Data Visualisation Using R

Lecture-3

Suman Rakshit

School of EECMS, Curtin University

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Outline
Quick review
Deep dive into themes
Text elements
Line elements
Rectangular elements
Custom theme creation
Ggplot2 in-built themes and others
Important scale functions
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7. Ggplot-2 and Ggthemes in-built themes
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A quick recap of Ggplot2 basics

- Three most important components for any visualisation are: (i) data (ii) aesthetic mapping and (iii) geometry.
- Aesthetic mapping is performed using the function `aes(x, y, color, fill, shape, size, alpha)`.
- Geometry corresponds to *chart type*, and is specified using `geom_⋆()`, where a chart type is specified in place of ⋆.
- Visible attributes are specified outside `aes()` and, most often, inside the `geom_⋆()` function.

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Deep dive into themes layer

- The themes layer provides all non-data related visible attributes – `theme()` allows you to modify all non-data ink in your visualisation.

- Three main visual elements of themes layer:

  1. `text`: modify using `element_text()`
  2. `line`: modify using `element_line()`
  3. `rectangle`: modify `element_rect()`

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Important: element_⋆() functions!

Element	R-Function	Example
Text	element_text()	element_text(face = "bold")
Line	element_line()	element_line(color = "red")
Rectangle	element_rect()	element_rect(fill = "grey")

One important element_⋆() function is element_blank() — this function removes any themes-based visual element.

Example: theme(panel.grid = element_blank()) removes all panel grid-lines.

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text element hierarchy structure

- axis.title
  - axis.title.x
    - axis.title.x.top
    - axis.title.x.bottom
  - axis.title.y
    - axis.title.y.left
    - axis.title.y.right
- title
  - legend.title
  - plot.title
  - plot.subtitle
  - plot.caption
  - plot.tag
- axis.text
  - axis.text.x
    - axis.text.x.top
    - axis.text.x.bottom
  - axis.text.y
    - axis.text.y.left
    - axis.text.y.right
- legend.text
- strip.text
  - strip.text.x
  - strip.text.y

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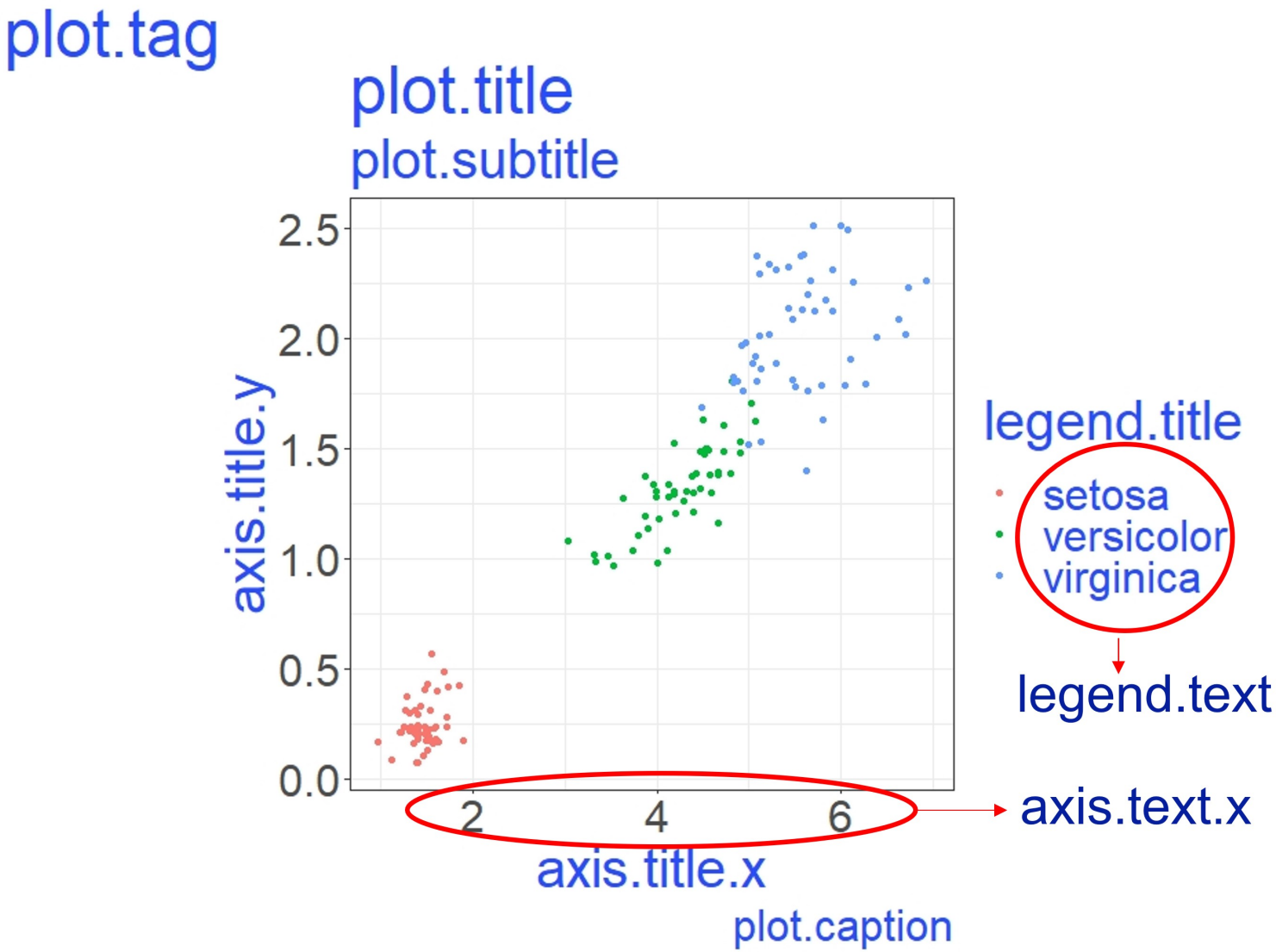
Visualize `text` elements in a plot



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RCode to specify text elements

```
# Standard scatter plot
ggplot(iris, aes(Petal.Length, Petal.
    Width, color=Species)) +
geom_point() + theme_bw() +
# Specify text elements using labs()
labs(color = "legend.title",
      title = "plot.title",
      subtitle = "plot.subtitle",
      caption = "plot.caption",
      tag = "plot.tag",
      x = "axis.title.x",
      y = "axis.title.y") +
# Modify text size and color
theme(text = element_text(size = 30,
                          color = "#2A4DFA"))
```


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Visualize `strip.text`

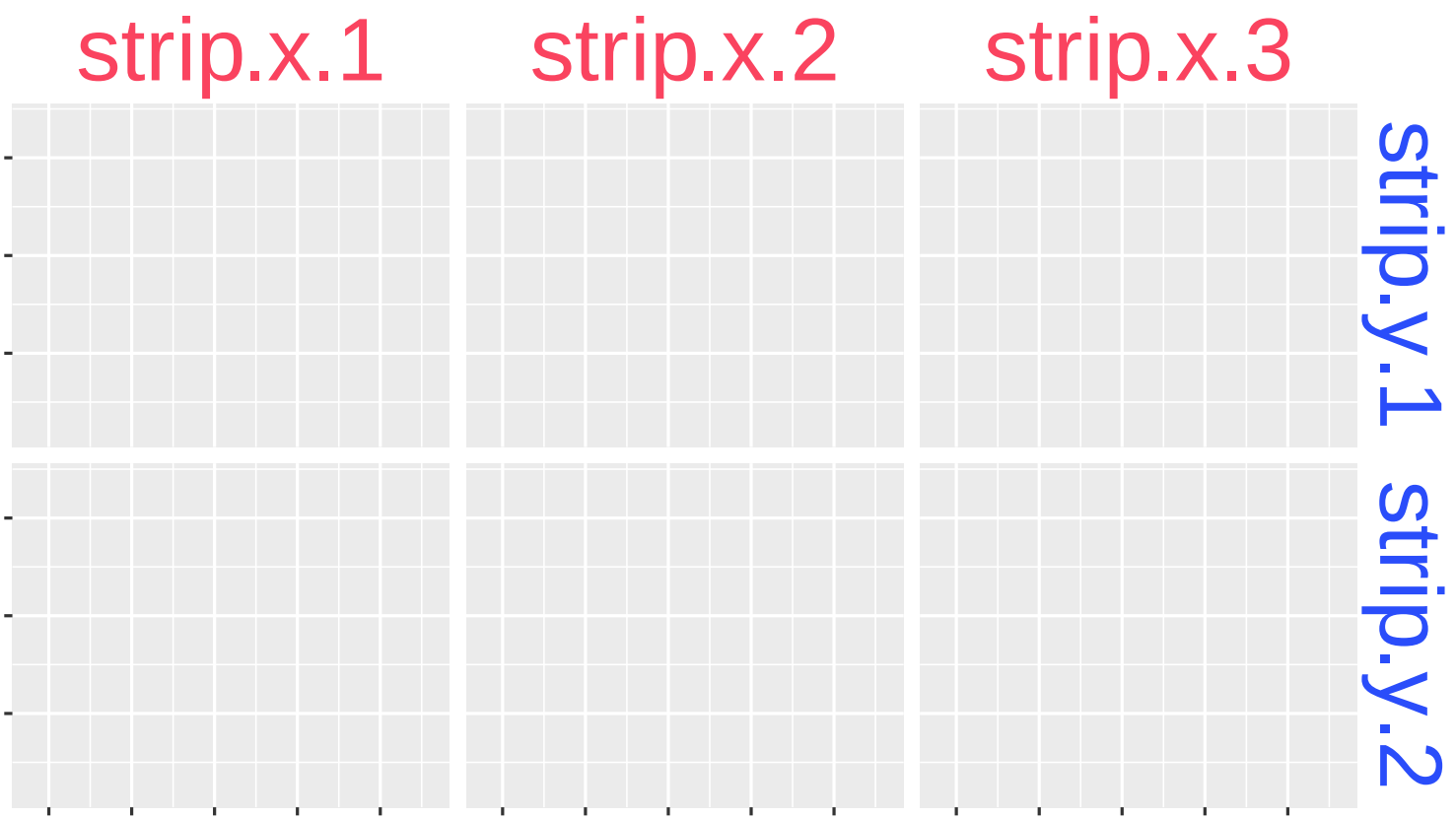

Figure 1: `strip.text.x` and `strip.text.y`.

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Modified `strip.text`

We modified the font family, color and size of the `strip.text` element in the plot.

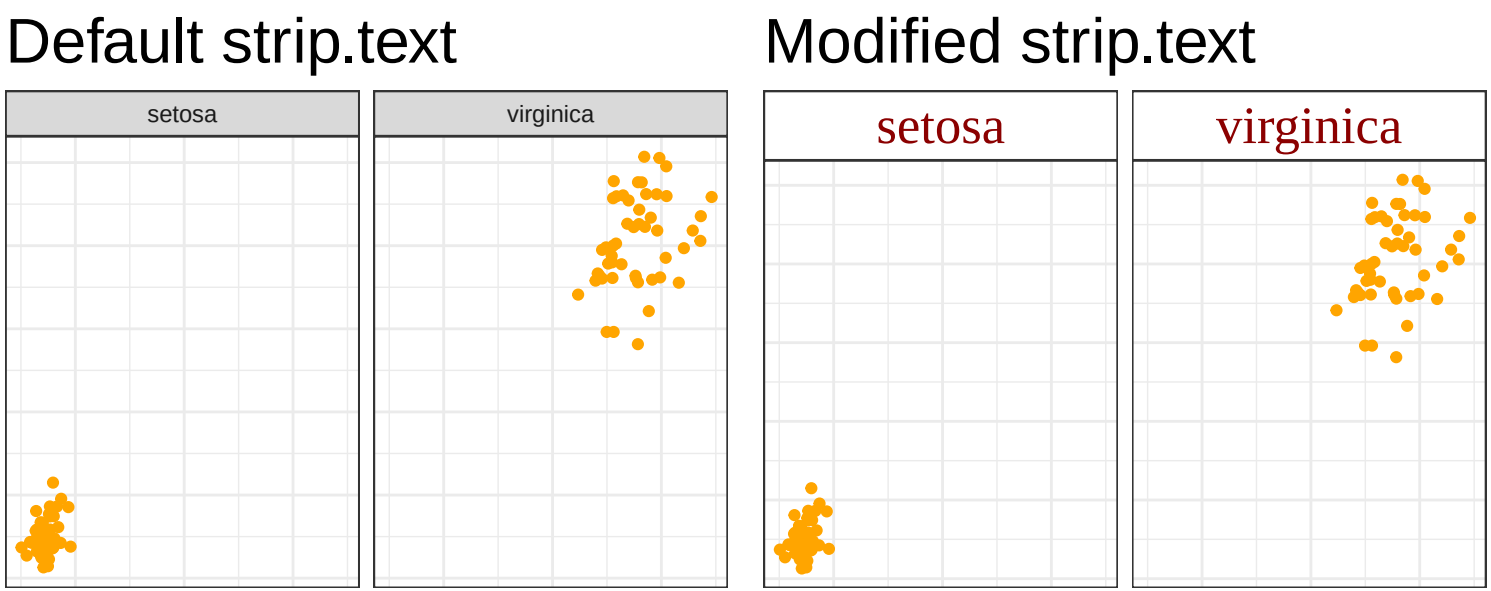

Figure 2: *Left*: Default `strip.text`; *Right*: Font family, color and size are modified of `strip.text`.

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RCode to modify strip.text

```
# Modify font family, size, and color
theme(strip.text = element_text(
                      family = "serif",
                        size = 20,
                       color = "#8b0000"))
```

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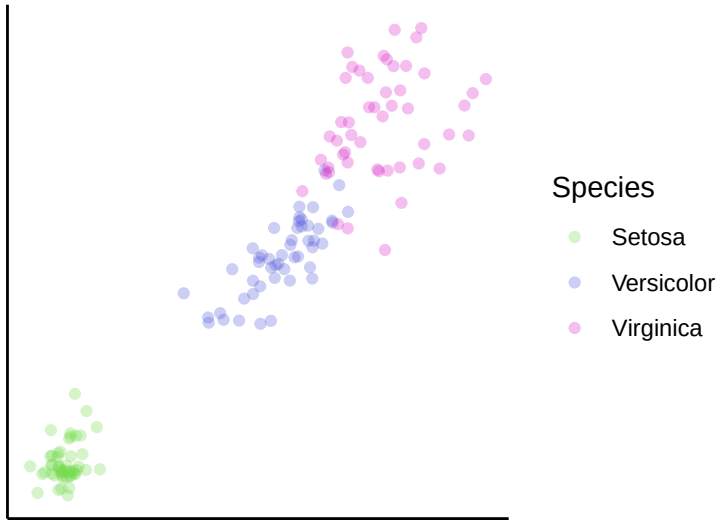
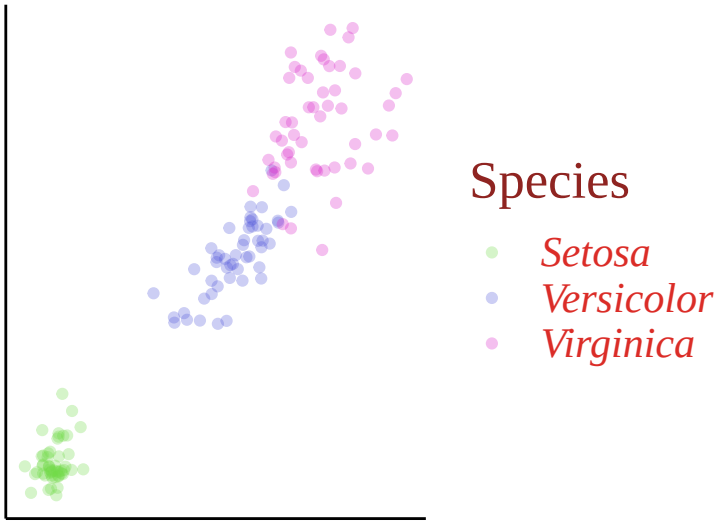
Modified `legend.title` and `legend.text`

We modified the font family, color and size of `legend.title` and `legend.text`.

Default legend.text and legend.title



Modified legend.text and legend.title



Can you spot the problem that still remains with the `legend guide`?

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RCode: modify legend text elements

```
# Modify font family, size, and color
theme( # modify legend.title
legend.title = element_text(
family = "serif", size = 20,
      color = "#8F2421"),

        # modify legend.text
 legend.text = element_text(
 family = "serif", face = "italic",
 size = 16, color = "#DB2C27"))
```


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Fix legend guide using `guides` layer

- Sometimes we want the "*geoms in the legend*" to display differently to the "*geoms in the plot*".
- This is particularly important when the size of the points is small or the transparency of the points is high.
- To modify legend guides, we can use the `override.aes` parameter of `guide_legend()`.

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Example: modify legend guides for clarity

We have increased the size and the value of the alpha attribute of the points used in the legend guide.

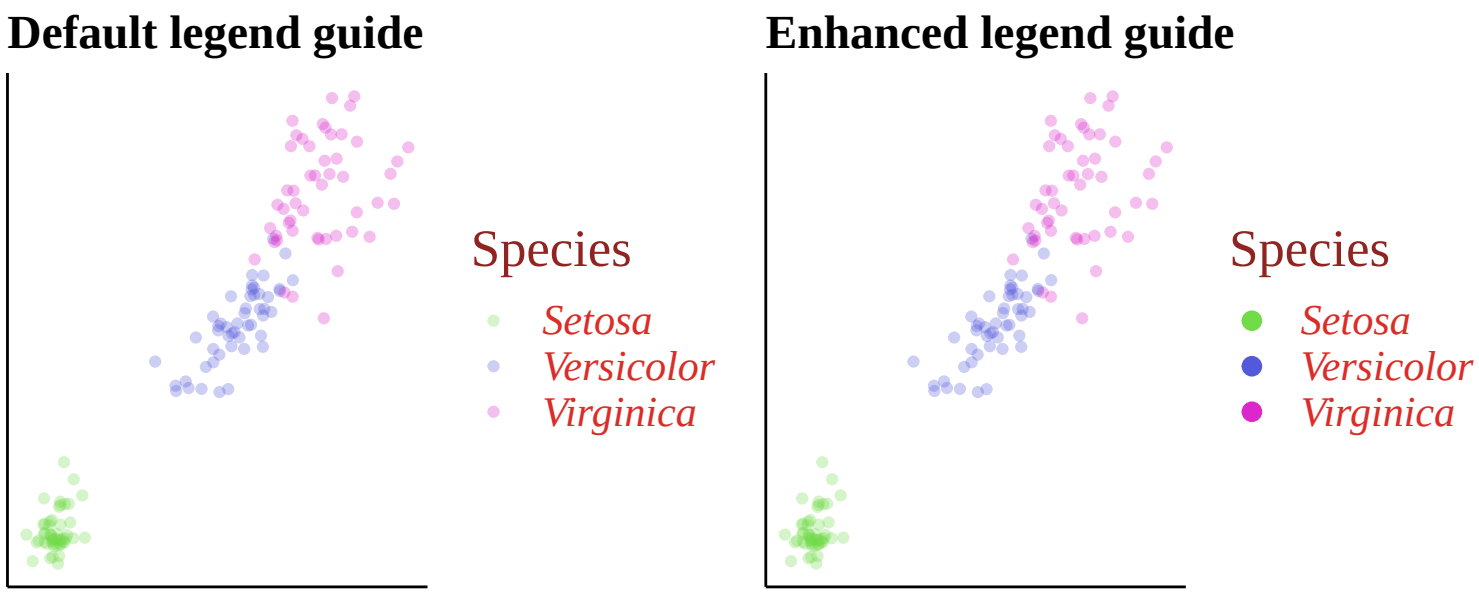

Figure 3: *Left*: default legend guide; *Right*: Legend point size has been increased to 3 and alpha value to 1.

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RCode to modify legend guide

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# Create new color guide object
col_guide <- guide_legend(
        override.aes = list(alpha = 1,
                            size = 3))

# Modify size and alpha of legend points
ggplot(iris, aes(Petal.Length,
                 Petal.Width,
                 color = Species)) +
# Call geom_point() with alpha 0.30
geom_point(alpha = 0.30) +
# Modify the points in the legend guide
guides(color = col_guide)
```


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Specify legend position

- One of the key tricks to enhance the visualisation is to be creative with the legend position.
- The easiest way to modify the legend position is to use the `legend.position` argument in `theme()` layer.
- It is easy to put the legend at the left (`legend.position = "left"`), right (`legend.position = "right"`), top (`legend.position = "top"`), or bottom (`legend.position = "bottom"`) of the plot.
- Another useful call is `legend.position = "none"` – it removes the legend from the plot.

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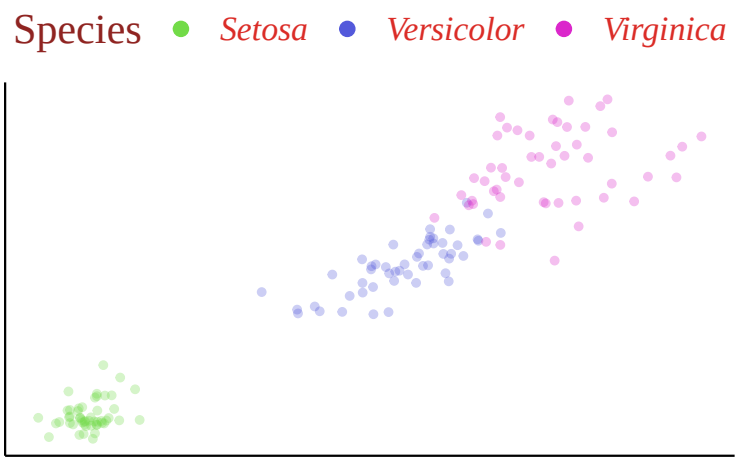
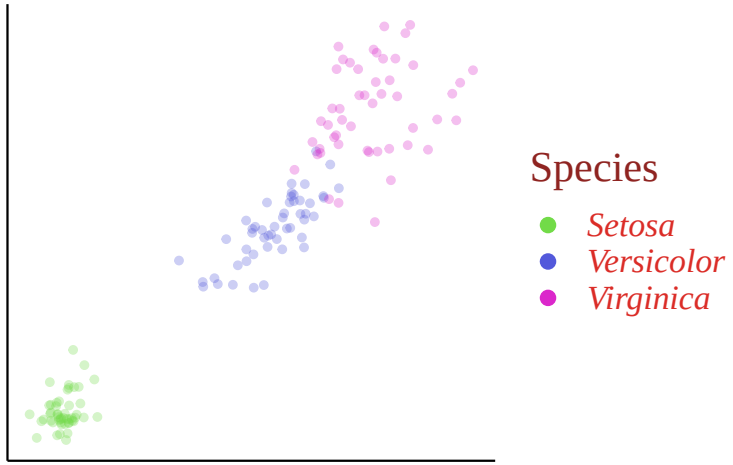
Example of different legend positions

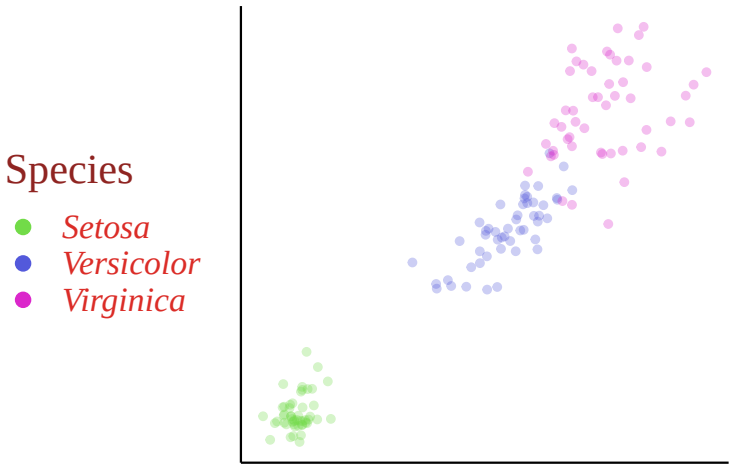
legend.position = "top"



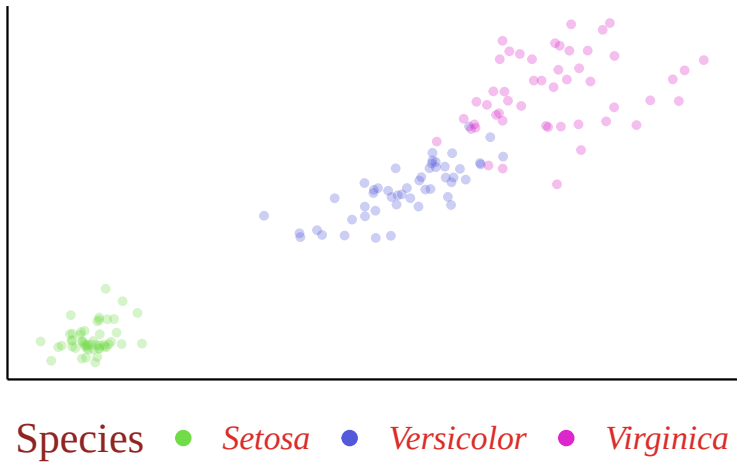
legend.position = "right"



legend.position = "left"



legend.position = "bottom"



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RCode to specify legend.position

```
# Legend position at the top
theme(legend.position = "top")

# Legend position at the right
theme(legend.position = "right")

# Legend position at the left
theme(legend.position = "left")

# Legend position at the bottom
theme(legend.position = "bottom")

# Remove legend completely
theme(legend.position = "none")
```


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Putting legend inside the plot

- In most academic publication, the legends are required to be placed inside the plot.
- This is particularly useful when you have a lot of blank space in your plot.
- This can be achieved by passing a numeric vector with x and y coordinates to the `legend.position` parameter in the `theme()` layer.
- The x and y coordinates represent a relative location in the panel:
  1. `c(0, 0)` is bottom left;
  2. `c(0, 1)` is top left;
  3. `c(1, 0)` is bottom right;
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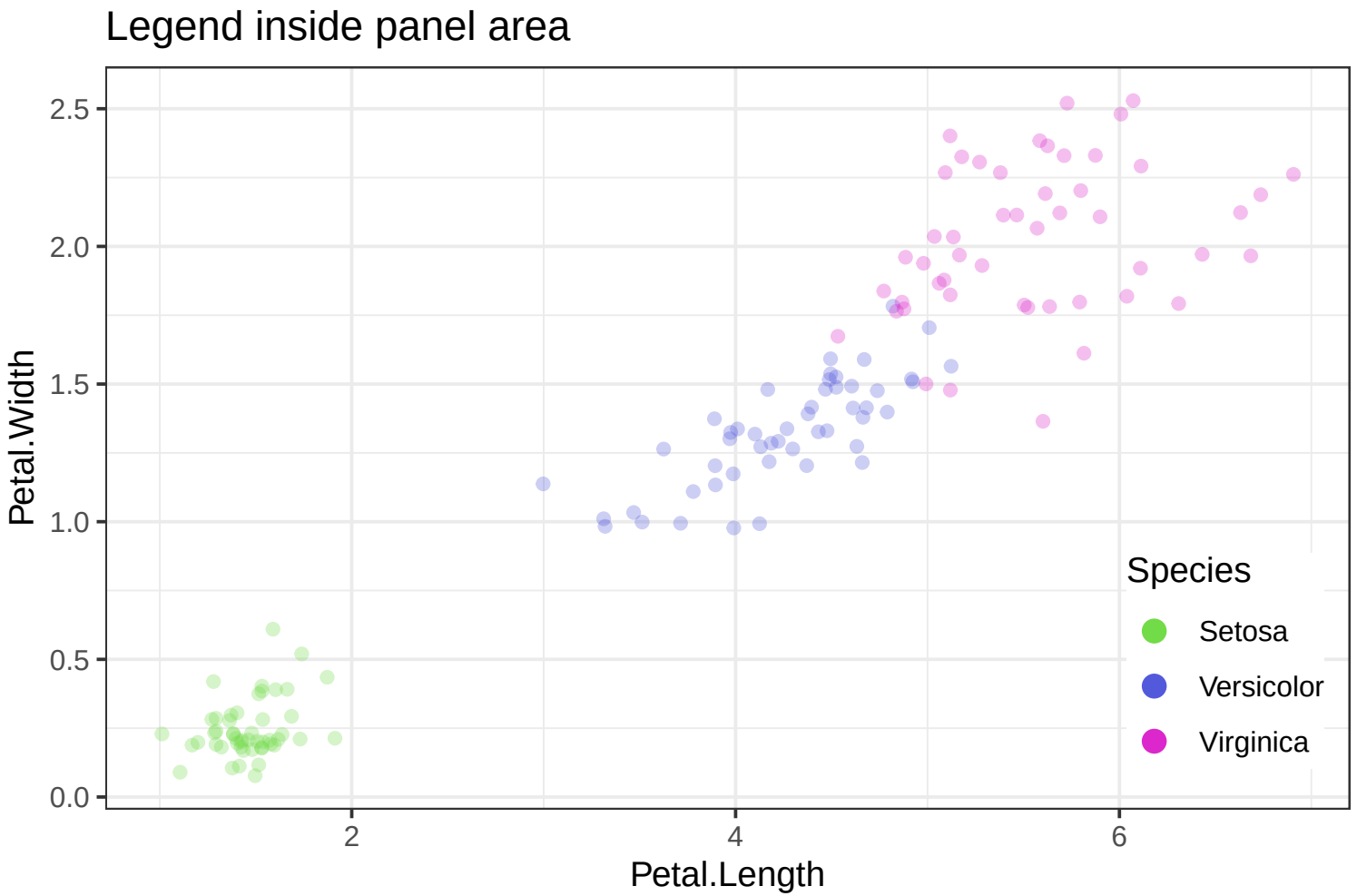
Example: legend inside the plot



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RCode: legend inside the plot

```
##################################
# Specify legend position at the #
# bottom right corner of the plot #
##################################
theme(legend.position = c(0.9, 0.2),
##################################
# Remove the legend margin for   #
# an enhanced visualisation      #
##################################
legend.margin = margin(0,0,0,0,  "mm"))
```

Note: Specifying a suitable legend position this way would often require a lot of trial and error on your part.

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line element hierarchy structure

- panel.grid
  - panel.grid.major
    - panel.grid.major.x
    - panel.grid.major.y
  - panel.grid.minor
    - panel.grid.minor.x
    - panel.grid.minor.y
- axis.ticks
  - axis.ticks.x
    - axis.ticks.x.top
    - axis.ticks.x.bottom
- axis.line
  - axis.line.x
    - axis.line.x.top
    - axis.line.x.bottom
  - axis.line.y
    - axis.line.y.left
    - axis.line.y.right
  - axis.ticks.y
    - axis.ticks.y.left
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Figure 4: Use `element_line()` to modify all line elements.

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Modifying `panel.grid` lines

We changed the color, size and linetype attributes of `panel.grid` lines.

Figure 5: Use `panel.grid` parameter inside `theme()` to modify both major and minor panel grid-lines.

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RCode: modify panel.grid lines

```
##########################################
# Specify panel grid line attributes#
##########################################
mygrid <- element_line(color = "blue",
                       size = 1,
                       linetype = "dashed")
##########################################
# Use panel.grid parameter inside    #
# theme() layer to modify grid lines#
##########################################
theme(panel.grid = mygrid)
```


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Modify height of `axis.ticks`

- Because axis ticks are treated as line elements, these can be modified using `element_line()` like any other line elements.
- However, to modify the height of the axis ticks, we need to use the `axis.ticks.length` parameter of the `theme()` layer.
- The `axis.ticks.length` parameter accepts an object of the class `unit()`.
- The first argument of `unit()` is a length value, and the second argument is a length unit. For example, to specify 1 cm, we shall use `unit(1, "cm")`.

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Modifying `axis.ticks.length`

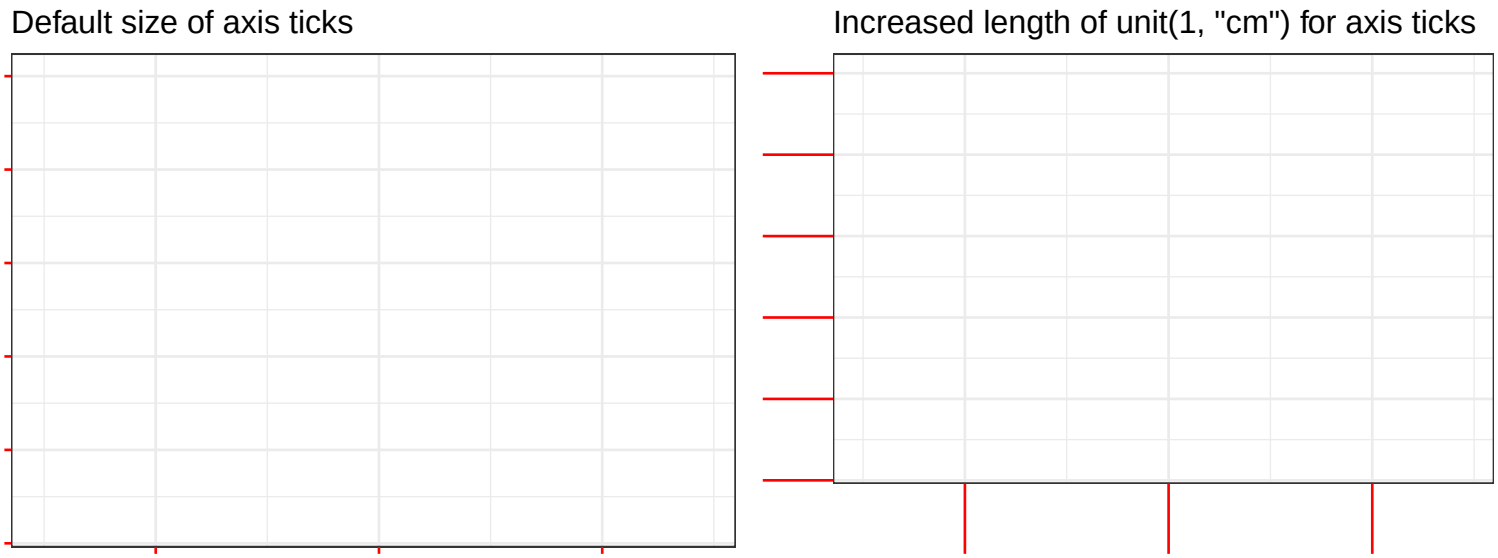

Figure 6: `axis.ticks.length = unit(1, "cm")` is used inside the `theme()` layer to modify the length of axis ticks.

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`rect` element hierarchy structure

- `legend.background`
- `legend.key`
- `legend.box.background`
- `panel.background`
- `panel.border`
- `plot.background`
- `strip.background`
  - `strip.background.x`
  - `strip.background.y`

Figure 7: Use `element_rect()` to modify all rectangular elements.

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Create customised theme – Curtin theme

We have created a customised theme inspired by the colors prominent in the Curtin University logo.

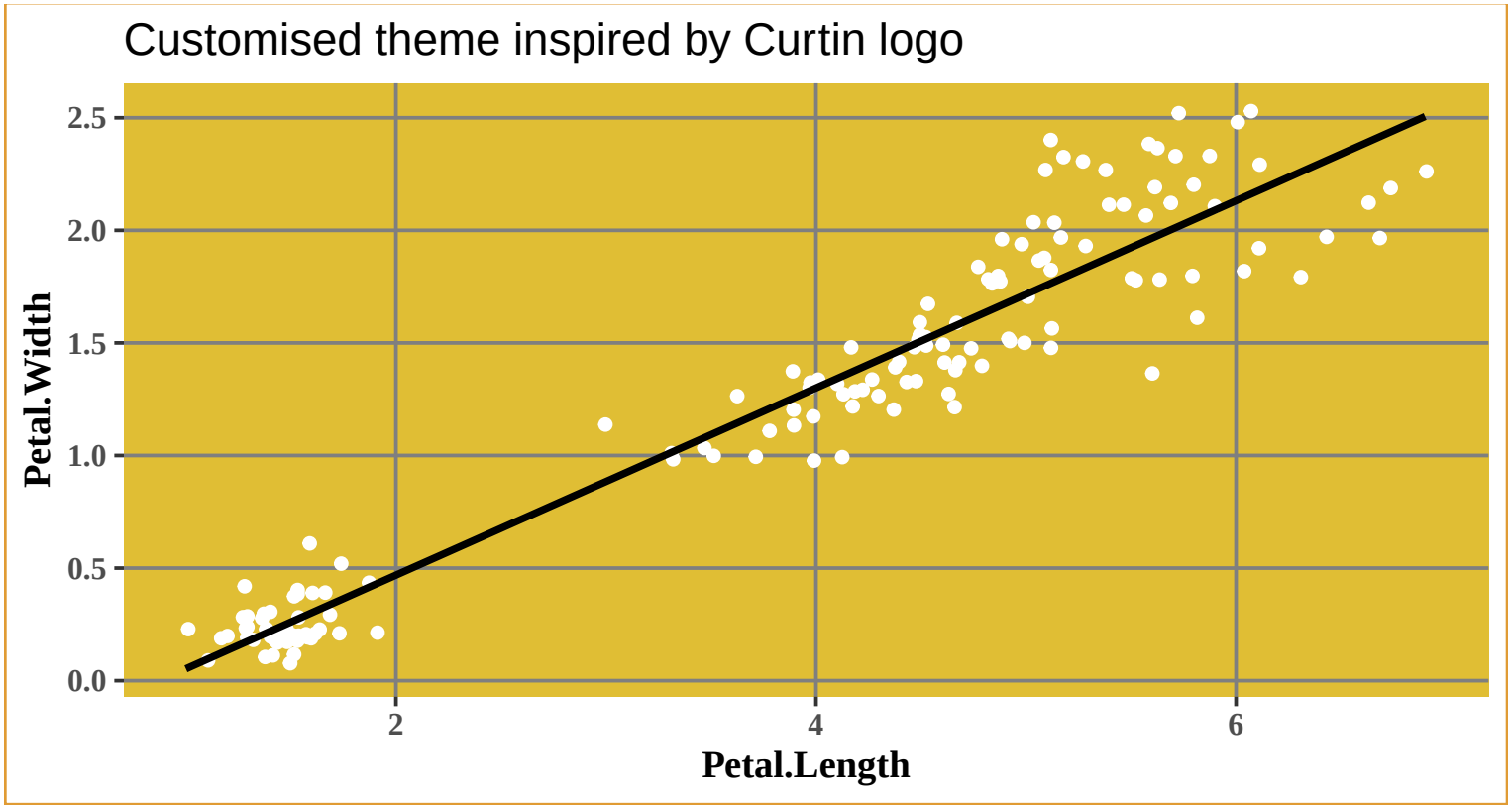

Figure 8: Relationship between iris Petal.Width and Petal.Length, fitted using the linear regression model.

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RCode: create Curtin theme

```
# Create custom theme
curtin_theme <-
theme(plot.background =
        element_rect(color = "#E09B34"),
      panel.background =
        element_rect(fill = "#E0BE34"),
      panel.grid.major =
        element_line(color = "gray50"),
      panel.grid.minor = element_blank(),
      axis.text =
        element_text(face = "bold",
                     family = "serif"),
      axis.title =
        element_text(face = "bold",
                     family = "serif"))
```

Curtin University

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RCode: use Curtin theme to plot

```
# Plot Petal.Width vs Petal.Length
ggplot(iris,
       aes(x = Petal.Length,
           y = Petal.Width)) +
# Add jittered points
geom_point(position =
             position_jitter(seed = 123),
             color = "white",
             size = 1.3) +
# Add the line of best fit
geom_smooth(method = "lm",
             se = FALSE,
             color = "black") +
# Add Curtin theme object
curtin_theme
```


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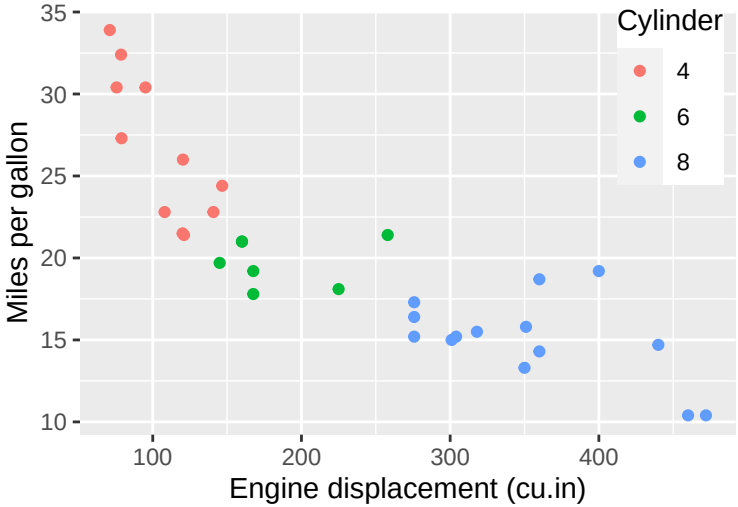
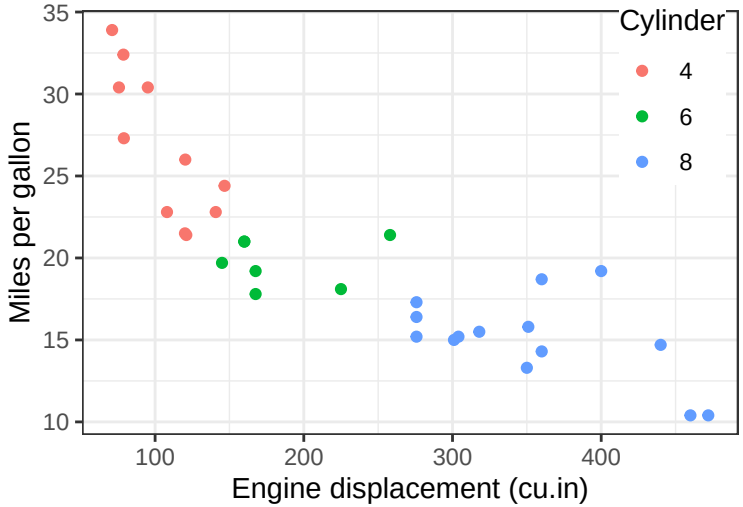
Use ggplot2 in-built themes

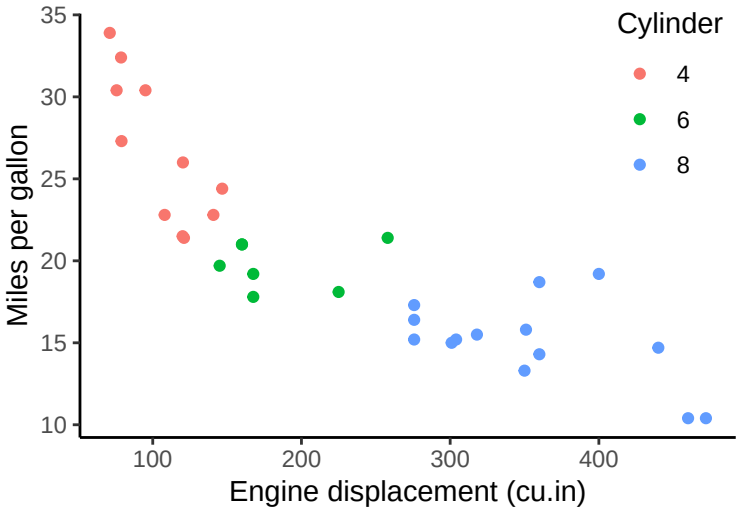
Default: theme_grey()



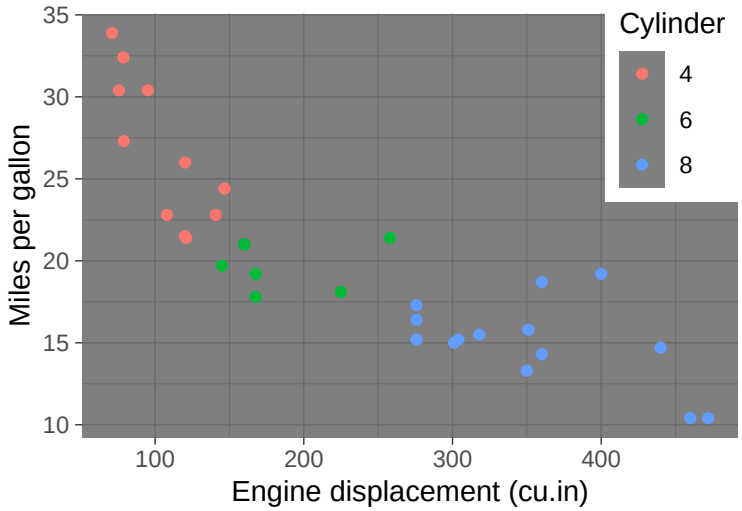
theme_bw()



theme_classic()



theme_dark()



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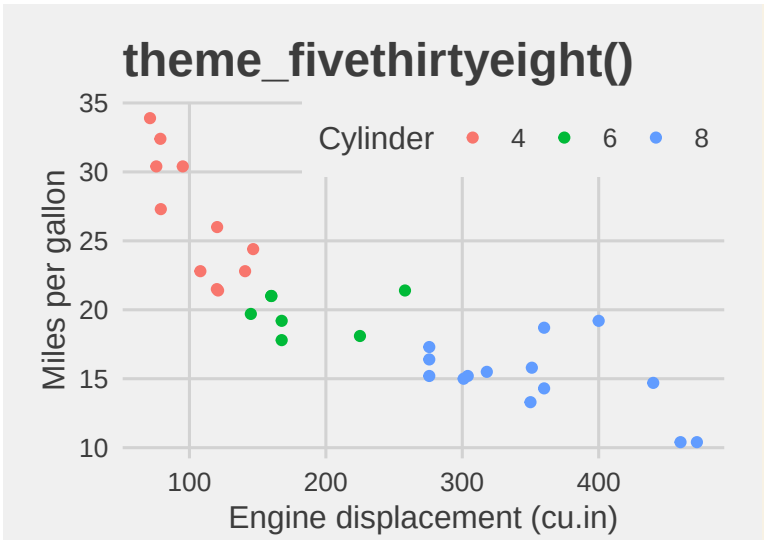
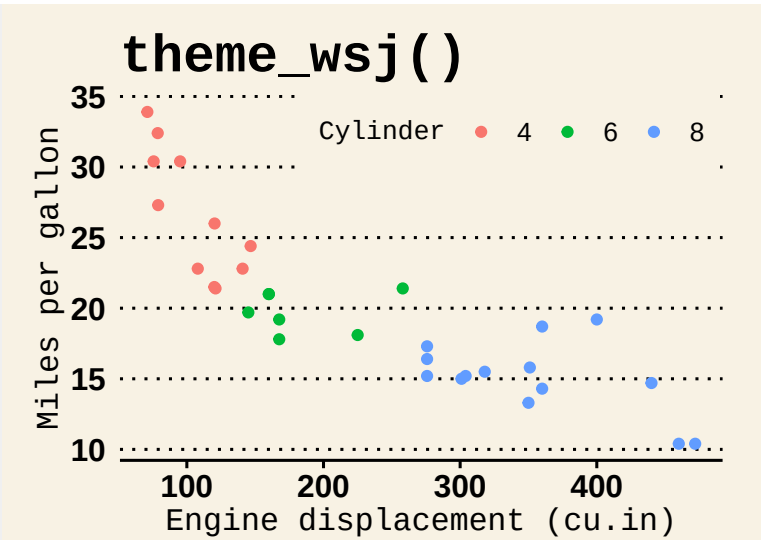
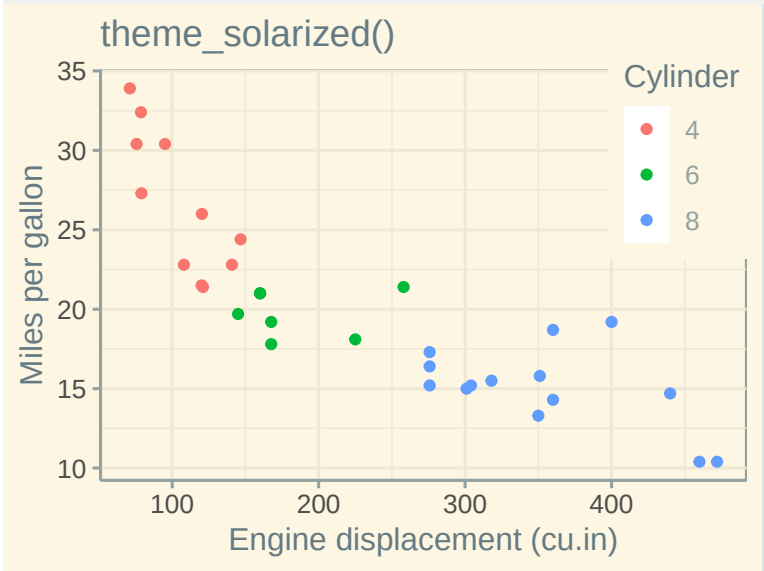
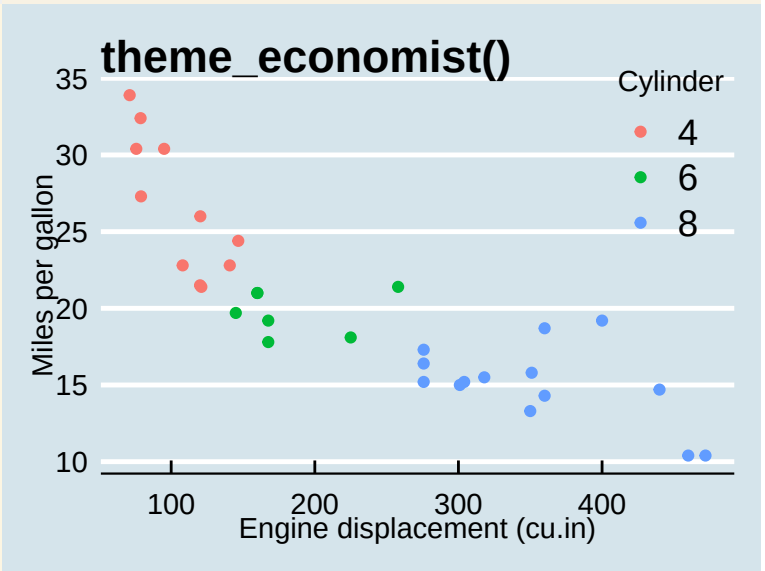
Use ggthemes package for more themes









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Important `scale_*_*()` class of functions

- We have seen that `aes()` is used to map variables to visual aesthetics. The `scale` functions are used to modify or enhance this mapping.

- For every aesthetic, we have corresponding `scale` functions. For example, for the `x` and `y` aesthetics, the corresponding scales functions are of the forms `scale_x_*()` and `scale_y_*()`, respectively.

- The last $\star$ corresponds to the type of variable that is mapped to the visual aesthetic. For example, if a continuous variable is mapped to the `x` axis, then the corresponding scale function is `scale_x_continuous()`.

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Useful arguments of `scale_x_continuous()`

- `trans`: name of the transformation, e.g., `"log10"`, `"sqrt"`, and `"log"`.
- `breaks`: a numeric vector of positions for axis labels to appear.
- `labels`: a character vector giving labels (must be same length as `breaks`).
- `position`: the position of the axis, e.g., `"top"` or `"bottom"` for the `x`-axis.

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Example: Diamond price vs log 10(carat)

We used `scale_x_continuous()` to transform the x-axis into log 10 scale, and used the `scale_y_continuous()` to change the y-axis labels.

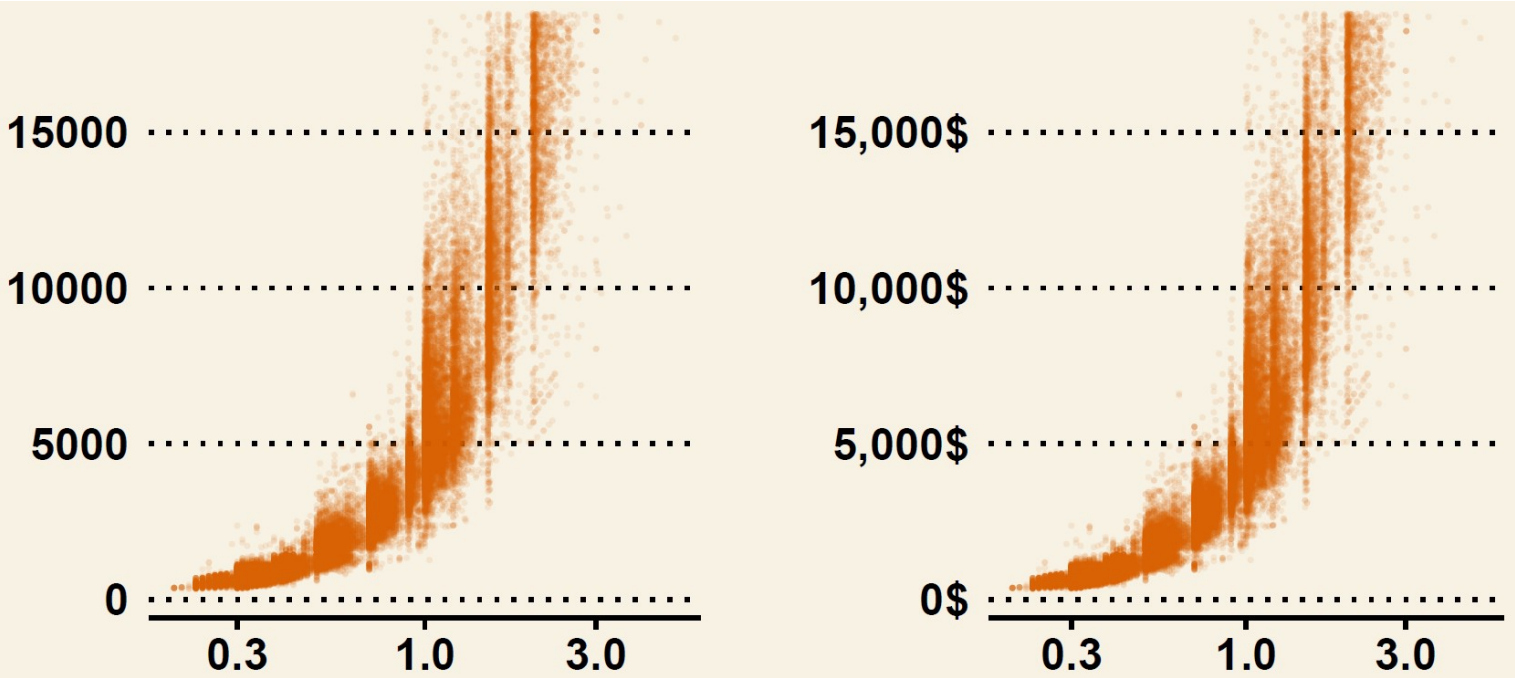

Figure 9: *Left*: Default y-axis labels; *Right*: Dollar sign and comma are added to the price for visual enhancement

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RCode: scale_y_continuous() example

```
# Plot diamond price vs log10(carat)
ggplot(diamonds, aes(carat, price)) +
geom_point(size = 0.1,
           alpha=0.10,
           color = "#D55E00") +
# Change x-axis to log-scale
scale_x_continuous(
    "log10(carat)",
    trans = "log10") +
# Change y-axis labels
scale_y_continuous(
    breaks = c(0, 5000, 10000, 15000),
    labels = c("0$", "5,000$",
               "10,000$", "15,000$")) +
theme_wsj()
```


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scale_color_⋆() functions

- scale_color_brewer() and scale_color_manual() are two useful functions that allow us to change the default color produced by mapping to the color aesthetics.
- The scale_color_brewer() provides sequential, diverging and qualitative color schemes from the R-package RColorBrewer.
- Modify the type and palette argument inside scale_color_brewer():
  - type – one of "seq" (sequential), "div" (divergent), and "qual" (qualitative).
  - palette – If a string, will use the named palette. If a number, will index into the list of palettes of appropriate type.
    - Diverging: BrBg, PiYG, RdYlBu, RdYlGr, Spectral.
    - Qualitative: Accent, Set1, Set2, Pastel1.
    - Sequential: Blues, YlOrRd, YlGnBu, Purples.

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Example: `scale_color_brewer()`

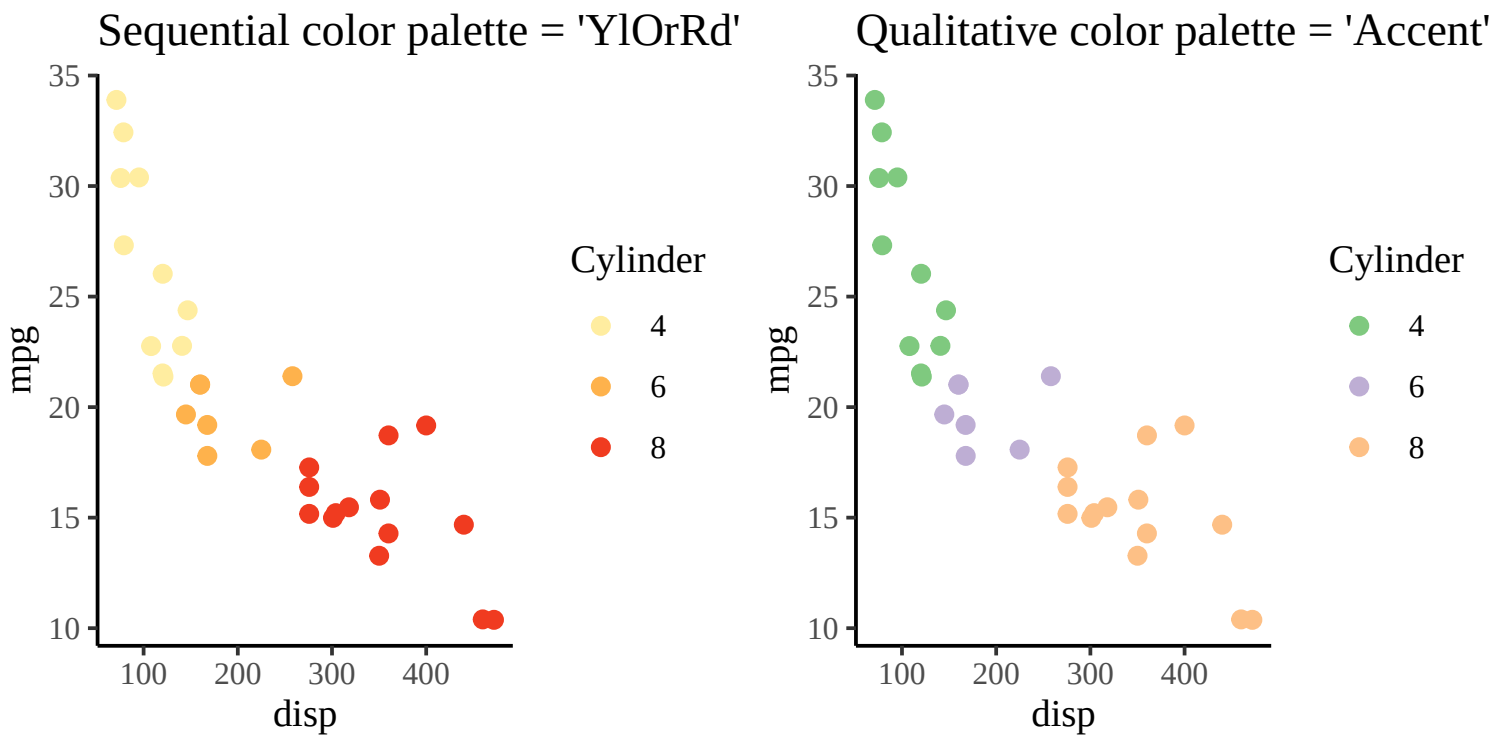

Figure 10: *Left*: Sequential color palette used; *Right*: Qualitative color palette used

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RCode: scale_color_brewer() example

```
baseplt <- ggplot(mtcars,aes(disp, mpg,
                color = factor(cyl))) +
              geom_point()
# Use a sequential palette
baseplt +
scale_color_brewer("Cylinder",
                   type = "seq",
                   palette = "YlOrRd")
# Use a qualitative palette
baseplt +
scale_color_brewer("Cylinder",
                  type = "qual",
                  palette = "Accent")
```


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`scale_color_manual()` function

- `scale_color_manual()` provides the most flexibility, as it allows you to create own discrete color scale.

- The two most important parameters are `values` and `breaks`:
  - `values`: for a categorical variable, provide a vector specifying colors for each category; for a continuous variable, provide a vector specifying colors for number of categories created by the number of `breaks`;
  - `breaks`: levels for which a color band is specified.

- Similarly, for `fill` aesthetics, we have `scale_fill_brewer()` and `scale_fill_manual()` functions.

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  - `breaks`: levels for which a color band is specified.
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Example: `scale_color_manual()`

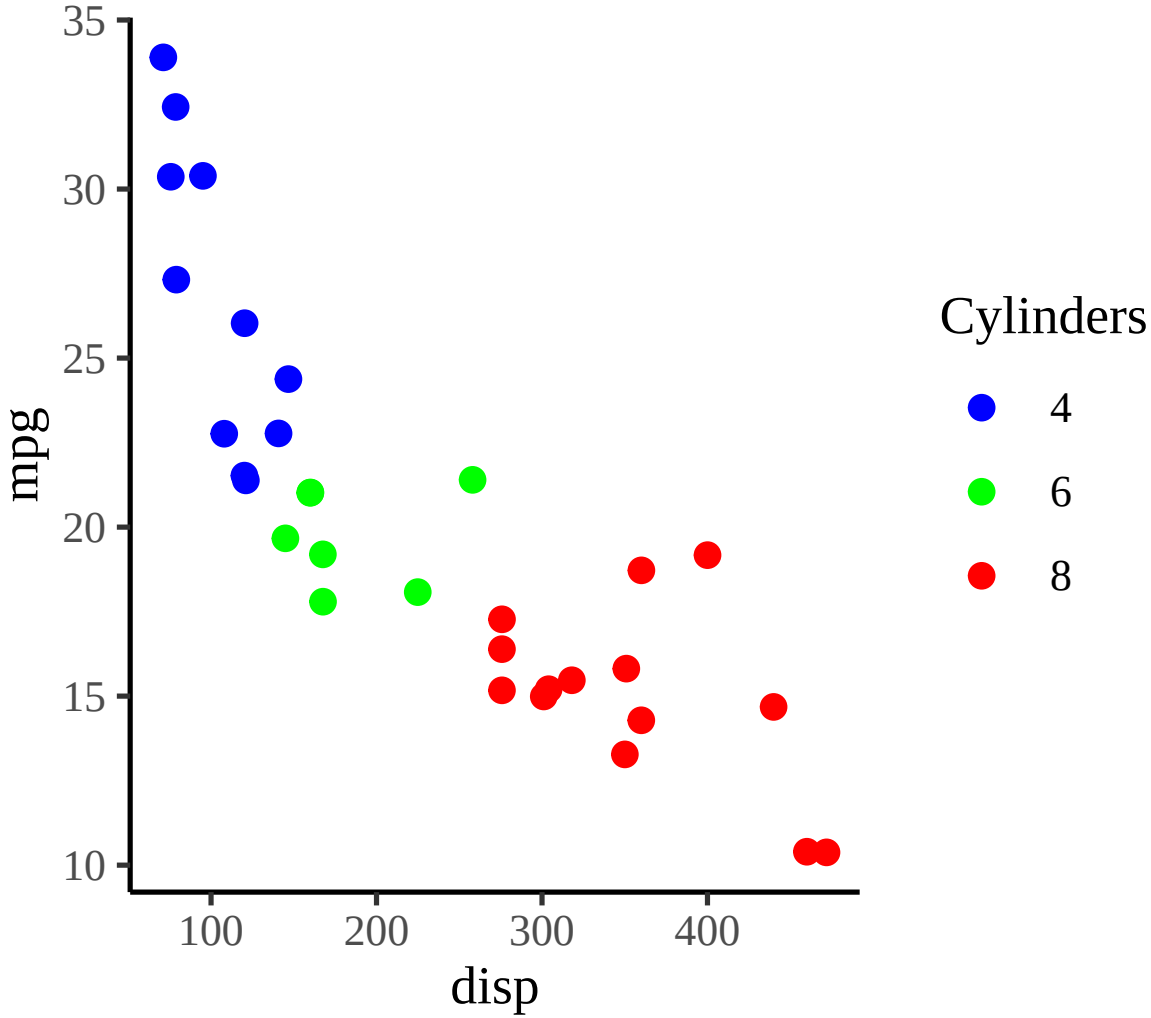

Figure 11: User-specified discrete color scale for three cylinder numbers in the mtcars dataset.

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RCode: scale_color_manual() example

```
baseplt <- ggplot(mtcars,aes(disp, mpg,
           color = factor(cyl))) +
           geom_point()

# Define a named vector with your
    favourite colors
col_vec <- c("4" = "blue",
             "6" = "green",
             "8" = "red")

# Use your favourite colors
baseplt +
 scale_color_manual("Cylinders",
                    values = col_vec)
```


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- Theme elements are all non-data ink in the plot.
- Use `element_text()`, `element_line()`, and `element_rect()` to modify three main theme elements.
- You can specify plot title, tag, caption, legend title, axis title in the `labs()` function.
- Use `override.aes` parameter of `guide_legend()` to modify legend guides.
- You can build custom themes or use many in-built themes from different R-packages.
- Use `scale` functions to modify the default aesthetic mappings.
- Use `scale_color_manual()` to select customised colors for the plot.

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