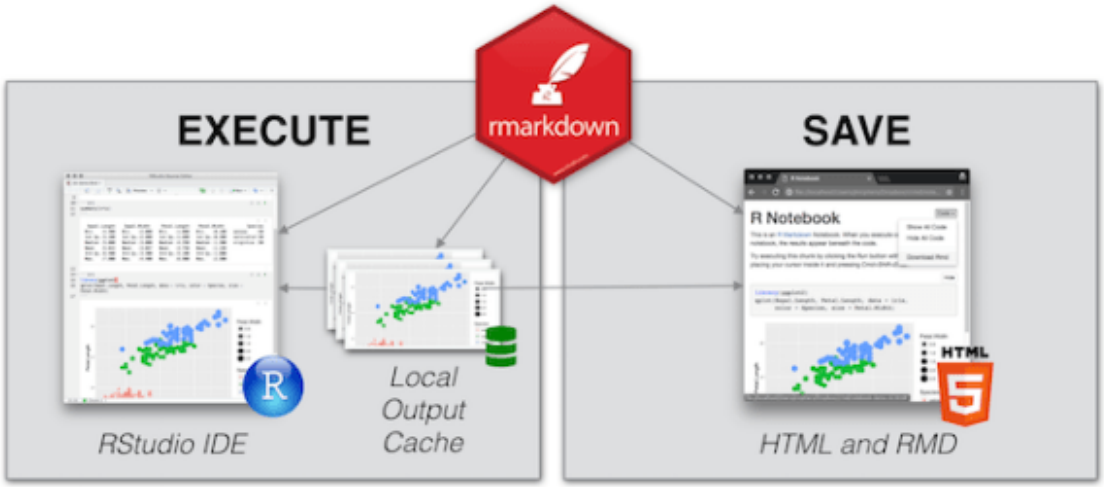
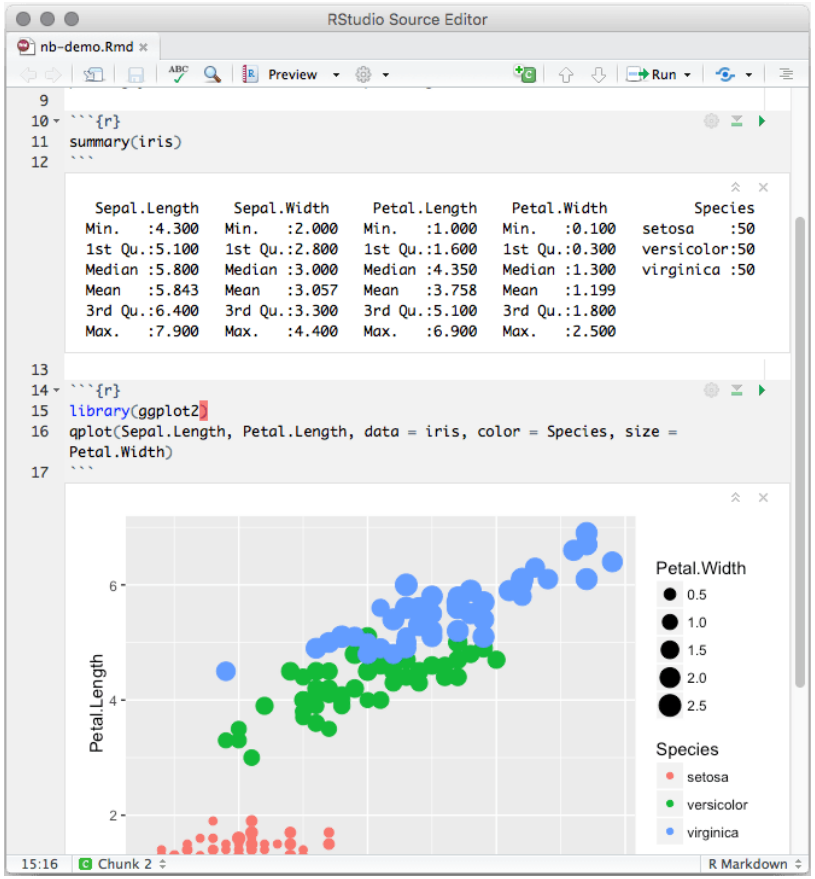


R Documentation

Pilsung Kang
School of Industrial Management Engineering
Korea University

R Notebook

- R Notebook
  - ✓ An R Markdown document with chunks that can be executed independently and interactively, with output visible immediately beneath the input

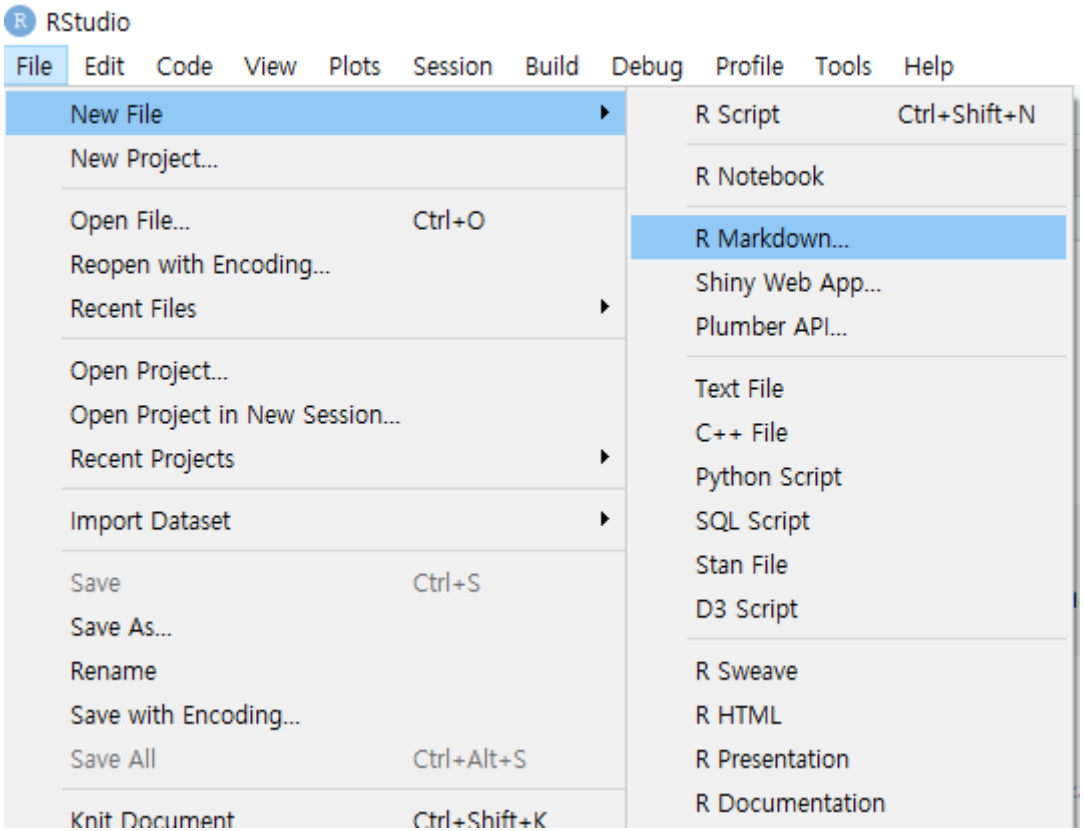


R Notebook

- R Notebook
  - ✓ An implementation of Literate Programming that allows for direct interaction with R while producing a reproducible document with publication-quality output
  - ✓ Any R Markdown document can be used as a notebook, and all R Notebooks can be rendered to other R Markdown document
  - ✓ A notebook can therefore be thought of as a special execution mode for R Markdown documents
  - ✓ The immediacy of notebook mode makes it a good choice while authoring the R Markdown document and iterating on code

R Notebook

- Create a new notebook file



R Notebook

- Document information
  - ✓ Default

```
---
title: "R Notebook"
output: html_notebook
---

```

  - ✓ We can add other information such as name and date

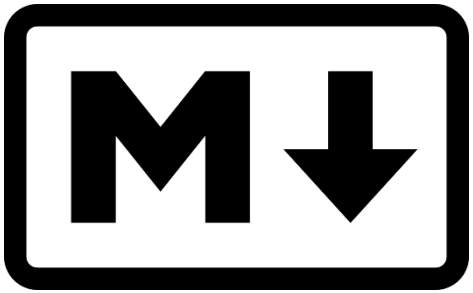
```
---
title: "R Notebook Example"
author: "Pilsung Kang"
date: '2019-10-07'
output:
  html_document:
    df_print: paged
  html_notebook: default
  pdf_document: default
---
```

R Notebook

- Some useful shortcuts
  - ✓ Ctrl+Shift+Enter
    - Excuting a chunk of r script
  - ✓ Ctrl+Alt+I
    - Add a new chunk
  - ✓ Ctrl+Shft+K
    - Preview the result
  - ✓ The preview shows you a rendered HTML copy of the contents of the editor
  - ✓ Consequently, unlike *Knit*, *Preview* does not run any R code chunks. Instead, the output of the chunk when it was last run in the editor is displayed

R Notebook

- Markdown
  - ✓ **Markdown** is a lightweight markup language with plain text formatting syntax. Its design allows it to be converted to many output formats, but the original tool by the same name only supports HTML. Markdown is often used to format readme files, for writing messages in online discussion forums, and to create rich text using a plain text editor. (https://en.wikipedia.org/wiki/Markdown)



R Notebook

- Markdown Syntax: https://www.markdownguide.org/basic-syntax/

Headings

To create a heading, add number signs (#) in front of a word or phrase. The number of number signs you use should correspond to the heading level. For example, to create a heading level three (<h3>), use three number signs (e.g., ### My Header).

Markdown	HTML	Rendered Output
# Heading level 1	Heading level 1	Heading level 1
## Heading level 2	Heading level 2	Heading level 2
### Heading level 3	Heading level 3	Heading level 3
#### Heading level 4	Heading level 4	Heading level 4
##### Heading level 5	Heading level 5	Heading level 5
###### Heading level 6	Heading level 6	Heading level 6

Alternate Syntax

Alternatively, on the line below the text, add any number of == characters for heading level 1 or -- characters for heading level 2.

Markdown	HTML	Rendered Output
Heading level 1 ==========	Heading level 1	Heading level 1
Heading level 2 ----------	Heading level 2	Heading level 2

Paragraphs

To create paragraphs, use a blank line to separate one or more lines of text. You should not indent paragraphs with spaces or tabs.

Markdown	HTML	Rendered Output
I really like using Markdown. I think I'll use it to format all of my documents from now on.	I really like using Markdown. I think I'll use it to format all of my documents from now on.	I really like using Markdown. I think I'll use it to format all of my documents from now on.

Line Breaks

To create a line break (
), end a line with two or more spaces, and then type return.

Markdown	HTML	Rendered Output
This is the first line. And this is the second line.	This is the first line. And this is the second line.	This is the first line. And this is the second line.

Emphasis

You can add emphasis by making text bold or italic.

Bold

To bold text, add two asterisks or underscores before and after a word or phrase. To bold the middle of a word for emphasis, add two asterisks without spaces around the letters.

Markdown	HTML	Rendered Output
I just love **bold text**.	I just love bold text.	I just love **bold text**.
I just love __bold text__.	I just love bold text.	I just love **bold text**.
Love**is**bold	Loveisbold	Love**is**bold

R Notebook

- Markdown Syntax: https://www.markdownguide.org/basic-syntax/

Italic

To italicize text, add one asterisk or underscore before and after a word or phrase. To italicize the middle of a word for emphasis, add one asterisk without spaces around the letters.

Markdown	HTML	Rendered Output
`Italicized text is the *cat's meow*.`	`Italicized text is the <em>cat's meow</em>.`	Italicized text is the *cat's meow*.
`Italicized text is the _cat's meow_.`	`Italicized text is the <em>cat's meow</em>.`	Italicized text is the *cat's meow*.
`A*cat*meow`	`A<em>cat</em>meow`	A*cat*meow

Bold and Italic

To emphasize text with bold and italics at the same time, add three asterisks or underscores before and after a word or phrase.

Markdown	HTML	Rendered Output
`This text is ***really important***.`	`This text is <strong><em>really important</em></strong>.`	This text is ***really important***.
`This text is ___really important___.`	`This text is <strong><em>really important</em></strong>.`	This text is ***really important***.
`This text is __*really important*__.`	`This text is <strong><em>really important</em></strong>.`	This text is ***really important***.
`This text is **_really important_**.`	`This text is <strong><em>really important</em></strong>.`	This text is ***really important***.

Blockquotes

To create a blockquote, add a > in front of a paragraph.

```
> Dorothy followed her through many of the beautiful rooms in her castle.
```

The rendered output looks like this:

> Dorothy followed her through many of the beautiful rooms in her castle.

Blockquotes with Multiple Paragraphs

Blockquotes can contain multiple paragraphs. Add a > on the blank lines between the paragraphs.

```
> Dorothy followed her through many of the beautiful rooms in her castle.
>
> The Witch bade her clean the pots and kettles and sweep the floor and keep the fire fed with wood.
```

The rendered output looks like this:

> Dorothy followed her through many of the beautiful rooms in her castle.
>
> The Witch bade her clean the pots and kettles and sweep the floor and keep the fire fed with wood.

Nested Blockquotes

Blockquotes can be nested. Add a >> in front of the paragraph you want to nest.

```
> Dorothy followed her through many of the beautiful rooms in her castle.
>
>> The Witch bade her clean the pots and kettles and sweep the floor and keep the fire fed with wood.
```

The rendered output looks like this:

> Dorothy followed her through many of the beautiful rooms in her castle.
>
> > The Witch bade her clean the pots and kettles and sweep the floor and keep the fire fed with wood.

R Notebook

- Markdown Syntax: https://www.markdownguide.org/basic-syntax/

Blockquotes with Other Elements

Blockquotes can contain other Markdown formatted elements. Not all elements can be used — you'll need to experiment to see which ones work.

```
> #### The quarterly results look great!
>
> - Revenue was off the chart.
> - Profits were higher than ever.
>
>  *Everything* is going according to **plan**.
```

The rendered output looks like this:

> #### The quarterly results look great!
>
> - Revenue was off the chart.
> - Profits were higher than ever.
>
> *Everything* is going according to **plan**.

Lists

You can organize items into ordered and unordered lists.

Ordered Lists

To create an ordered list, add line items with numbers followed by periods. The numbers don't have to be in numerical order, but the list should start with the number one.

Markdown	HTML	Rendered Output

`1. First item`
`2. Second item`
`3. Third item`
`4. Fourth item`
	`<ol>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item</li>`
	`<li>Fourth item</li>`
	`</ol>`
		1. First item
		2. Second item
		3. Third item
		4. Fourth item

`1. First item`
`1. Second item`
`1. Third item`
`1. Fourth item`
	`<ol>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item</li>`
	`<li>Fourth item</li>`
	`</ol>`
		1. First item
		2. Second item
		3. Third item
		4. Fourth item

`1. First item`
`8. Second item`
`3. Third item`
`5. Fourth item`
	`<ol>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item</li>`
	`<li>Fourth item</li>`
	`</ol>`
		1. First item
		2. Second item
		3. Third item
		4. Fourth item

`1. First item`
`2. Second item`
`3. Third item`
`  1. Indented item`
`  2. Indented item`
`4. Fourth item`
	`<ol>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item`
	`<ol>`
	`<li>Indented item</li>`
	`<li>Indented item</li>`
	`</ol>`
	`</li>`
	`<li>Fourth item</li>`
	`</ol>`
		1. First item
		2. Second item
		3. Third item
		  1. Indented item
		  2. Indented item
		4. Fourth item

R Notebook

- Markdown Syntax: https://www.markdownguide.org/basic-syntax/

Unordered Lists

To create an unordered list, add dashes (-), asterisks (*), or plus signs (+) in front of line items. Indent one or more items to create a nested list.

Markdown	HTML	Rendered Output

`- First item`
`- Second item`
`- Third item`
`- Fourth item`
	`<ul>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item</li>`
	`<li>Fourth item</li>`
	`</ul>`
		• First item
		• Second item
		• Third item
		• Fourth item

`* First item`
`* Second item`
`* Third item`
`* Fourth item`
	`<ul>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item</li>`
	`<li>Fourth item</li>`
	`</ul>`
		• First item
		• Second item
		• Third item
		• Fourth item

`+ First item`
`* Second item`
`- Third item`
`+ Fourth item`
	`<ul>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item</li>`
	`<li>Fourth item</li>`
	`</ul>`
		• First item
		• Second item
		• Third item
		• Fourth item

`- First item`
`- Second item`
`- Third item`
`  - Indented item`
`  - Indented item`
`- Fourth item`
	`<ul>`
	`<li>First item</li>`
	`<li>Second item</li>`
	`<li>Third item`
	`<ul>`
	`<li>Indented item</li>`
	`<li>Indented item</li>`
	`</ul>`
	`</li>`
	`<li>Fourth item</li>`
	`</ul>`
		• First item
		• Second item
		• Third item
		  ◦ Indented item
		  ◦ Indented item
		• Fourth item

✓ And much more in the website…

Adding Elements in Lists

To add another element in a list while preserving the continuity of the list, indent the element four spaces or one tab, as shown in the following examples.

Paragraphs

```
*   This is the first list item.
*   Here's the second list item.

    I need to add another paragraph below the second list item.

*   And here's the third list item.
```

The rendered output looks like this:

- This is the first list item.
- Here's the second list item.

  I need to add another paragraph below the second list item.

- And here's the third list item.

Blockquotes

```
*   This is the first list item.
*   Here's the second list item.

    > A blockquote would look great below the second list item.

*   And here's the third list item.
```

The rendered output looks like this:

- This is the first list item.
- Here's the second list item.

  > A blockquote would look great below the second list item.

- And here's the third list item.

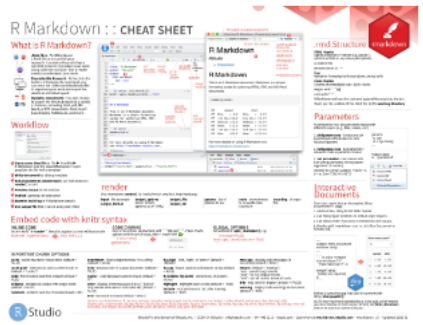
R Notebook

- Rmd file and its output

08_R Notebook Example.Rmd

Knit | Insert | Run

```
1  ---
2  title: "R Notebook Example"
3  author: "Pilsung Kang"
4  date: '2020-12-10'
5  output:
6    html_document:
7      df_print: paged
8    html_notebook: default
9    pdf_document: default
10 ---
11
12 This document shows an example of [ggplot](https://ggplot2.tidyverse.org/index.html
13 ) package in **R Notebook**.
14
15 ## Basic Syntax of (R) Markdown
16
17 [Basic Syntax of Markdown](https://www.markdownguide.org/basic-syntax/)
18
19 [R markdown homepage](https://rmarkdown.rstudio.com/)
20
21 ![R markdown cheatsheet](https://d33wubrfki0l68.cloudfront.net/374f4c769f97c4ded7300d521e
   b59b24168a7261/c72ad/lesson-images/cheatsheets-1-cheatsheet.png)
```



R Notebook

R Notebook Example

Pilsung Kang

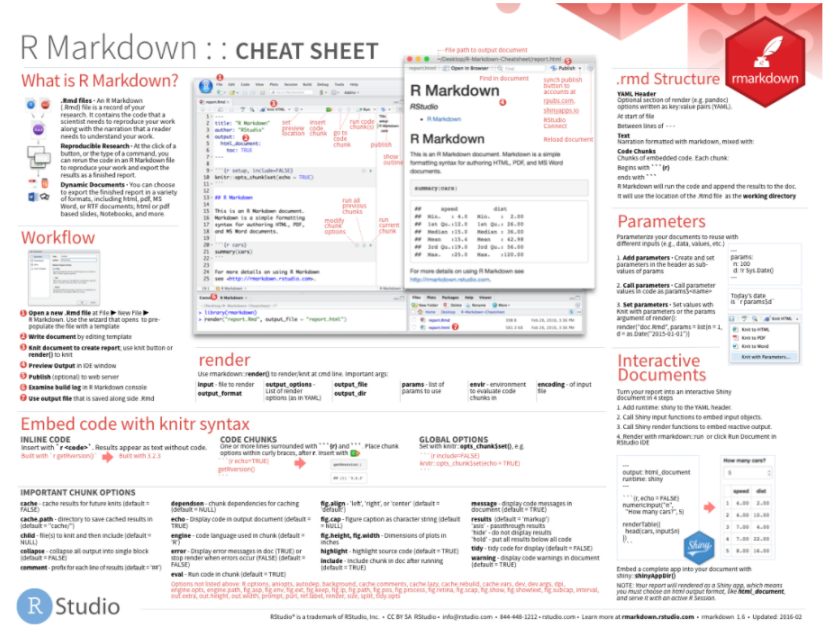
2020-12-10

This document shows an example of ggplot package in **R Notebook**.

Basic Syntax of (R) Markdown

Basic Syntax of Markdown

R markdown homepage



R markdown cheatsheet

Keyboard shortcuts

- Try executing a chunk of R script by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.
- Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.
- When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to preview the HTML file).
- The preview shows you a rendered HTML copy of the contents of the editor. Consequently, unlike *Knit*, *Preview* does not run any R code chunks. Instead, the output of the chunk when it was last run in the editor is displayed.

Load the dataset

(Note) The following contents are taken from this website

```
require(ggplot2)
```

```
## Loading required package: ggplot2
```

This dataset provides fuel economy data from 1999 and 2008 for 38 popular models of cars. The dataset is shipped with ggplot2 package.

Variable	Type	Description	Details
manufacturer	string	car manufacturer	15 manufacturers
model	string	model name	38 models
displ	numeric	engine displacement in liters	1.6 - 7.0, median: 3.3
year	integer	year of manufacturing	1999, 2008
cyl		number of cylinders	4, 5, 6, 8
trans	string	type of transmission	automatic, manual (many sub types)
drv	string	drive type	f, r, 4, f=front wheel, r=rear wheel, 4=4 wheel
cty	integer	city mileage	miles per gallon
hwy	integer	highway mileage	miles per gallon
fl	string	fuel type	5 fuel types (diesel, petrol, electric, etc.)
class string	vehicle	class	7 types (compact, SUV, minivan etc.)

Description of **mpg** dataset

```
data("mpg")
head(mpg)
```

manufacturer <chr>	model <chr>	displ <dbl>	year <int>	cyl <int>	trans <chr>	drv <chr>	cty <int>	hwy <int>	fl <chr>
audi	a4	1.8	1999	4	auto(l5)	f	18	29	p
audi	a4	1.8	1999	4	manual(m5)	f	21	29	p
audi	a4	2.0	2008	4	manual(m6)	f	20	31	p
audi	a4	2.0	2008	4	auto(av)	f	21	30	p
audi	a4	2.8	1999	6	auto(l5)	f	16	26	p
audi	a4	2.8	1999	6	manual(m5)	f	18	26	p

6 rows | 1-10 of 11 columns

R Notebook

- Table in markdown and in the output file

```
## Load the dataset

(Note) The following contents are taken from [this website](https://rpubs.com/shailesh/mpg-exploration)

```{r}
require(ggplot2)
```

This dataset provides fuel economy data from 1999 and 2008 for 38 popular models of cars. The dataset is shipped with ggplot2 package.

Variable	Type	Description	Details
manufacturer	string	car manufacturer	15 manufacturers
model	string	model name	38 models
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```

R Notebook

- Table in markdown and in the output file

Load the dataset

(Note) The following contents are taken from this website

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cty	integer	city mileage	miles per gallon
hwy	integer	highway mileage	miles per gallon
fl	string	fuel type	5 fuel types (diesel, petrol, electric, etc.)
class string	vehicle	class	7 types (compact, SUV, minivan etc.)

R Notebook

- Evaluation and Display options
  - ✓ eval = T(F): (Do Not) Run the script
  - ✓ echo = T(F): (Do not) Show the script (not the result of the script) in the output file

eval=T: Run the script

echo=T: show the script (**not the result**) in the output file

```
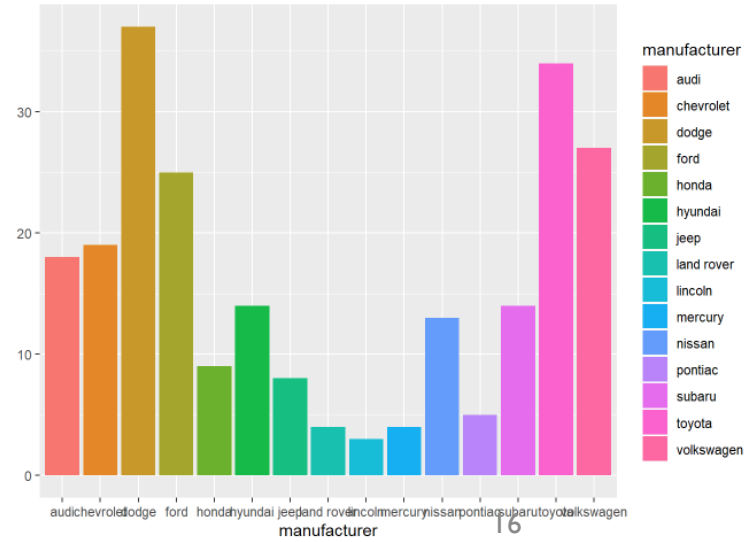
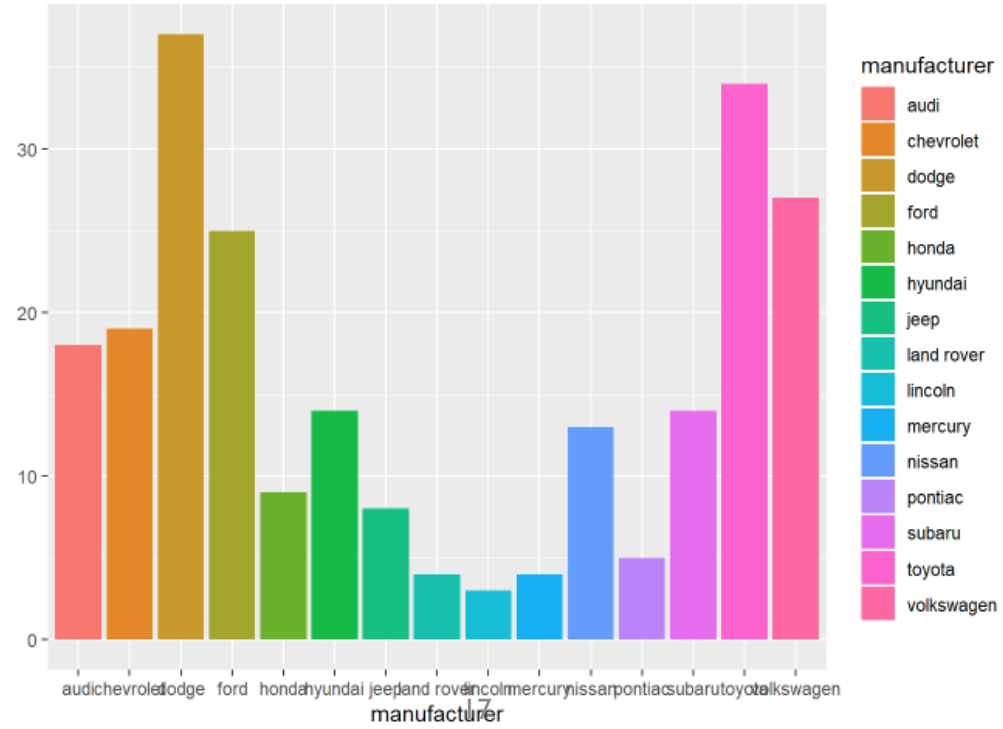
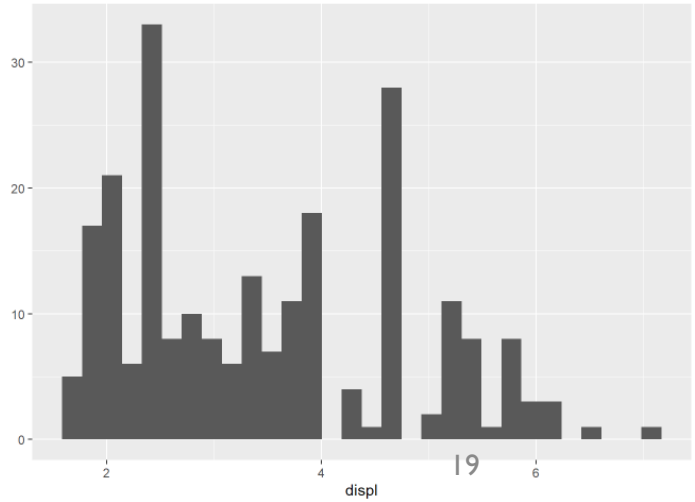
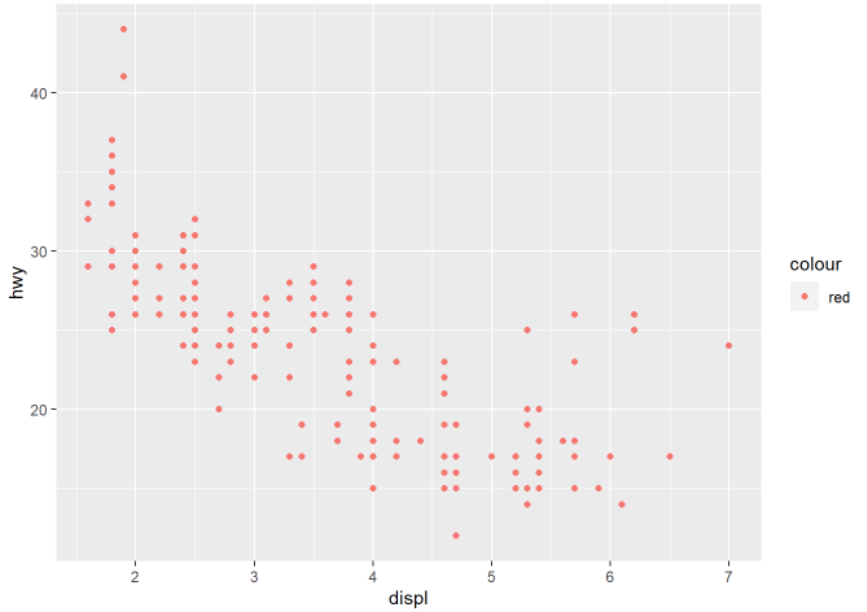
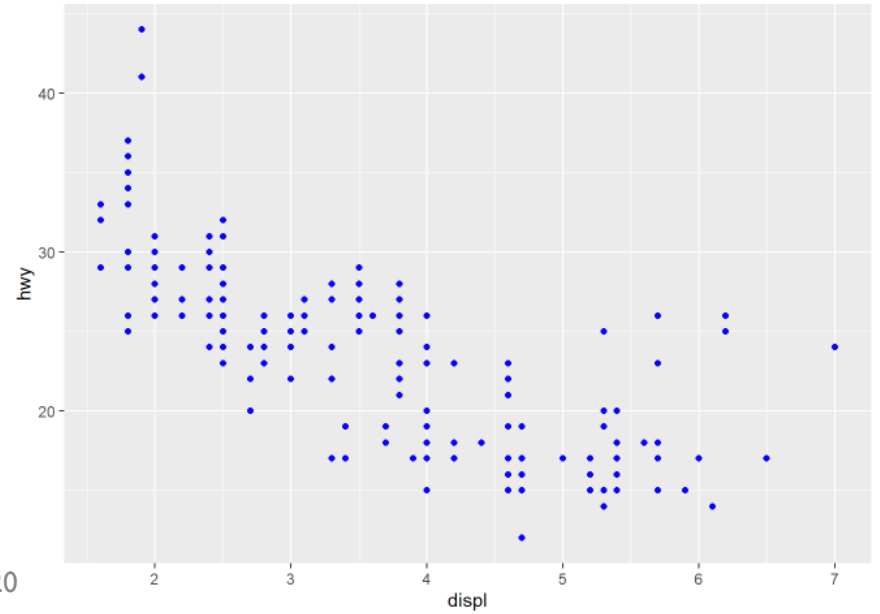
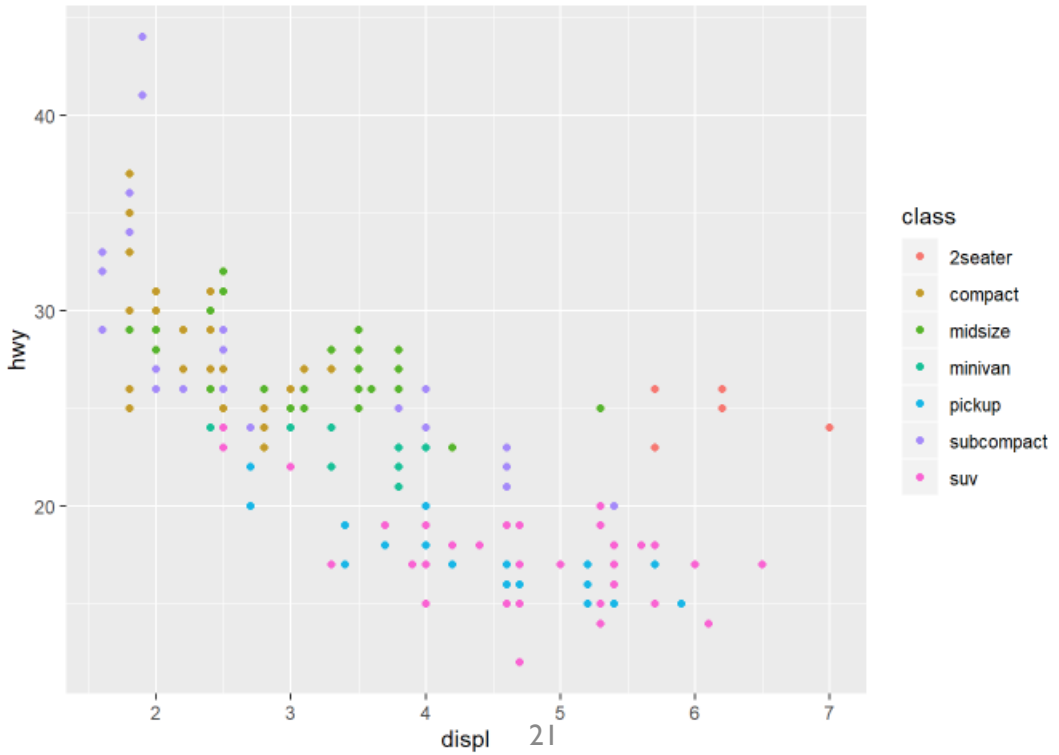
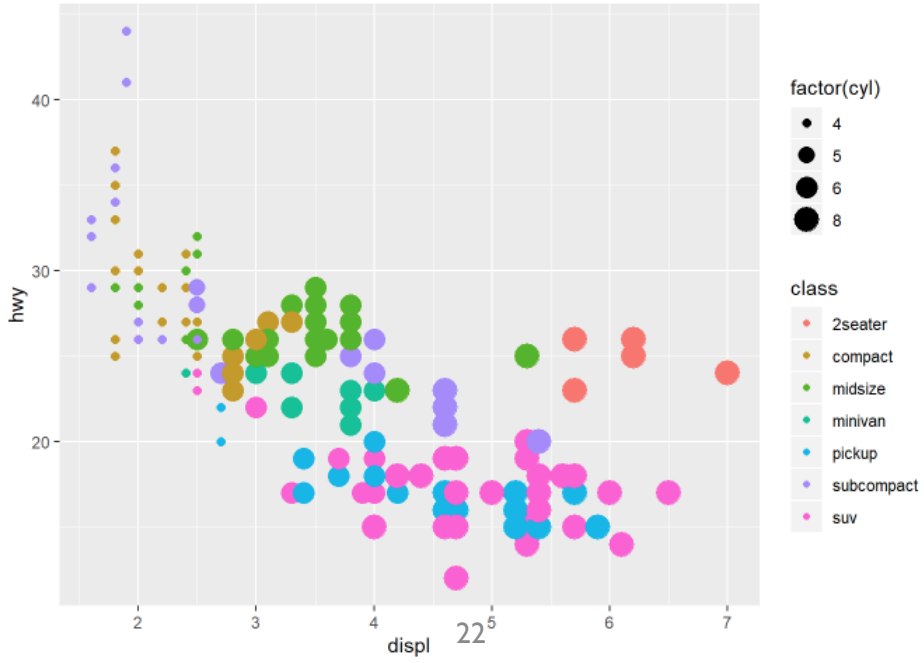
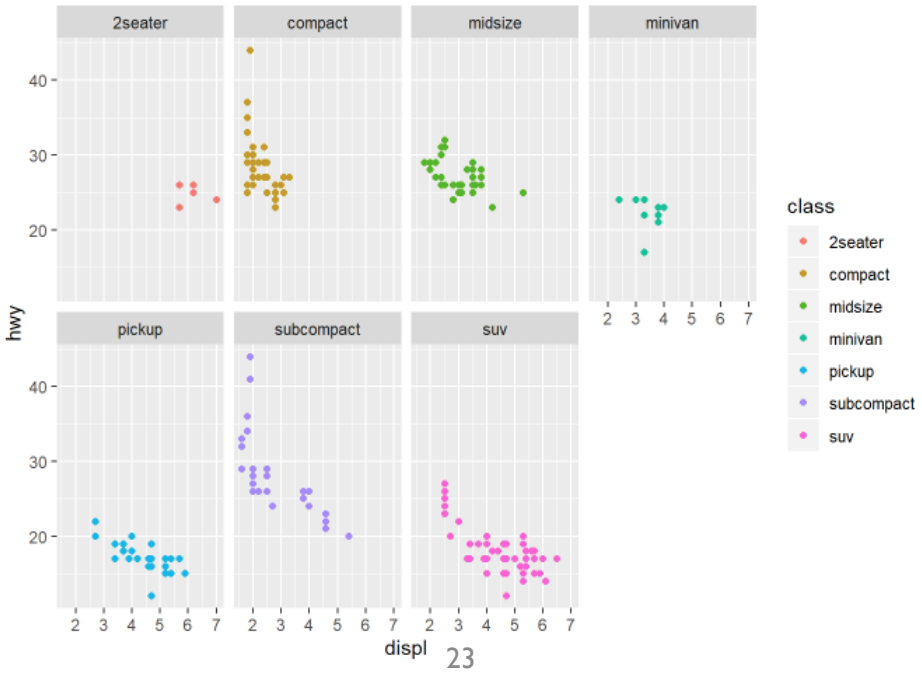
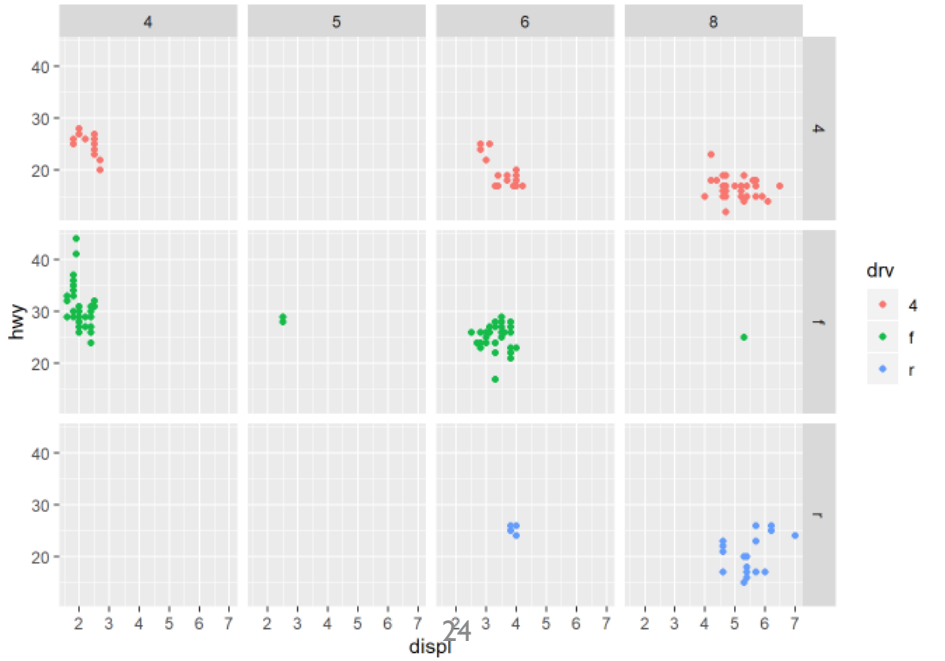
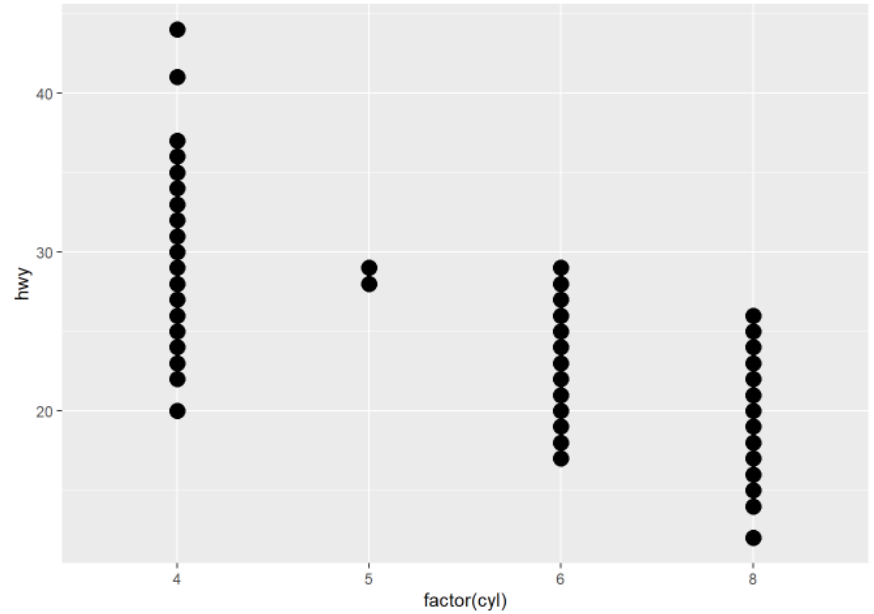
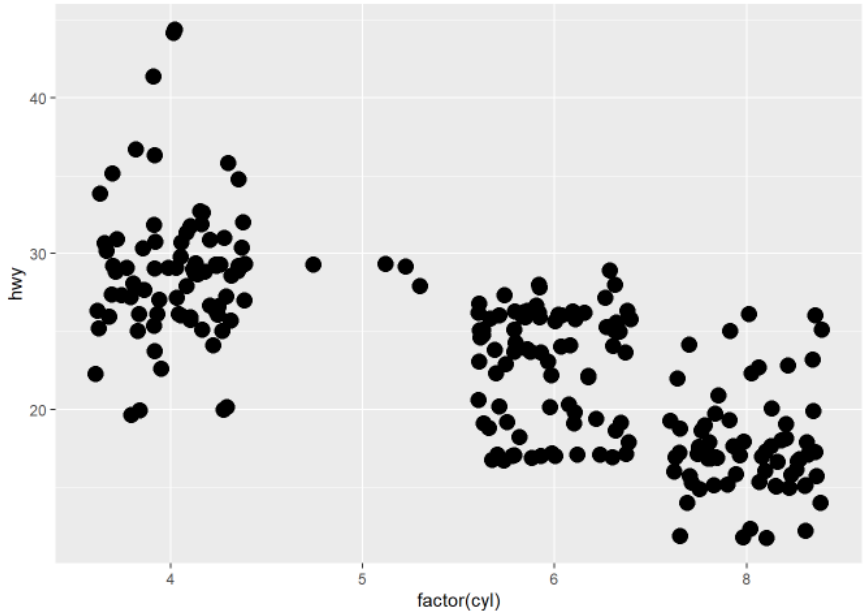
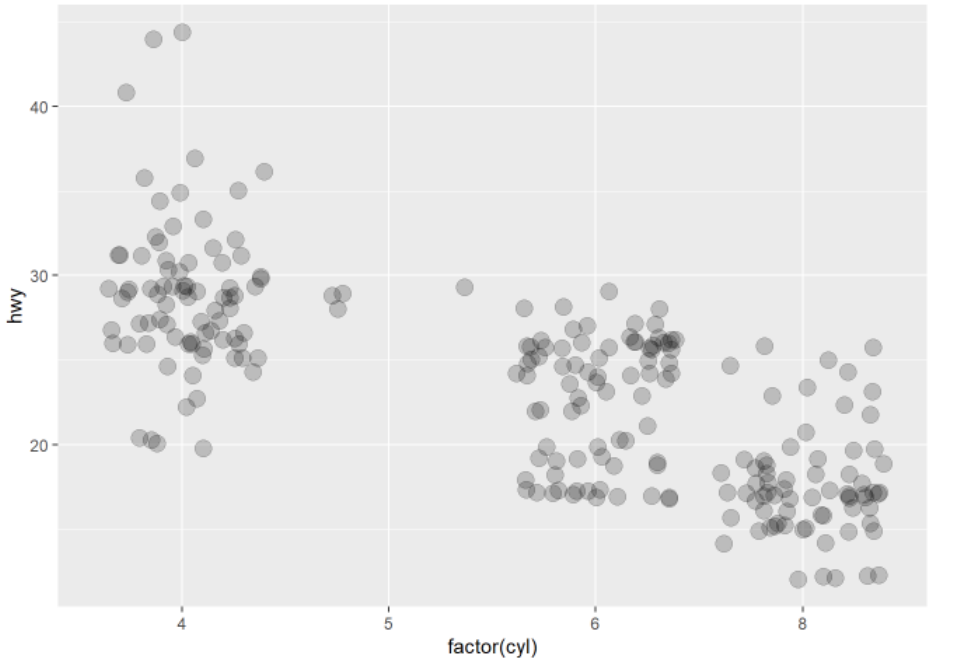
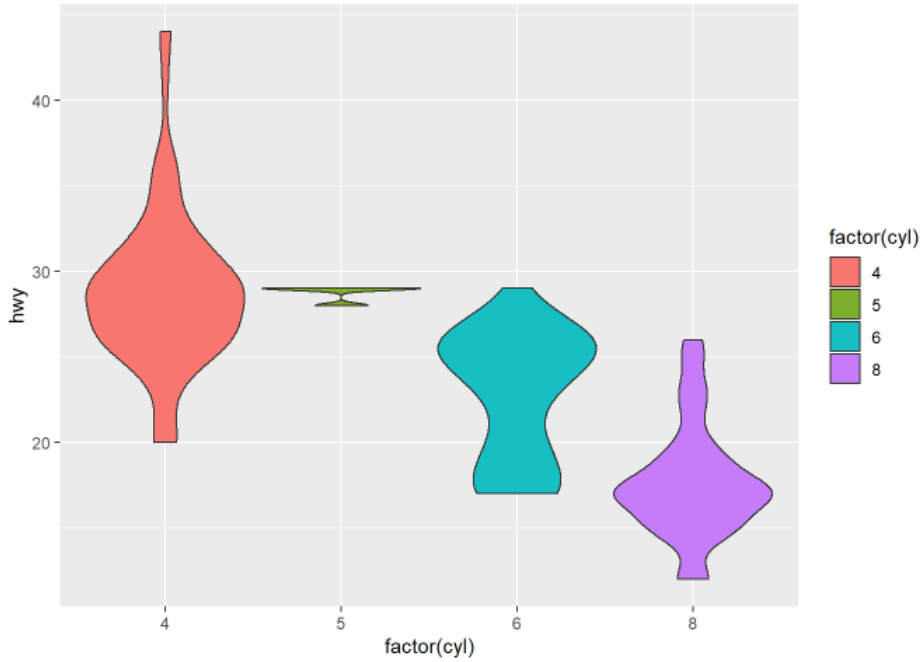
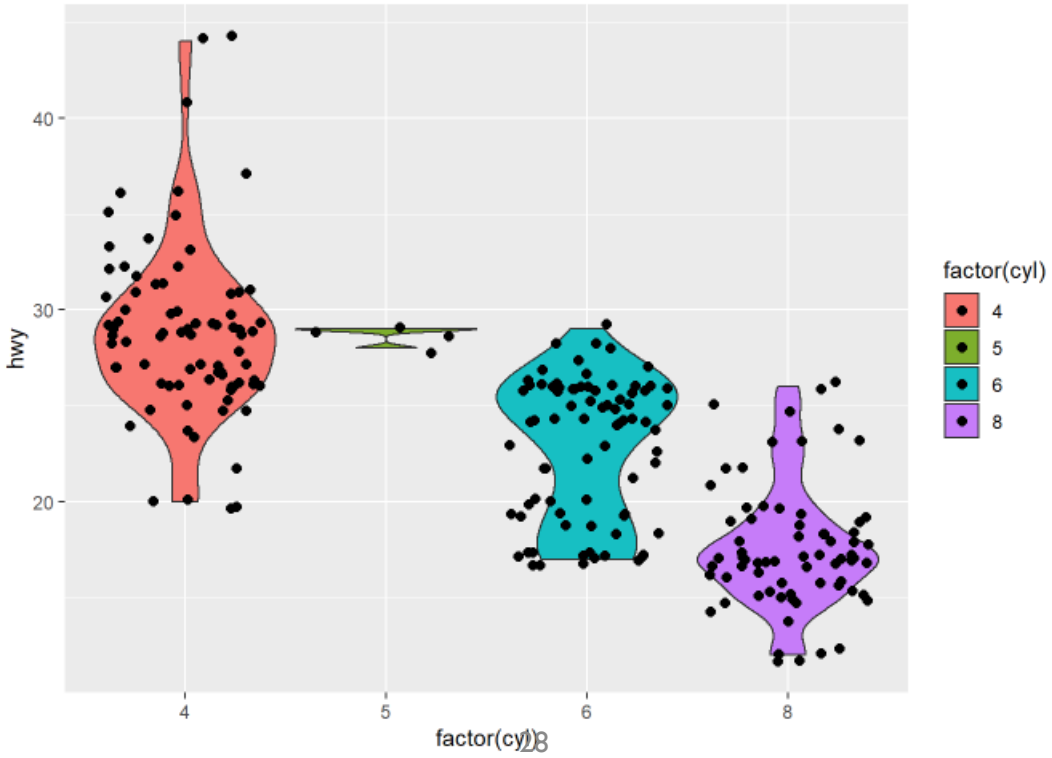
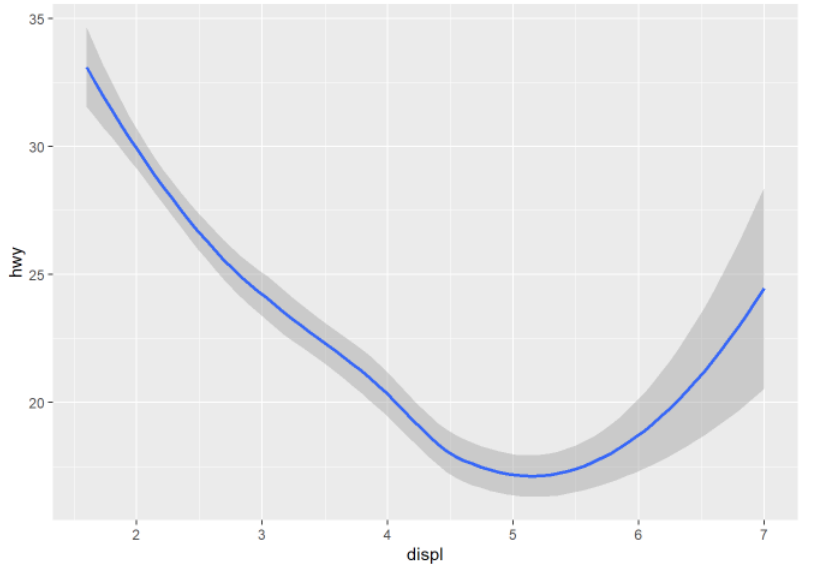
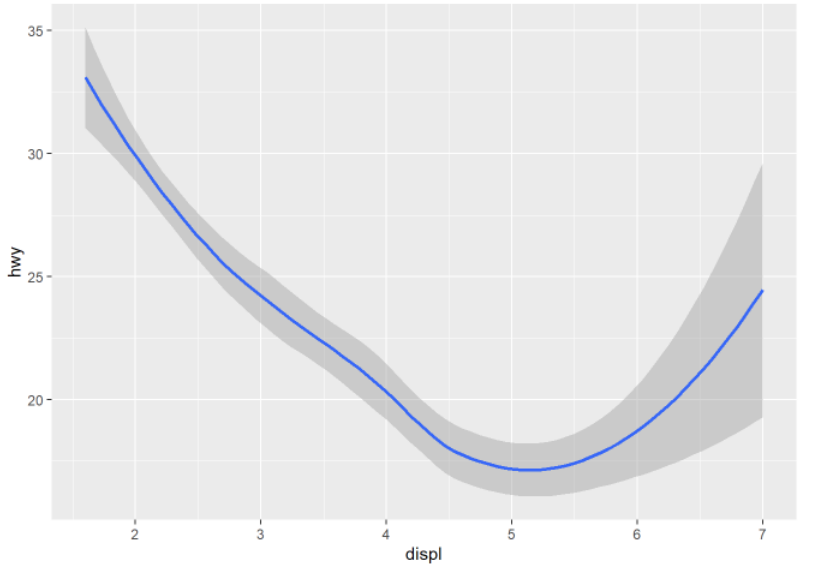
table(mpg$manufacturer)
```

```
##
##       audi  chevrolet      dodge       ford      honda    hyundai
##         18         19         37         25          9         14
##       jeep land rover    lincoln    mercury     nissan    pontiac
##          8          4          3          4         13          5
##     subaru     toyota volkswagen
##         14         34         27
```

```
qplot(manufacturer, data=mpg, geom="bar", fill=manufacturer)
```



R Notebook

- Evaluation and Display options

```
93 ```{r, eval=T, echo=F}
94 qplot(manufacturer, data=mpg, geom="bar", fill=manufacturer)
95 ```
```

✓ Only the result is displayed and the script is not displayed in the output file

eval=T: Run run the script

echo=F: Do not show the script (**not the result**) in the output file



R Notebook

- Evaluation and Display options

```
**eval=F**: Do not run the script

**echo=T**: show the script in the output file

```{r, eval=F, echo=T}
qplot(manufacturer, data=mpg, geom="bar", fill=manufacturer)
```
```

✓ Do not run the script but display the script in the output file

eval=F: Do not run the script

echo=T: show the script in the output file

```
qplot(manufacturer, data=mpg, geom="bar", fill=manufacturer)
```

  - Only the script is displayed

- Eval = T and Echo = T are the default arguments

R Notebook

- Compare the Rmd file and its output

```
106 Example 2: Bar plot for manufacturer: Histogram for displacement
107
108 ```{r, eval=T, echo=T}
109 summary(mpg$displ)
110 qplot(displ, data=mpg, geom="histogram", bin=20)
111 ```
```

Example 2: Bar plot for manufacturer: Histogram for displacement

```
summary(mpg$displ)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.600   2.400   3.300   3.472   4.600   7.000
```

```
qplot(displ, data=mpg, geom="histogram", bin=20)
```

```
## Warning: Ignoring unknown parameters: bin
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



R Notebook

- Compare the Rmd file and its output

```
## Draw plots with ggplot( ) function

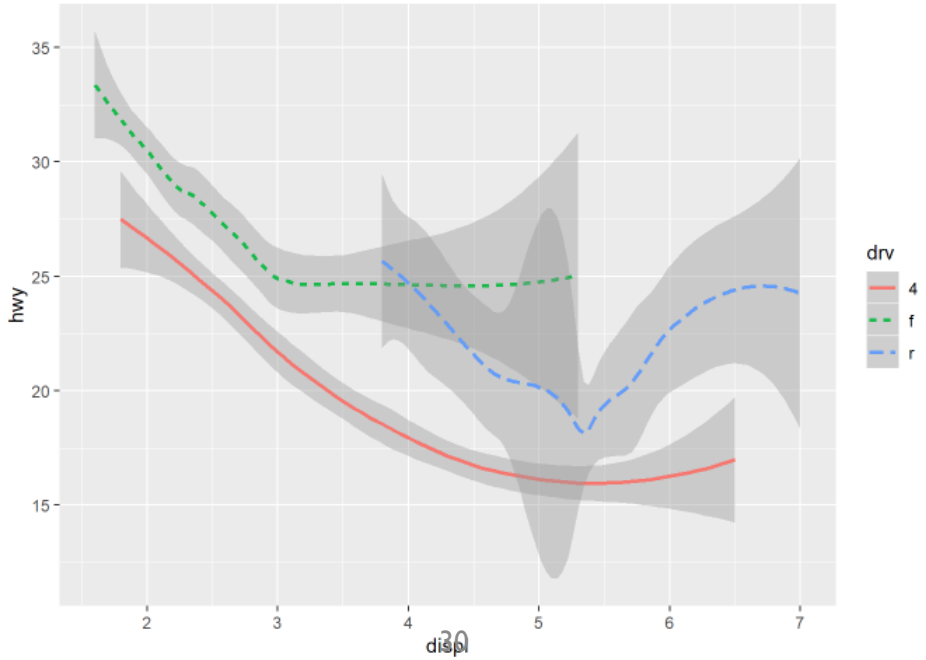
We can draw the same graph using **qplot( )** and **ggplot( )**

```{r, eval=T, echo=T}
qplot(displ, hwy, data=mpg, geom="point", color='red')
ggplot(mpg, aes(x = displ, y = hwy)) + geom_point(color='blue')
```
```

Draw plots with ggplot( ) function

We can draw the same graph using **qplot( )** and **ggplot( )**

```
qplot(displ, hwy, data=mpg, geom="point", color='red')
```




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



R Notebook

- Compare the Rmd file and its output

````
Looking at the data separately for each class
```{r}
ggplot(mpg, aes(x = displ, y = hwy, color=class)) + geom_point()
```
````

Looking at the data separately for each class

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



R Notebook

- Compare the Rmd file and its output

```
Add another information using the size of points
```{r}
ggplot(mpg, aes(x = displ, y = hwy, colour = class)) +
       geom_point(aes(size = factor(cyl)))
```
```

Add another information using the size of points

```
ggplot(mpg, aes(x = displ, y = hwy, colour = class)) +
       geom_point(aes(size = factor(cyl)))
```

```
## Warning: Using size for a discrete variable is not advised.
```



R Notebook

- Compare the Rmd file and its output

```
Separate graphs for each vehicle class
```{r}
ggplot(data = mpg) +
        geom_point(mapping = aes(x = displ, y = hwy, color=class)) +
        facet_wrap(~ class, nrow = 2)
```
```

Separate graphs for each vehicle class

```
ggplot(data = mpg) +
       geom_point(mapping = aes(x = displ, y = hwy, color=class)) +
       facet_wrap(~ class, nrow = 2)
```



R Notebook

- Compare the Rmd file and its output

````
Creating facets on the basis of two variables : number of cylinders and type of drive
```{r}
ggplot(data = mpg) +
        geom_point(mapping = aes(x = displ, y = hwy, color=drv)) +
        facet_grid(drv ~ cyl)
```
````

Creating facets on the basis of two variables : number of cylinders and type of drive

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



R Notebook

- Compare the Rmd file and its output

````
147 Continuous + categorical
148 ```{r}
149 p <- ggplot(mpg, aes(factor(cyl), hwy))
150 p + geom_point(size=4)  # Overlaid dots
151 p + geom_point(size=4, position="jitter")  # Jittered dots
152 p + geom_point(size=4, position="jitter", alpha=.2)  # Transparent dots
153 ```
````

Continuous + categorical

```
p <- ggplot(mpg, aes(factor(cyl), hwy))
p + geom_point(size=4)  # Overlaid dots
```




```
p + geom_point(size=4, position="jitter")  # Jittered dots
```



R Notebook

- Compare the Rmd file and its output

```
Continuous + categorical
```{r}
p <- ggplot(mpg, aes(factor(cyl), hwy))
p + geom_point(size=4)  # Overlaid dots
p + geom_point(size=4, position="jitter")  # Jittered dots
p + geom_point(size=4, position="jitter", alpha=.2)  # Transparent dots
```
```

```
p + geom_point(size=4, position="jitter", alpha=.2)  # Transparent dots
```



R Notebook

- Compare the Rmd file and its output

```
155 Violin plots
156 ```{r}
157 p3 <- ggplot(mpg, aes(x=factor(cyl), y=hwy, fill=factor(cyl)))
158 p3 + geom_violin(scale = "width")
159 ```
```

Violin plots

```
p3 <- ggplot(mpg, aes(x=factor(cyl), y=hwy, fill=factor(cyl)))
p3 + geom_violin(scale = "width")
```



R Notebook

- Compare the Rmd file and its output

```
161  Add jittered dots for fun
162  ```{r}
163  p3 + geom_violin(scale = "width") + geom_point(size=2, position="jitter")
164  ```
```

Add jittered dots for fun

```
p3 + geom_violin(scale = "width") + geom_point(size=2, position="jitter")
```



R Notebook

- Compare the Rmd file and its output

````
166 Estimating a smooth curve for the relationship between displacement and highway mileage:
167 ```{r}
168 ggplot(data = mpg) + geom_smooth(mapping = aes(x = displ, y = hwy))
169 ggplot(data = mpg) + geom_smooth(mapping = aes(x = displ, y = hwy), level=0.99)
170 ```
````

Estimating a smooth curve for the relationship between displacement and highway mileage:

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

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```




```
ggplot(data = mpg) + geom_smooth(mapping = aes(x = displ, y = hwy), level=0.99)
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



R Notebook

- Compare the Rmd file and its output

````
Separate curve for each type of drive:
```{r}
ggplot(data = mpg) +
        geom_smooth(mapping = aes(x = displ, y = hwy, linetype = drv, color=drv))
```
````

Separate curve for each type of drive:

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

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



R Notebook

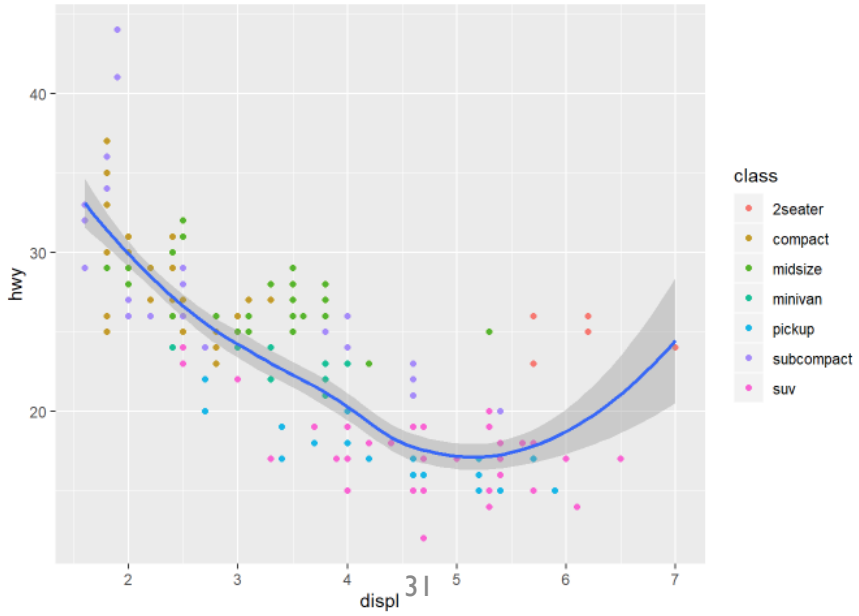
- Compare the Rmd file and its output

```
178 Overlaying a smooth curve on top of scatter plot:
179 ```{r}
180 ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
181         geom_point(mapping=aes(color=class)) +
182         geom_smooth()
183 ```
```

Overlaying a smooth curve on top of scatter plot:

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

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



R Notebook

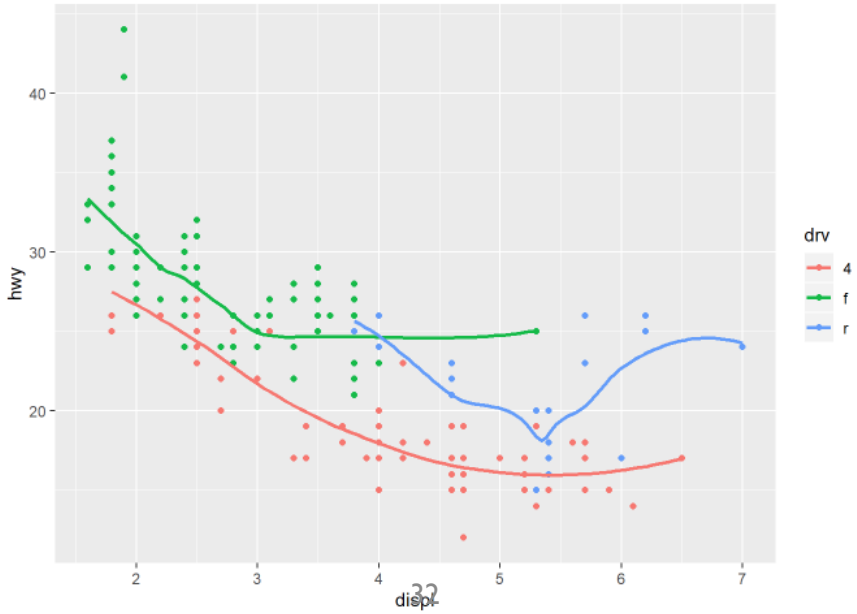
- Compare the Rmd file and its output

```
185 Grouping data by drive and then drawing scatter plot with estimated curve for each group:
186 ```{r}
187 ggplot(data = mpg, mapping = aes(x = displ, y = hwy, color = drv)) +
188         geom_point() +
189         geom_smooth(se = FALSE)
190 ```
```

Grouping data by drive and then drawing scatter plot with estimated curve for each group:

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

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```




ANY
questions?