Data visualization and a grammar of graphics

Overview

Quick review of dplyr

The grammar of graphics

ggplot

Announcement

If you would like an additional review of ggplot, William (our course manager) is teaching a short course 2:30-4pm on Oct 13th

- In-person and online

You can sign up here

Very quick dplyr review

The **tidyverse** is a set of packages that makes it easy to process data frames

dplyr is a package that has a set of verbs for transformations data

- All these function **take a data frame** and other arguments and **return a data frame**

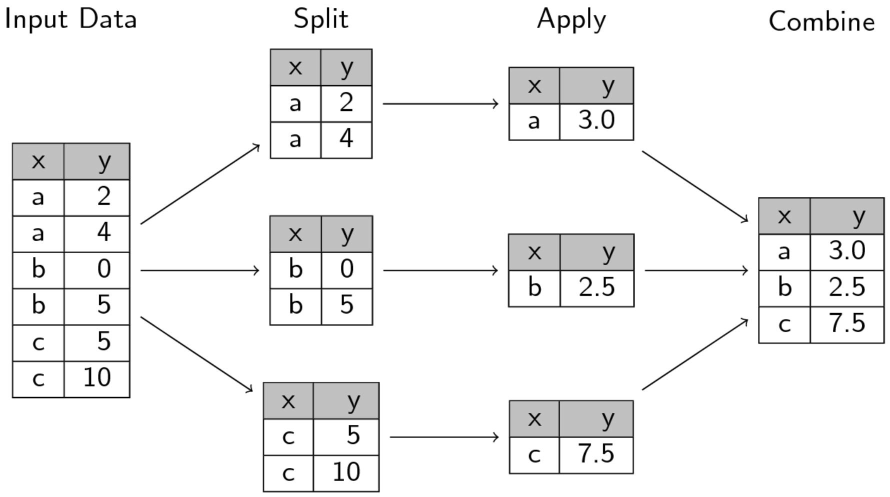
1. filter()
2. select()
3. mutate()
4. arrange()
5. summarize()
6. group_by()

```
film_results <- movies |>
    filter(title_type == "Feature Film") |>
    select(critics_score, audience_score, genre) |>
     mutate(audience_prefers =
            audience_score - critics_score) |>
     group_by(genre) |>
      summarize(mean_audience_prefers =
             mean(audience_prefers)) |>
      arrange(desc(mean_audience_prefers))


head(film_results )
```

Very quick dplyr review: group_by

group_by: split, apply, combine



Input Data

x	y
a	2
a	4
b	0
b	5
c	5
c	10

Split

x	y
a	2
a	4

x	y
b	0
b	5

x	y
c	5
c	10

Apply

x	y
a	3.0

x	y
b	2.5

x	y
c	7.5

Combine

x	y
a	3.0
b	2.5
c	7.5

group_by multiple items:

```
group_by(genre, mpaa_rating) |>
summarize(ms = mean(critics_score))
```

```
film_results <- movies |>
    filter(title_type == "Feature Film") |>
    select(critics_score, audience_score, genre) |>
     mutate(audience_prefers =
             audience_score - critics_score) |>
     group_by(genre) |>
      summarize(mean_audience_prefers =
              mean(audience_prefers)) |>
       arrange(desc(mean_audience_prefers))


head(film_results )
```

Very quick dplyr review: summarize

One can summarize multiple variables:

```
summarize(mean_pref = mean(audience_prefers),
                    med_pref = median(audience_prefers))
```

One can use the n() function to count how many items are in each group

```
group_by(genre) |>
summarize(num_genre = n())
```

```
film_results <- movies |>
    filter(title_type == "Feature Film") |>
    select(critics_score, audience_score, genre) |>
     mutate(audience_prefers =
             audience_score - critics_score) |>
     group_by(genre) |>
      summarize(mean_audience_prefers =
             mean(audience_prefers)) |>
      arrange(desc(mean_audience_prefers))

head(film_results )
```

Homework 5, part 2: flight delays

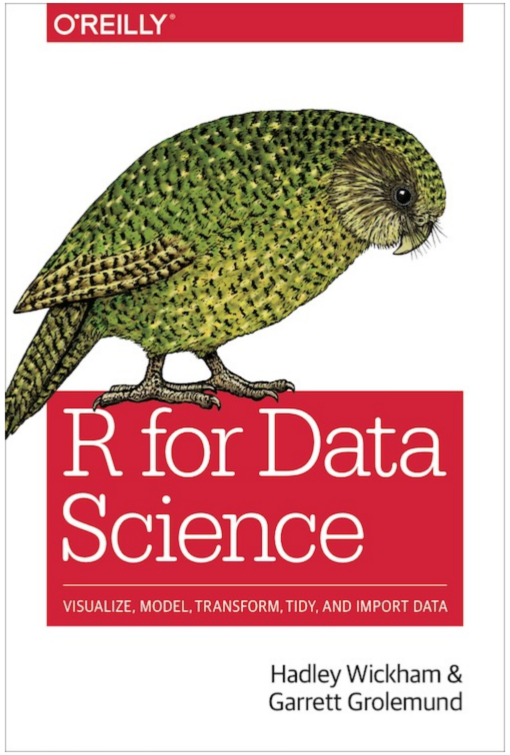
Steps:

1. What result do I want?

2. What steps can I take to get the result?

3. How can I implement these steps using dplyr?

Questions about dplyr?



Data visualization

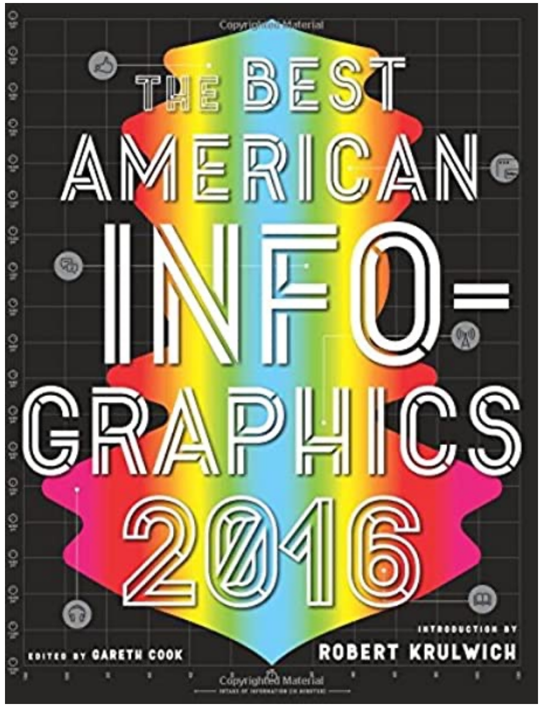
Q: What are some reasons we visualize data rather than just reporting statistics?

Note: History of data visualization after midterm

Homework 5 : Find an interesting data visualization

- https://www.reddit.com/r/dataisbeautiful/
- https://flowingdata.com/

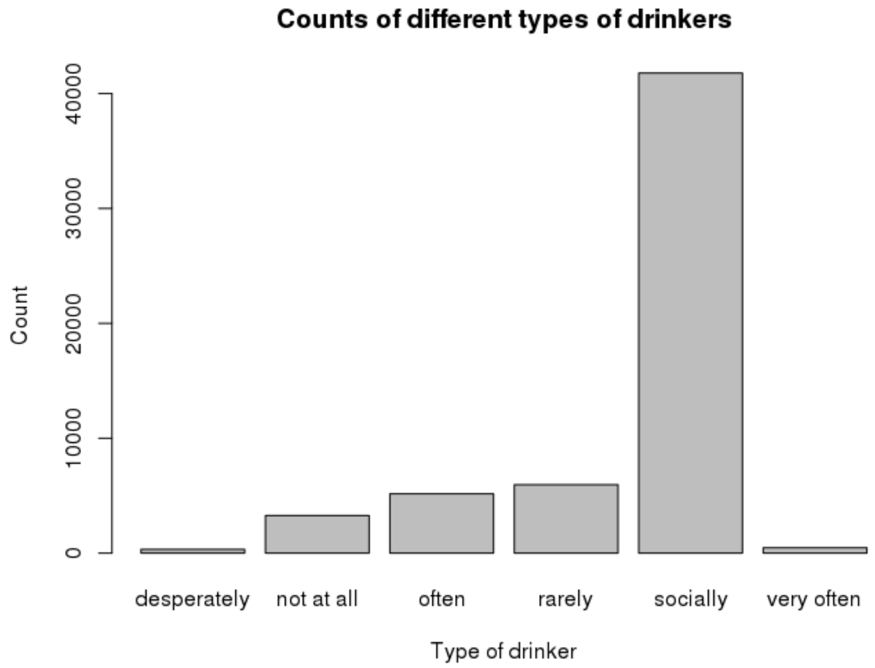
We will also discuss these visualizations after the midterm exam



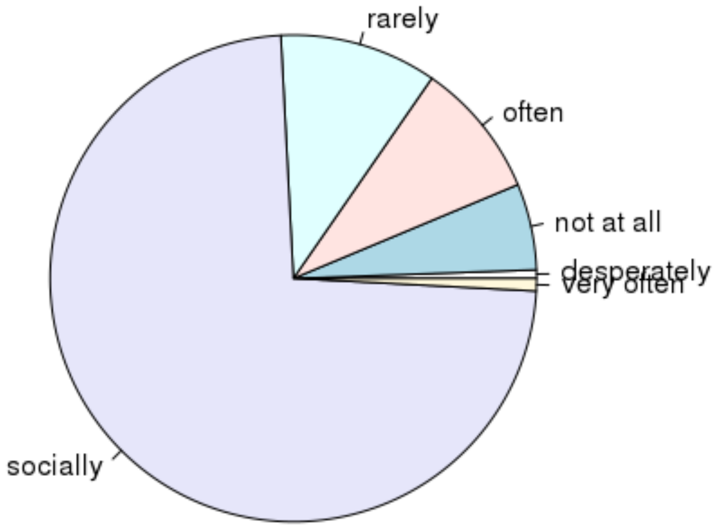
A grammar of graphics and ggplot

How have we plotted a single categorical variable?

Bar plot

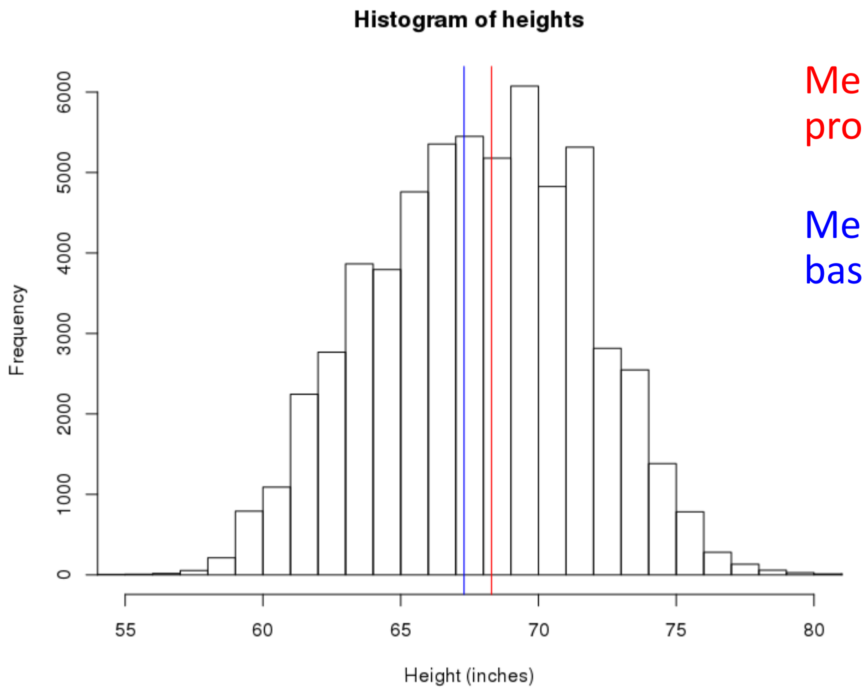


Pie chart



How have we plotted a single quantitative variable?

Histograms



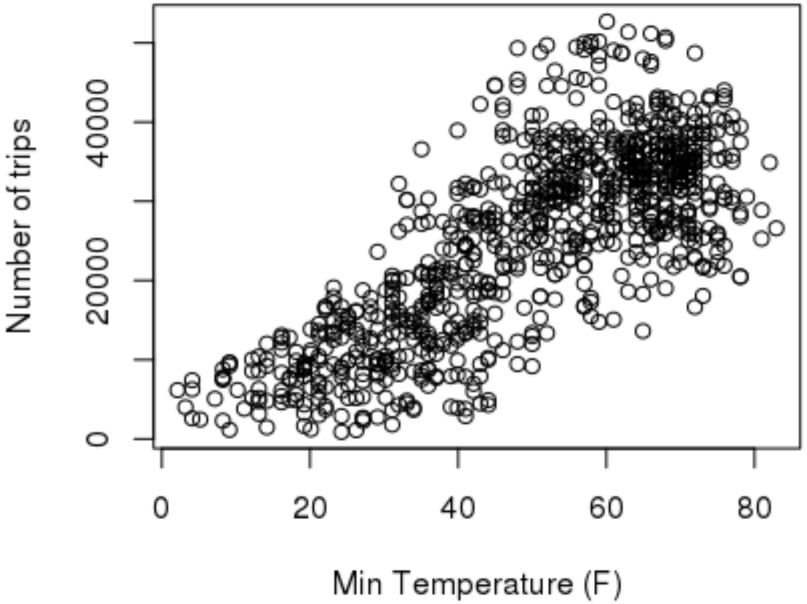
Mean height in the profiles data

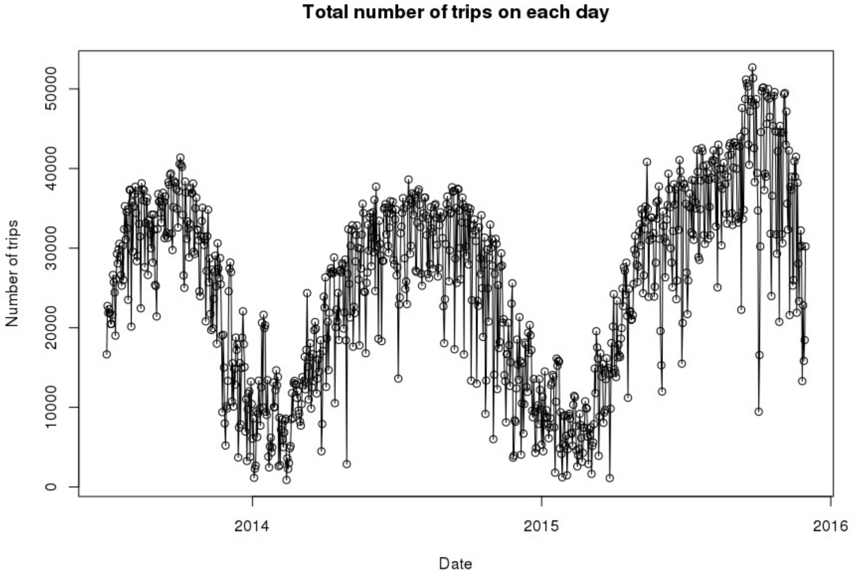
Mean height expected based on US population

How have we plotted a two quantitative variables?

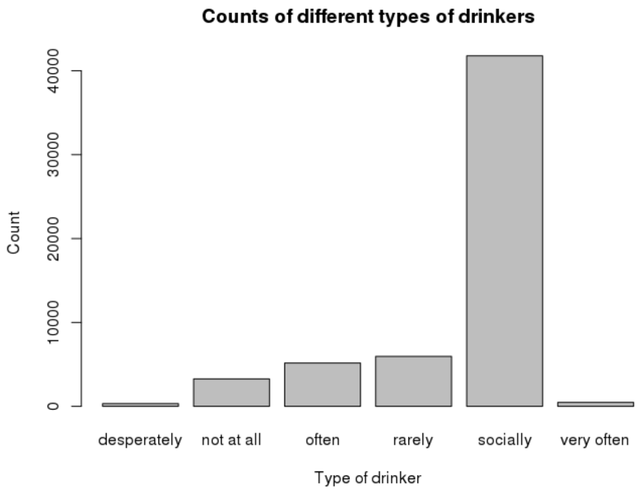
Scatter plots

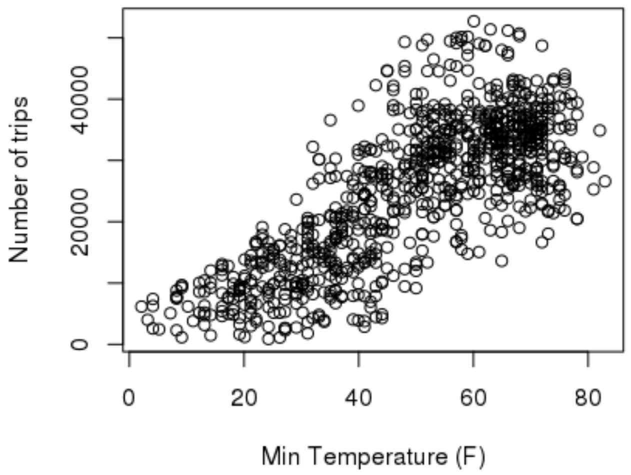
Line chart

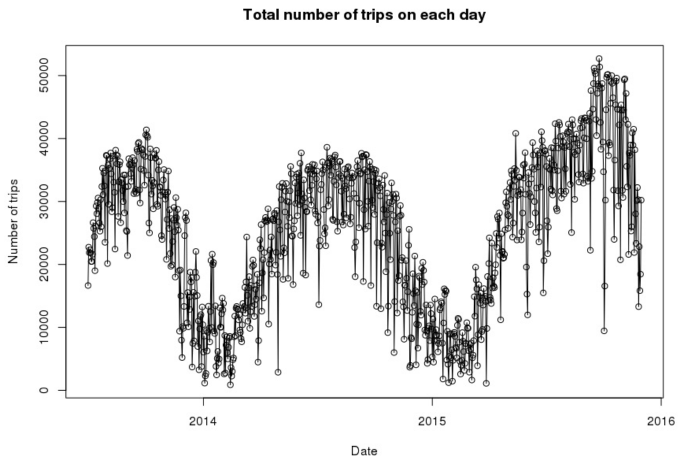


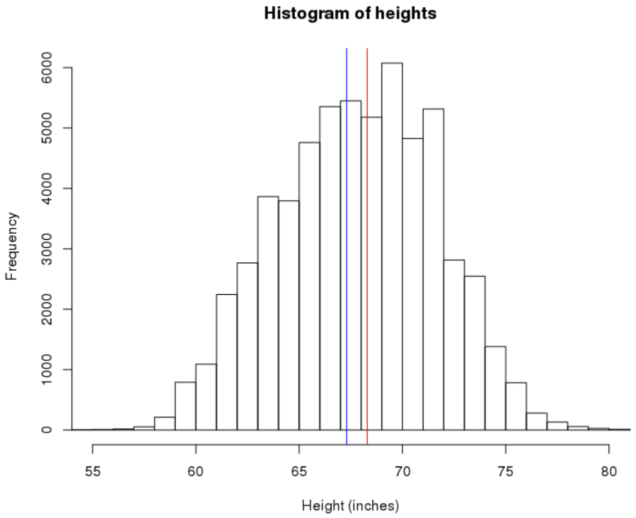


What are some similarities between these graphs?







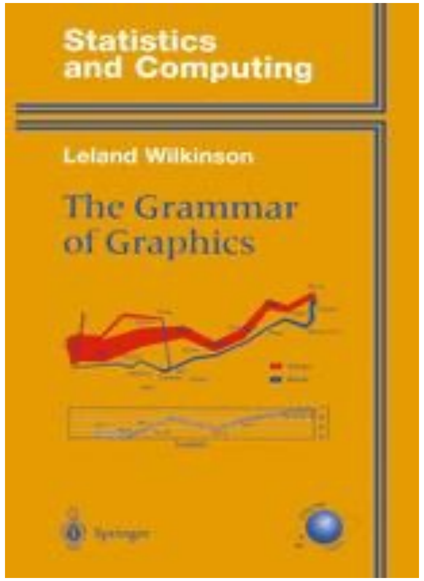


The grammar of graphics

Leland Wilkinson noticed similarities between many graphs and tried to generate a ‘grammar’ that could be used to express a graph

- i.e., a list elements that can be combined together to create a graph

First edition



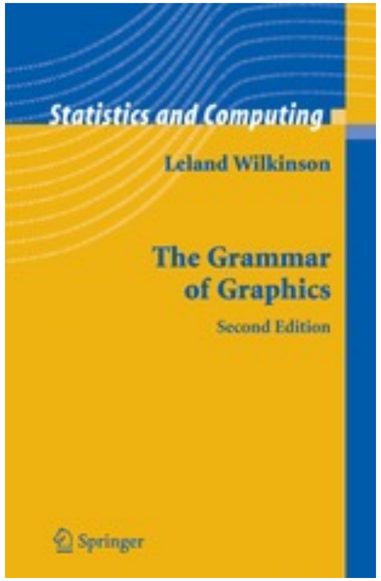
Statistics and Computing

Leland Wilkinson

The Grammar of Graphics

Springer

Second edition



Statistics and Computing

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Graphs are composed of…

A Frame: Coordinate system on which data is placed

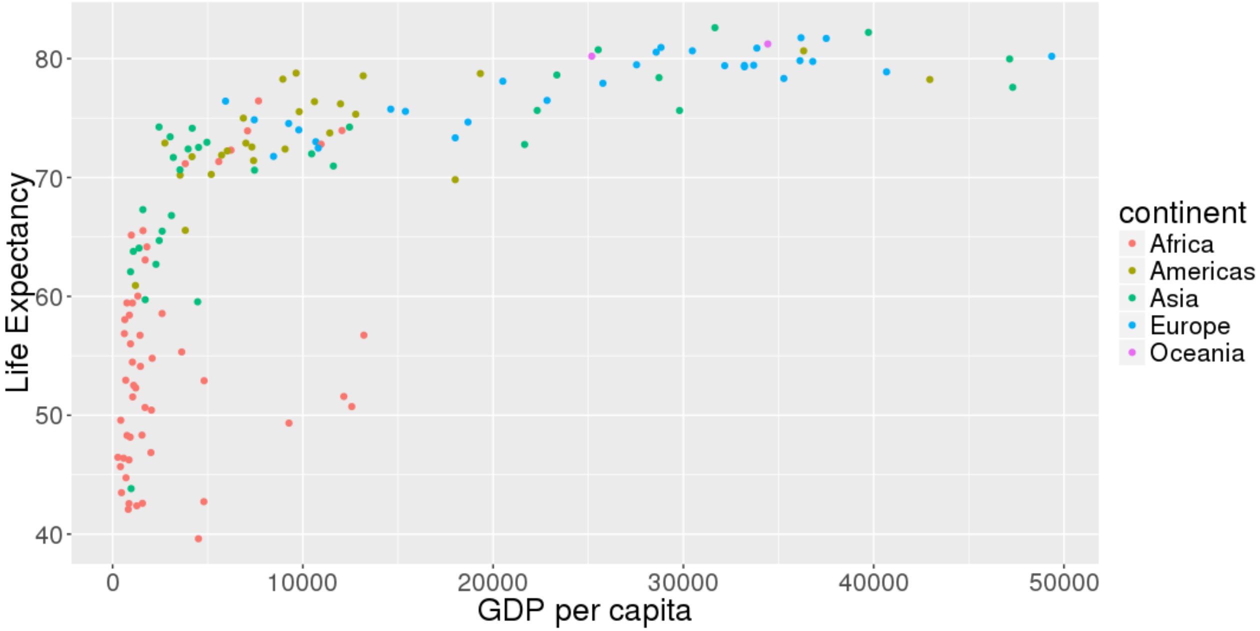
- E.g., Cartesian coordinate system, polar coordinates, etc.

Glyphs: basic graphic unit representing cases or statistics

- Contains visual properties (aesthetics) such as: shape, color, size, etc.
- Need to specify how properties of the data are **mapped** onto these aesthetics

Scales and guides: shows how to interpret axes and other properties of the glyphs

- i.e., gives information about how the data values were mapped into glyph properties



Plots can also contain…

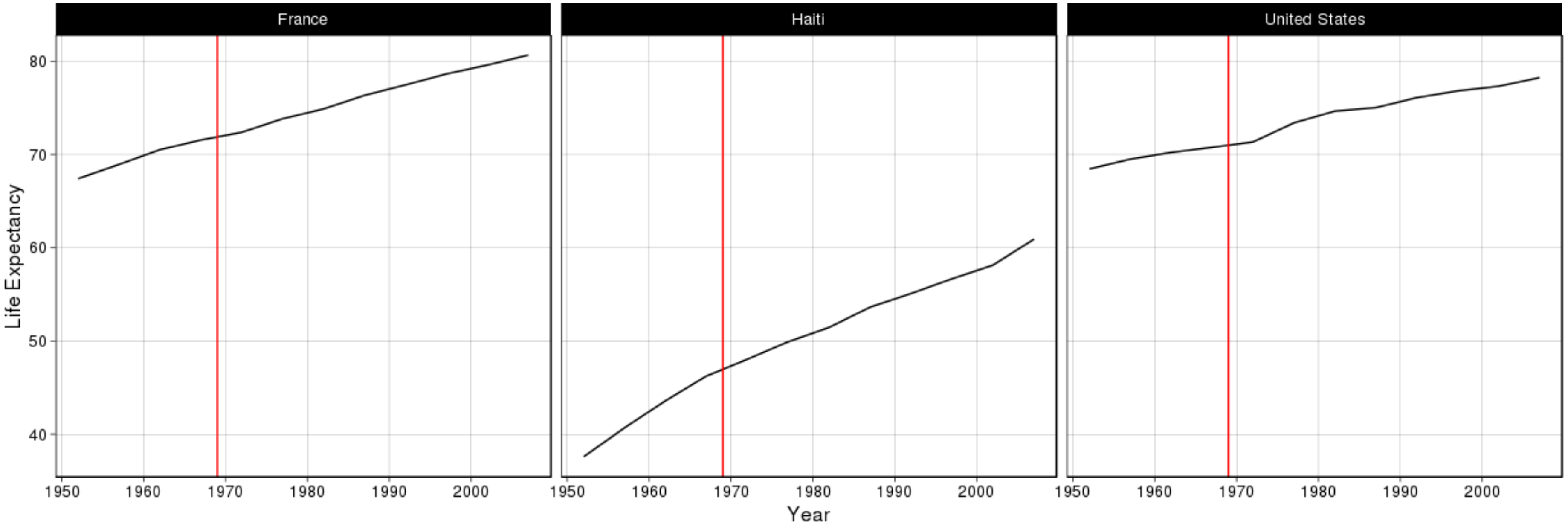
Facets: allows for multiple side-by-side graphs based on a categorical variable

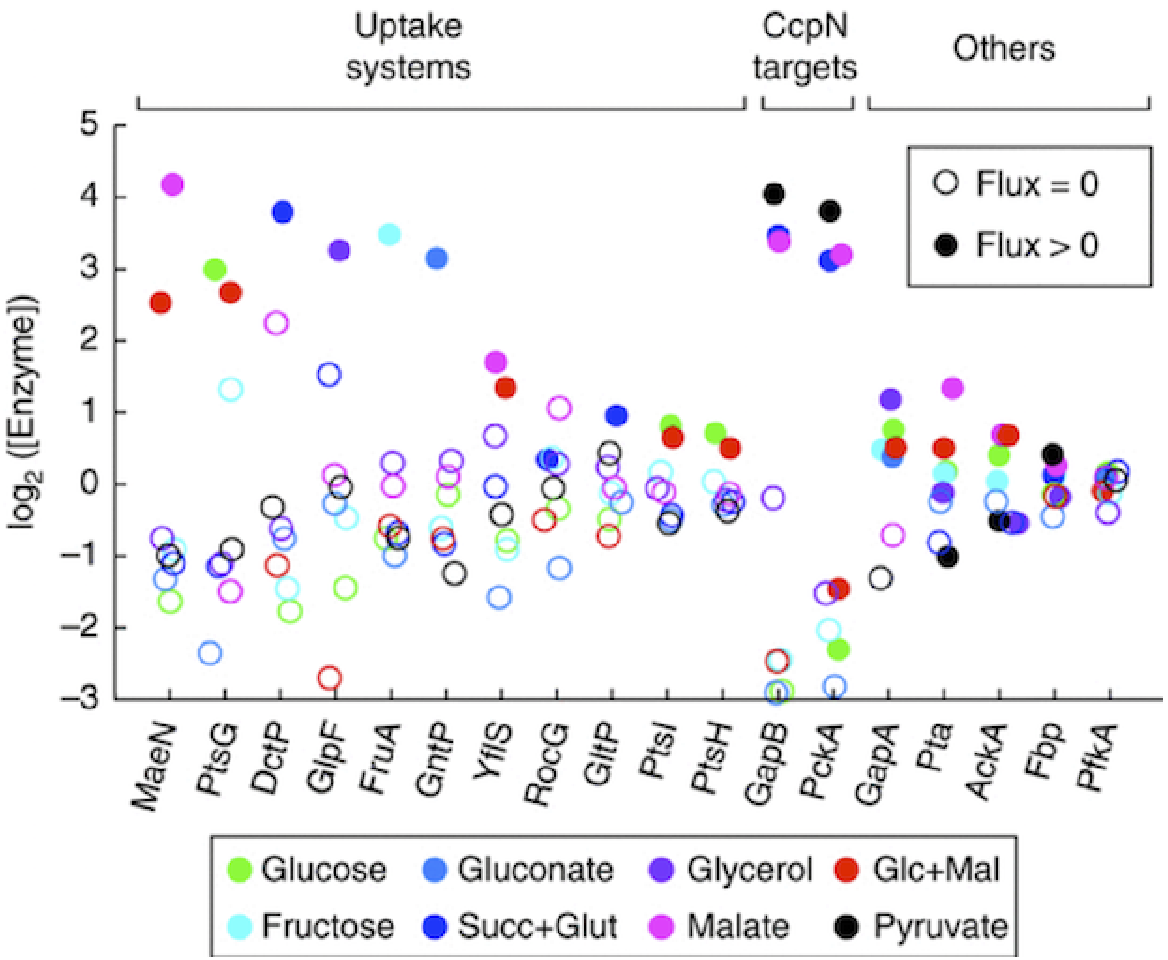
- Makes it easier to compare different conditions

Layers: allows for more than one types of data to be mapped onto the same figure

Theme: contains finer points of display

- E.g., font size, background color, etc.

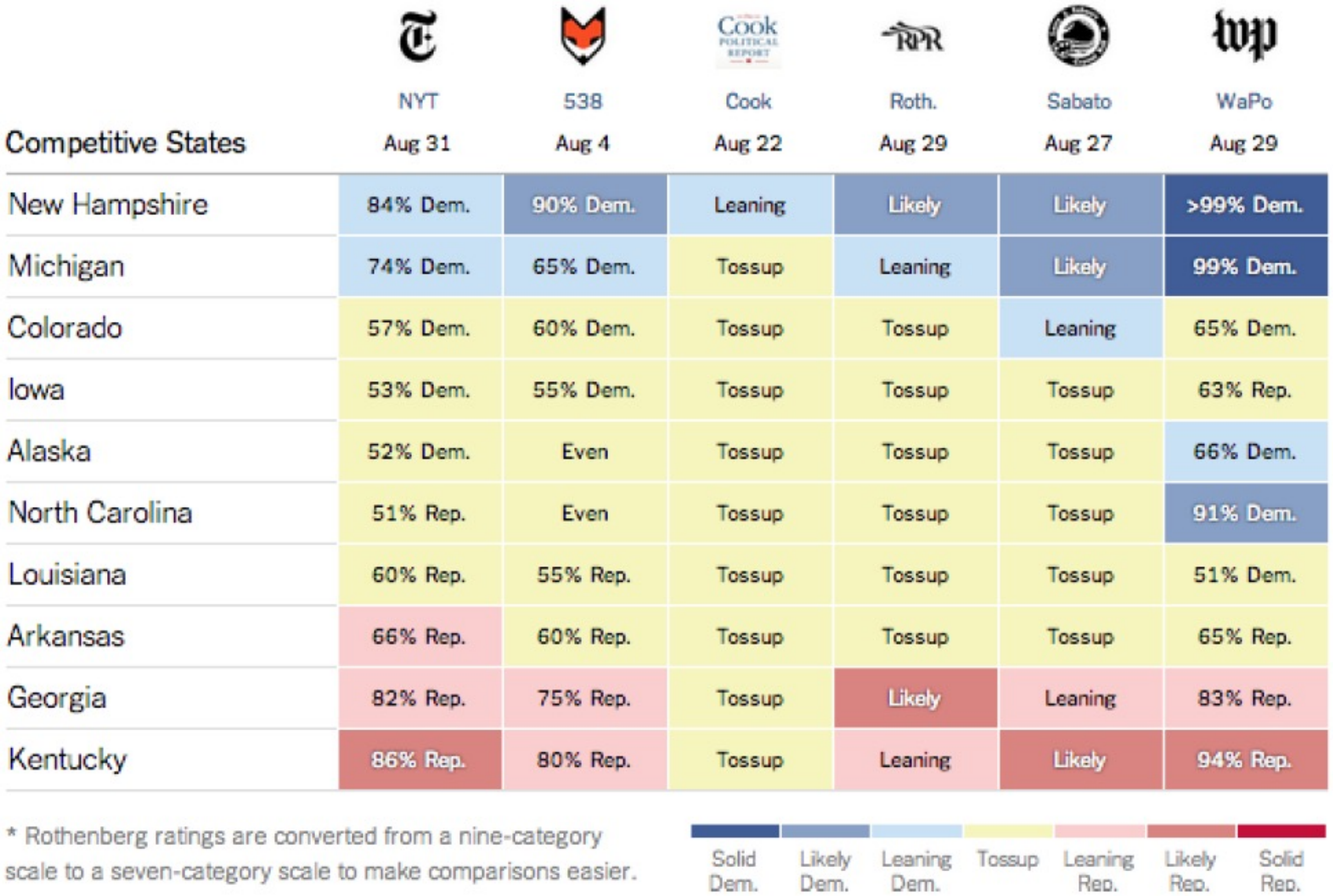




The variables are:

1. Log enzyme concentration
   - -3 to 5
2. Gene
   - MaeN, PtsG, …
3. Target
   - CcpN, Uptake,…
4. Flux
   - Zero or positive
5. Molecule:
   - Glocose, Fructose, …

What are the mappings between each variable and visual attribute?



Competitive States	NYT Aug 31	538 Aug 4	Cook Aug 22	Roth. Aug 29	Sabato Aug 27	WaPo Aug 29
New Hampshire	84% Dem.	90% Dem.	Leaning	Likely	Likely	>99% Dem.
Michigan	74% Dem.	65% Dem.	Tossup	Leaning	Likely	99% Dem.
Colorado	57% Dem.	60% Dem.	Tossup	Tossup	Leaning	65% Dem.
Iowa	53% Dem.	55% Dem.	Tossup	Tossup	Tossup	63% Rep.
Alaska	52% Dem.	Even	Tossup	Tossup	Tossup	66% Dem.
North Carolina	51% Rep.	Even	Tossup	Tossup	Tossup	91% Dem.
Louisiana	60% Rep.	55% Rep.	Tossup	Tossup	Tossup	51% Dem.
Arkansas	66% Rep.	60% Rep.	Tossup	Tossup	Tossup	65% Rep.
Georgia	82% Rep.	75% Rep.	Tossup	Likely	Leaning	83% Rep.
Kentucky	86% Rep.	80% Rep.	Tossup	Leaning	Likely	94% Rep.

* Rothenberg ratings are converted from a nine-category scale to a seven-category scale to make comparisons easier.

Solid Dem.	Likely Dem.	Leaning Dem.	Tossup	Leaning Rep.	Likely Rep.	Solid Rep.

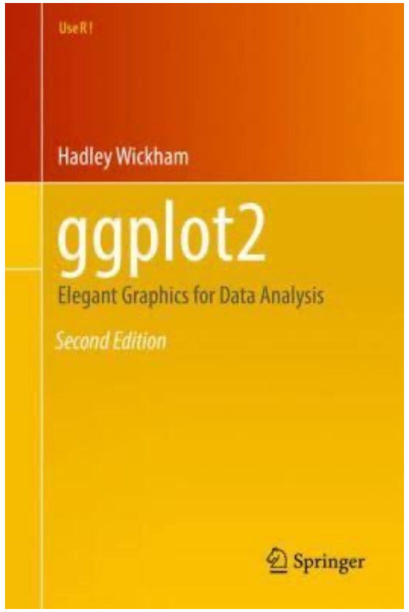
1. What variables define the frame?
2. What is the glyphs and the mapping from data to glyph?
3. What sets the order for the vertical variable?

ggplot

ggplot2 is an R package that implements the grammar of graphics

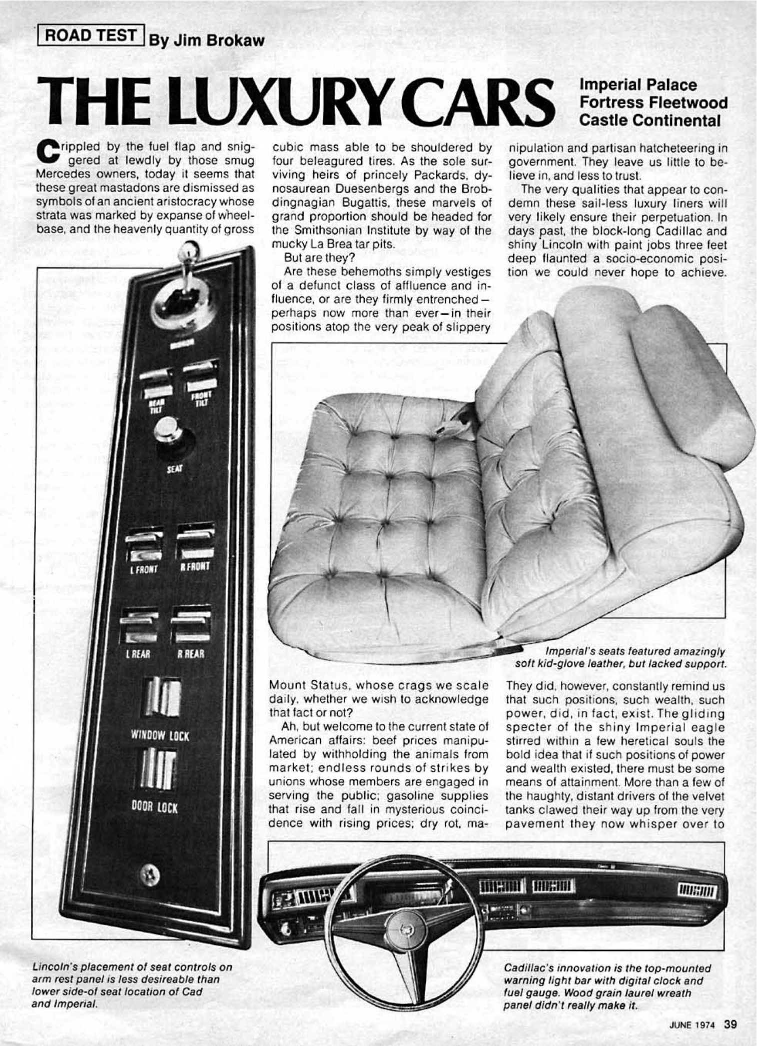
- It builds up graphics by starting with a frame, adding glyphs, etc.

```
# load the ggplot2 library
> library('ggplot2')
```



Get the book on GitHub

Example data: mtcars



ROAD TEST By Jim Brokaw

THE LUXURY CARS

Imperial Palace
Fortress Fleetwood
Castle Continental

Crippled by the fuel flap and sniggered at lewdly by those smug Mercedes owners, today it seems that these great mastadons are dismissed as symbols of an ancient aristocracy whose strata was marked by expanse of wheelbase, and the heavenly quantity of gross cubic mass able to be shouldered by four beleagured tires. As the sole surviving heirs of princely Packards, dynosaurean Duesenbergs and the Brobdingnagian Bugattis, these marvels of grand proportion should be headed for the Smithsonian Institute by way of the mucky La Brea tar pits.

But are they?

Are these behemoths simply vestiges of a defunct class of affluence and influence, or are they firmly entrenched—perhaps now more than ever—in their positions atop the very peak of slippery Mount Status, whose crags we scale daily, whether we wish to acknowledge that fact or not?

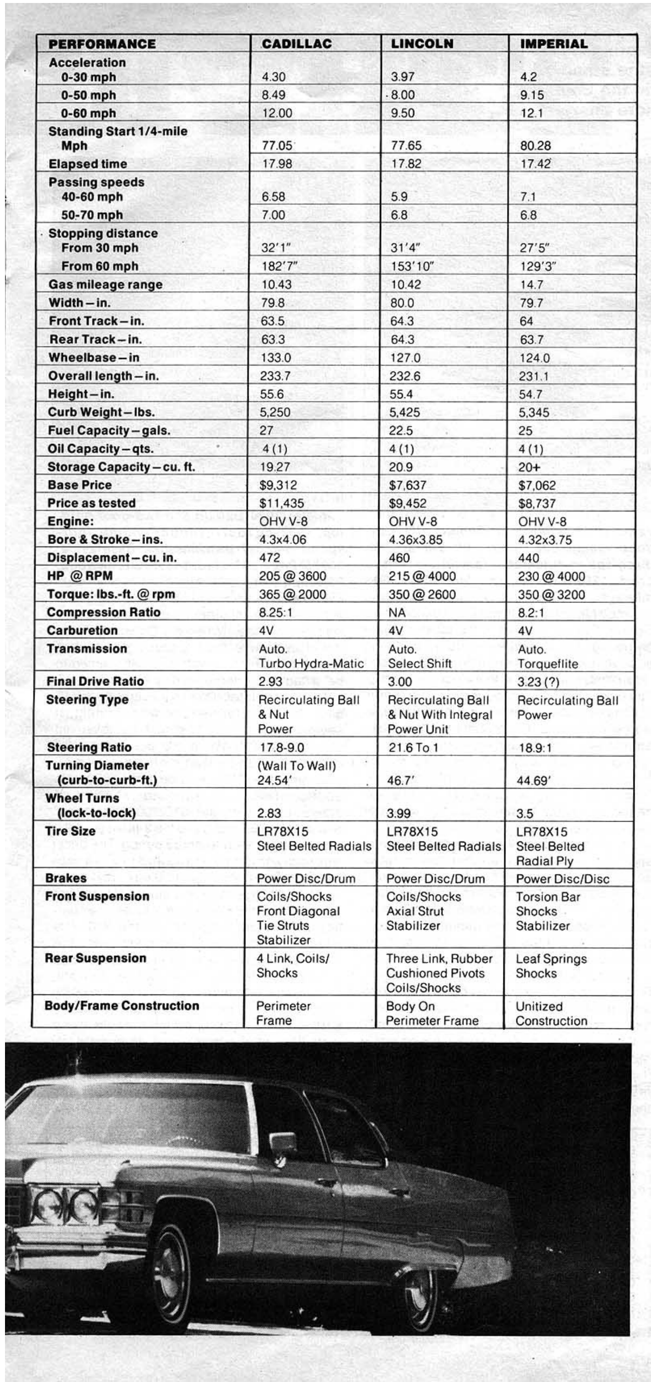
Ah, but welcome to the current state of American affairs: beef prices manipulated by withholding the animals from market; endless rounds of strikes by unions whose members are engaged in serving the public; gasoline supplies that rise and fall in mysterious coincidence with rising prices; dry rot, manipulation and partisan hatcheteering in government. They leave us little to believe in, and less to trust.

The very qualities that appear to condemn these sail-less luxury liners will very likely ensure their perpetuation. In days past, the block-long Cadillac and shiny Lincoln with paint jobs three feet deep flaunted a socio-economic position we could never hope to achieve. They did, however, constantly remind us that such positions, such wealth, such power, did, in fact, exist. The gliding specter of the shiny Imperial eagle stirred within a few heretical souls the bold idea that if such positions of power and wealth existed, there must be some means of attainment. More than a few of the haughty, distant drivers of the velvet tanks clawed their way up from the very pavement they now whisper over to

Imperial's seats featured amazingly soft kid-glove leather, but lacked support.

Lincoln's placement of seat controls on arm rest panel is less desireable than lower side-of seat location of Cad and Imperial.

Cadillac's innovation is the top-mounted warning light bar with digital clock and fuel gauge. Wood grain laurel wreath panel didn't really make it.



PERFORMANCE	CADILLAC	LINCOLN	IMPERIAL
Acceleration 0-30 mph	4.30	3.97	4.2
0-50 mph	8.49	8.00	9.15
0-60 mph	12.00	9.50	12.1
Standing Start 1/4-mile Mph	77.05	77.65	80.28
Elapsed time	17.98	17.82	17.42
Passing speeds 40-60 mph	6.58	5.9	7.1
50-70 mph	7.00	6.8	6.8
Stopping distance From 30 mph	32′1″	31′4″	27′5″
From 60 mph	182′7″	153′10″	129′3″
Gas mileage range	10.43	10.42	14.7
Width—in.	79.8	80.0	79.7
Front Track—in.	63.5	64.3	64
Rear Track—in.	63.3	64.3	63.7
Wheelbase—in	133.0	127.0	124.0
Overall length—in.	233.7	232.6	231.1
Height—in.	55.6	55.4	54.7
Curb Weight—lbs.	5,250	5,425	5,345
Fuel Capacity—gals.	27	22.5	25
Oil Capacity—qts.	4 (1)	4 (1)	4 (1)
Storage Capacity—cu. ft.	19.27	20.9	20+
Base Price	$9,312	$7,637	$7,062
Price as tested	$11,435	$9,452	$8,737
Engine:	OHV V-8	OHV V-8	OHV V-8
Bore & Stroke—ins.	4.3x4.06	4.36x3.85	4.32x3.75
Displacement—cu. in.	472	460	440
HP @ RPM	205 @ 3600	215 @ 4000	230 @ 4000
Torque: lbs.-ft. @ rpm	365 @ 2000	350 @ 2600	350 @ 3200
Compression Ratio	8.25:1	NA	8.2:1
Carburetion	4V	4V	4V
Transmission	Auto. Turbo Hydra-Matic	Auto. Select Shift	Auto. Torqueflite
Final Drive Ratio	2.93	3.00	3.23 (?)
Steering Type	Recirculating Ball & Nut Power	Recirculating Ball & Nut With Integral Power Unit	Recirculating Ball Power
Steering Ratio	17.8-9.0	21.6 To 1	18.9:1
Turning Diameter (curb-to-curb-ft.)	(Wall To Wall) 24.54′	46.7′	44.69′
Wheel Turns (lock-to-lock)	2.83	3.99	3.5
Tire Size	LR78X15 Steel Belted Radials	LR78X15 Steel Belted Radials	LR78X15 Steel Belted Radial Ply
Brakes	Power Disc/Drum	Power Disc/Drum	Power Disc/Disc
Front Suspension	Coils/Shocks Front Diagonal Tie Struts Stabilizer	Coils/Shocks Axial Strut Stabilizer	Torsion Bar Shocks Stabilizer
Rear Suspension	4 Link, Coils/ Shocks	Three Link, Rubber Cushioned Pivots Coils/Shocks	Leaf Springs Shocks
Body/Frame Construction	Perimeter Frame	Body On Perimeter Frame	Unitized Construction

mtcars data frame

How can you determine what variables are in a data frame?

```
> View(mtcars)      # only works in Rstudio, not in Markdown
> glimpse(mtcars)
> ? mtcars      # this data frame as a code book
```

```
[, 1]       mpg     Miles/(US) gallon
[, 2]       cyl     Number of cylinders
[, 4]       hp      Gross horsepower
[, 6]       wt      Weight (1000 lbs)
[, 9]       am      Transmission (0 = automatic, 1 = manual)
```

Do cars that weigh more use more fuel?

Question: do cars that weigh more use more fuel?

What variables in the mtcars data frame are of interest?

- mpg
- wt

We can create a scatter plot using base graphics…

```
> plot(mtcars$wt, mtcars$mpg)
```

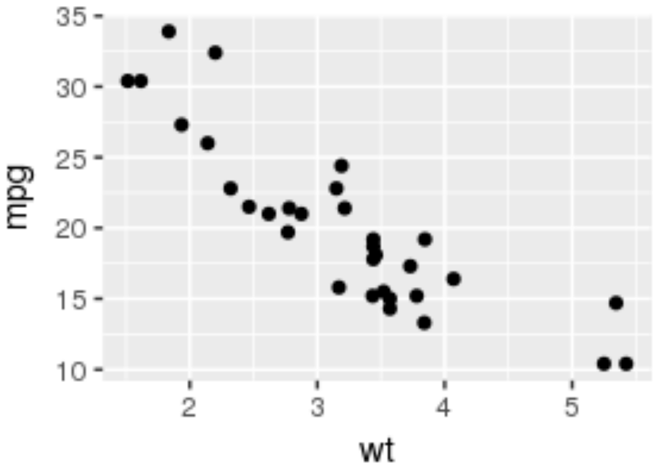
Creating a scatter plot in ggplot

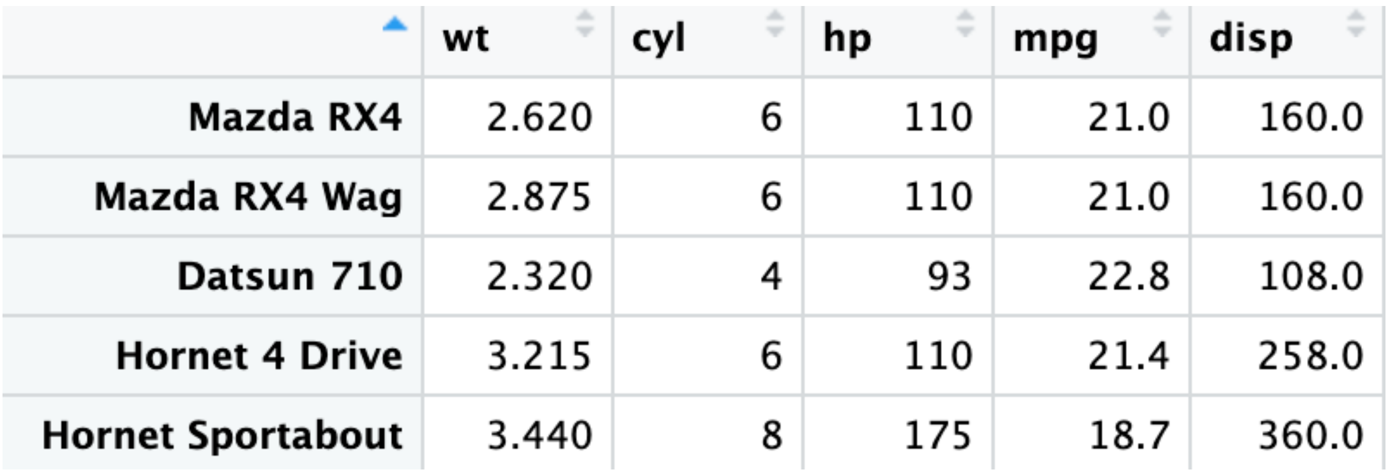
Data frame to be used

Aesthetic mapping

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

Adds a layer with glyphs





	wt	cyl	hp	mpg	disp
Mazda RX4	2.620	6	110	21.0	160.0
Mazda RX4 Wag	2.875	6	110	21.0	160.0
Datsun 710	2.320	4	93	22.8	108.0
Hornet 4 Drive	3.215	6	110	21.4	258.0
Hornet Sportabout	3.440	8	175	18.7	360.0

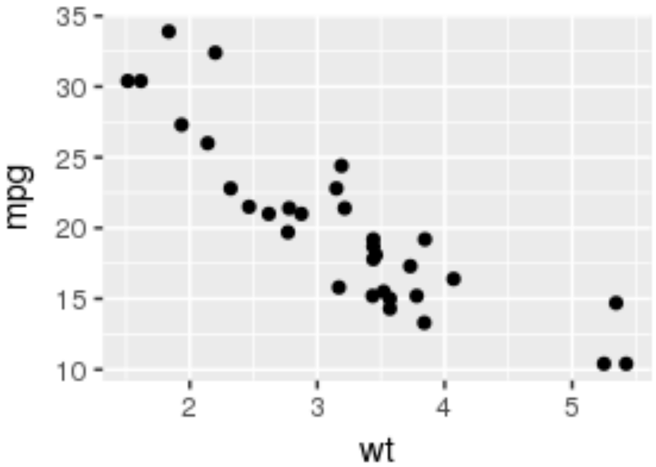
Creating a scatter plot in ggplot

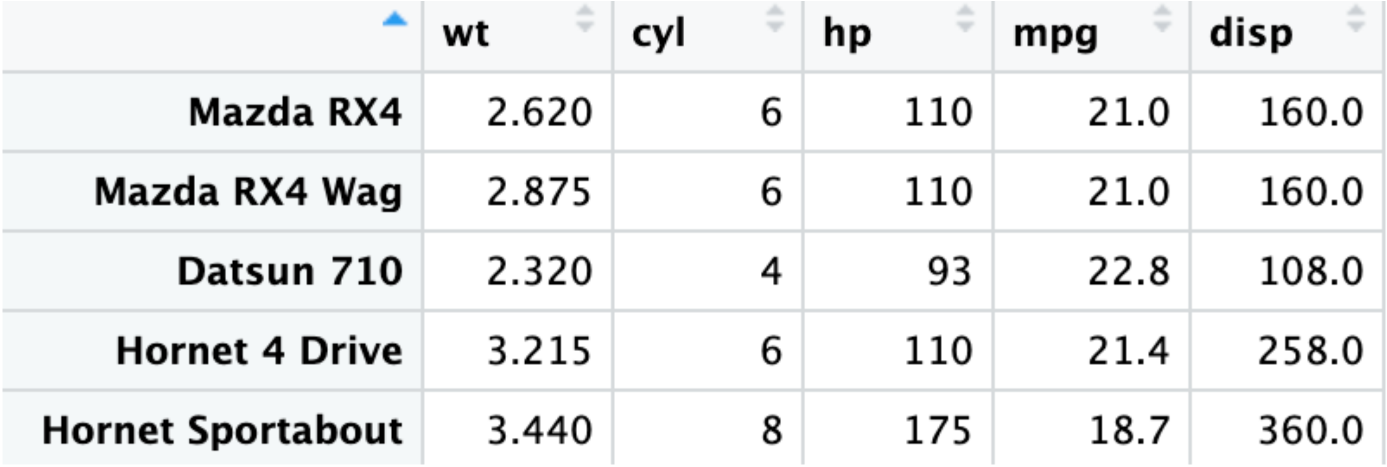
Data frame to be used

Aesthetic mapping

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

Adds a layer with glyphs





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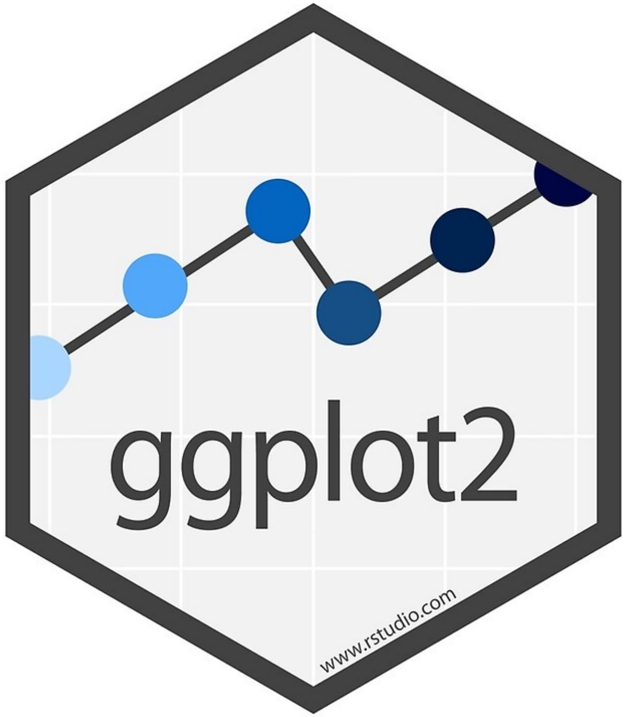
Hornet Sportabout	3.440	8	175	18.7	360.0

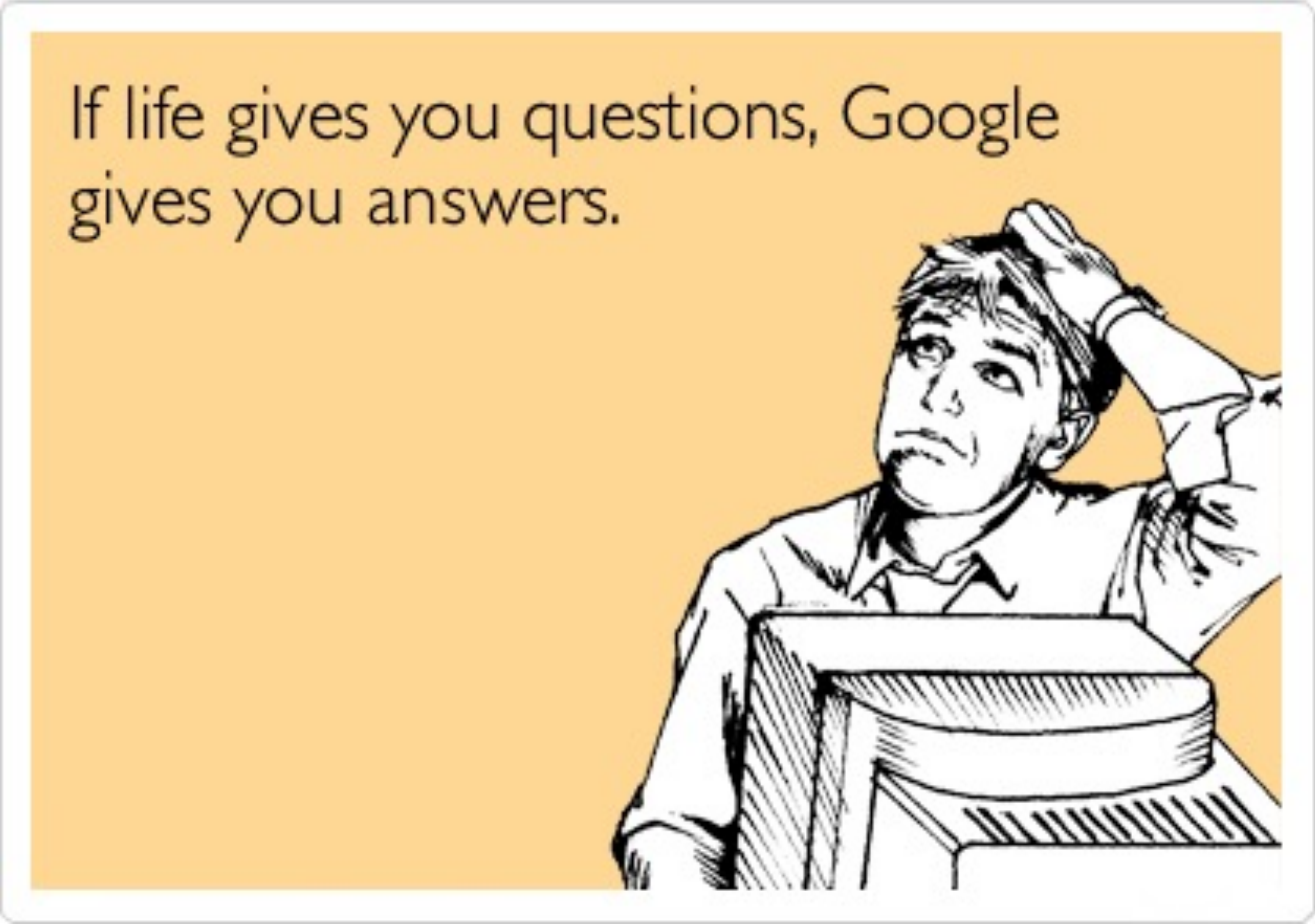
A lot more that ggplot can do!

- More aesthetic mapping
- Multiple glyphs/layers
- Axis labels
- Facets
- Visual themes
- Different coordinate systems
- Etc.



[The R Graph Gallery]

Let’s try the rest in R!


If life gives you questions, Google gives you answers.