_rect()`

# element_line()

```
ggplot(iris, aes(Sepal.Length, Sepal.Width)) +
 geom_point(aes(color = Species)) +
 theme(
  legend.background = element_rect(fill = "#fff6c2",
                                   color = "black",
                                   linetype = "dashed"),
  legend.key = element_rect(fill = "grey", color = "brown"),
  panel.background = element_rect(fill = "#005F59",
                                  color = "red", size = 3),
  panel.border = element_rect(color = "black",
                              fill = "transparent",
                      linetype = "dashed", size = 3),
  plot.background = element_rect(fill = "#a1dce9",
                                 color = "black",
                                  size = 1.3),
       legend.position = "bottom")
```



Open and go through:

`challenge-03-ggplot-themes.Rmd`

For answers go to:

`challenge-03-ggplot-themes-solution.Rmd`

# Session Information

```
devtools::session_info()
```

```
─ Session info ──────────────────────────────────────────────────────────────
 setting  value
 version  R version 3.6.0 (2019-04-26)
 os       macOS Mojave 10.14.6
 system   x86_64, darwin15.6.0
 ui       X11
 language (EN)
 collate  en_AU.UTF-8
```