

# Craft an Explanation



# Goal

Begin writing a 30-45 minute lesson  
that teaches your topic to a beginner.

# Warm Up

Get up and find a new seat next to the other people workshopping your topic.

Say hello and re-introduce yourself.



# Pop Quiz

What is the goal of training?

Beginner



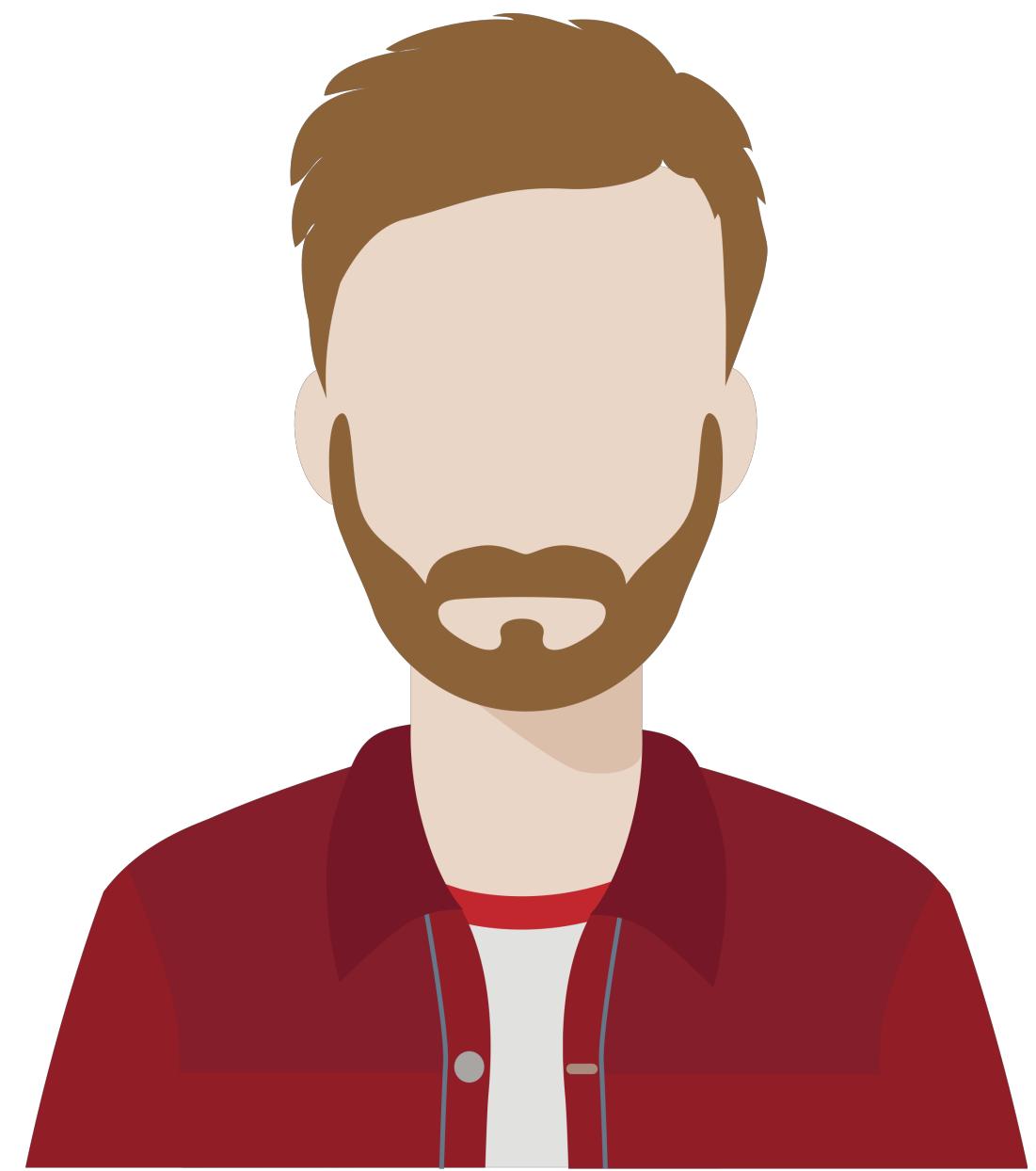
No  
mental model

Competent  
Practitioner



Useful  
mental model

Expert



Elaborate  
mental models



Beginner



No  
mental model

Competent  
Practitioner



Useful  
mental model

Expert

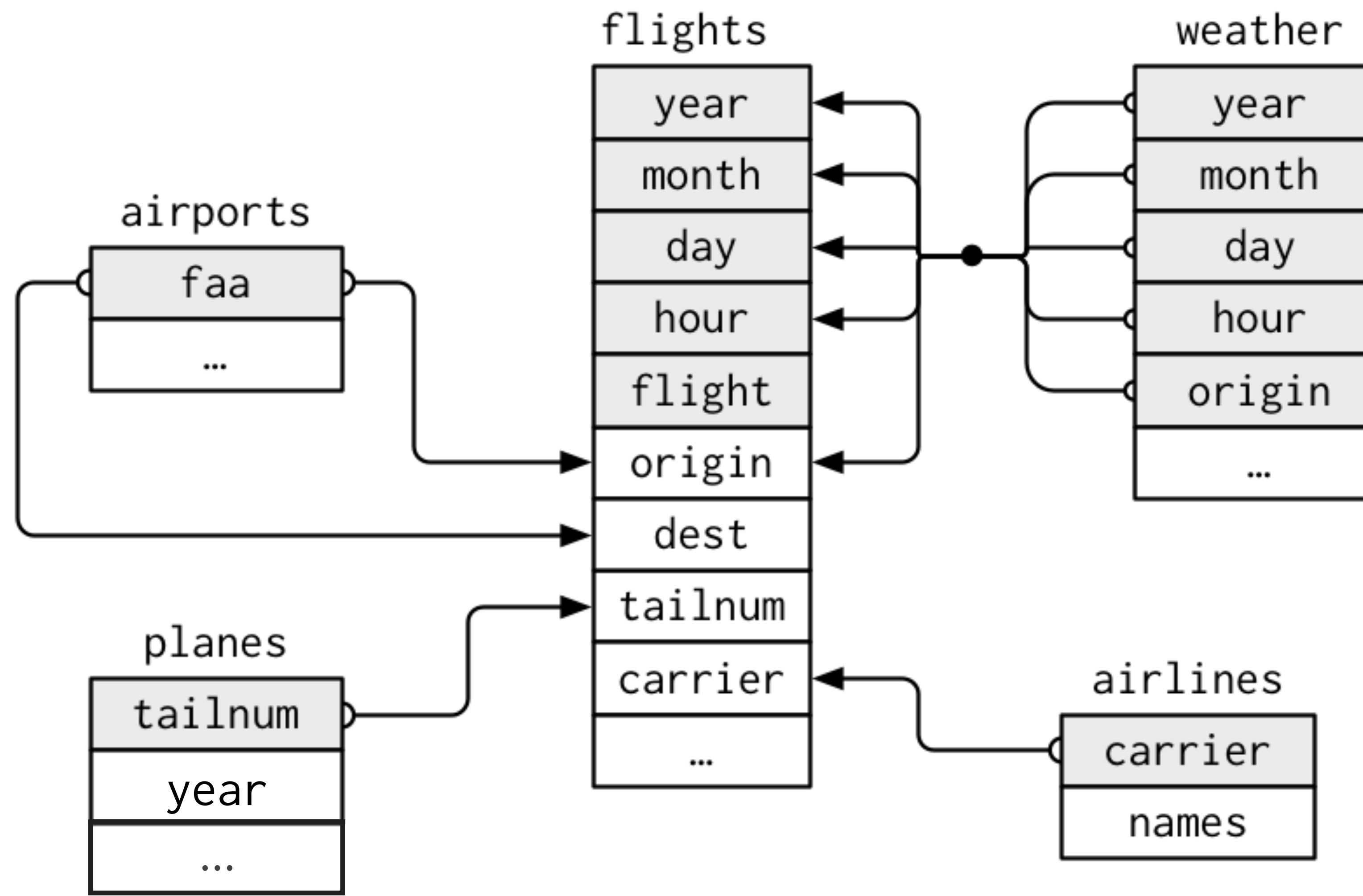


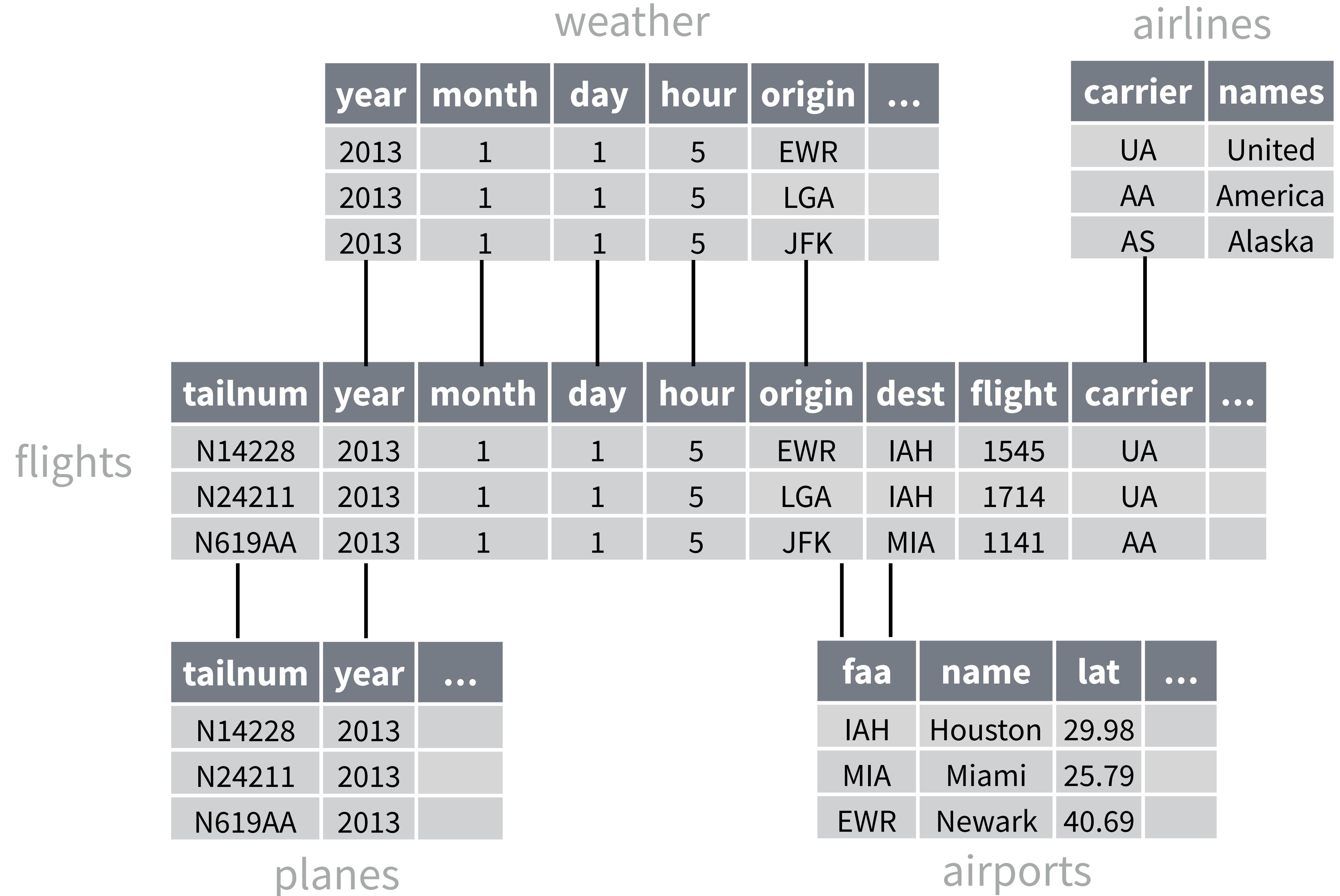
Elaborate  
mental models

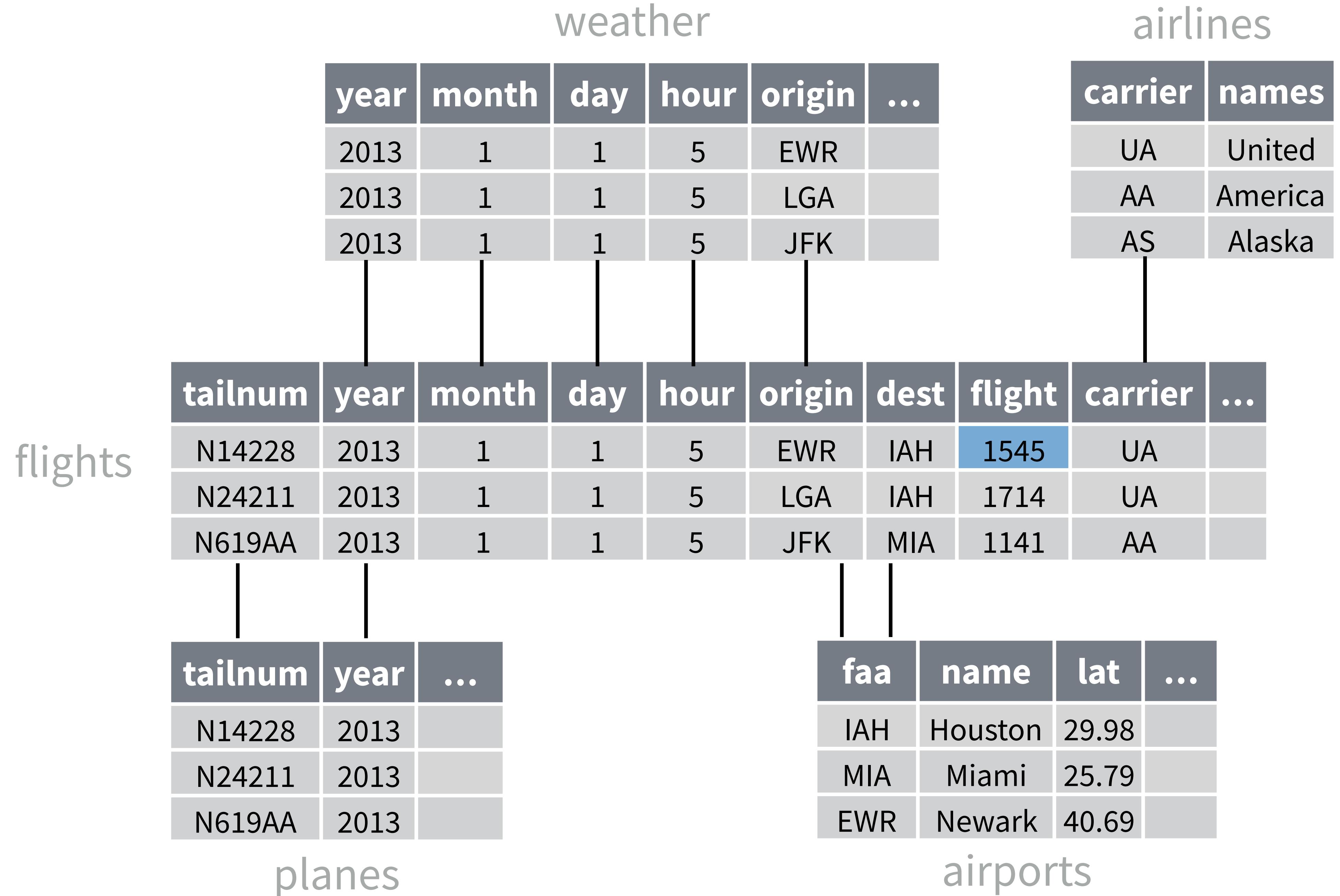
# The mental model

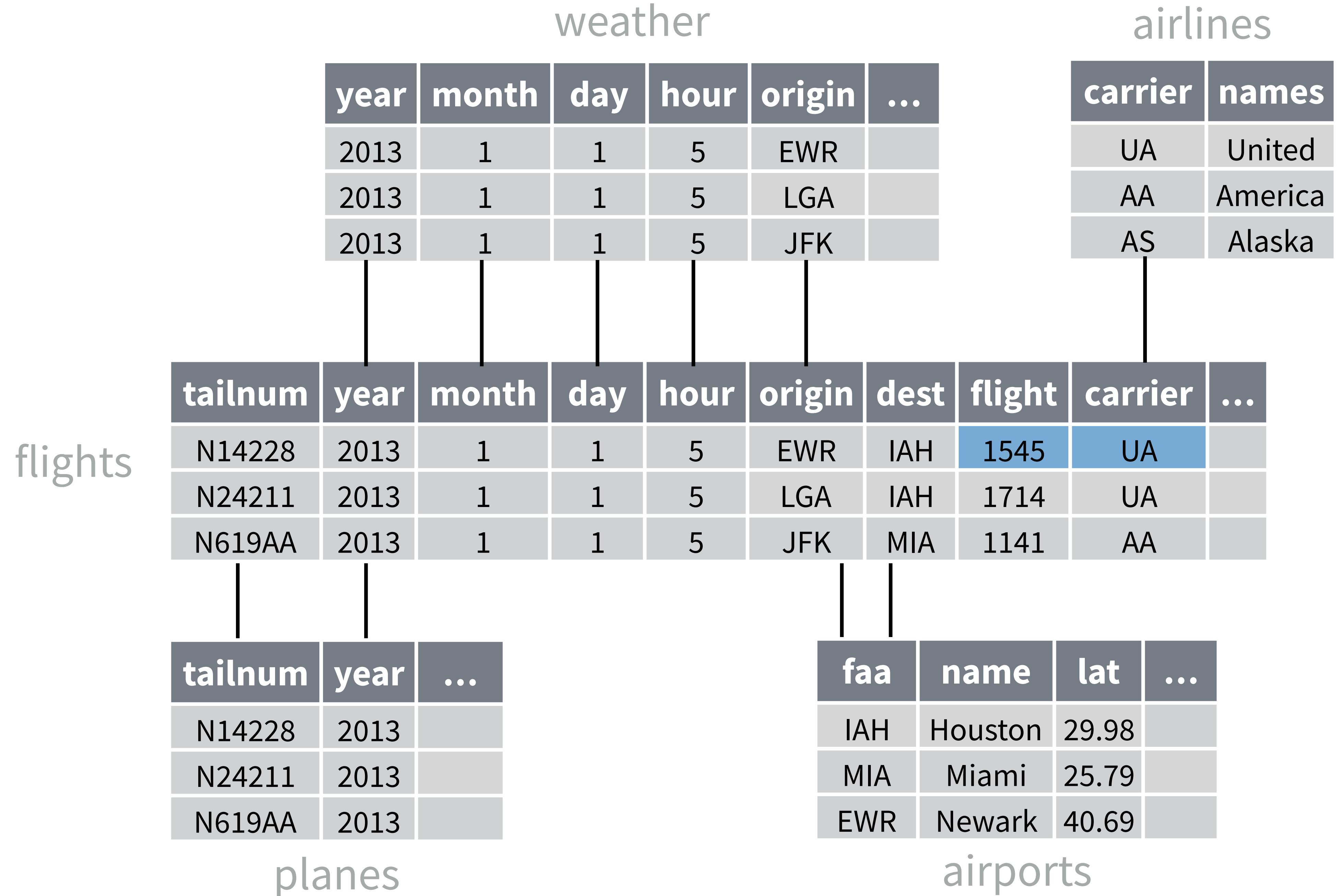
TR

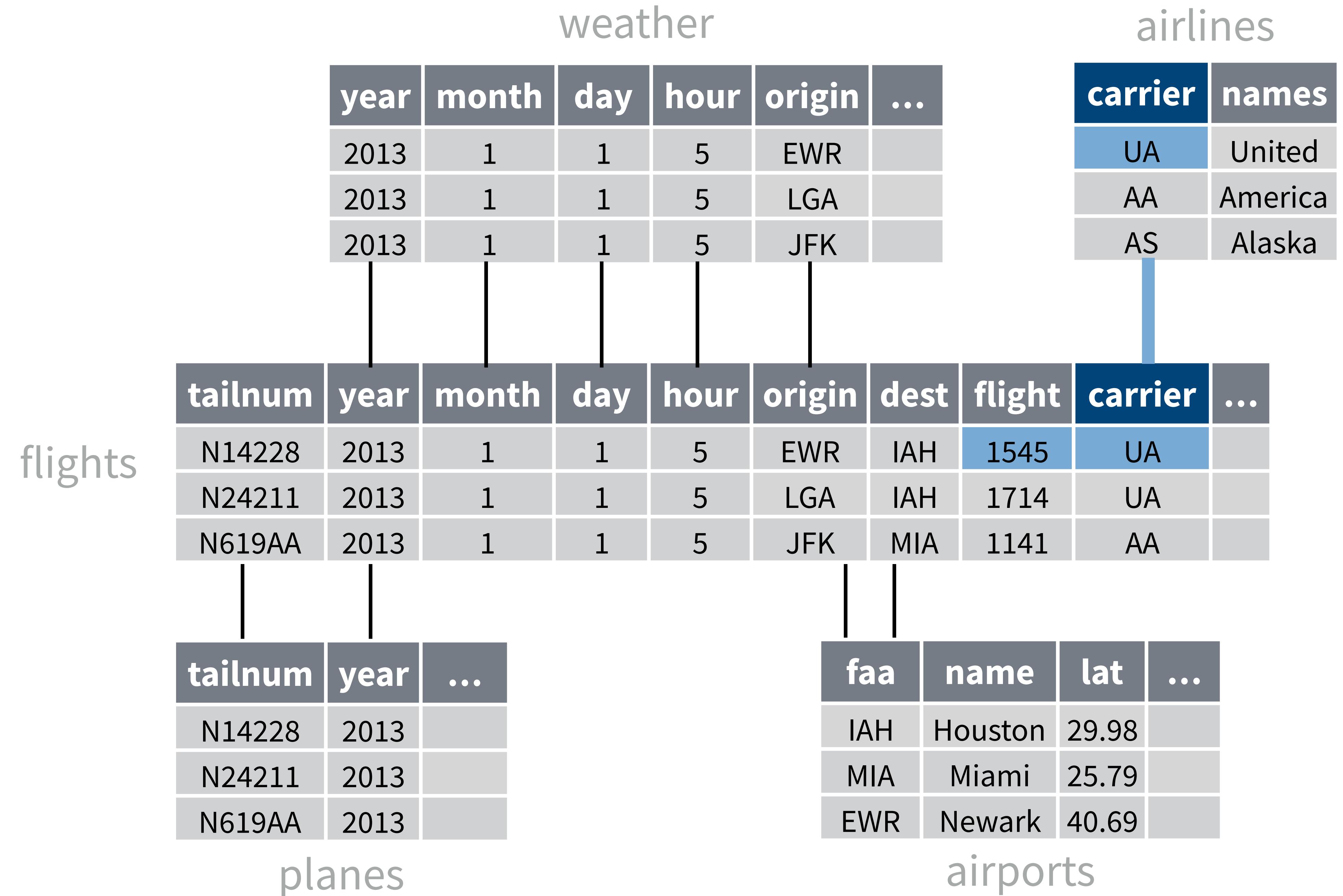
# nycflights13

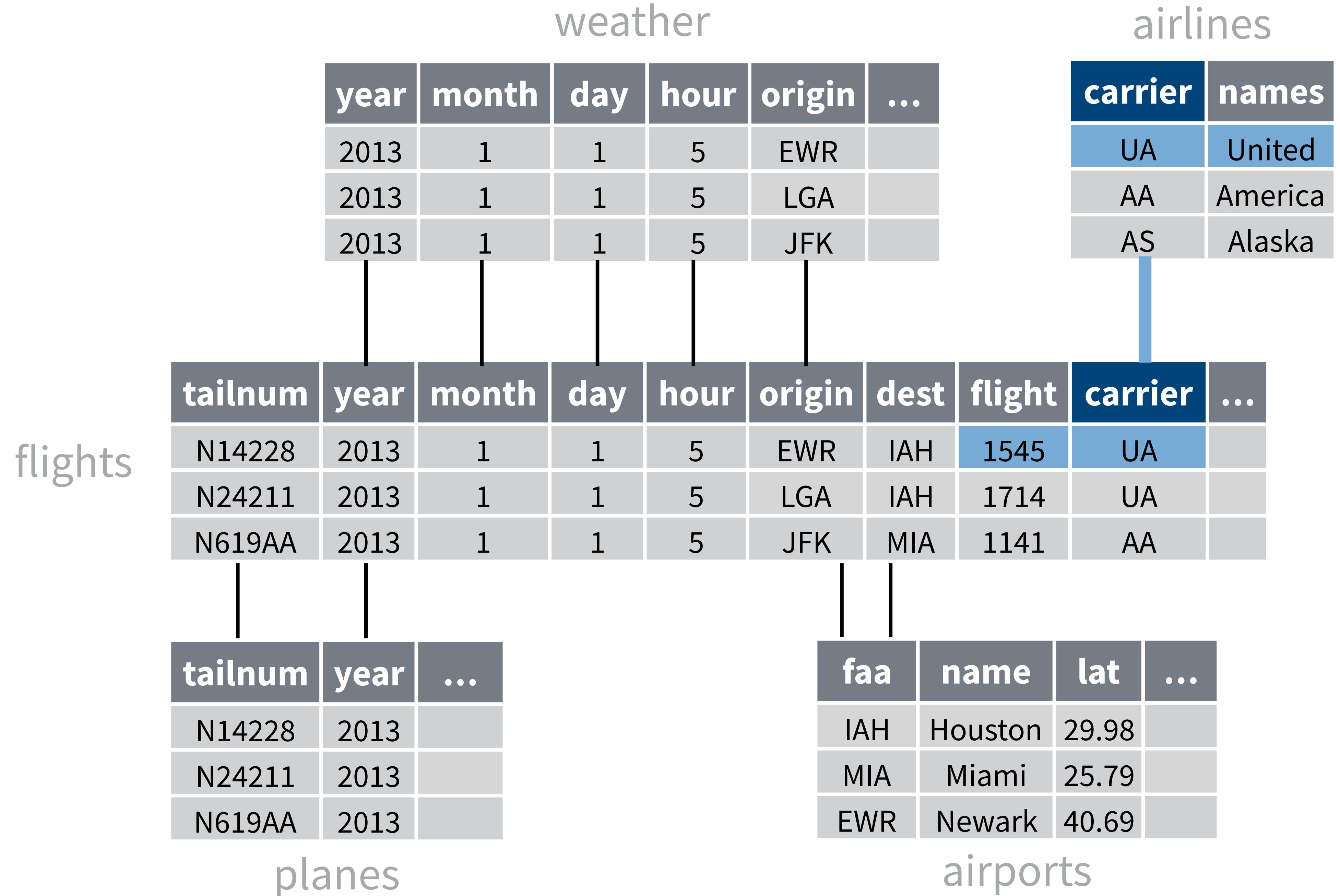


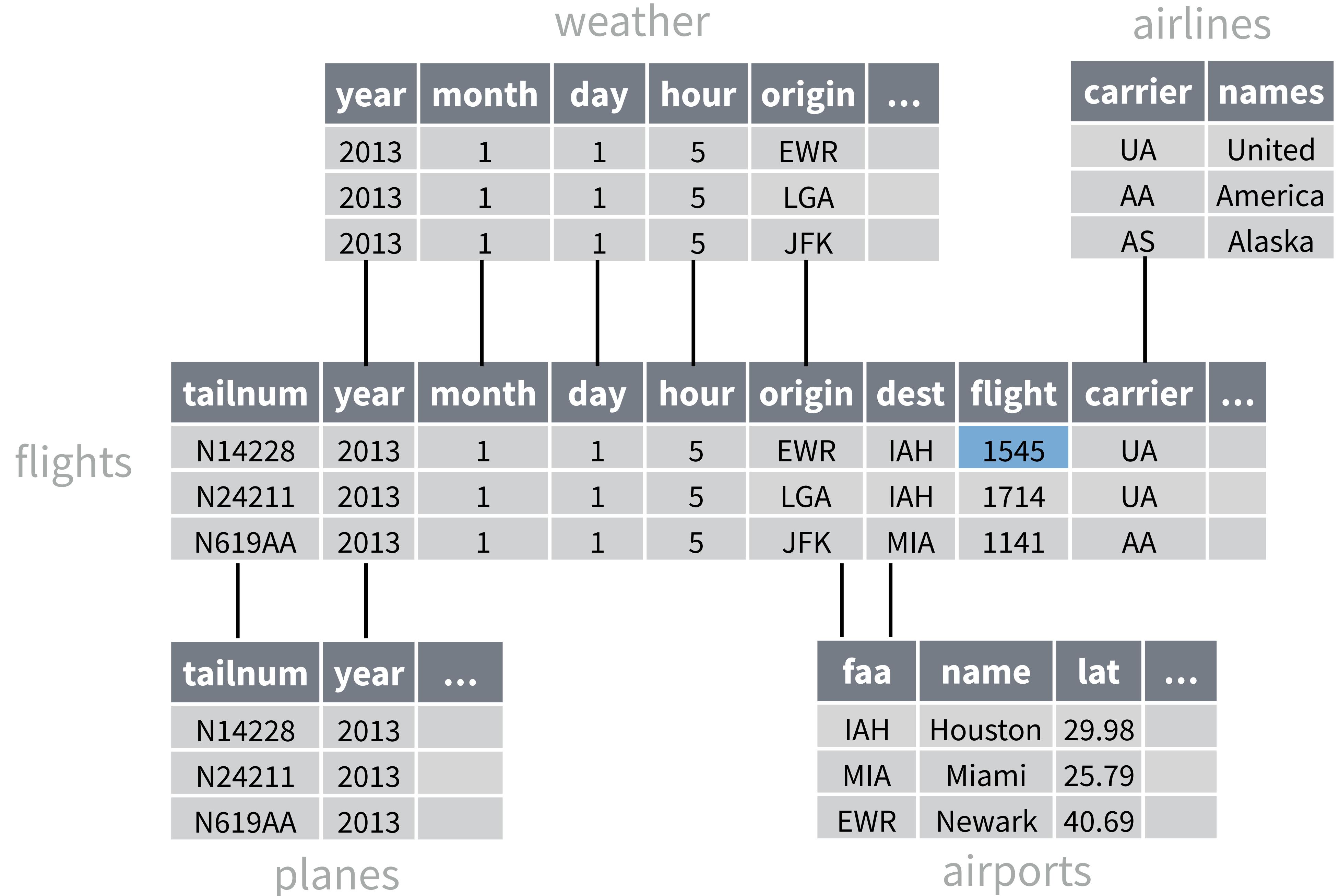


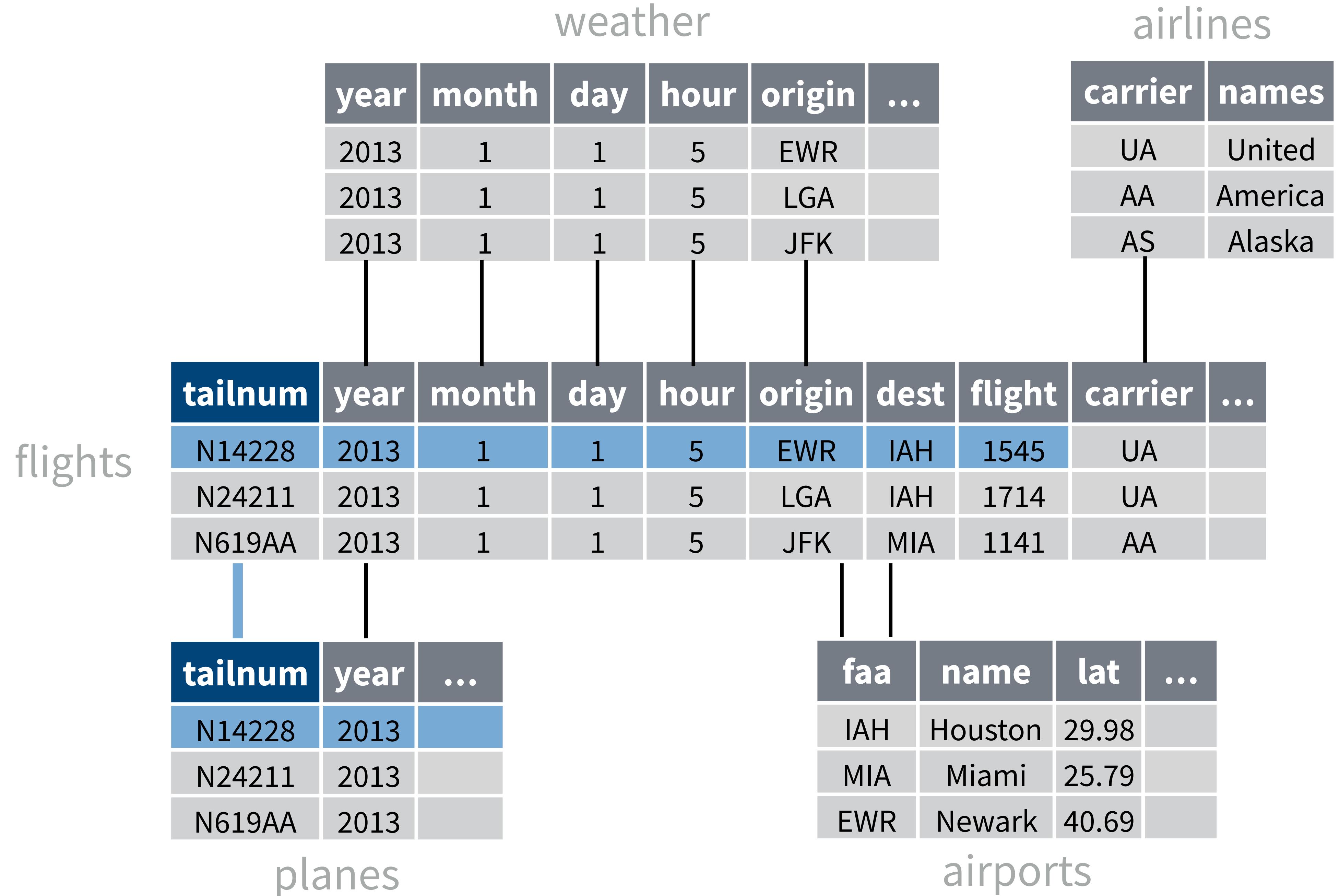




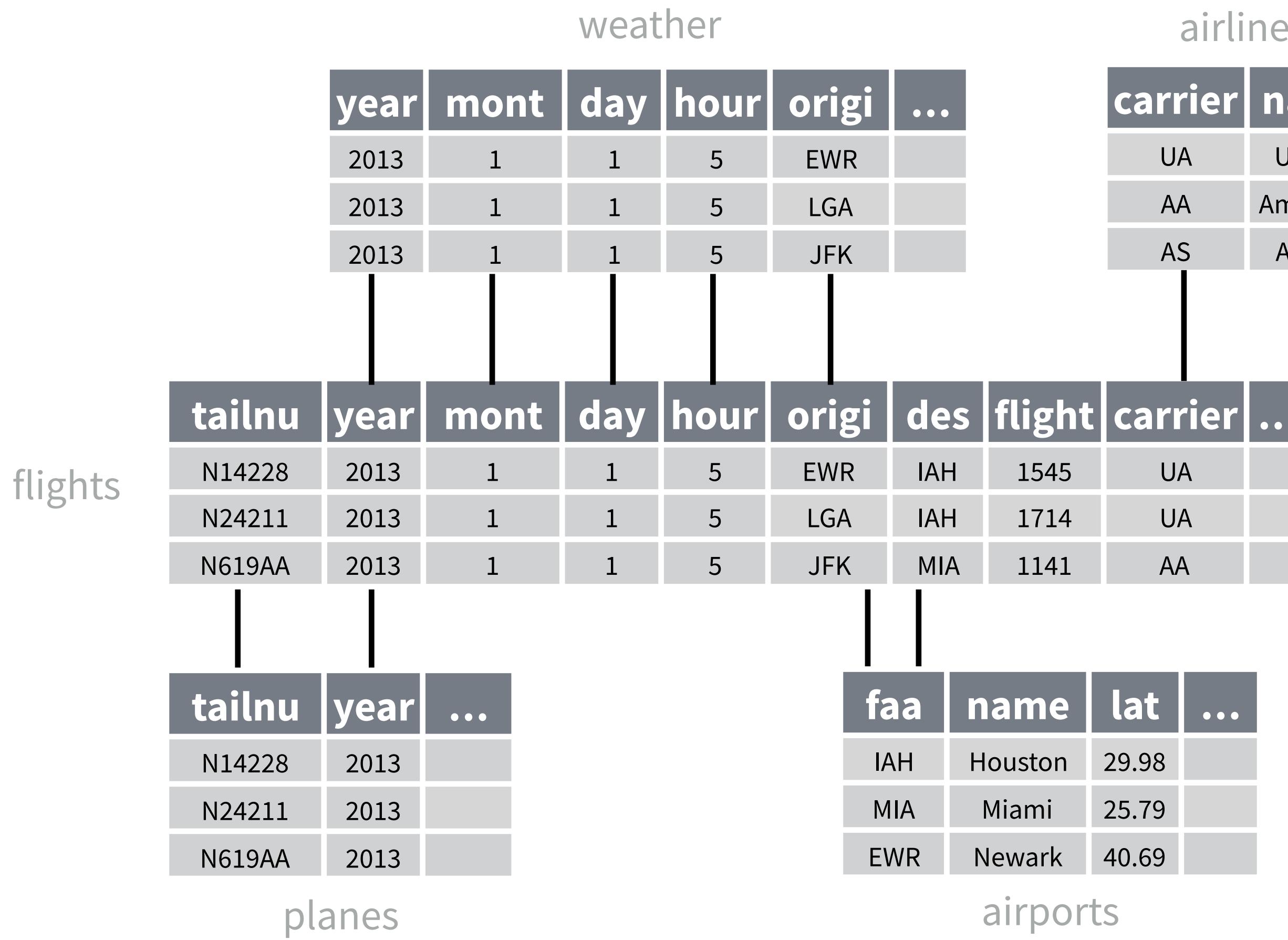








# Competent Practitioner



Useful  
mental model

flights

weather

airlines

year	month	day	hour	origin	...
2013	1	1	5	EWR	
2013	1	1	5	LGA	
2013	1	1	5	JFK	

carrier	names
UA	United
AA	America
AS	Alaska

tailnum	year	month	day	hour	origin	dest	flight	carrier	...
N14228	2013	1	1	5	EWR	IAH	1545	UA	
N24211	2013	1	1	5	LGA	IAH	1714	UA	
N619AA	2013	1	1	5	JFK	MIA	1141	AA	

tailnum	year	...
N14228	2013	
N24211	2013	
N619AA	2013	

faa	name	lat	...
IAH	Houston	29.98	
MIA	Miami	25.79	
EWR	Newark	40.69	
LGA	LaGuardi	40.77	

planes

Beginner



No  
mental model

- LGA is LaGuardia Airport
- It rained at JFK on 1/3/2013
- UA is United
- N619AA is a Cessna Plane
- Flight 1532 was delayed on 12/31/13
- Flight 1714 flew from LGA to IAH
- Houston airport is at 29.98 latitude
- Miami is MIA

# Beginner



No  
mental model

- LGA is LaGuardia Airport
- It rained in New York City in January 2013
- UA is United
- Flight 1532 was delayed on 12/31/13
- Flight 1532 was delayed on 12/31/13
- Houston airport is at 29.98 latitude
- Miami is MIA

# Your Turn

Spend five minutes drawing out and elaborating a concept map of your mental model for your package topic.

Label the connections.

Pay particular attention to what is a pre-requisite for what.

Think

05 : 00

Pair

01 : 00

# Your Turn

Compare your map to the people's next to you.  
Are they surprisingly different? similar?

Think

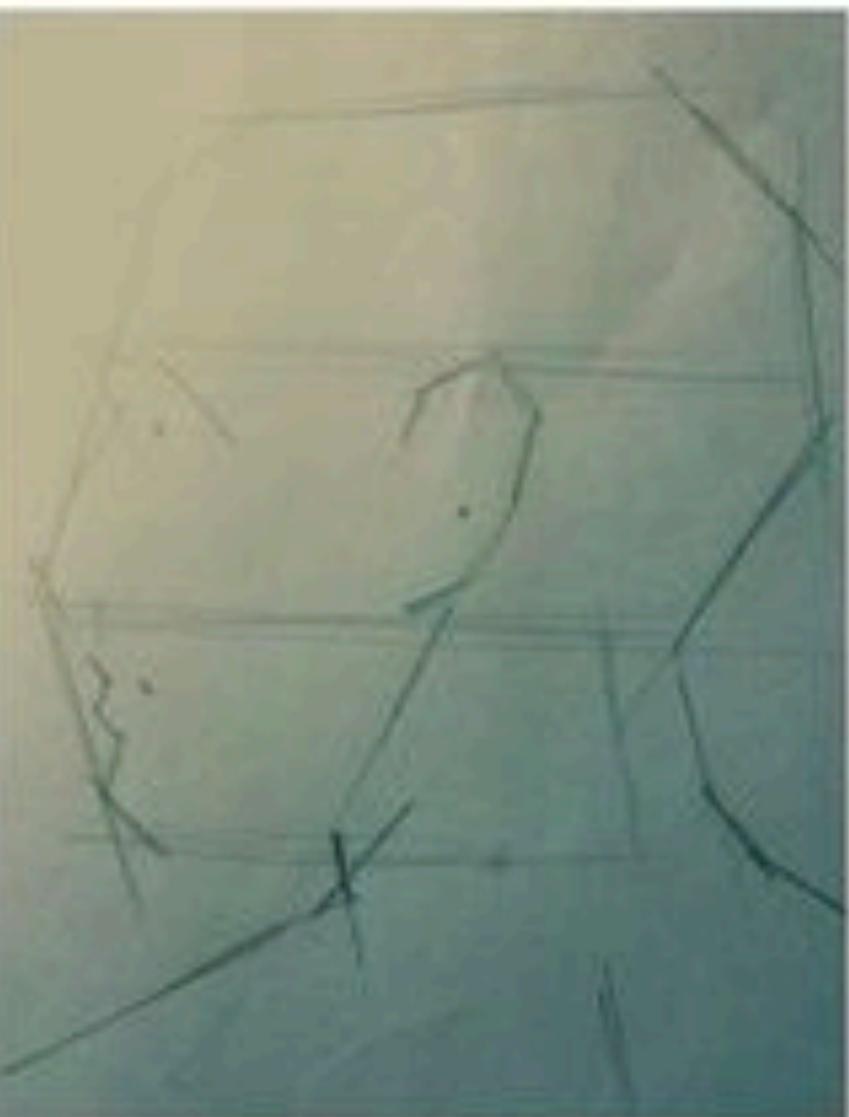
05 : 00

Pair

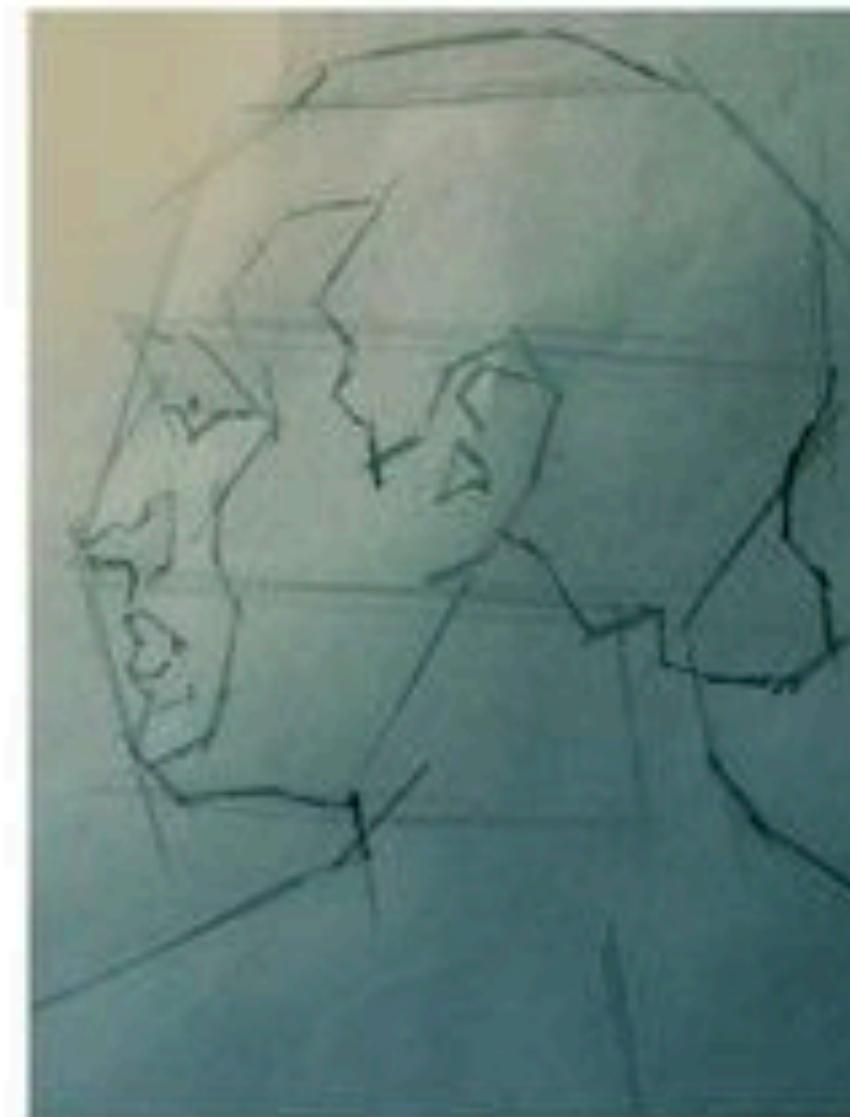
01 : 00

# Now what?

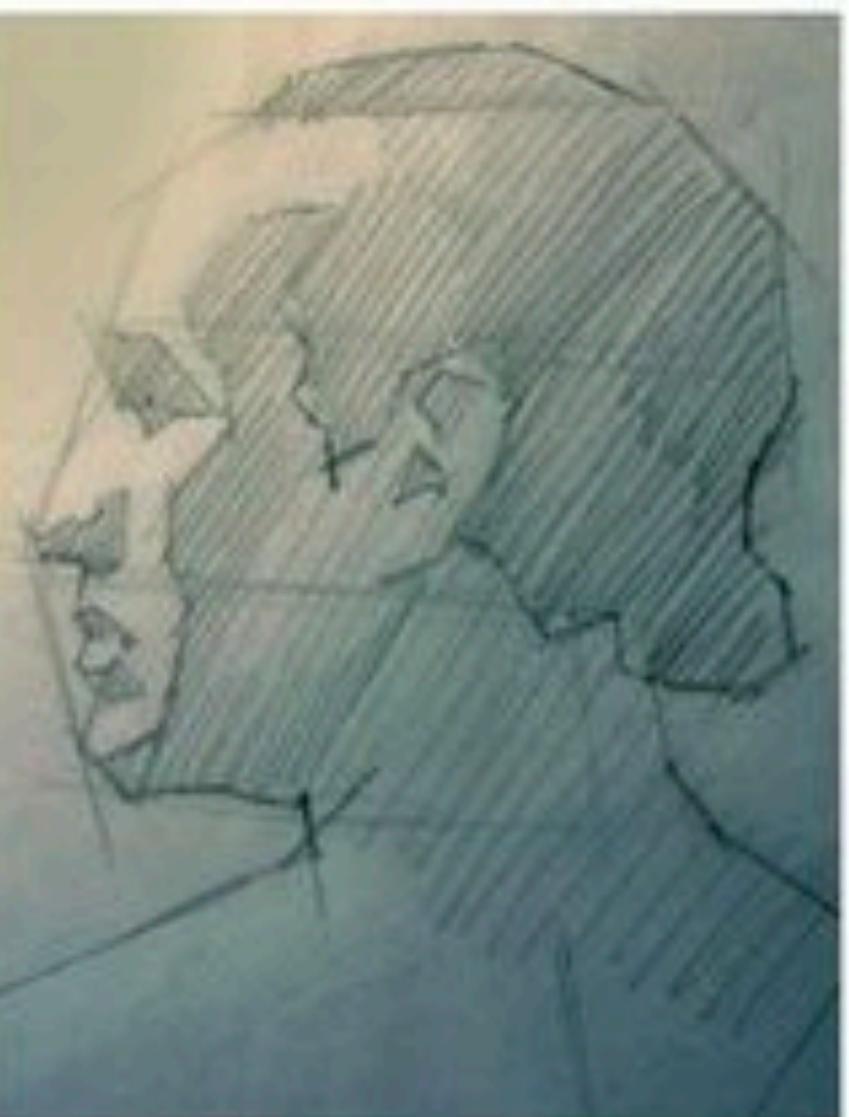
R



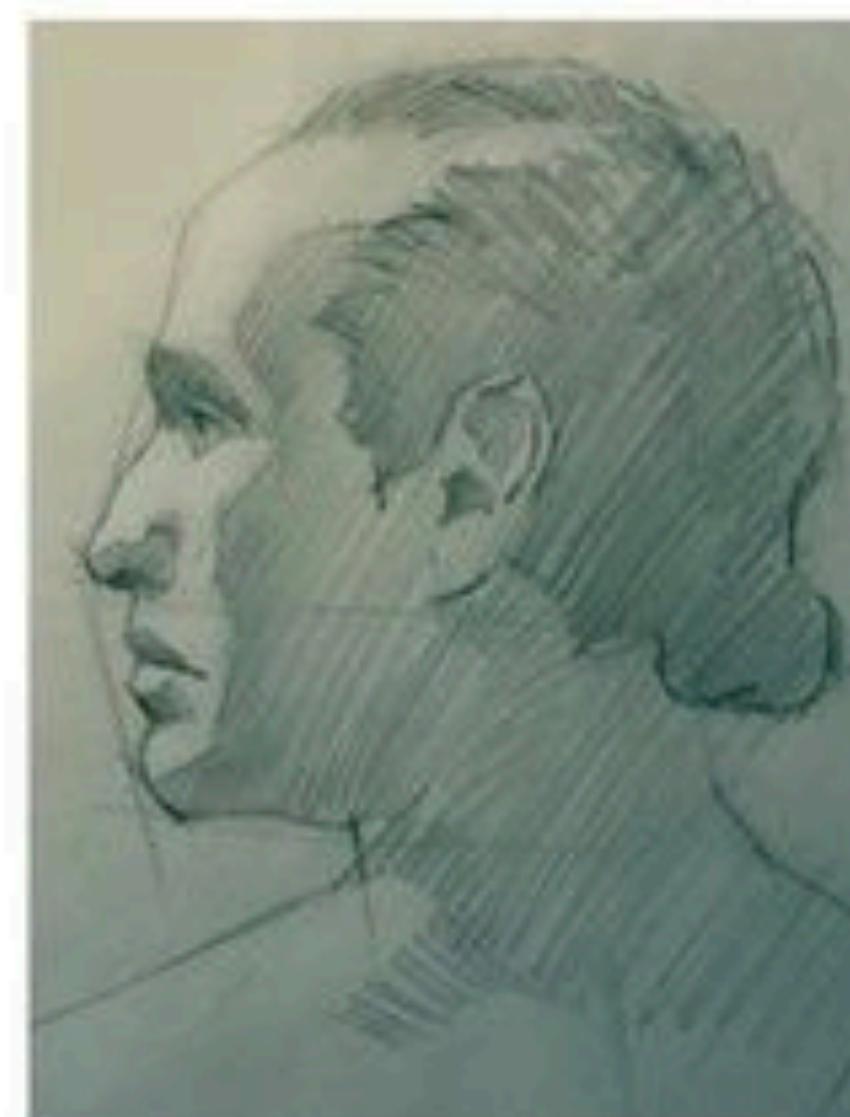
1. Initial set-up



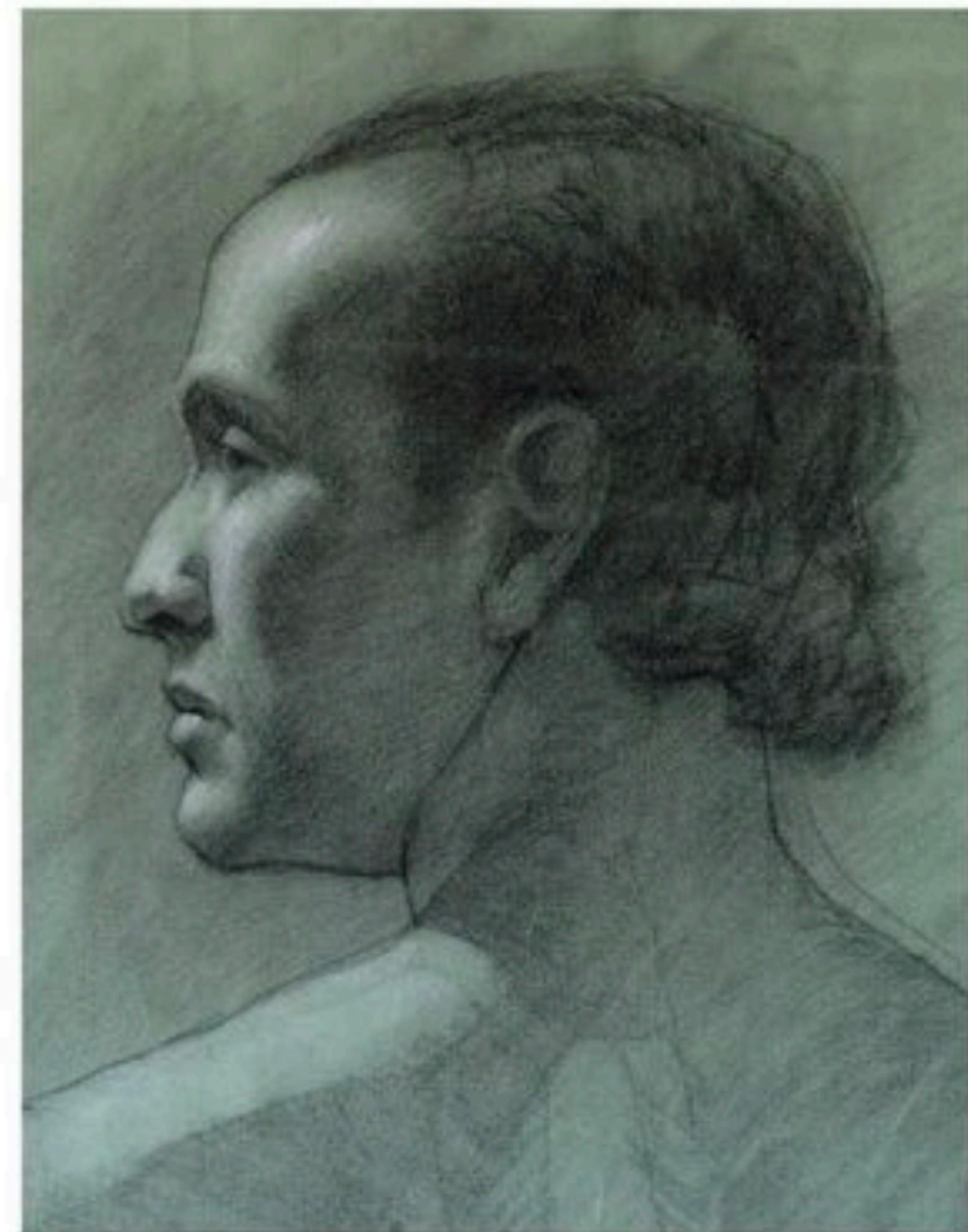
2. Find the major forms



3. Mass in the shadow shapes,  
they define the light shapes.



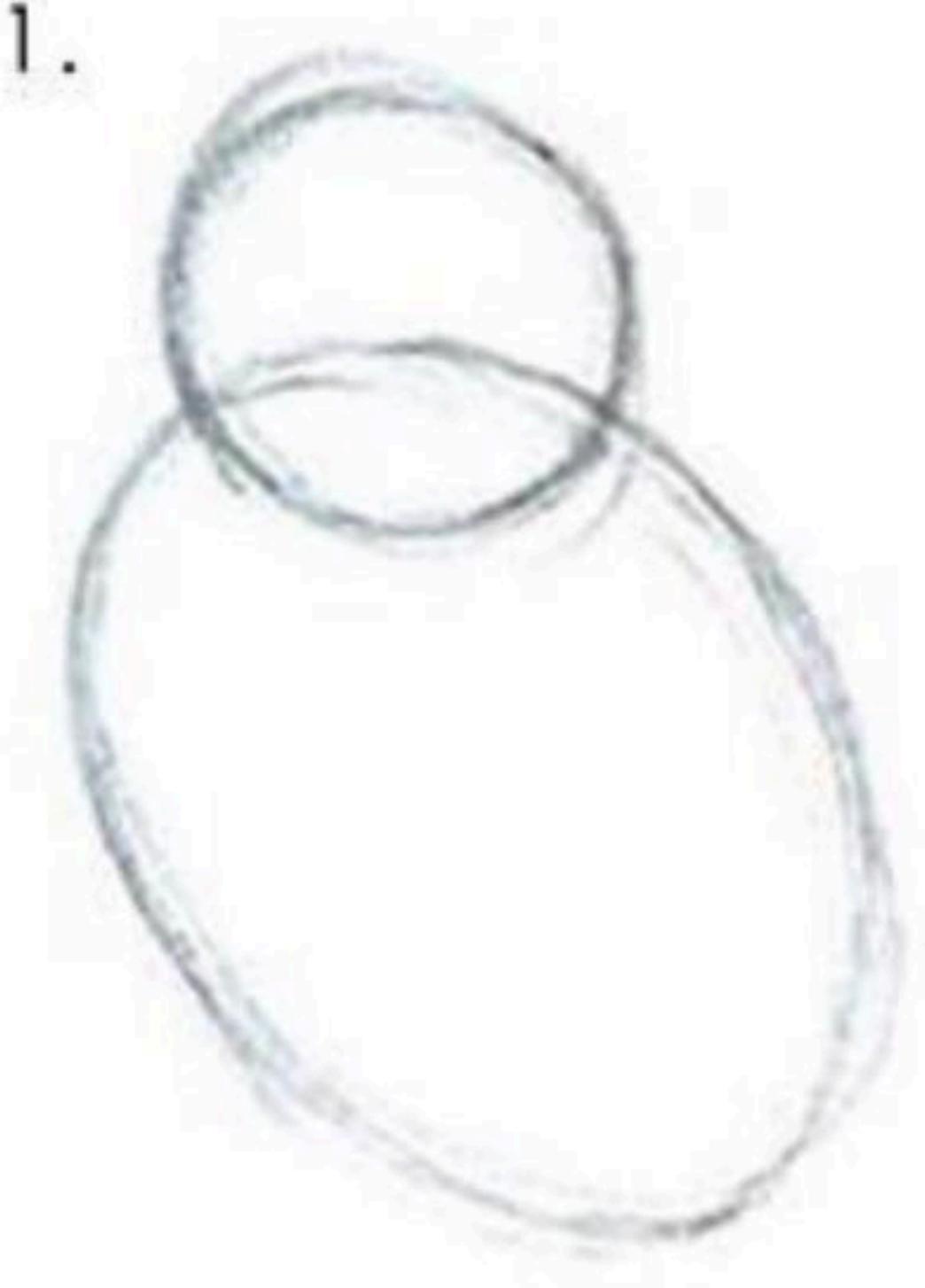
4. Further development of the  
shadow shapes.



Head study form life, charcoal and white chalk  
on green paper.

## How to draw an owl

1.



2.



1. Draw some circles

2. Draw the rest of the fucking owl

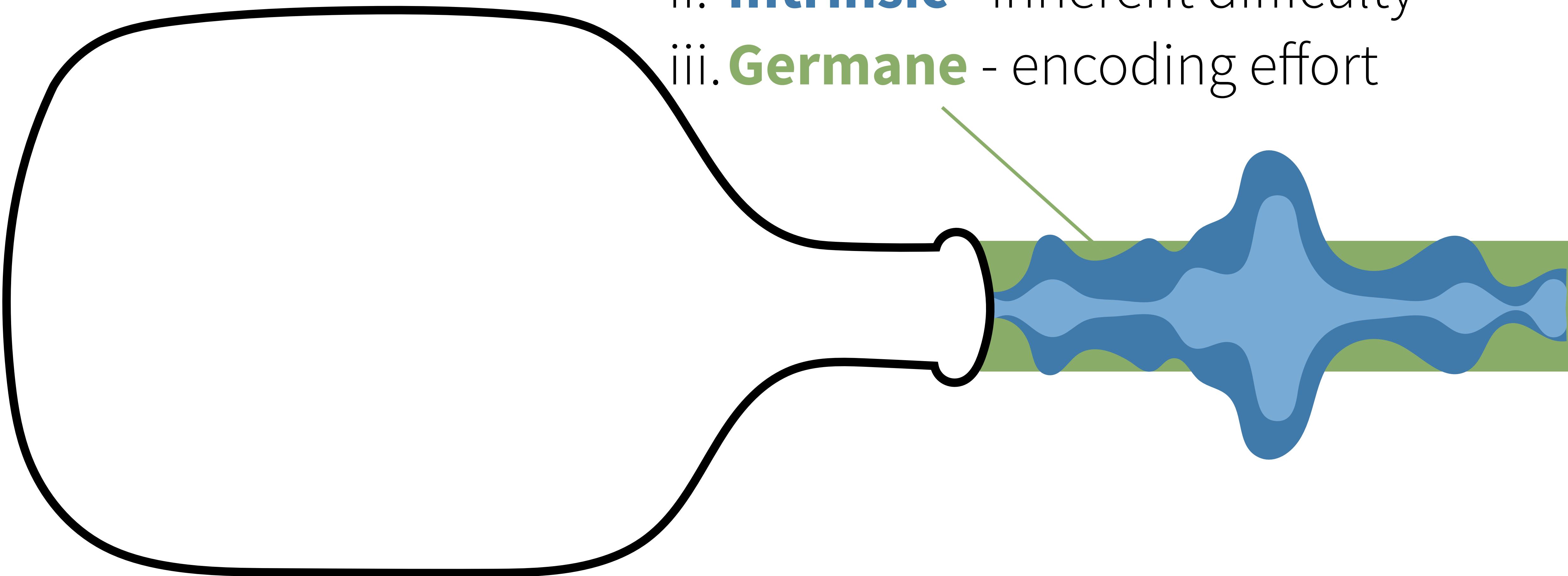
# Poll

What's better at conveying a mental model:

**Explanations**      or      **Exercises?**

# Cognitive Load Theory

- i. **Extraneous** - lost to distractions
- ii. **Intrinsic** - inherent difficulty
- iii. **Germane** - encoding effort



# TETRIS

The relentless building block video puzzle. <sup>TM\*</sup>

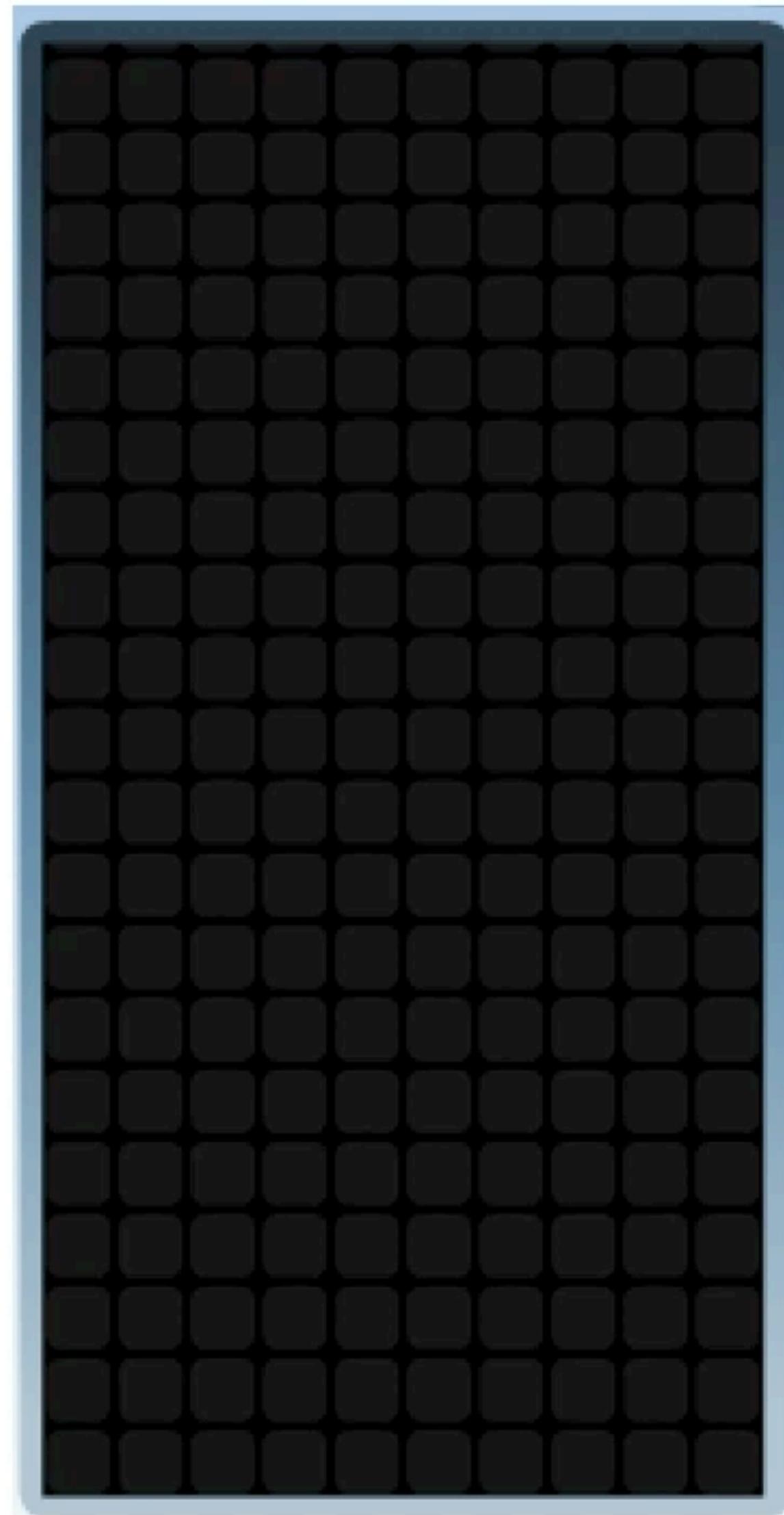


FROM  
RUSSIA  
WITH FUN!

Nintendo®

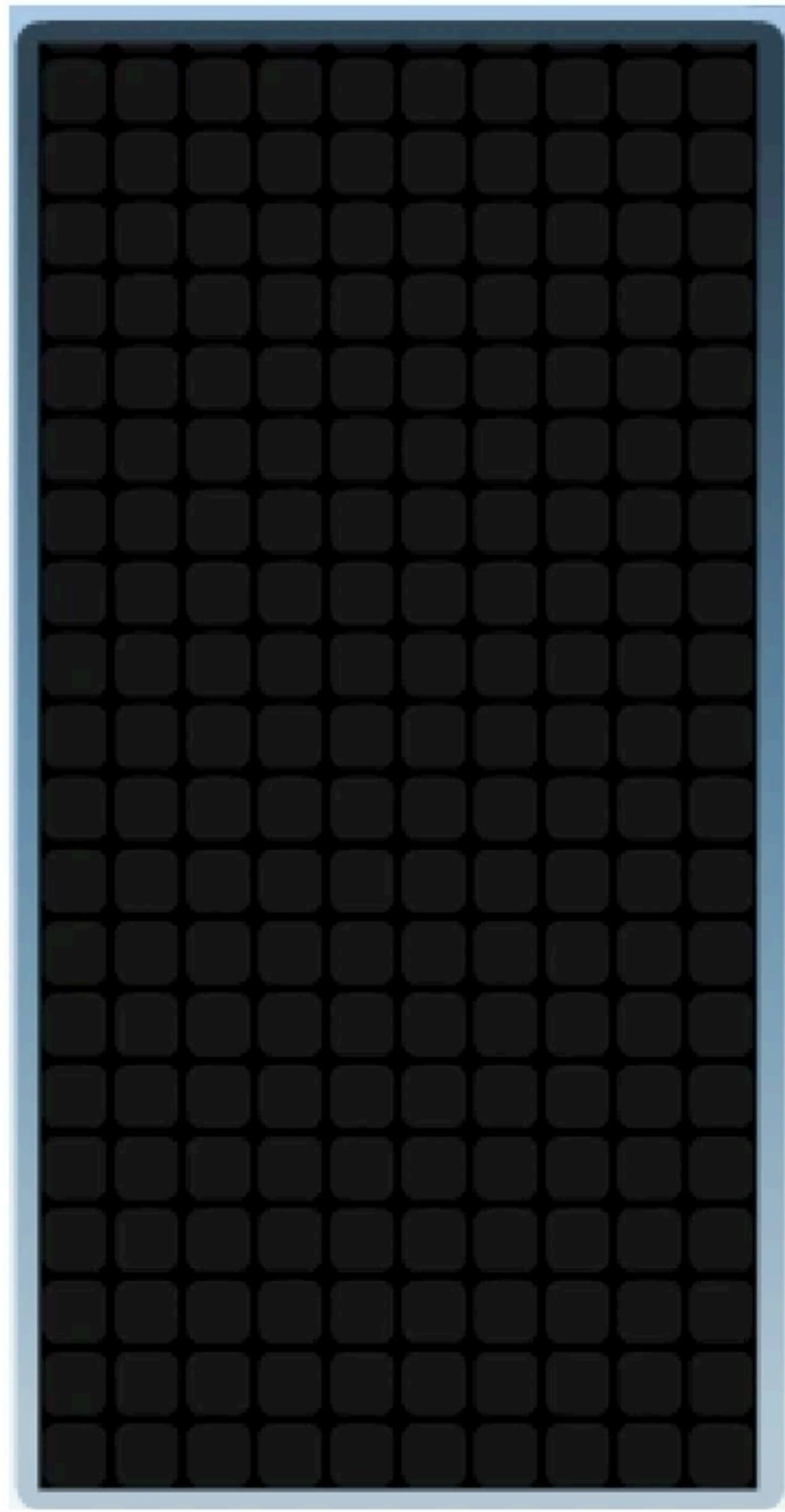


# Germane Load



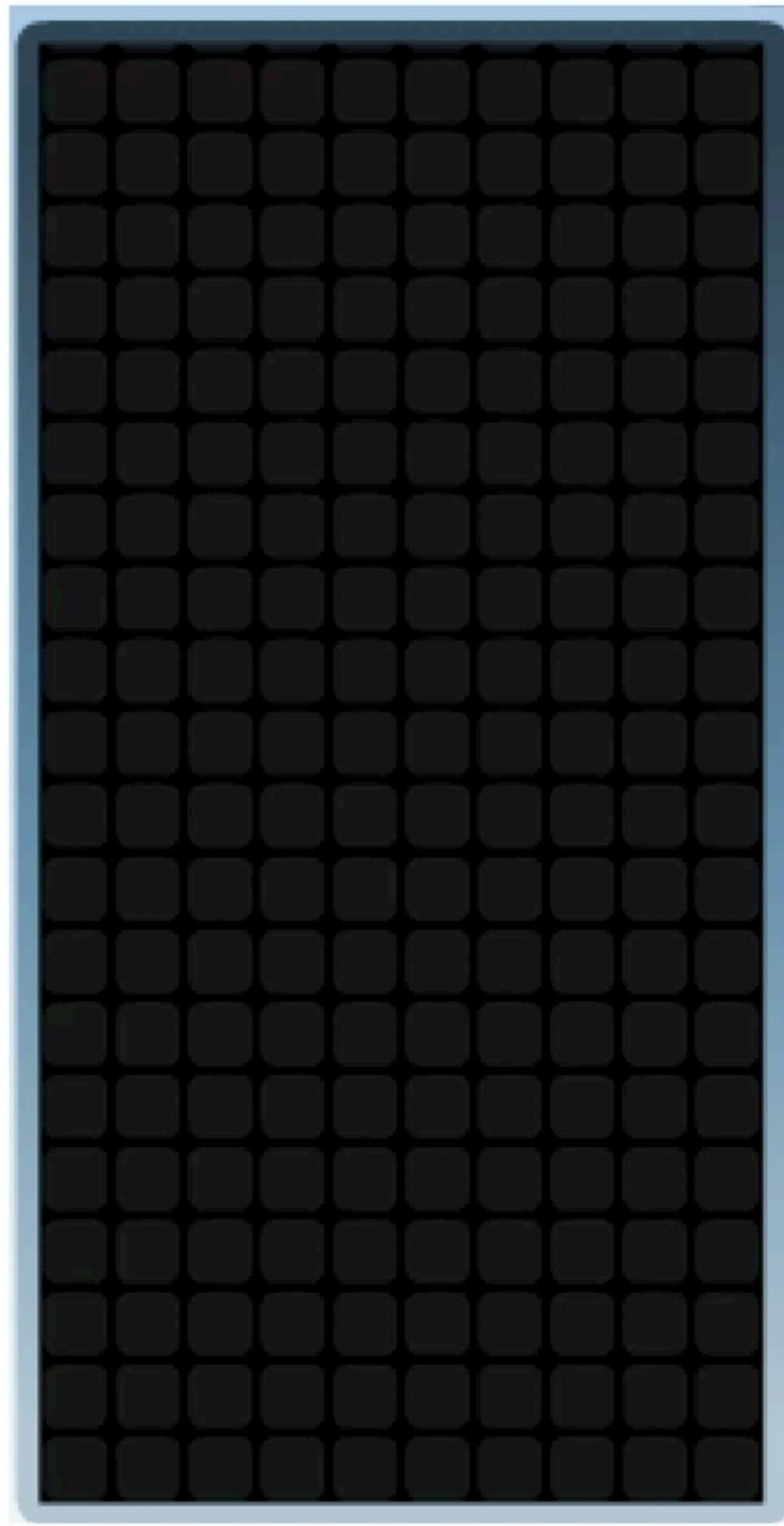
Exercises prevent  
this

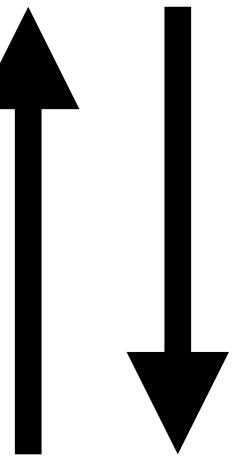
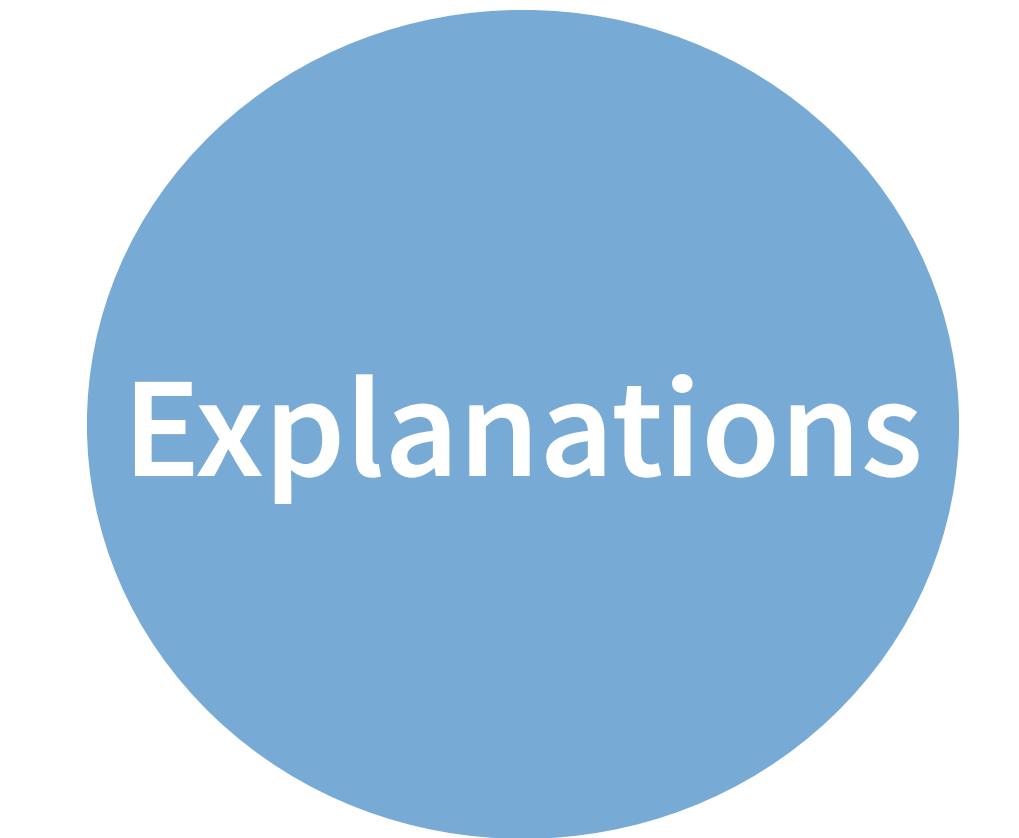
# Intrinsic Load

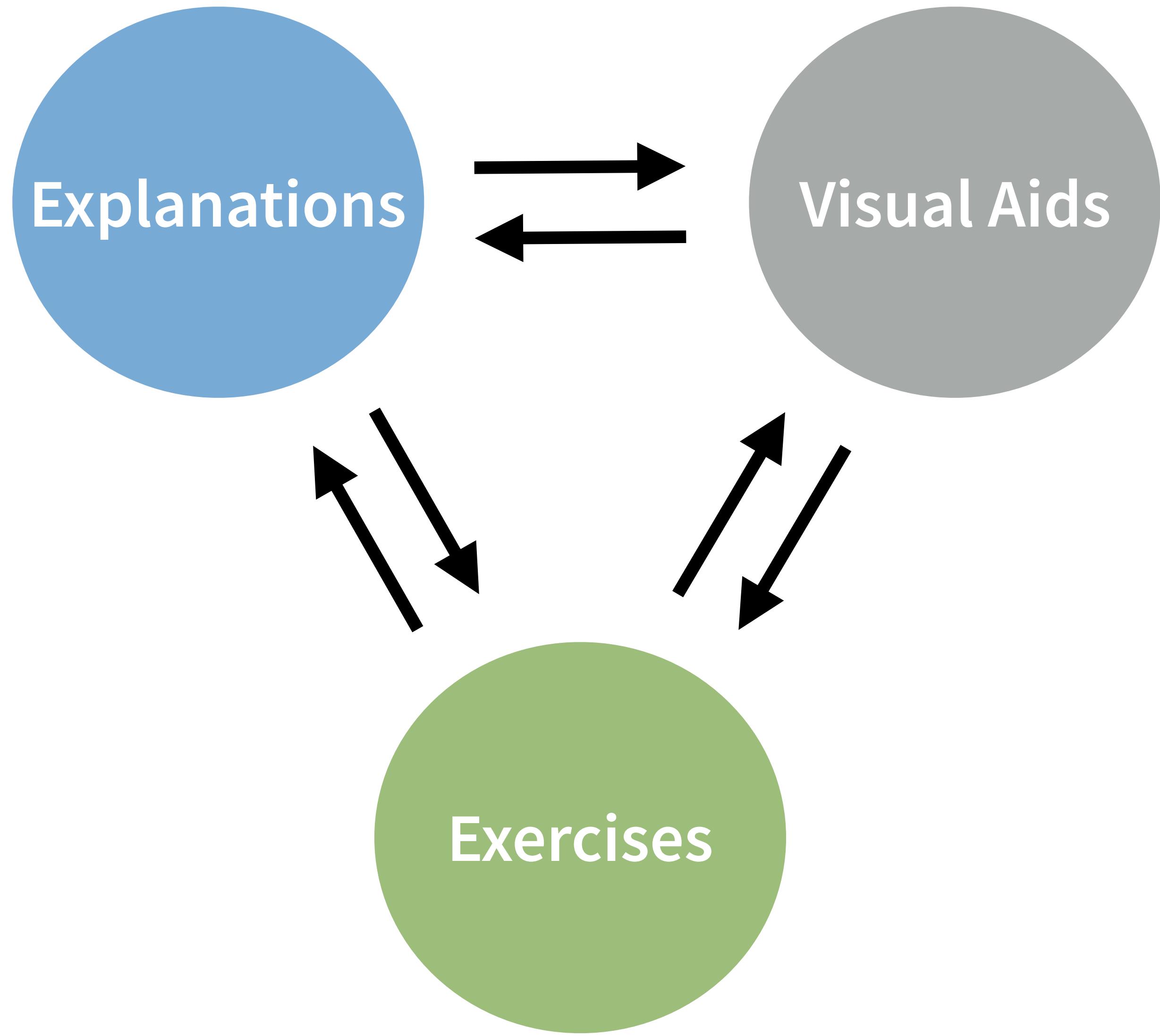


Explanations prevent  
this

# Extrinsic Load

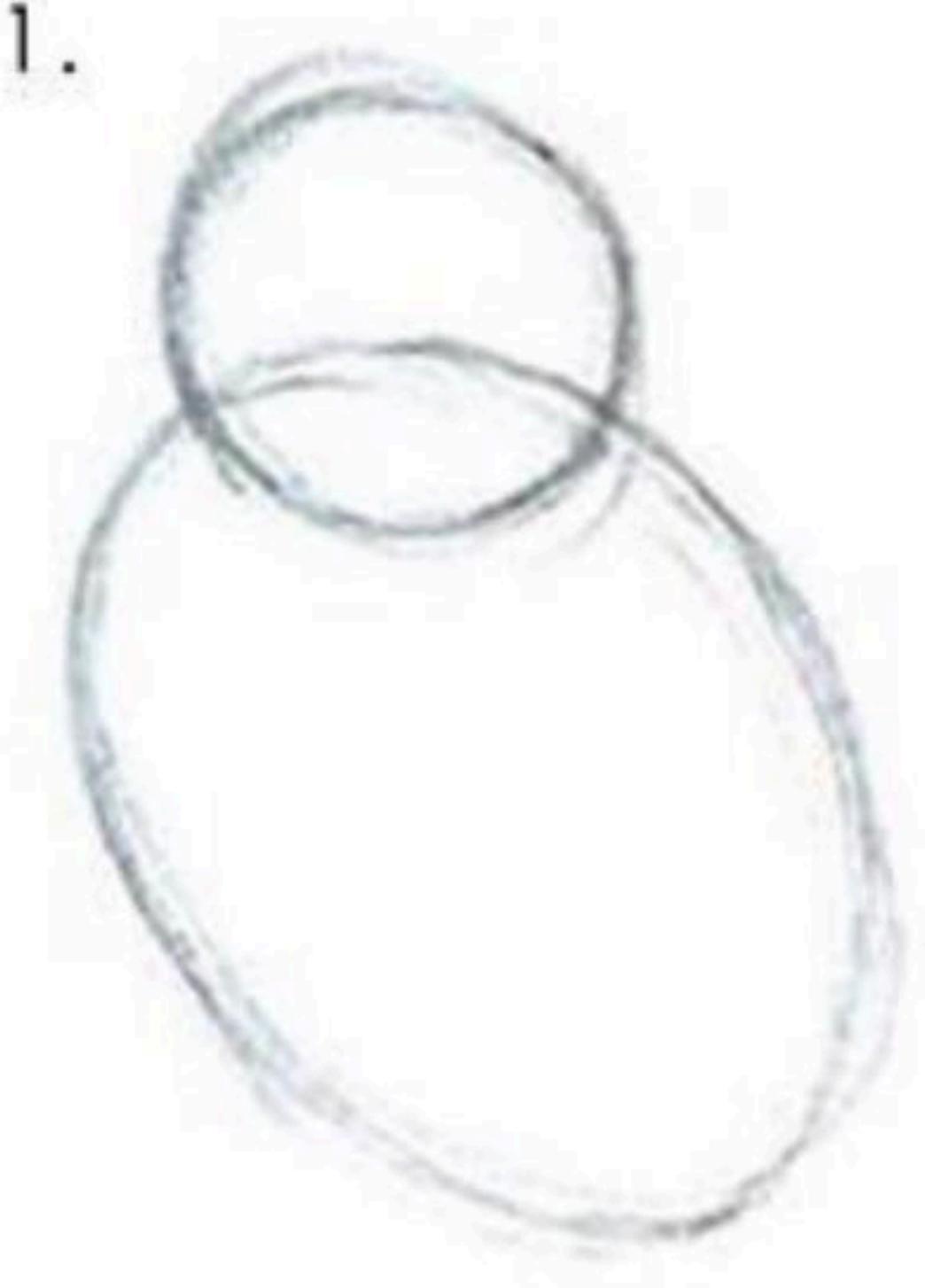






## How to draw an owl

1.



2.



1. Draw some circles

2. Draw the rest of the fucking owl

# Your Turn

Look at your concept map, and decide which key parts you would like to teach in a short lesson (~30-45 minutes).

Write a learning objective that encapsulates those parts.  
You can be vague at this step.



# How to Explain Anything Effectively

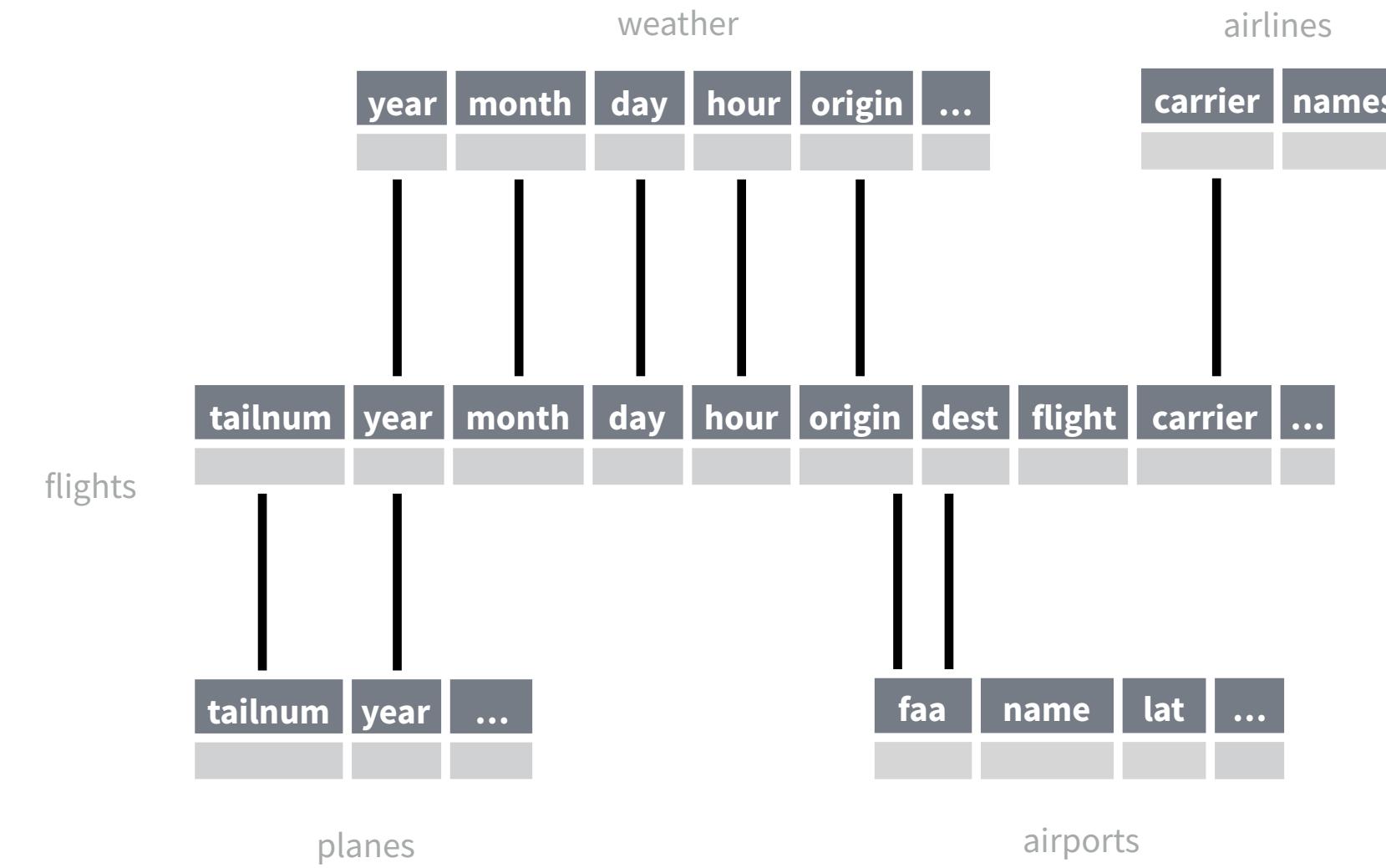
# **Goals**

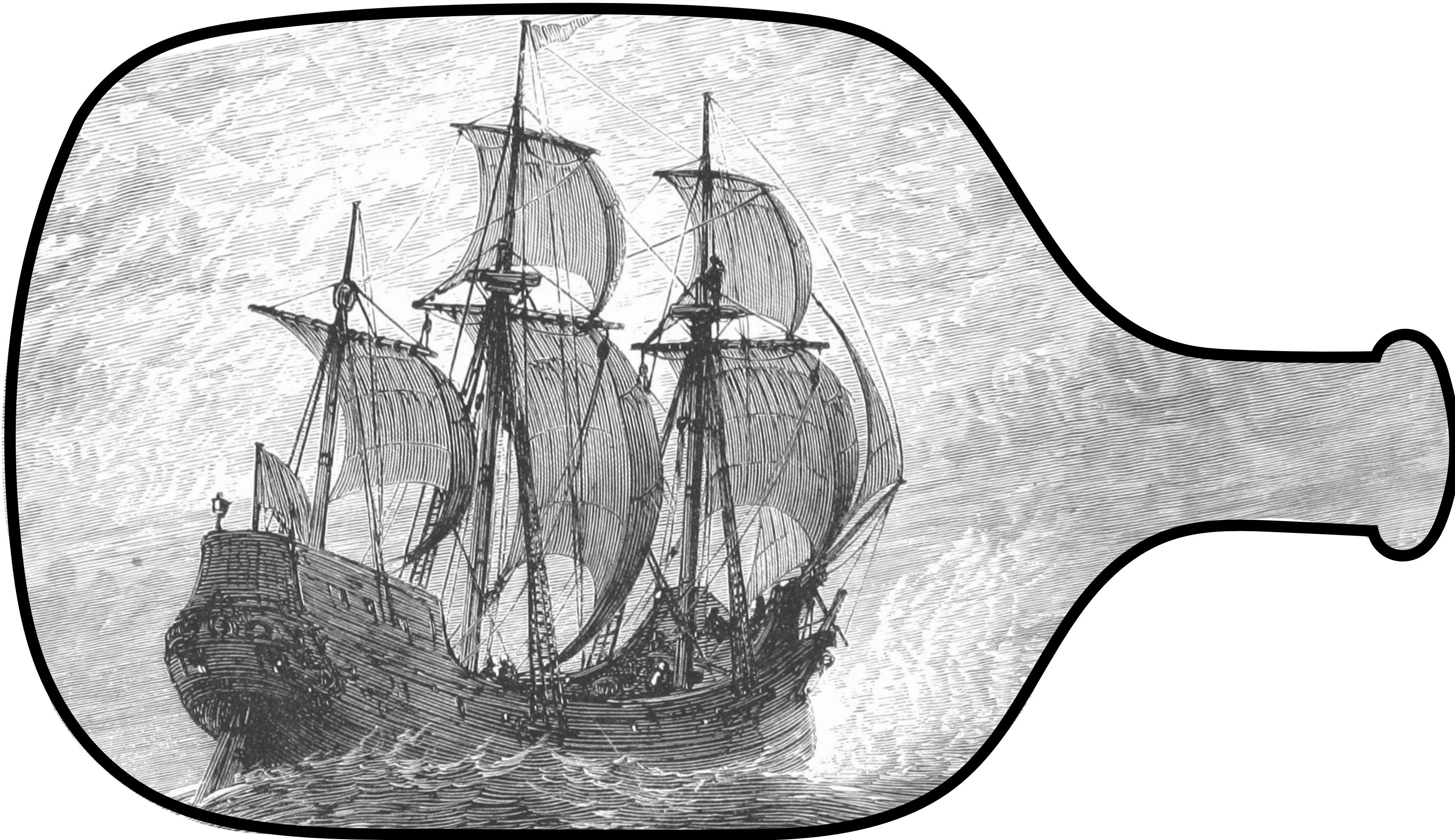
1. Reduce the intrinsic load

# Intrinsic Load Analogy

# Goals

1. Reduce the intrinsic load
2. Communicate the relationships



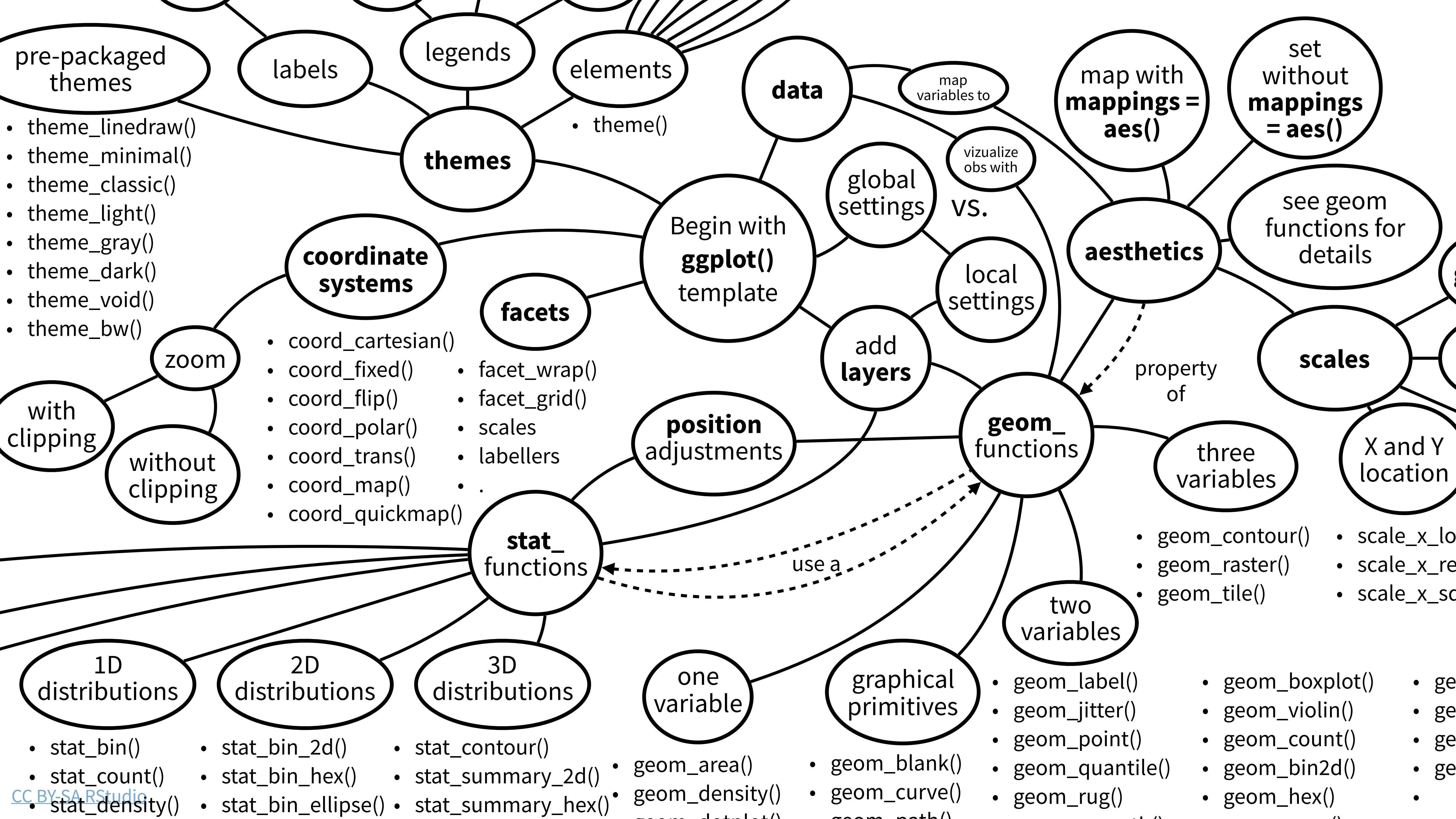


- 1. Lay the keel**
- 2. Build topics in order**
- 3. Connect to familiar things**

# Lay the keel

A large, semi-transparent circular watermark in the bottom right corner features two letters: 'R' on the top line and 'V' on the bottom line, both in a bold, sans-serif font.

R  
V



# What is the keel of your mental model?

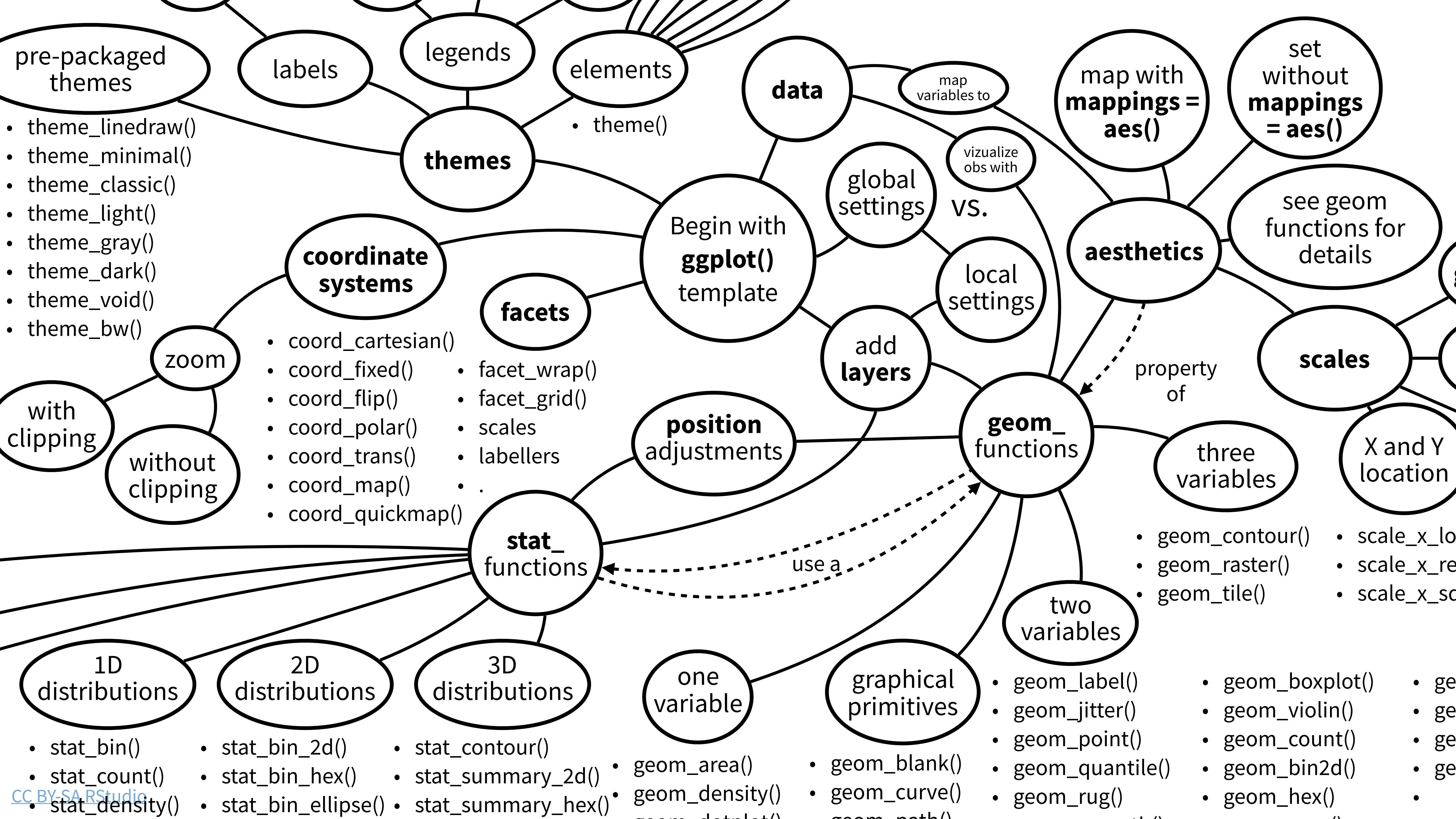
i.e., the core that everything else can hang on?



# Your Turn

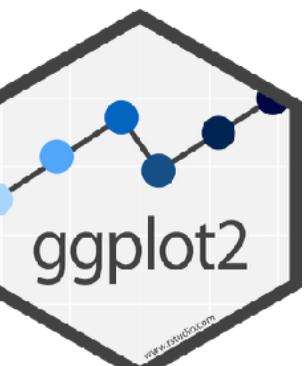
Examine the slides in 01-Data-Visualization. Spot the "initial" mental model of the section.



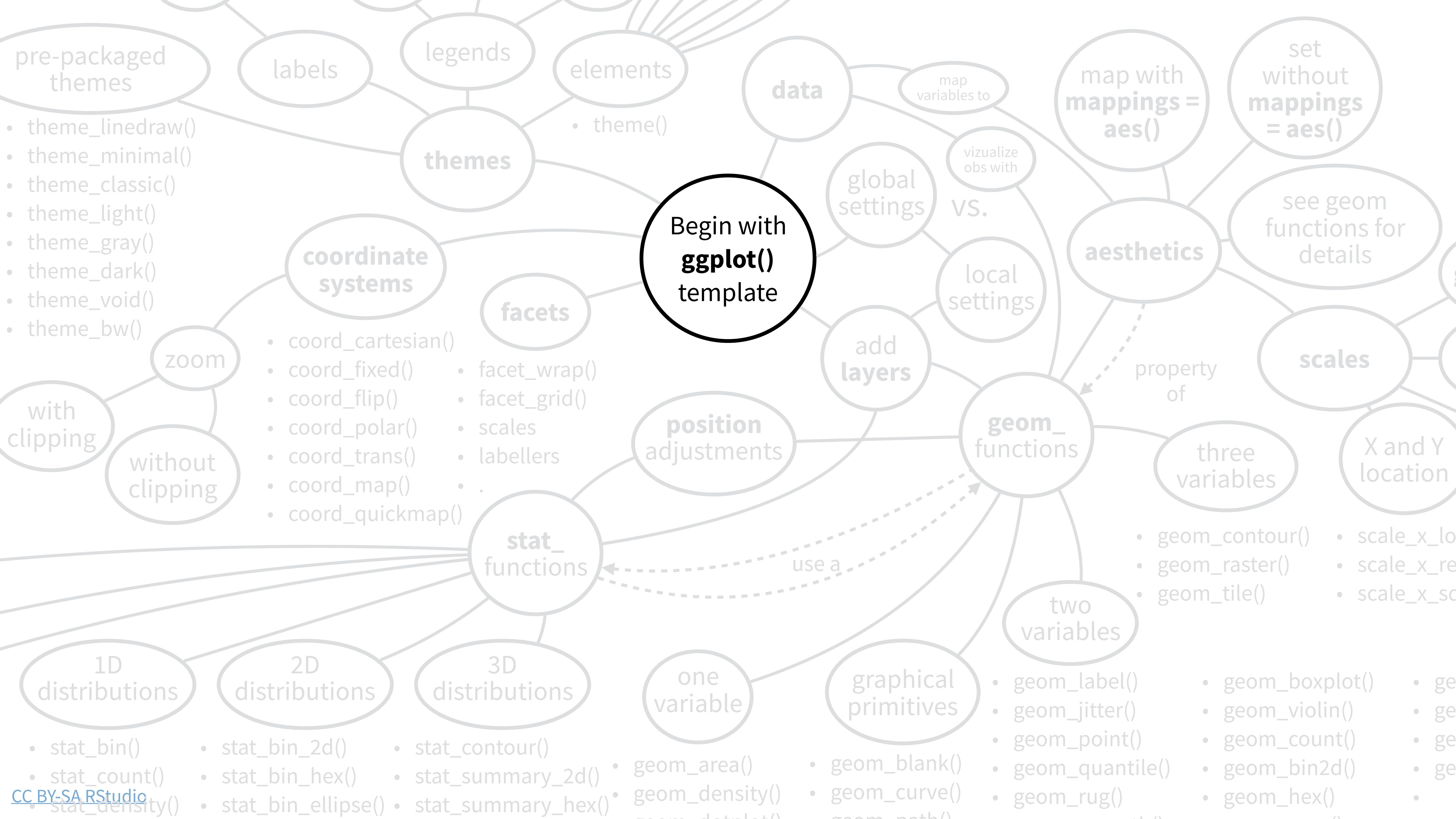


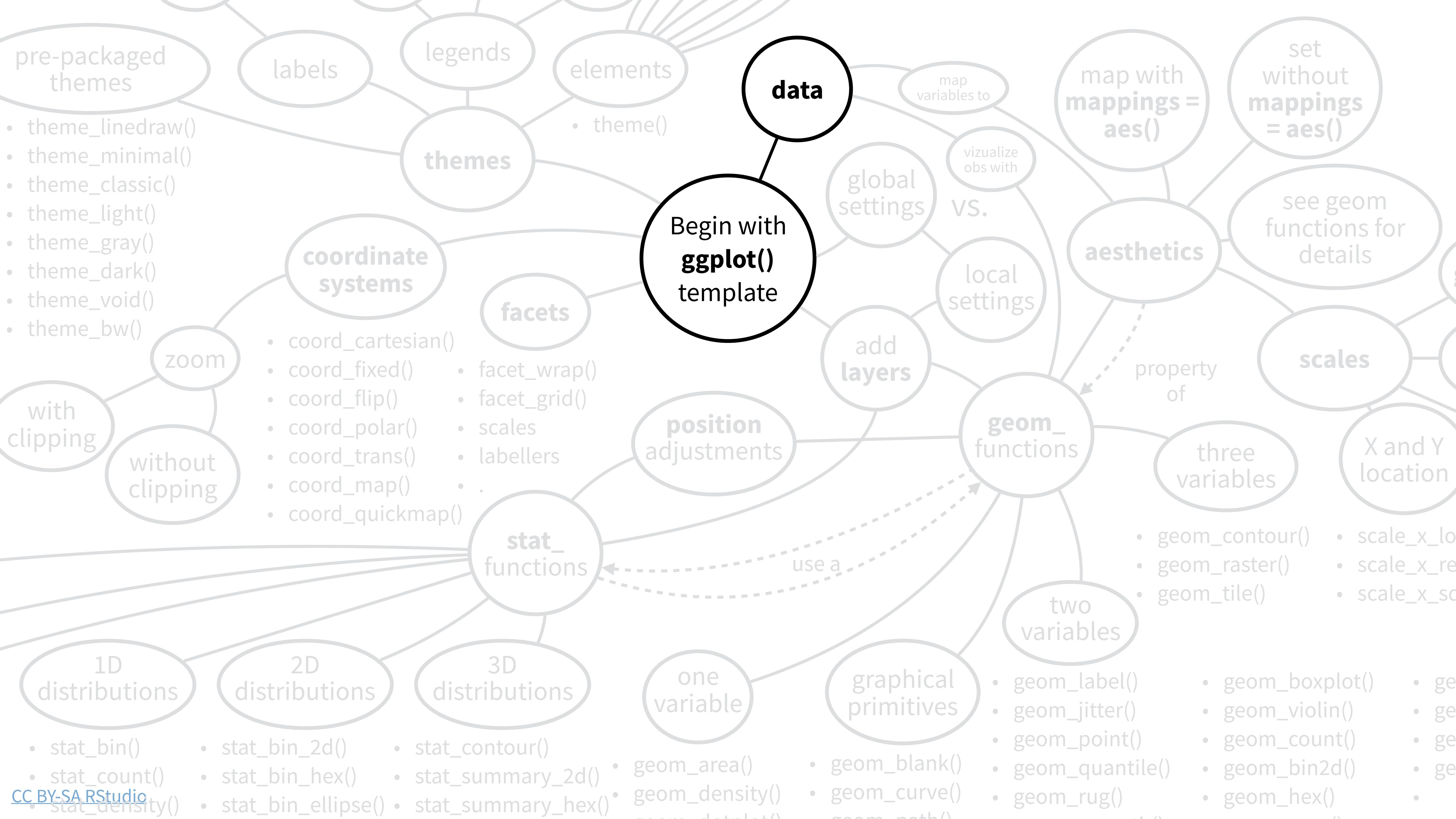
# A template

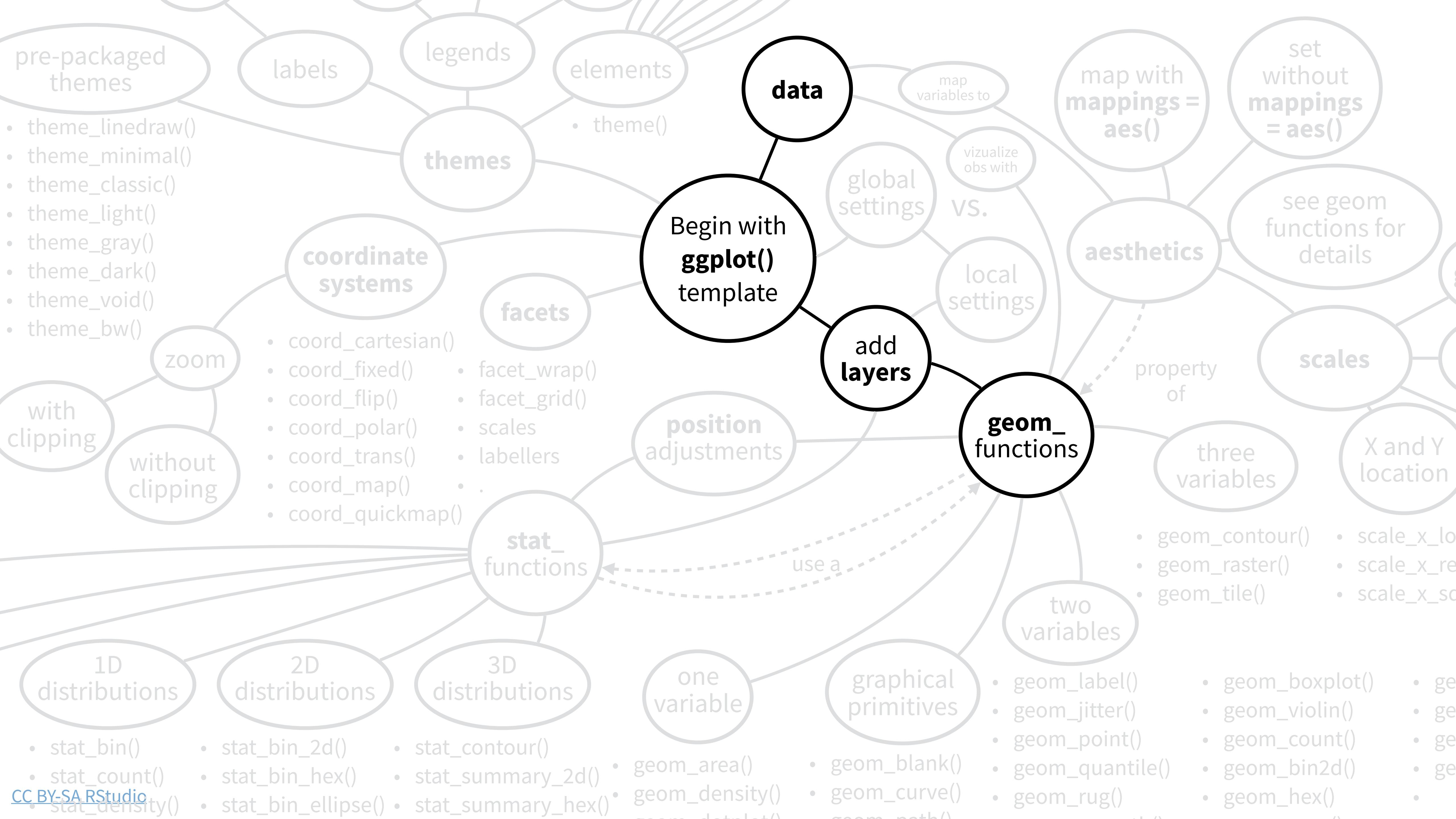
```
ggplot(data = <DATA>) +  
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

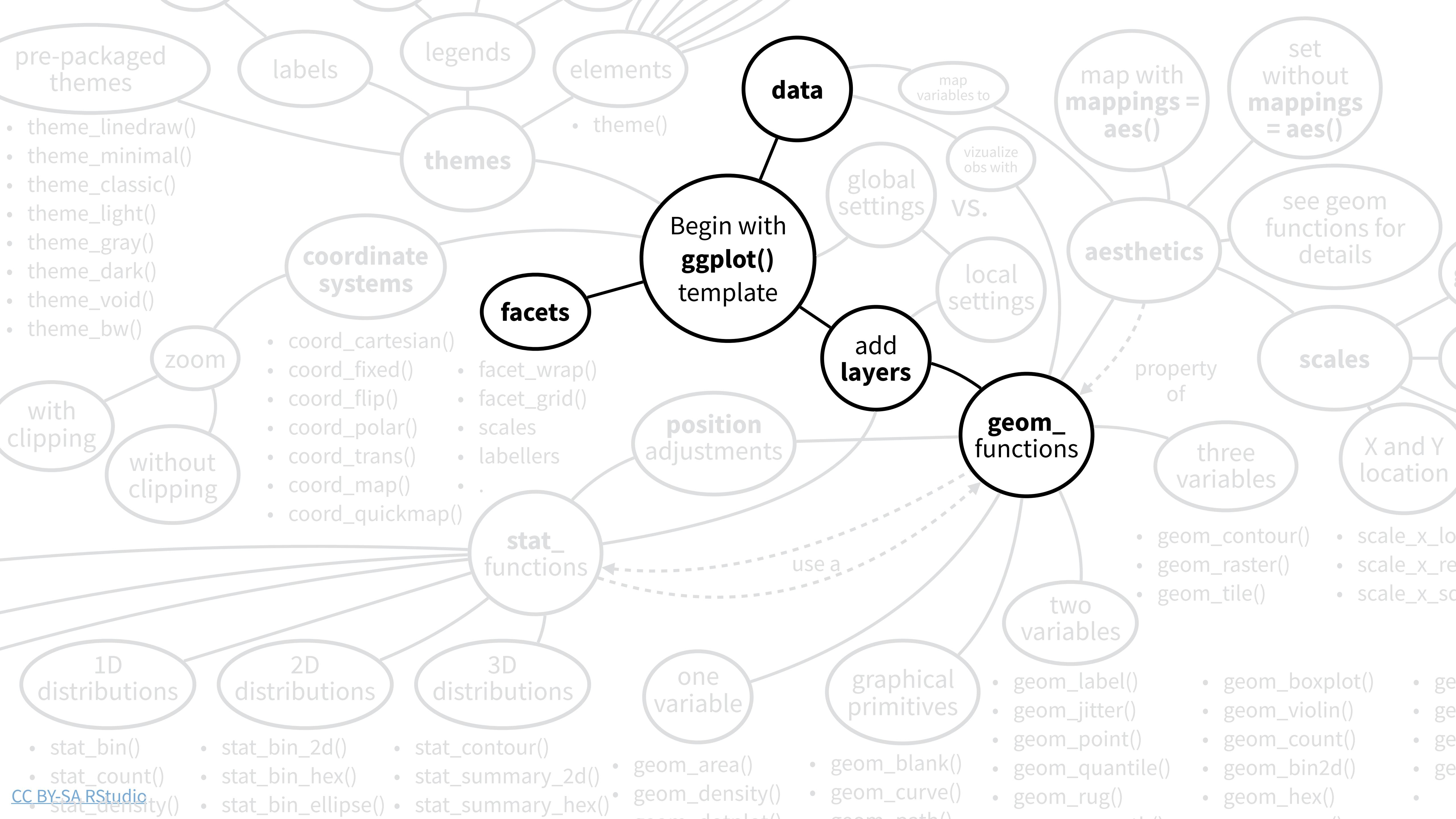


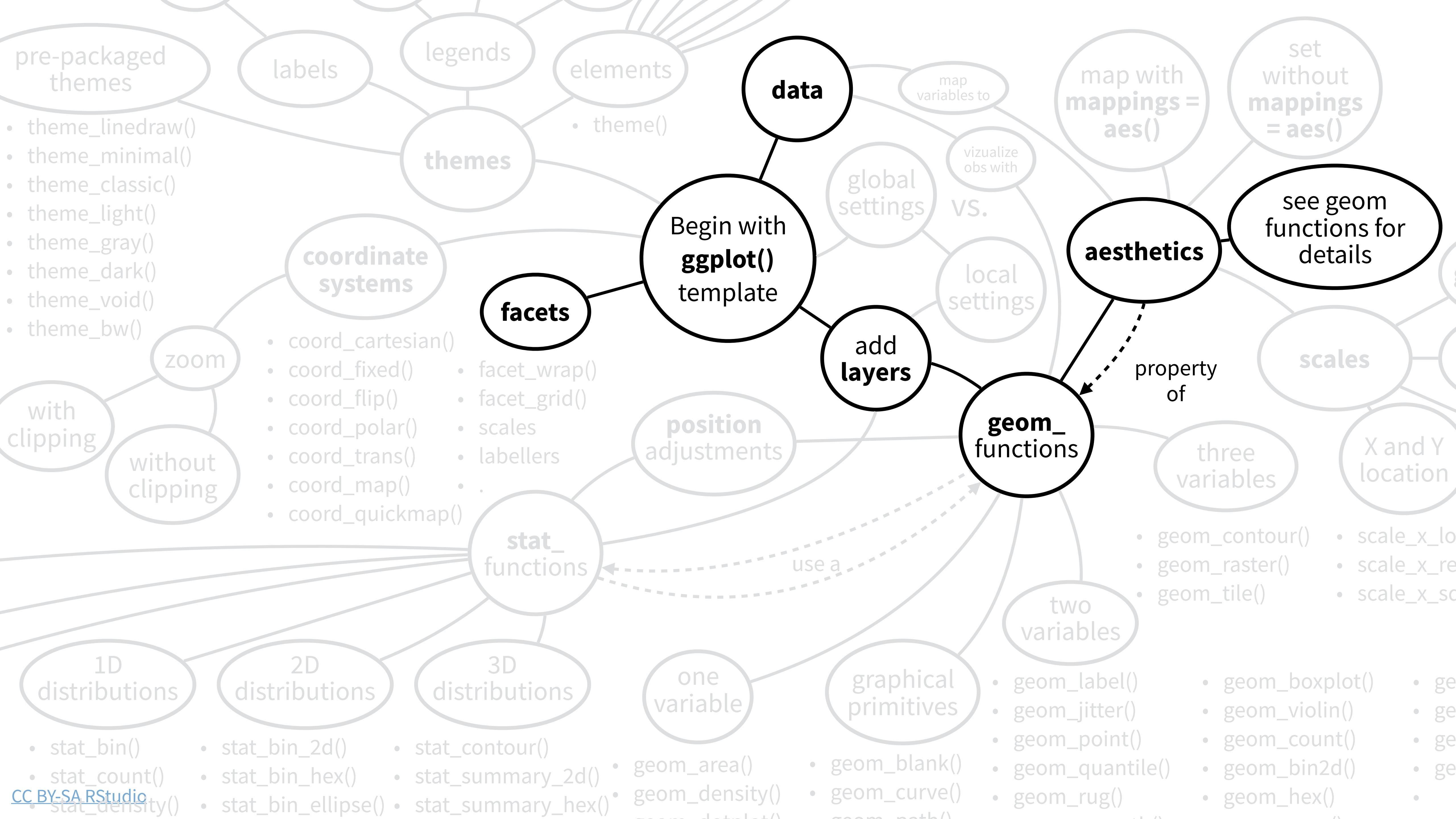
# Begin with **ggplot()** template



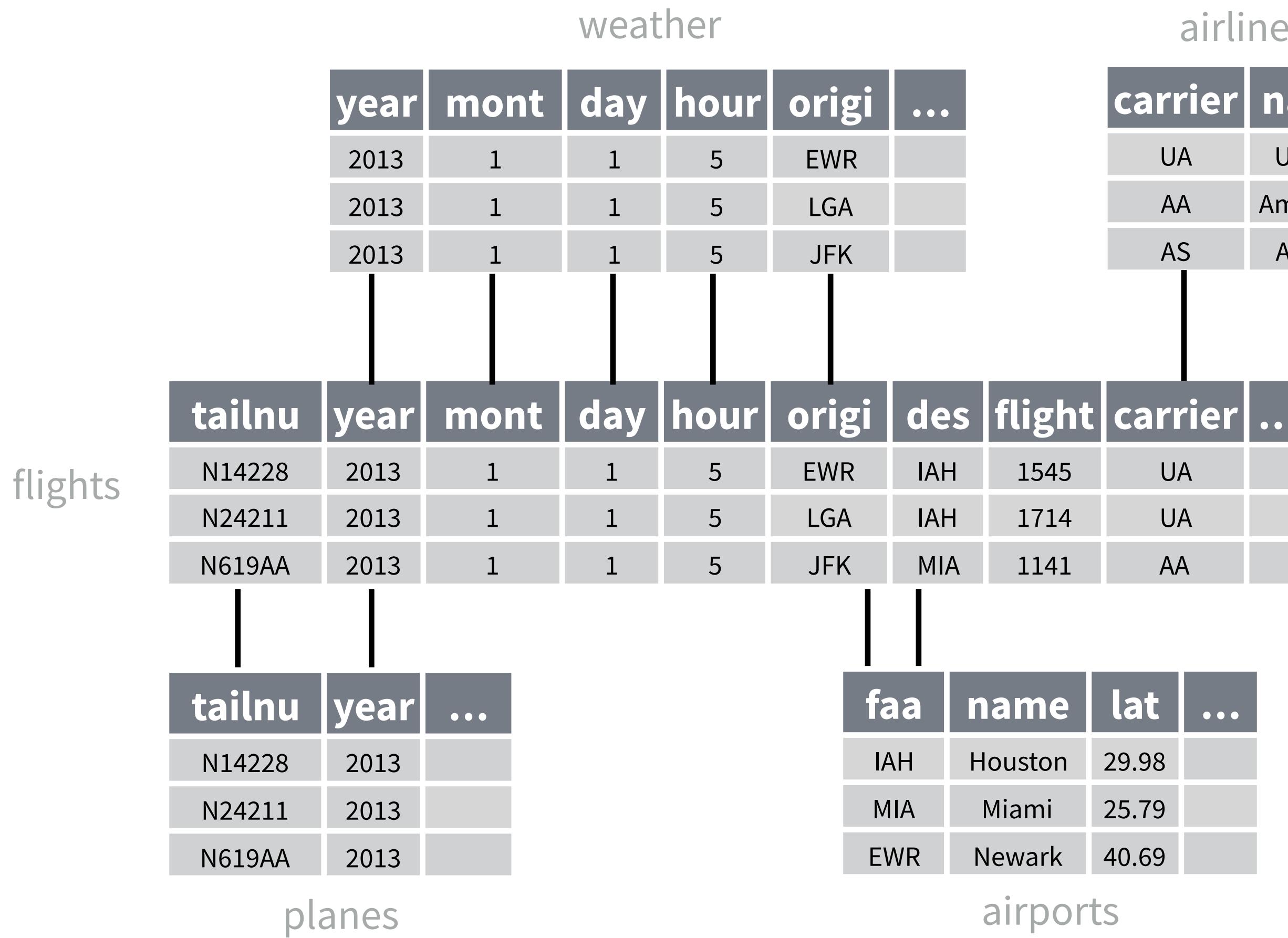






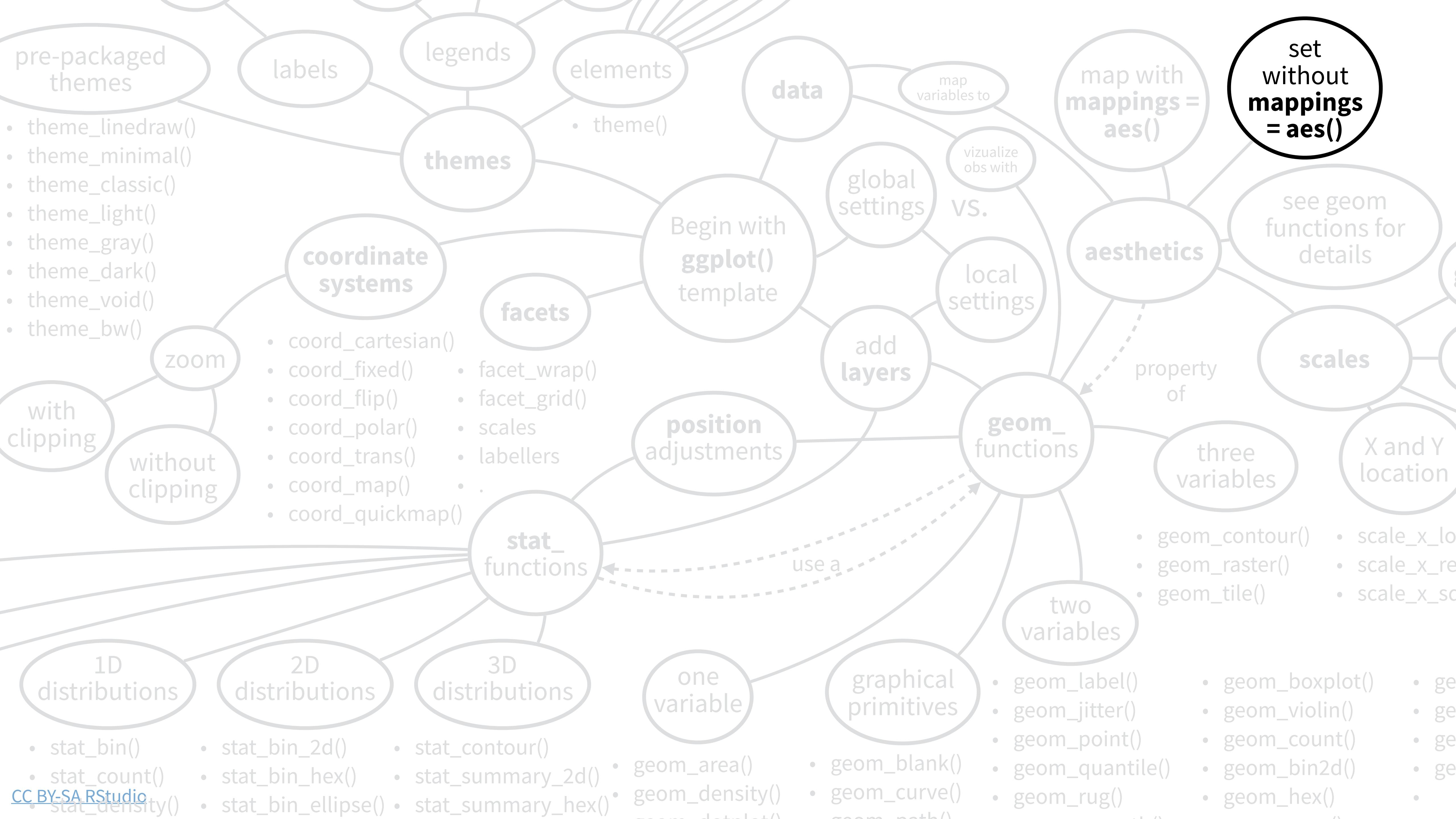


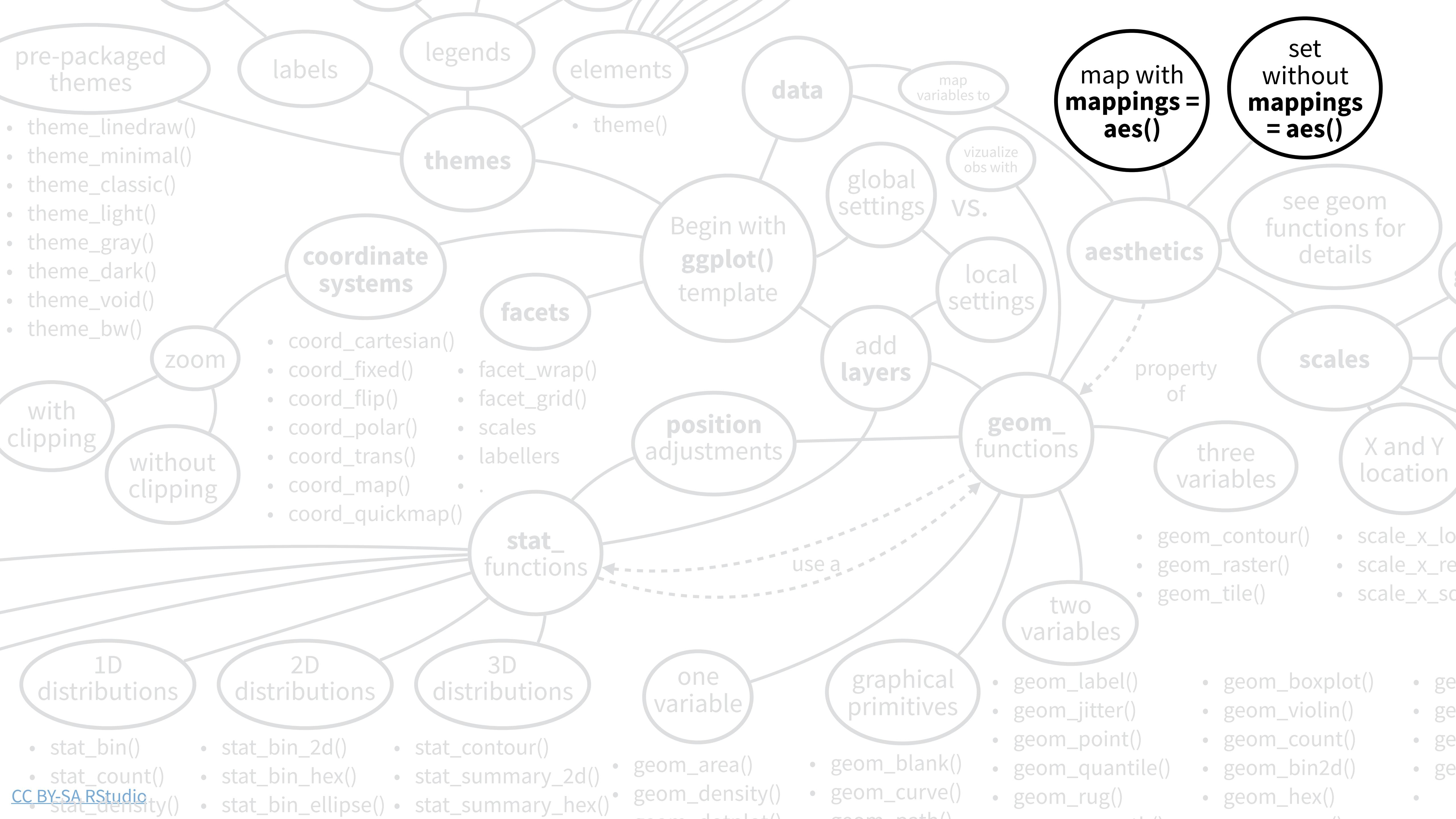
# Competent Practitioner



Useful  
mental model







**map with mappings = aes()**

**set without mappings = aes()**

pre-packaged themes

- theme\_linedraw()
- theme\_minimal()
- theme\_classic()
- theme\_light()
- theme\_gray()
- theme\_dark()
- theme\_void()
- theme\_bw()

labels

legends

elements

- theme()

themes

coordinate systems

zoom

with clipping

without clipping

facets

- coord\_cartesian()
- coord\_fixed()
- coord\_flip()
- coord\_polar()
- coord\_trans()
- coord\_map()
- coord\_quickmap()

stat\_functions

1D distributions

- stat\_bin()
- stat\_count()
- stat\_density()

2D distributions

- stat\_bin\_2d()
- stat\_bin\_hex()
- stat\_bin\_ellipse()

3D distributions

- stat\_contour()
- stat\_summary\_2d()
- stat\_summary\_hex()

one variable

- geom\_area()
- geom\_density()
- geom\_blank()
- geom\_quantile()
- geom\_rug()

graphical primitives

- geom\_boxplot()
- geom\_violin()
- geom\_count()
- geom\_bin2d()
- geom\_hex()

Begin with `ggplot()` template

global settings

local settings

add layers

position adjustments

geom\_functions

two variables

- geom\_label()
- geom\_jitter()
- geom\_point()
- geom\_boxplot()
- geom\_hex()

- geom\_boxplot()
- geom\_hex()
- geom\_violin()
- geom\_count()
- geom\_bin2d()

**map with mappings = aes()**

**set without mappings = aes()**

see geom functions for details

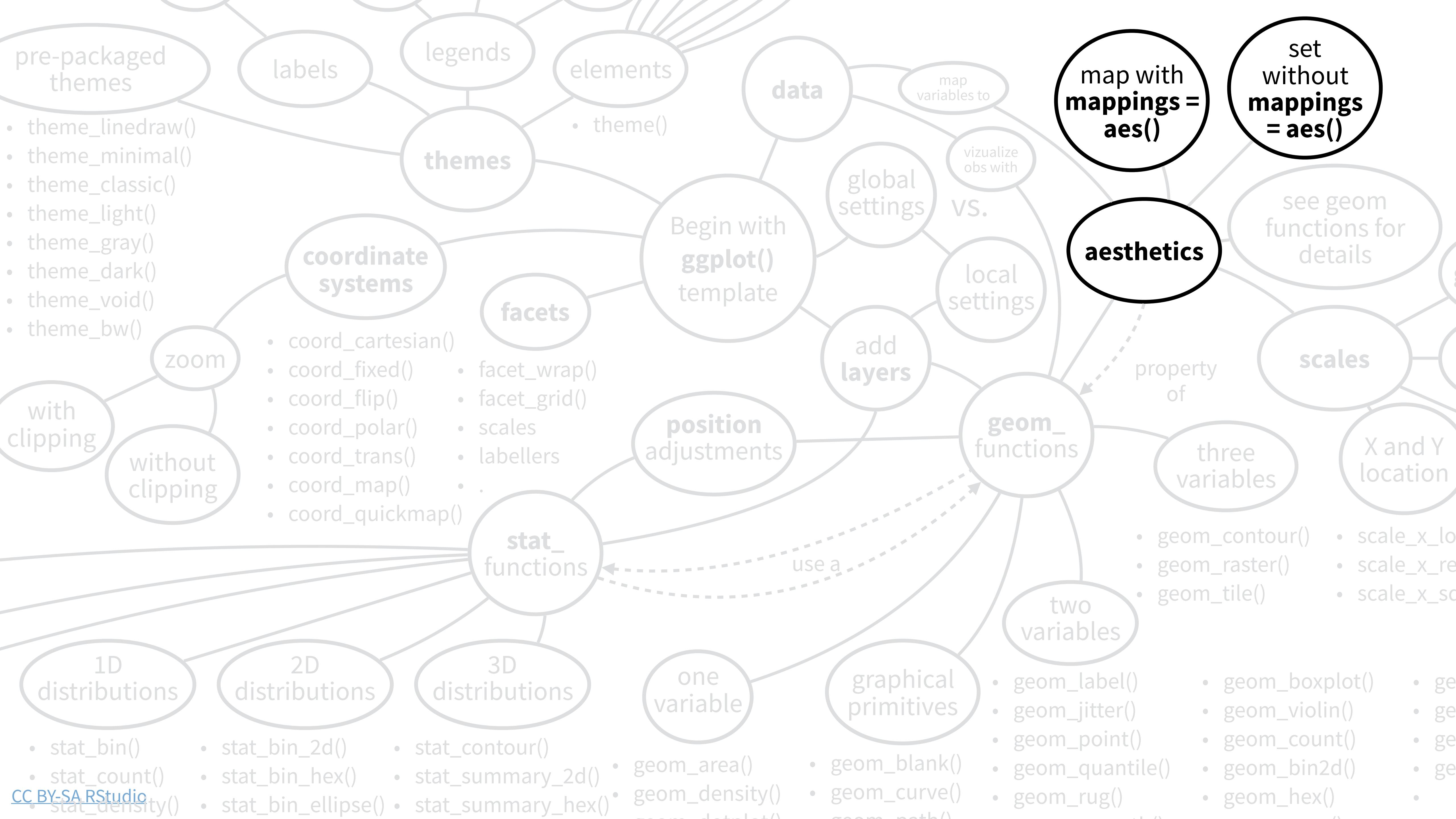
scales

X and Y location

three variables

- geom\_contour()
- geom\_raster()
- geom\_tile()

- scale\_x\_lo
- scale\_x\_re
- scale\_x\_sc



**map with mappings = aes()**

**set without mappings = aes()**

see geom functions for details

**scales**

X and Y location

- geom\_contour()
- geom\_raster()
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- scale\_x\_lo
- scale\_x\_re
- scale\_x\_sc

- geom\_boxplot()
- geom\_violin()
- geom\_count()
- geom\_bin2d()
- geom\_hex()

- geom
- geom
- geom
- geom
- geom

**geom\_functions**

two variables

- geom\_label()
- geom\_jitter()
- geom\_point()
- geom\_quantile()
- geom\_rug()

graphical primitives

add layers

position adjustments

one variable

global settings

local settings

data

map variables to

vizualize obs with

VS.

Begin with ggplot() template

legends

elements

themes

coordinate systems

facets

- coord\_cartesian()
- coord\_fixed()
- coord\_flip()
- coord\_polar()
- coord\_trans()
- coord\_map()
- coord\_quickmap()

zoom

without clipping

with clipping

1D distributions

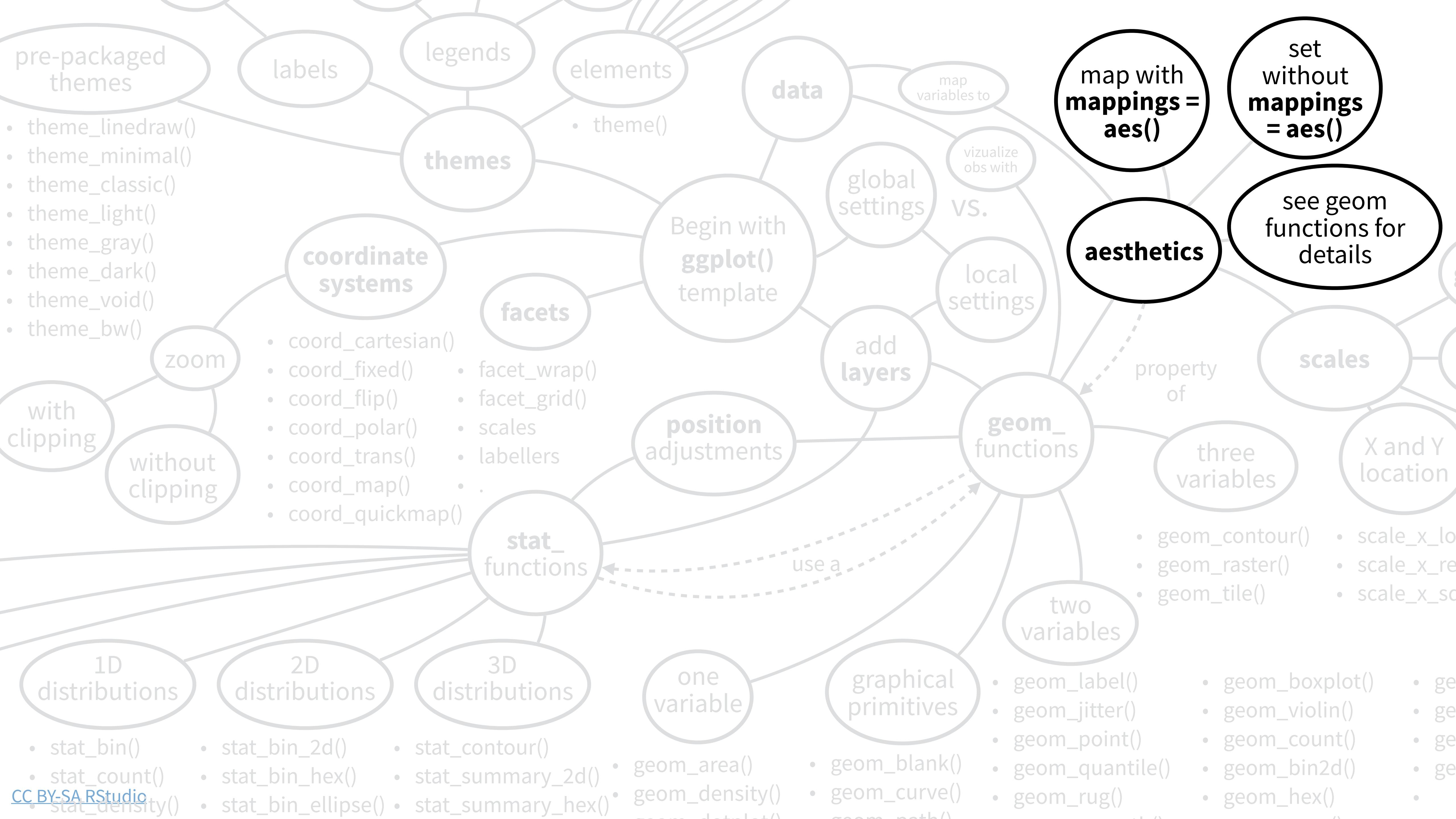
2D distributions

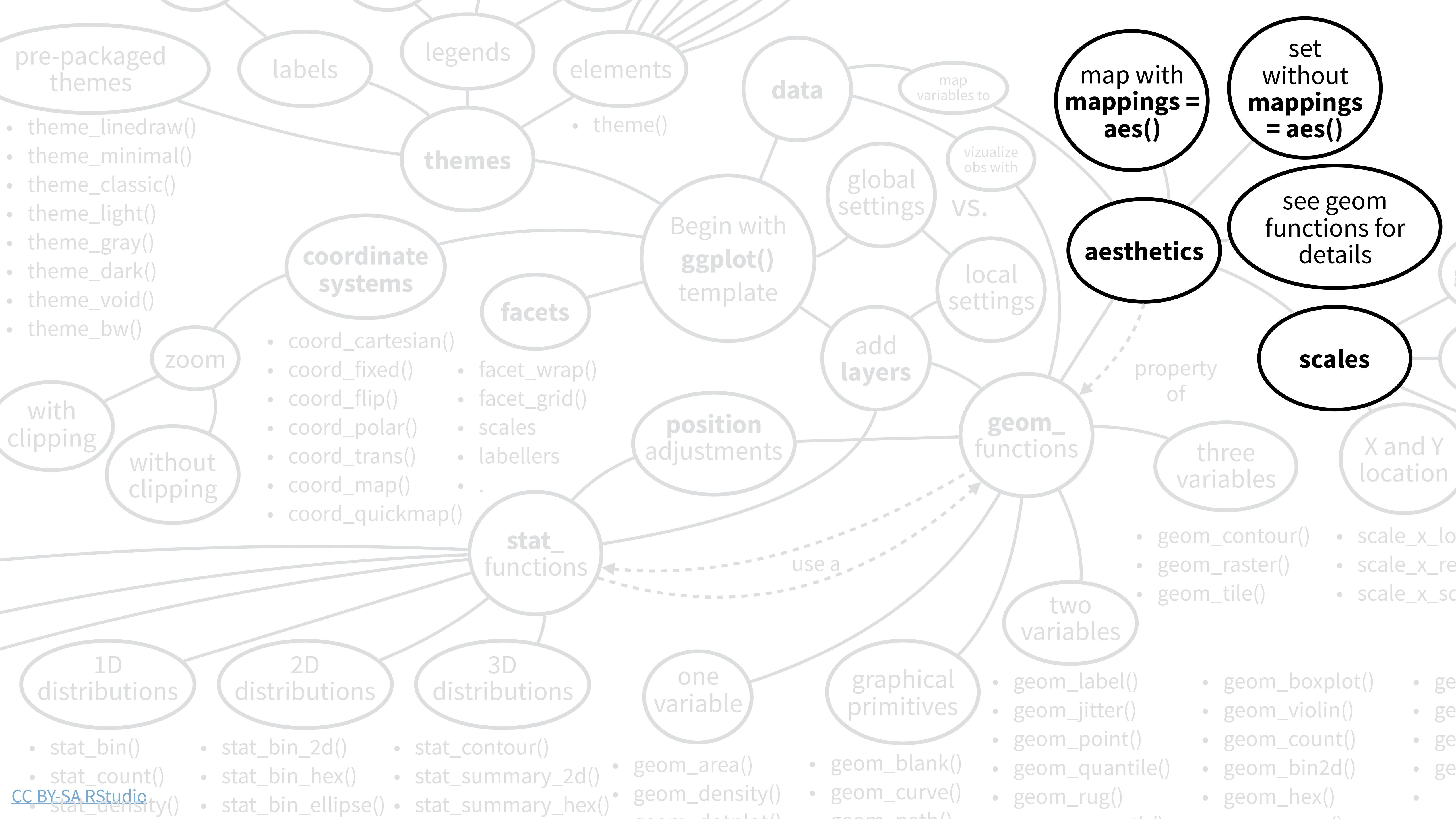
3D distributions

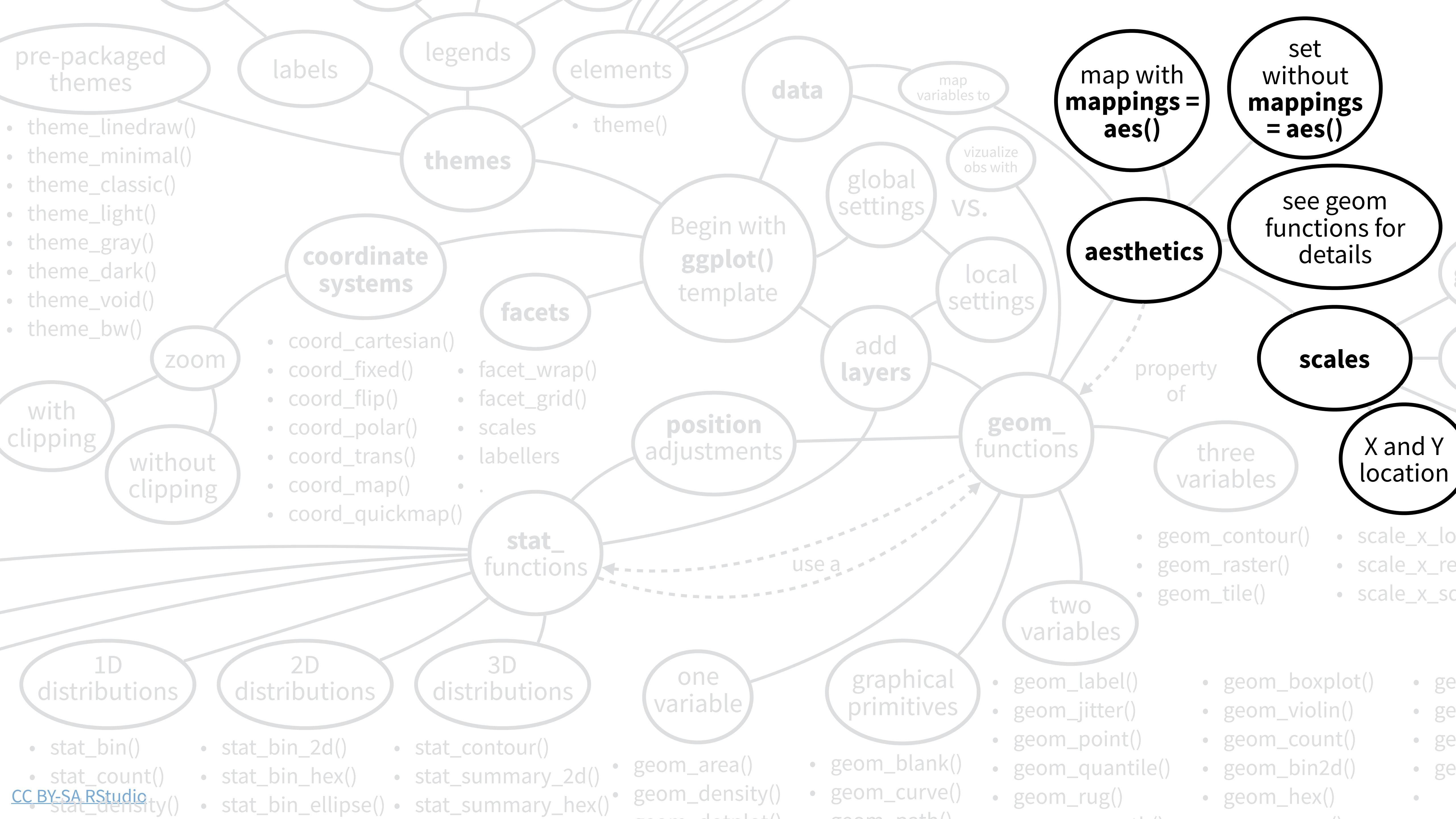
- stat\_bin()
- stat\_count()
- stat\_density()

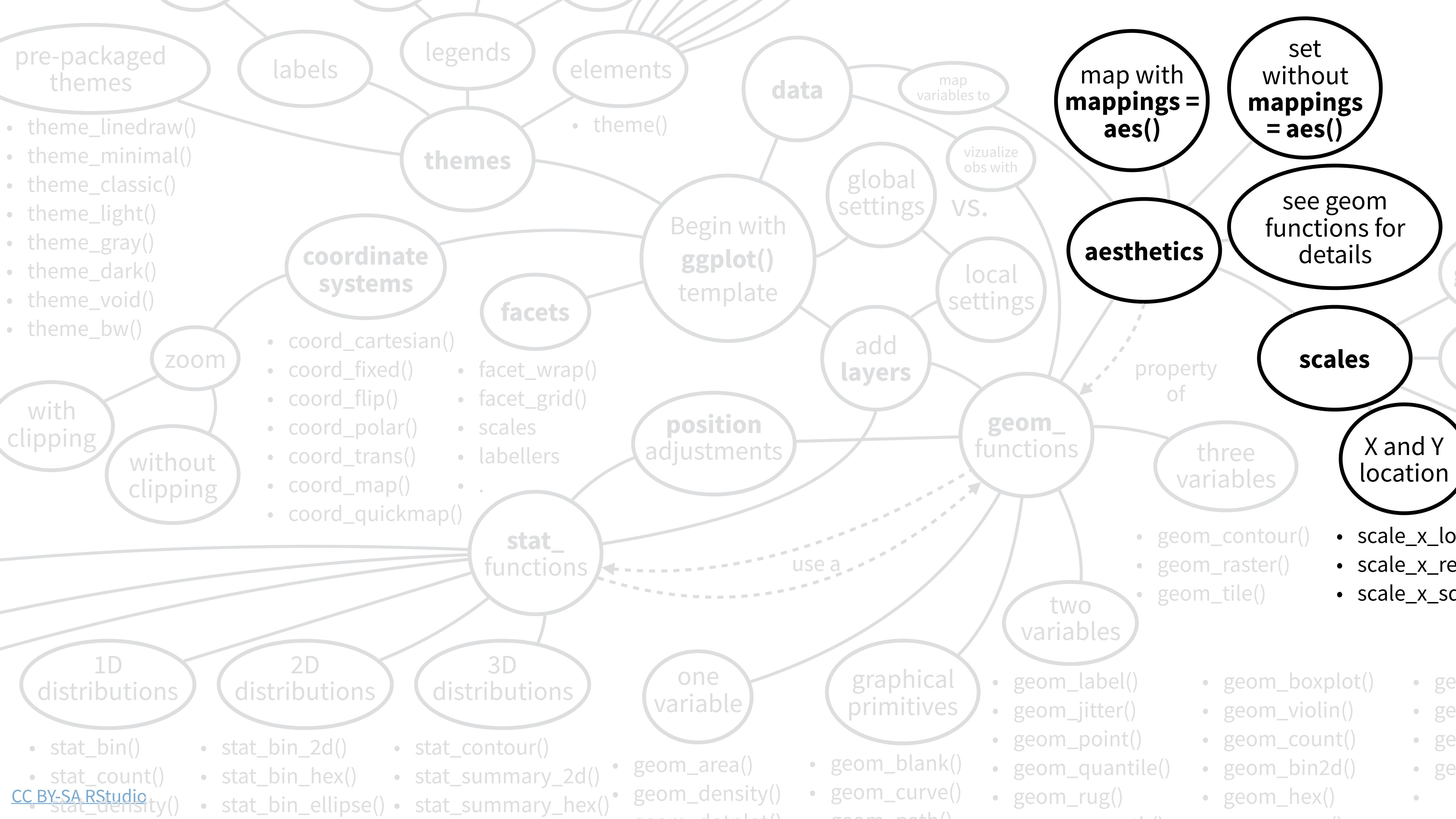
- stat\_bin\_2d()
- stat\_bin\_hex()
- stat\_bin\_ellipse()

- stat\_contour()
- stat\_summary\_2d()
- stat\_summary\_hex()

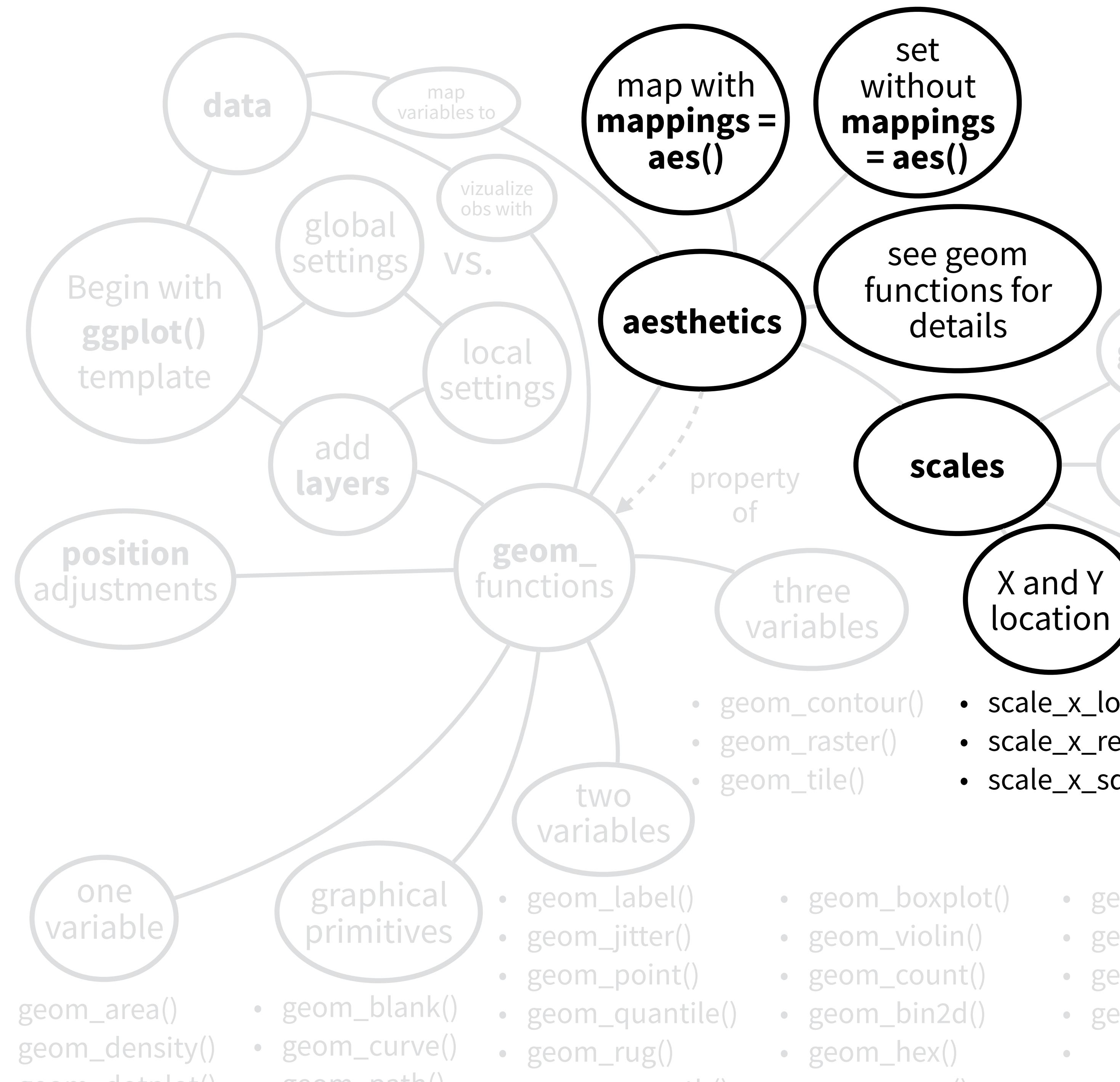








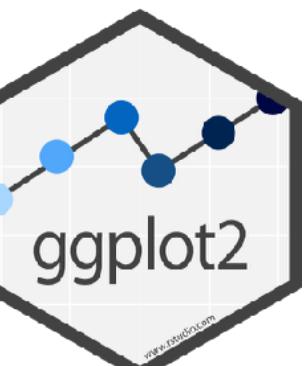
- set without **mappings** = `aes()`
- map with **mappings** = `aes()`
- **aesthetics**
- see geom functions for details
- **scales**
- X and Y location
- `scale_x_log10()`
- `scale_x_reverse()`
- `scale_x_sqrt()`



- set without **mappings** = `aes()`
- map with **mappings** = `aes()`
- **aesthetics**
- see geom functions for details
- **scales**
- X and Y location
- `scale_x_log10()`
- `scale_x_reverse()`
- `scale_x_sqrt()`

# A template

```
ggplot(data = <DATA>) +  
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```



# Your Turn

Choose a partner, work together to spot an initial "mental model" for your topic. (It might be the same for both topics).

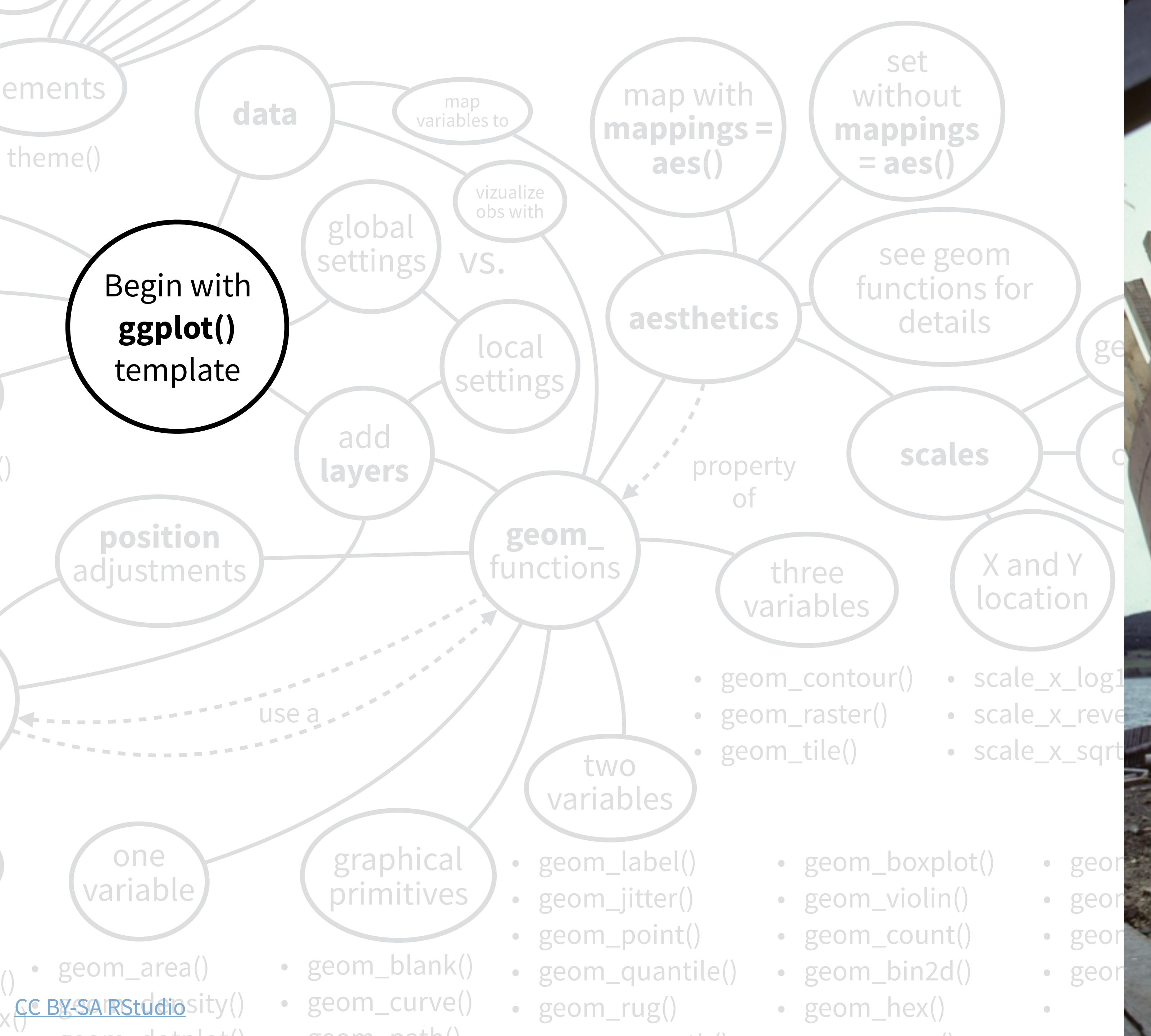
- An Analogy or Metaphor
- A Story
- A Diagram
- A Template, etc.

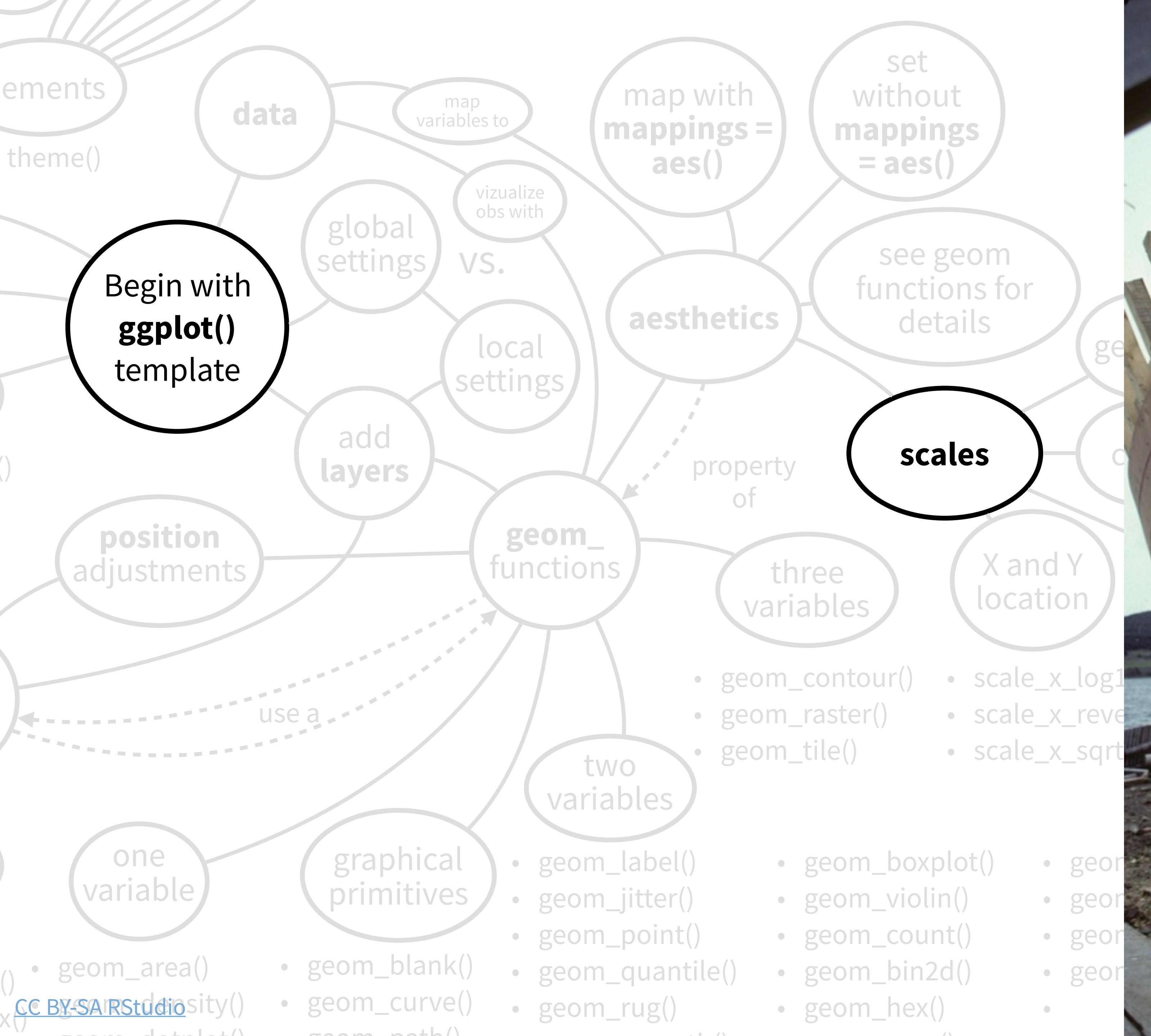


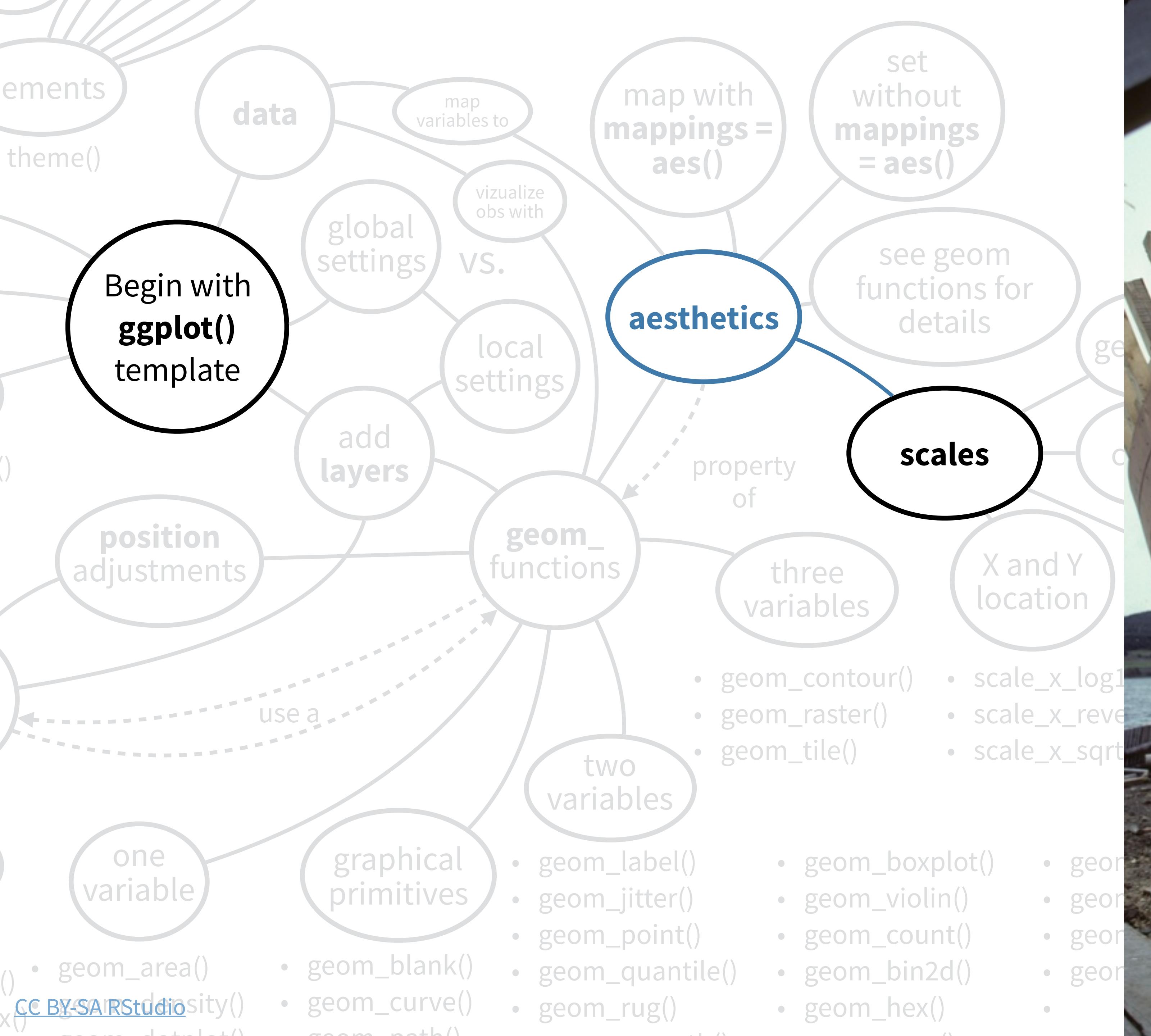
- 1. Lay the keel**
- 2. Build topics in order**

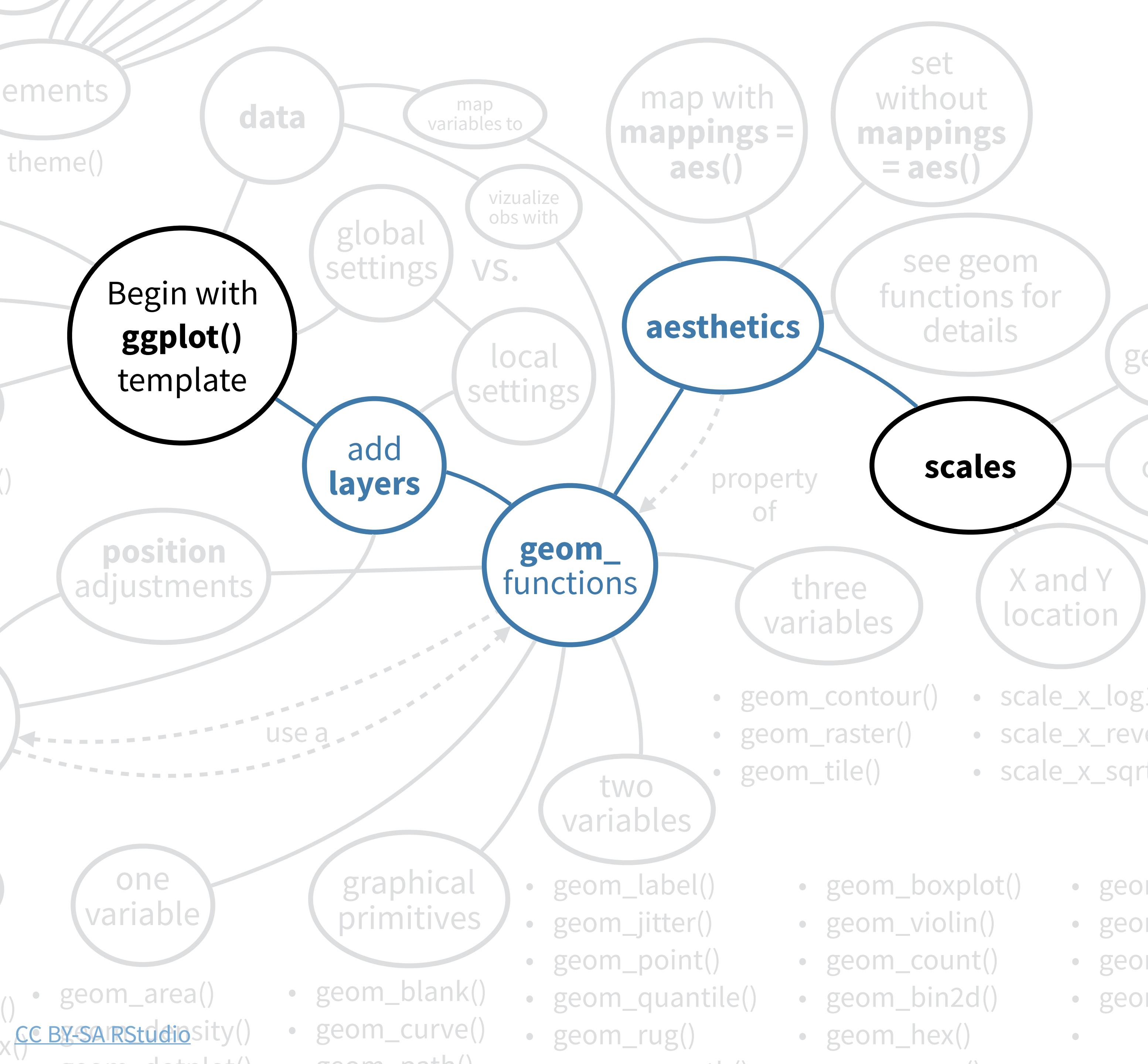
Build topics  
in order

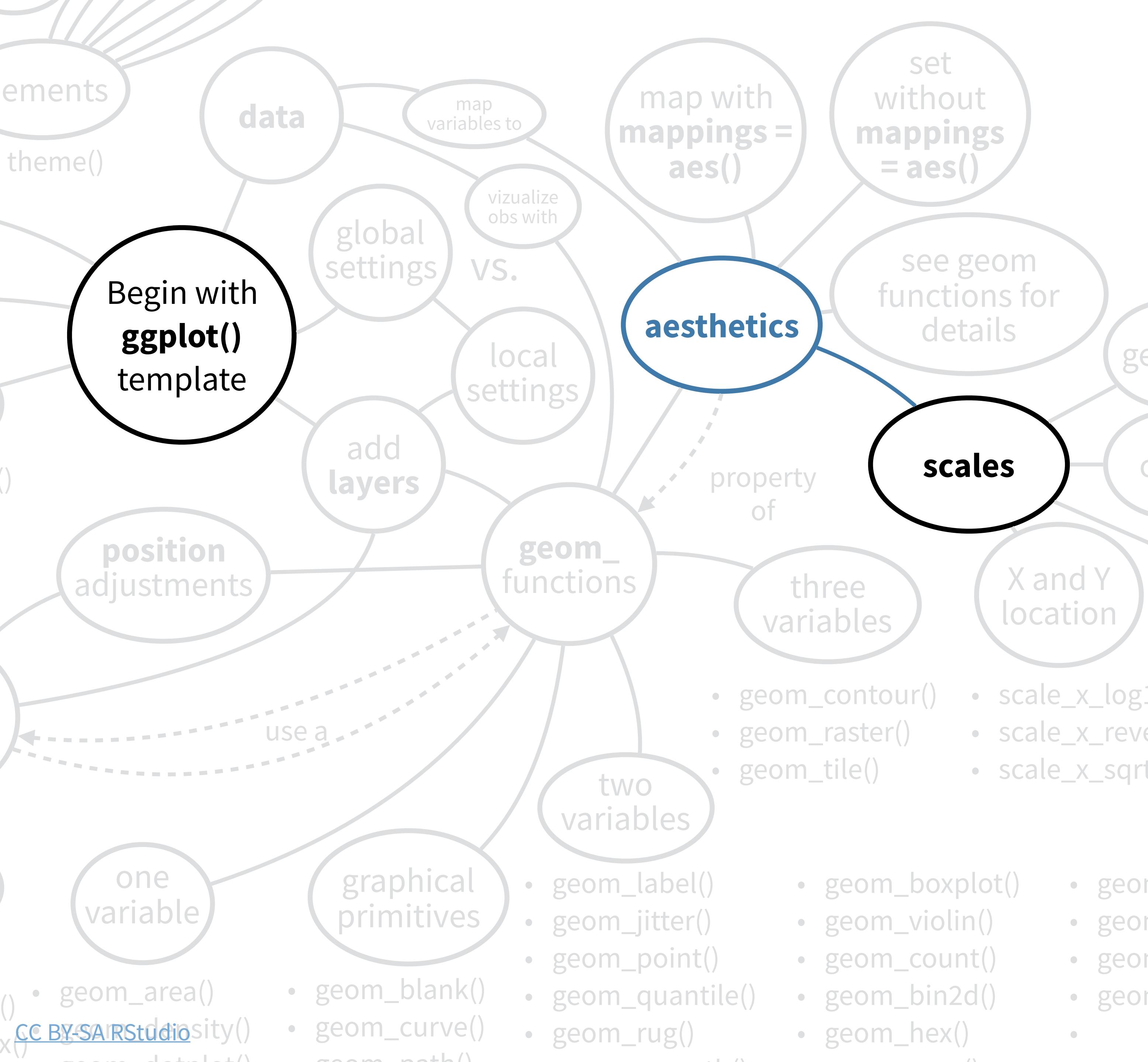
R

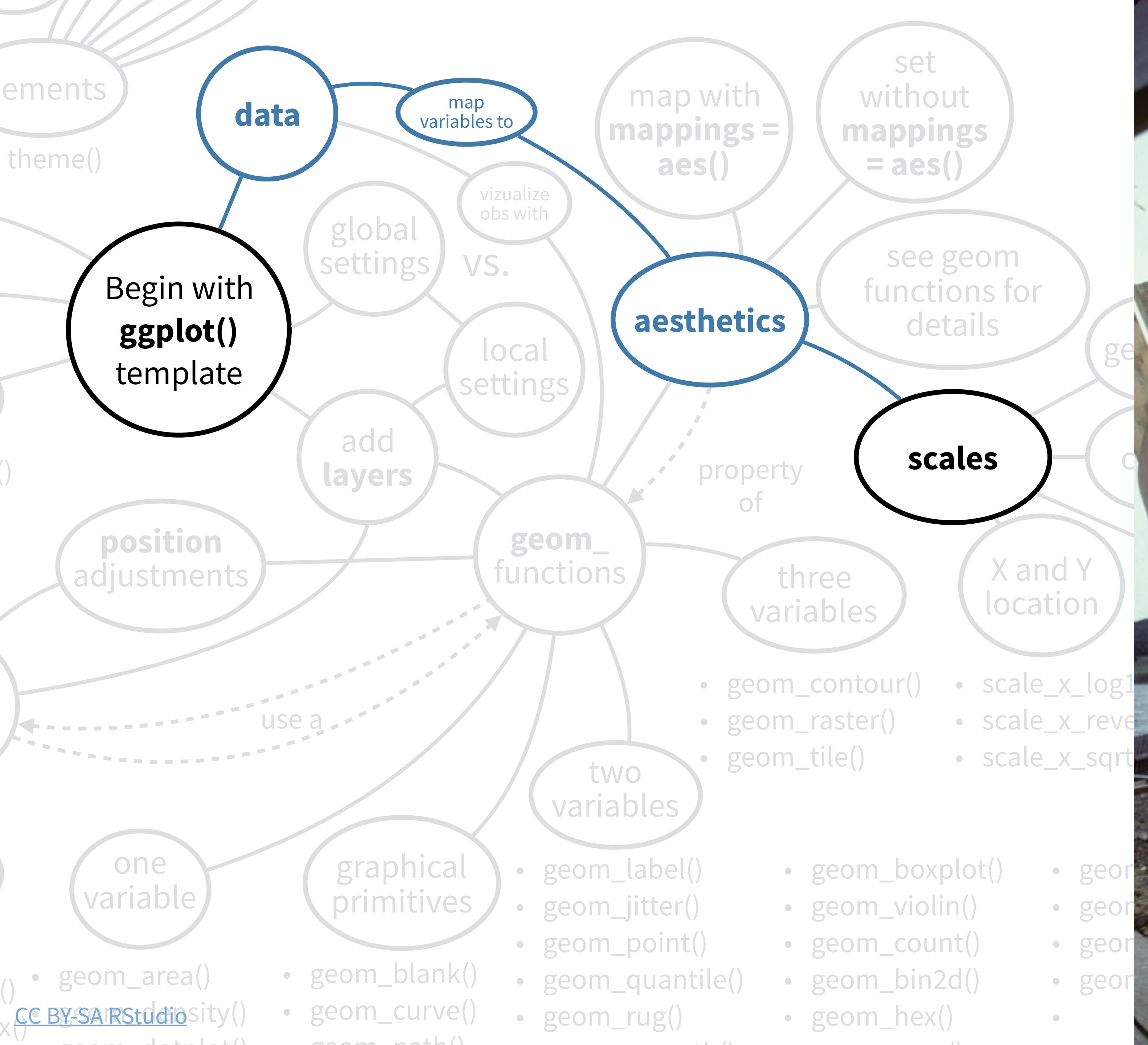


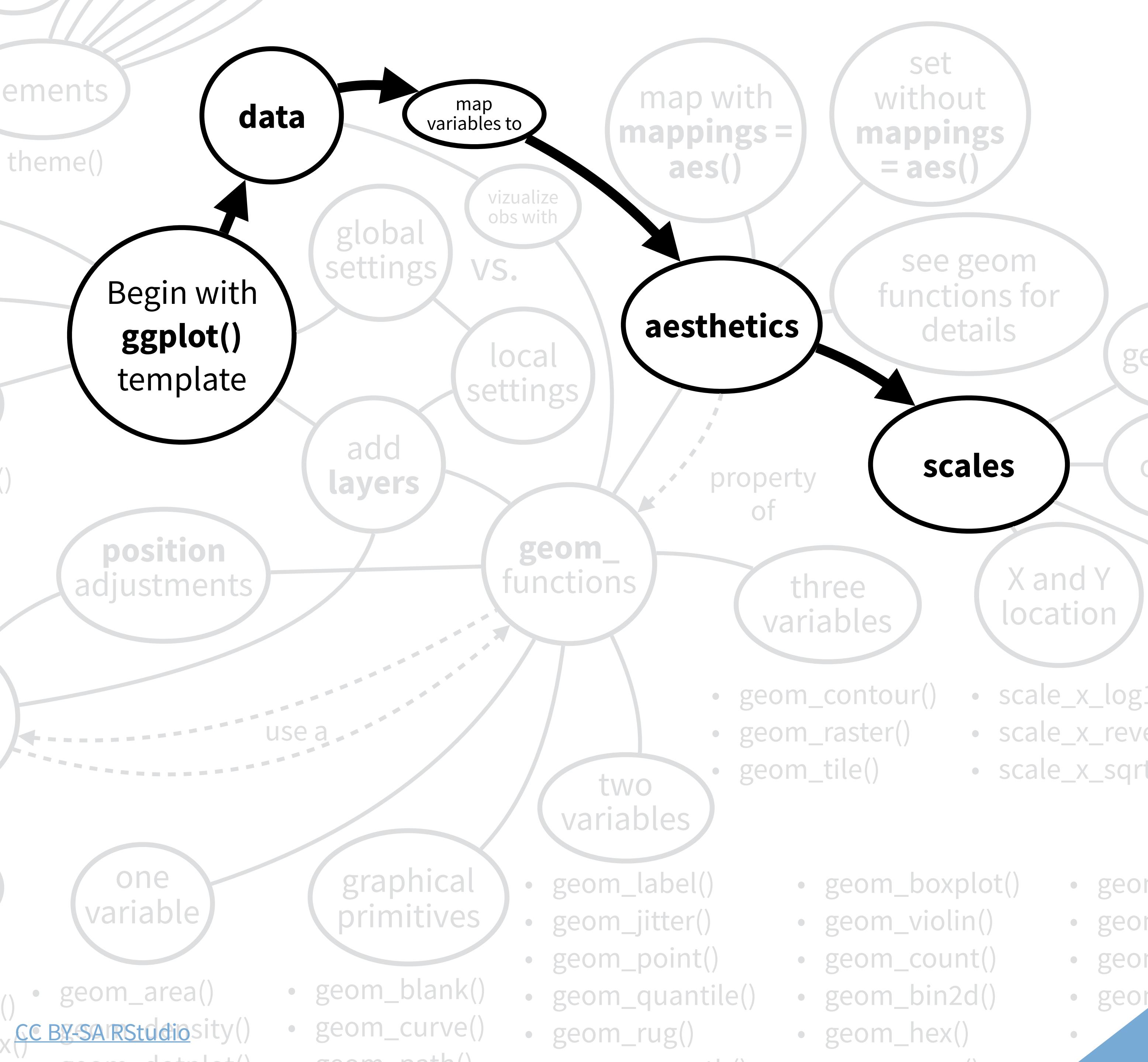












- 1. Lay the keel**
- 2. Build topics in order**
- 3. Connect to familiar things**

Connect to  
familiar things  
(or motivating ones)



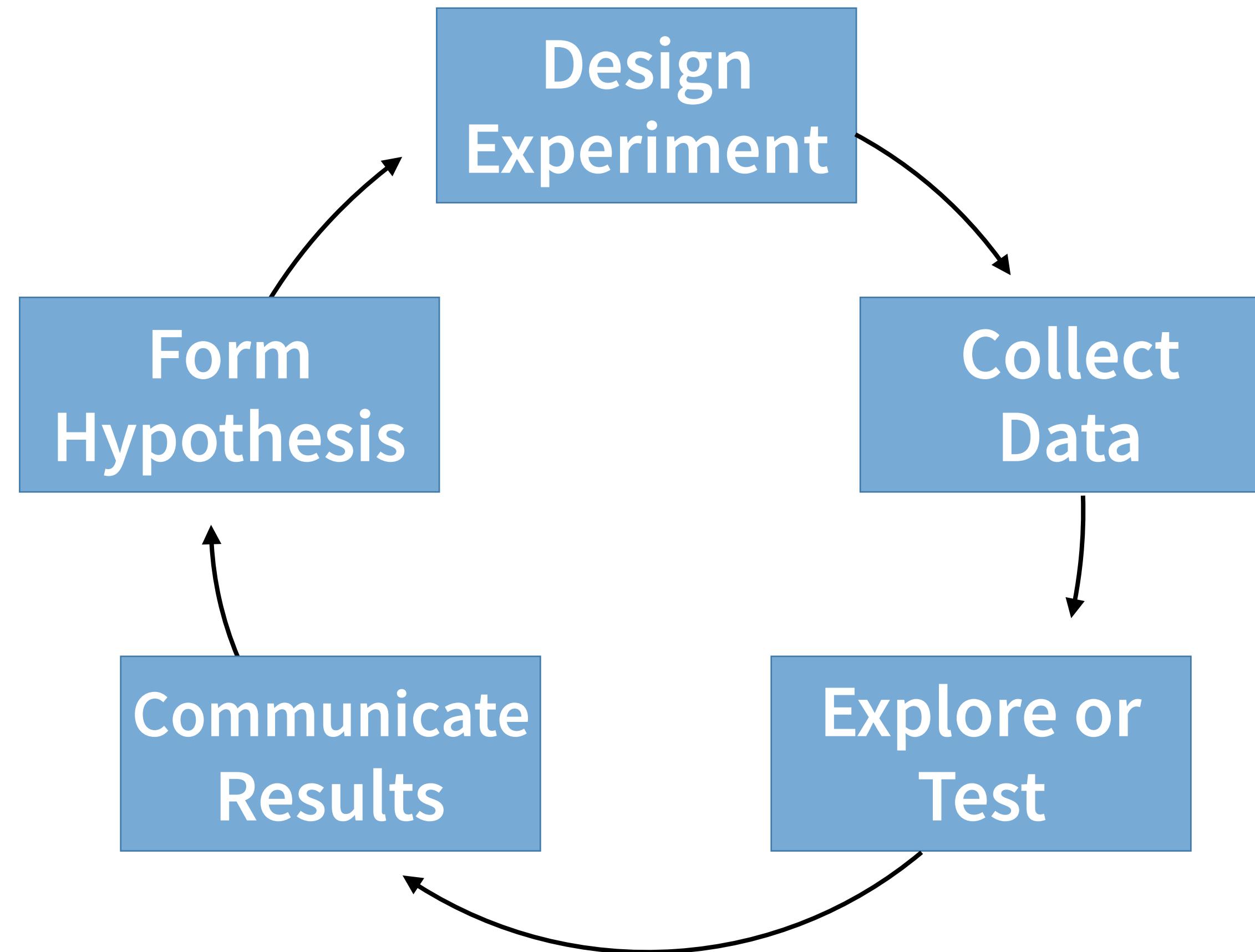
# Think

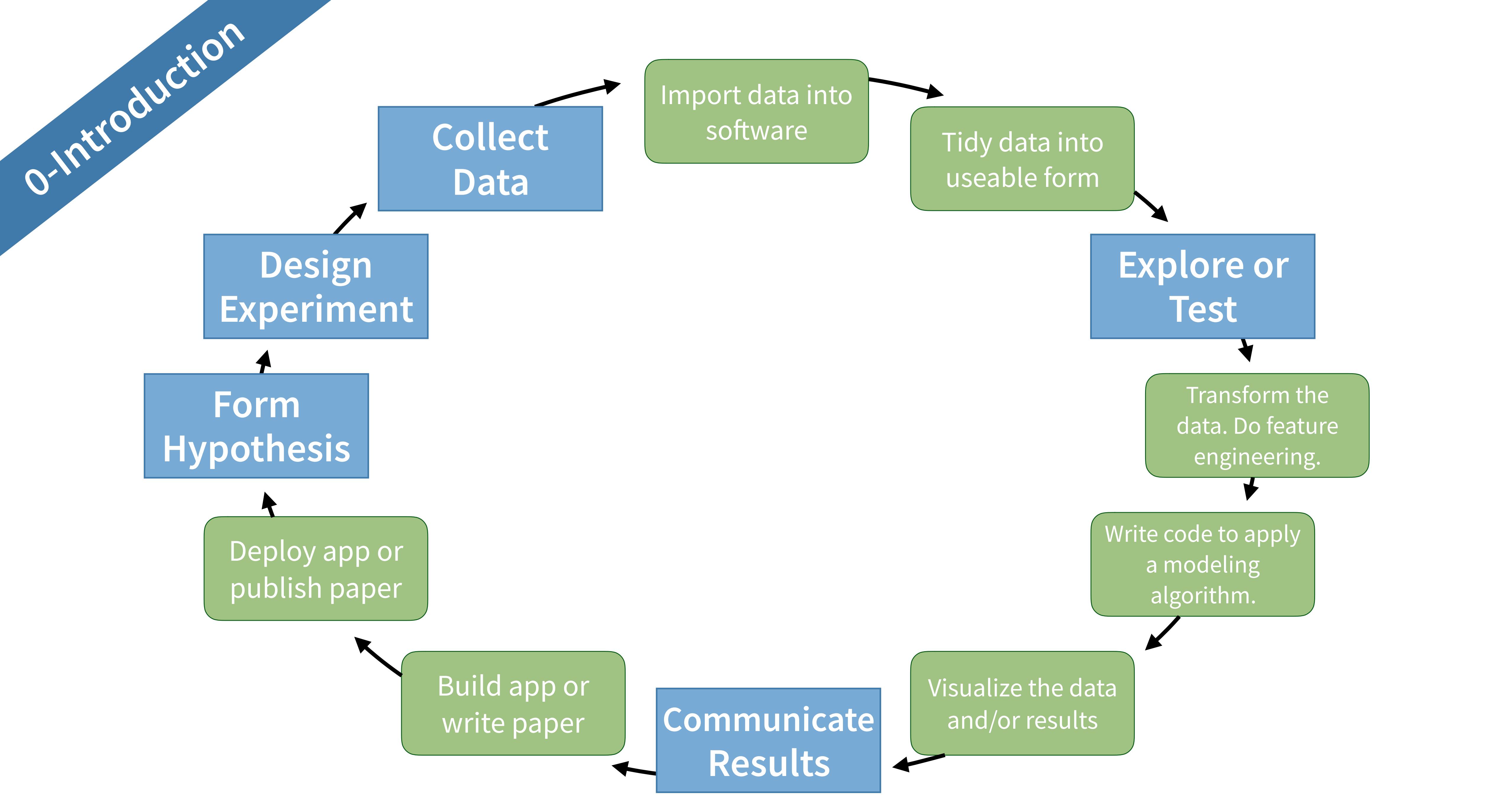
Imagine that you will explain the **map()** function to three different students:

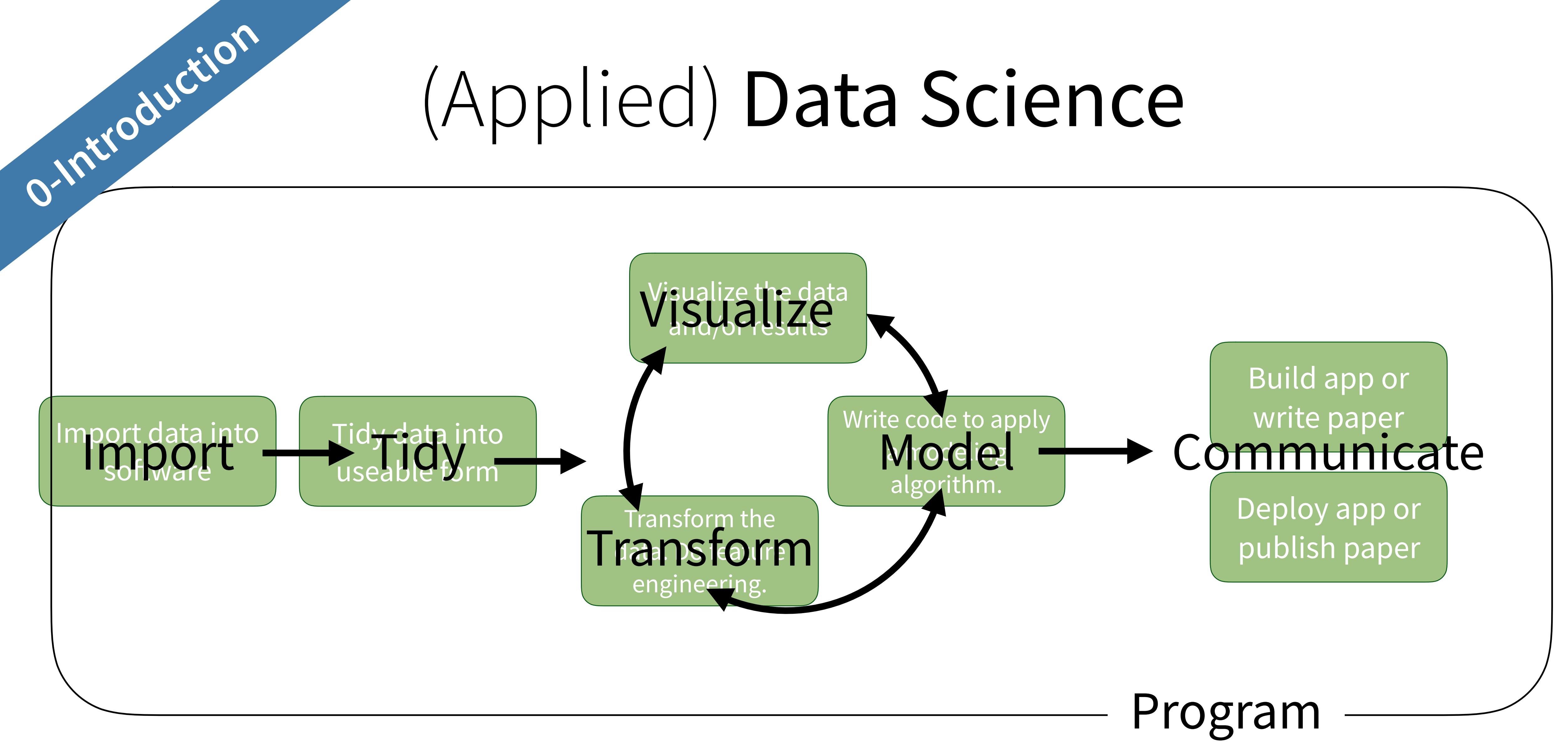
1. One who uses the **lapply()** family of functions
2. One who uses **for()** loops
3. One who has **never written** a **for()** loop

What questions will each ask?

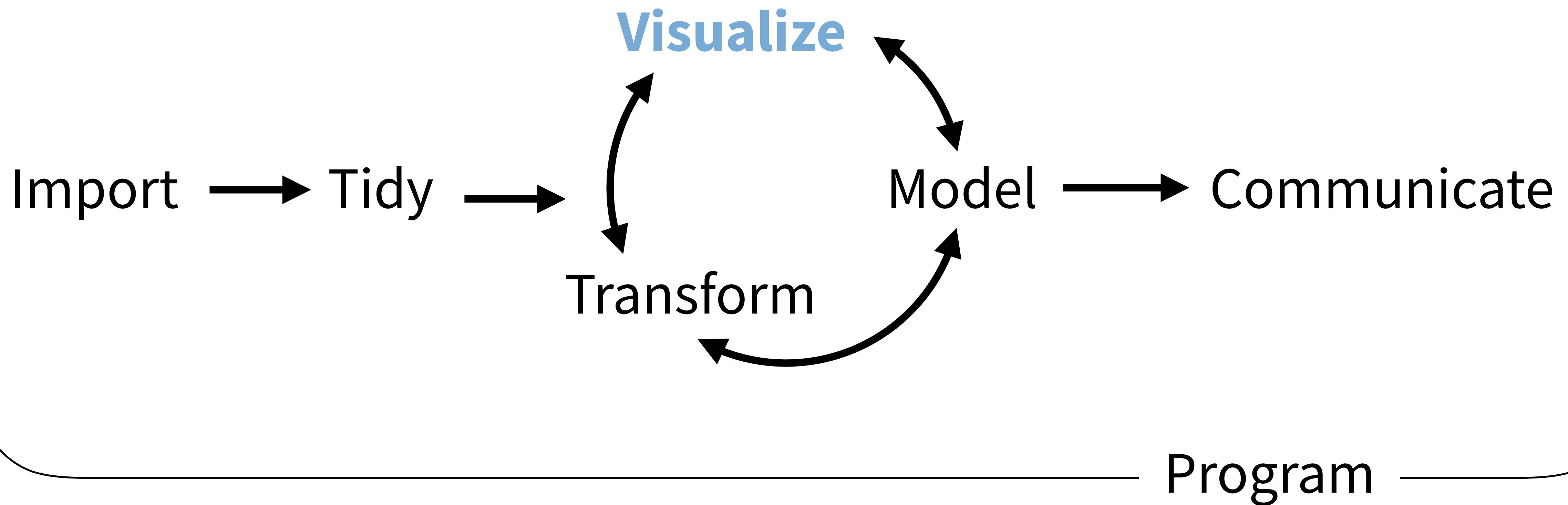
# "Data Science"







# (Applied) Data Science

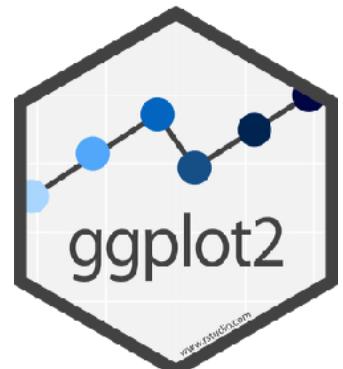
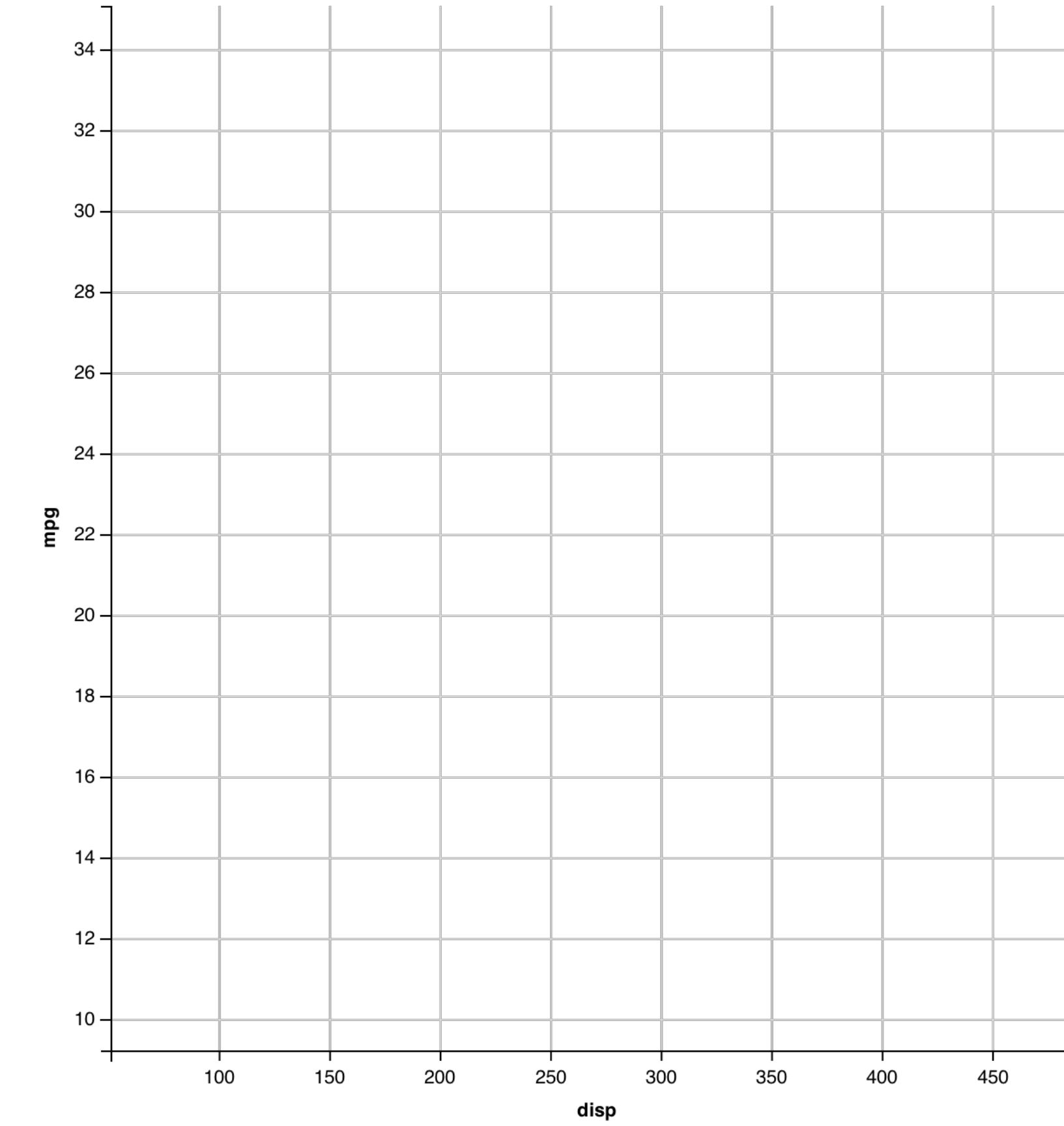


# 1-Visualize-Data

mpg	cyl	disp	hp	
21.0	6	160.0	2	●
21.0	6	160.0	2	●
22.8	4	108.0	1	●
21.4	6	258.0	2	●
18.7	8	360.0	3	●
18.1	6	225.0	2	●
14.3	8	360.0	5	●
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	●
17.8	6	167.6	2	●
16.4	8	275.8	3	●
17.3	8	275.8	3	●
15.2	8	275.8	3	●
10.4	8	472.0	4	●
10.4	8	460.0	4	●
14.7	8	440.0	4	●
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●

data

geom



# 1-Visualize-Data

## mappings

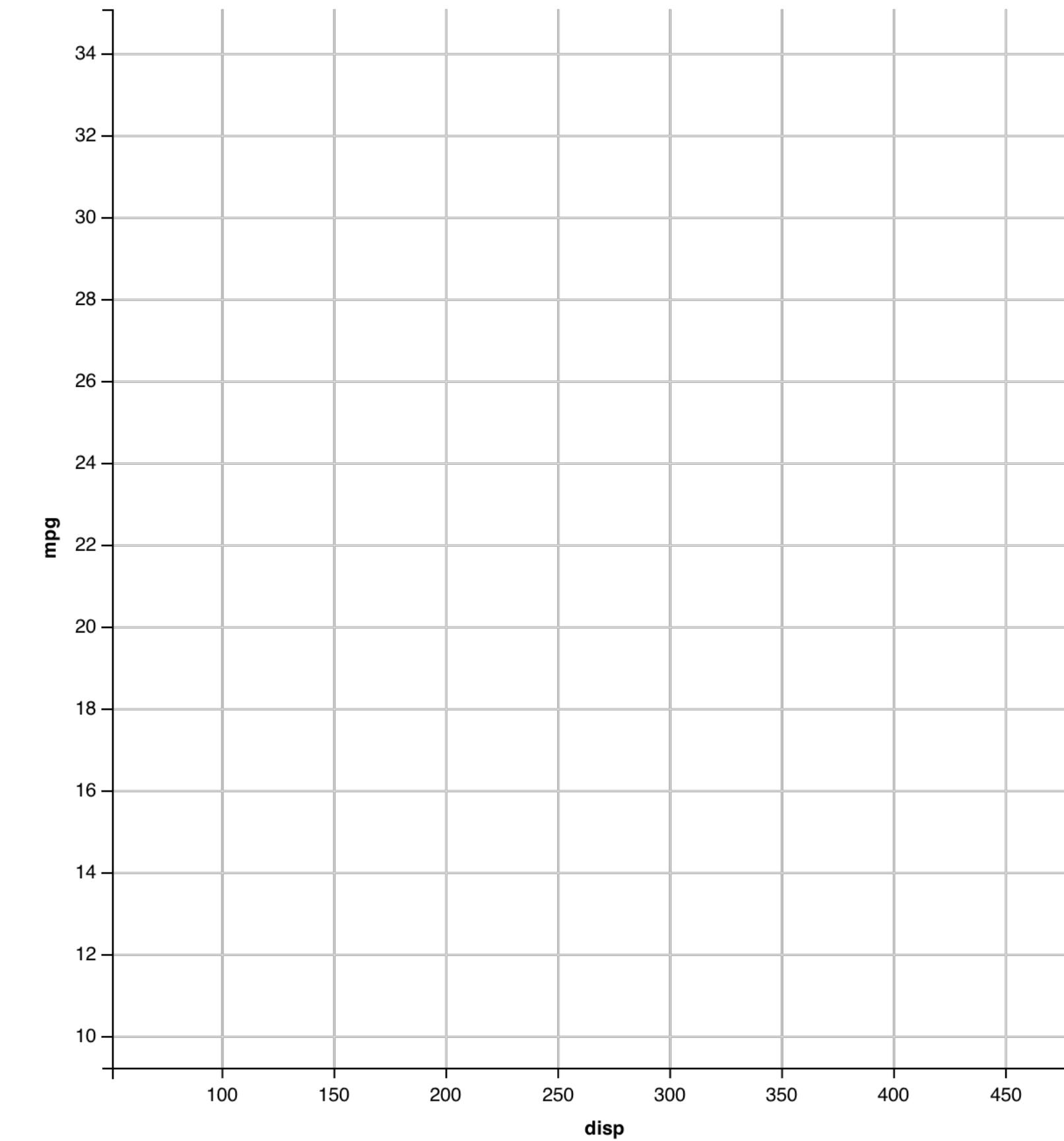
mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

fill



data

geom



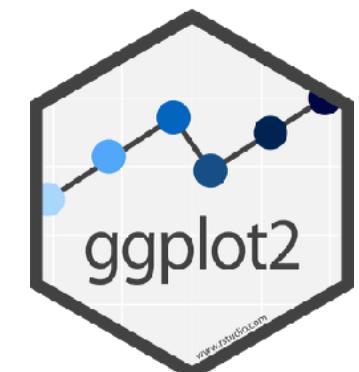
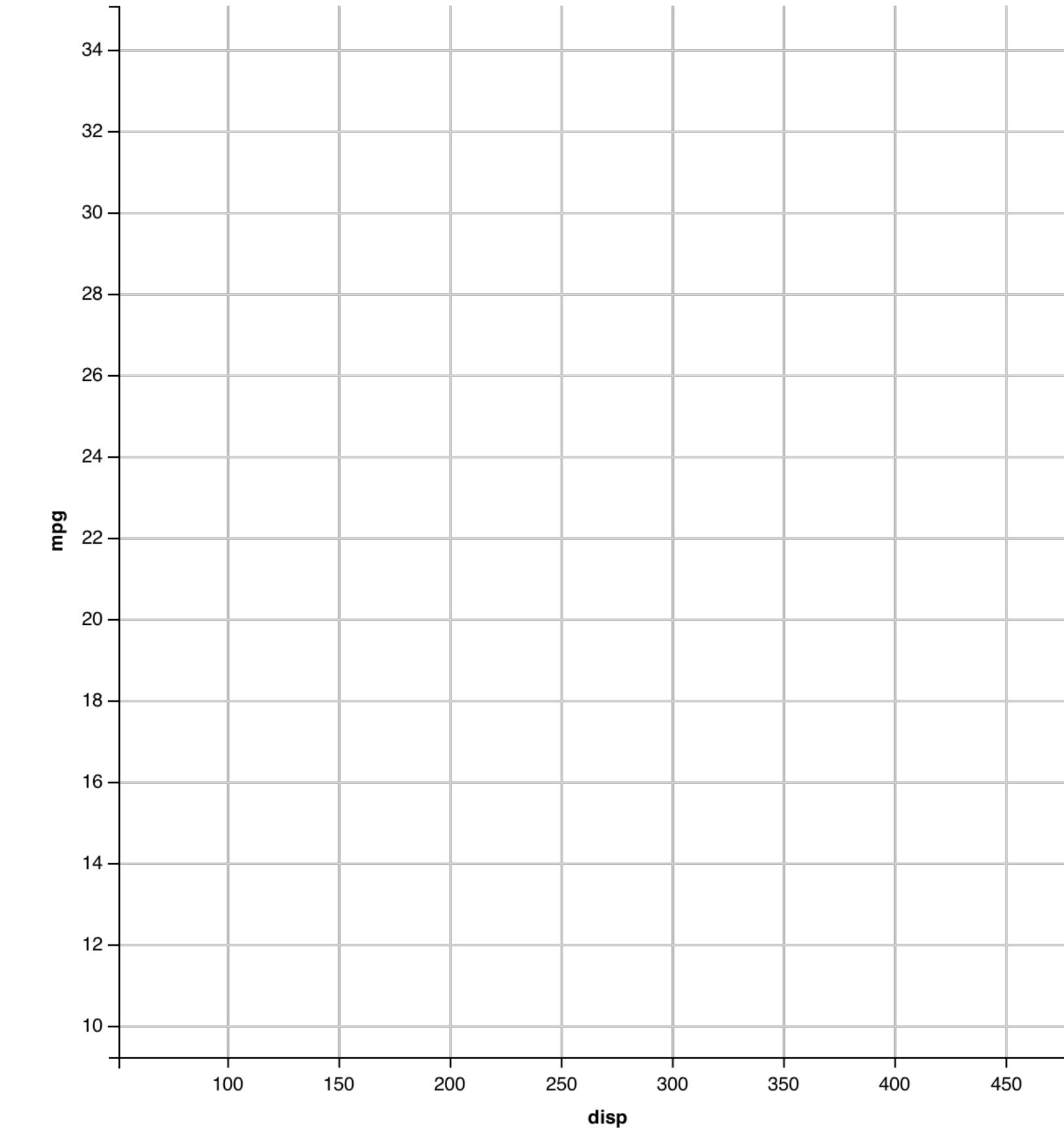
# 1-Visualize-Data

## mappings

	shape		fill
mpg	cyl	disp	hp
21.0	6 +	160.0	2
21.0	6 +	160.0	2
22.8	4 ●	108.0	1
21.4	6 +	258.0	2
18.7	8 ♦	360.0	3
18.1	6 +	225.0	2
14.3	8 ♦	360.0	5
24.4	4 ●	146.7	1
22.8	4 ●	140.8	1
19.2	6 +	167.6	2
17.8	6 +	167.6	2
16.4	8 ♦	275.8	3
17.3	8 ♦	275.8	3
15.2	8 ♦	275.8	3
10.4	8 ♦	472.0	4
10.4	8 ♦	460.0	4
14.7	8 ♦	440.0	4
32.4	4 ●	78.7	1
30.4	4 ●	75.7	1
33.9	4 ●	71.1	1

data

geom



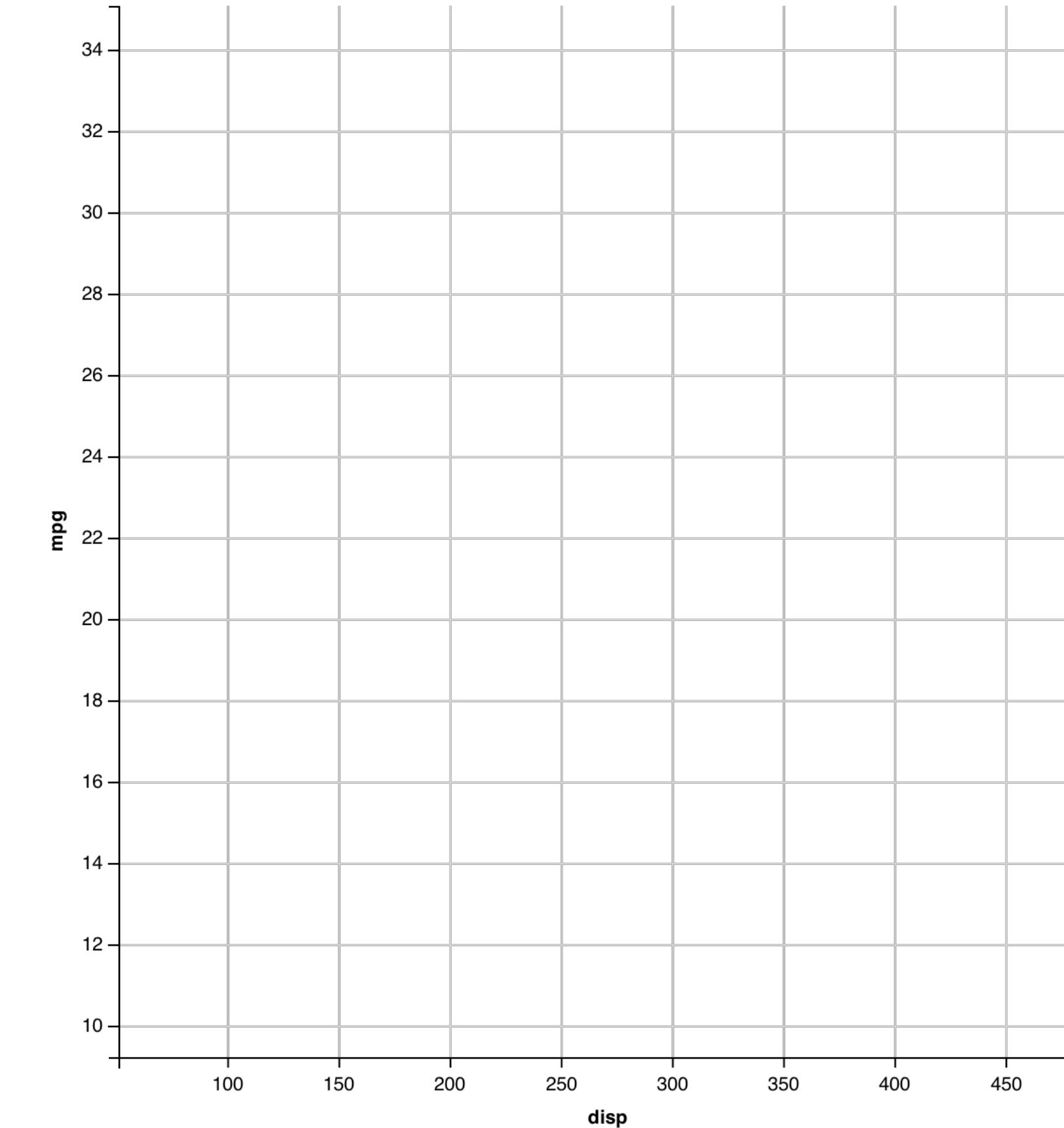
# 1-Visualize-Data

## mappings

	shape	x	fill
mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

data

geom



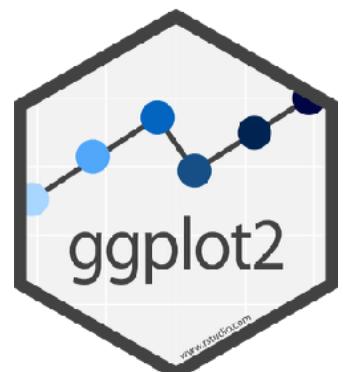
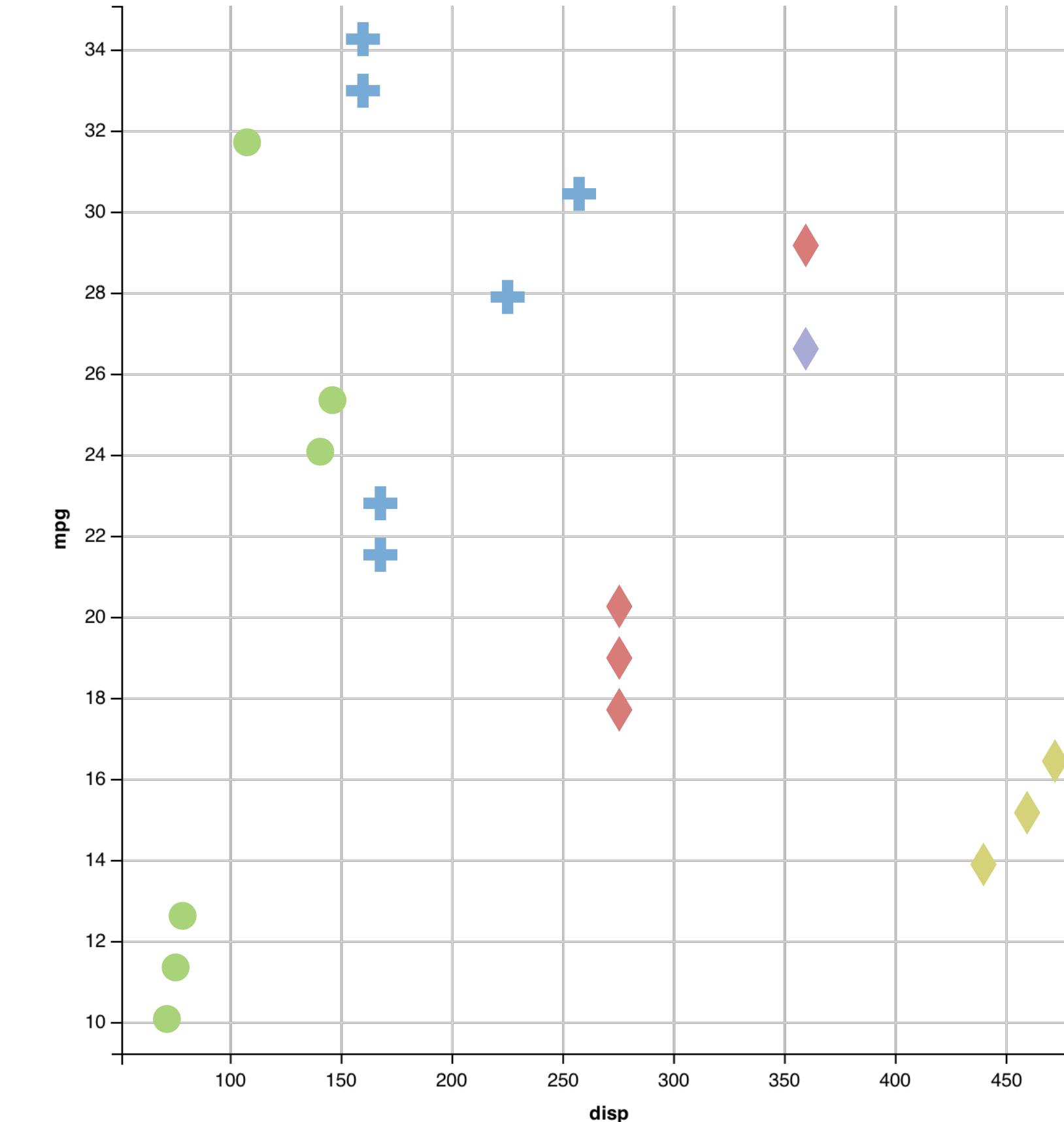
# 1-Visualize-Data

## mappings

	y	shape	x	fill
	mpg	cyl	disp	hp
21.0	6	160.0	2	
21.0	6	160.0	2	
22.8	4	108.0	1	
21.4	6	258.0	2	
18.7	8	360.0	3	
18.1	6	225.0	2	
14.3	8	360.0	5	
24.4	4	146.7	1	
22.8	4	140.8	1	
19.2	6	167.6	2	
17.8	6	167.6	2	
16.4	8	275.8	3	
17.3	8	275.8	3	
15.2	8	275.8	3	
10.4	8	472.0	4	
10.4	8	460.0	4	
14.7	8	440.0	4	
32.4	4	78.7	1	
30.4	4	75.7	1	
33.9	4	71.1	1	

data

geom



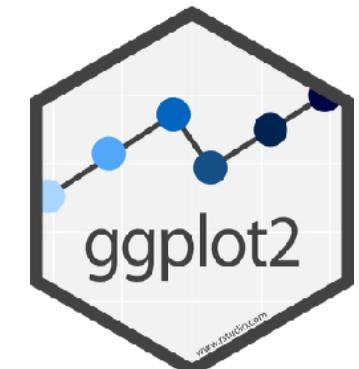
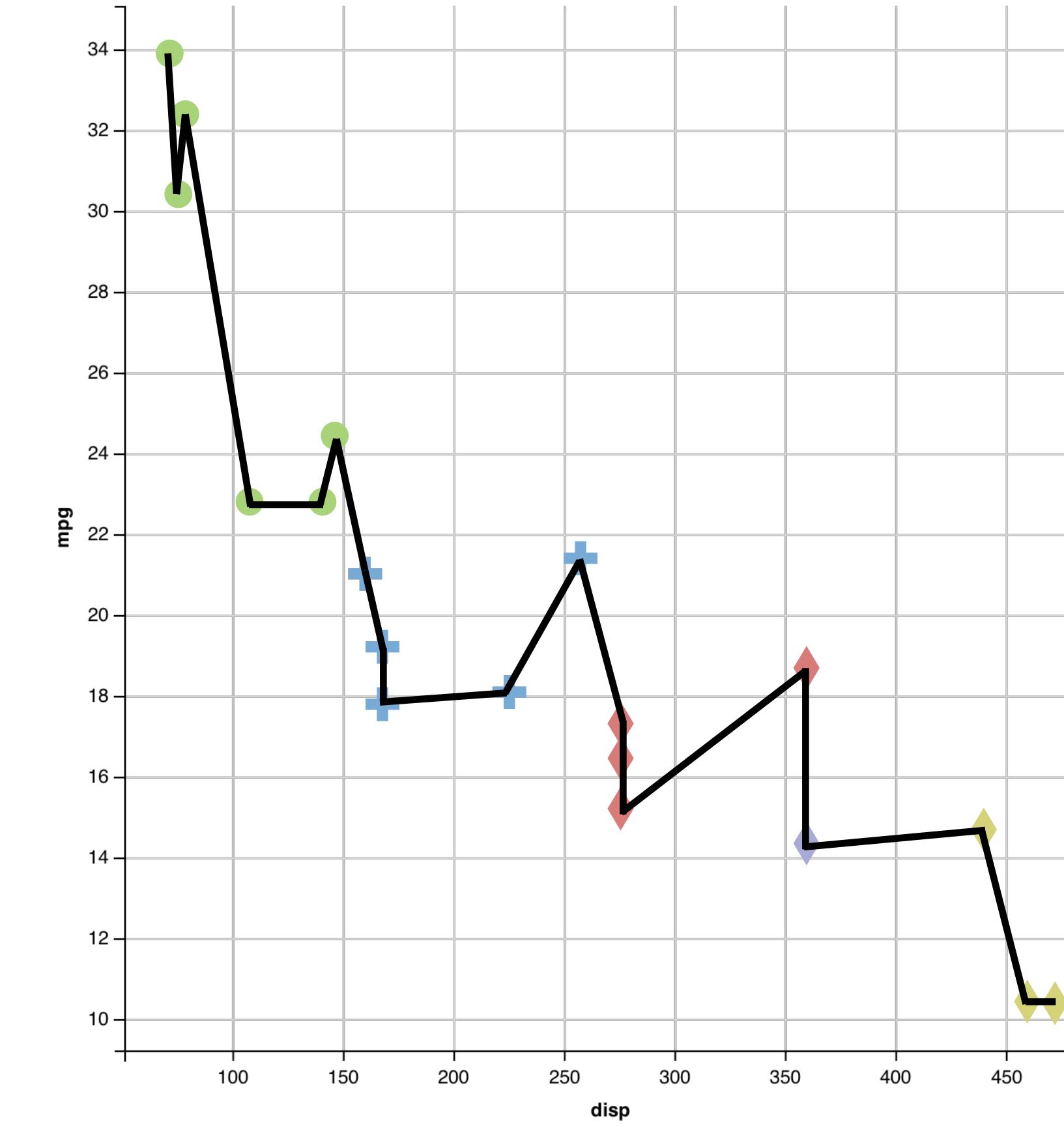
# 1-Visualize-Data

## mappings

	y	shape	x	fill
	mpg	cyl	disp	hp
21.0	6	160.0	2	
21.0	6	160.0	2	
22.8	4	108.0	1	
21.4	6	258.0	2	
18.7	8	360.0	3	
18.1	6	225.0	2	
14.3	8	360.0	5	
24.4	4	146.7	1	
22.8	4	140.8	1	
19.2	6	167.6	2	
17.8	6	167.6	2	
16.4	8	275.8	3	
17.3	8	275.8	3	
15.2	8	275.8	3	
10.4	8	472.0	4	
10.4	8	460.0	4	
14.7	8	440.0	4	
32.4	4	78.7	1	
30.4	4	75.7	1	
33.9	4	71.1	1	

data

geom  
points  
lines



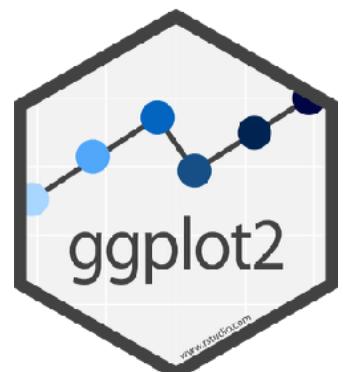
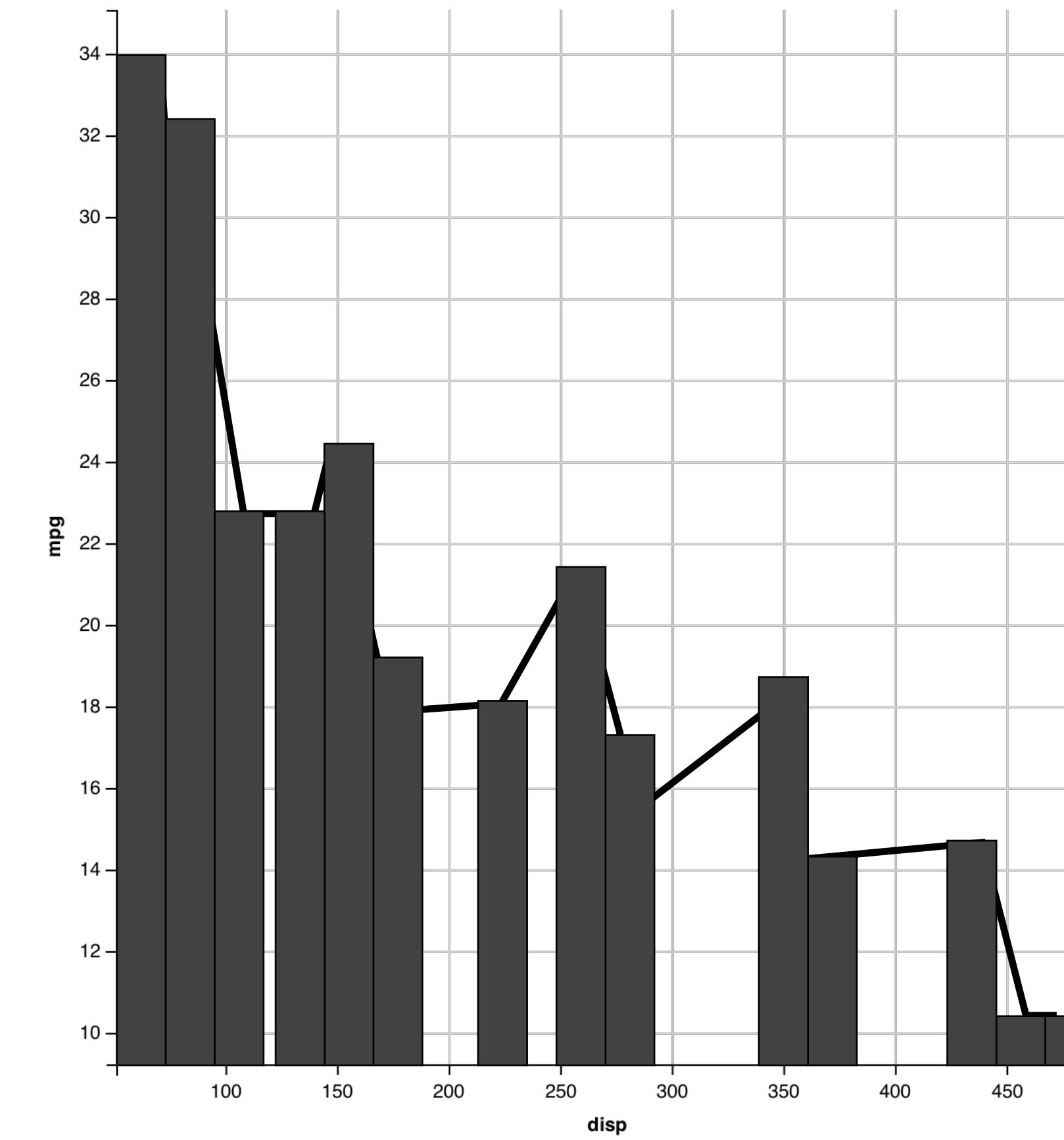
# 1-Visualize-Data

## mappings

	y	x	
mpg	↑	↓	
cyl	↑	↓	
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

data

geom  
points  
lines  
bars



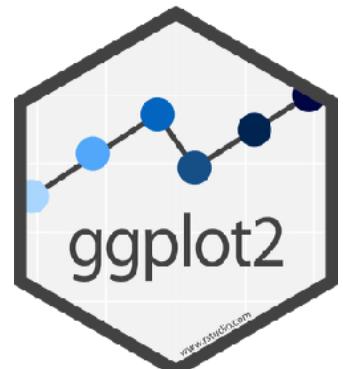
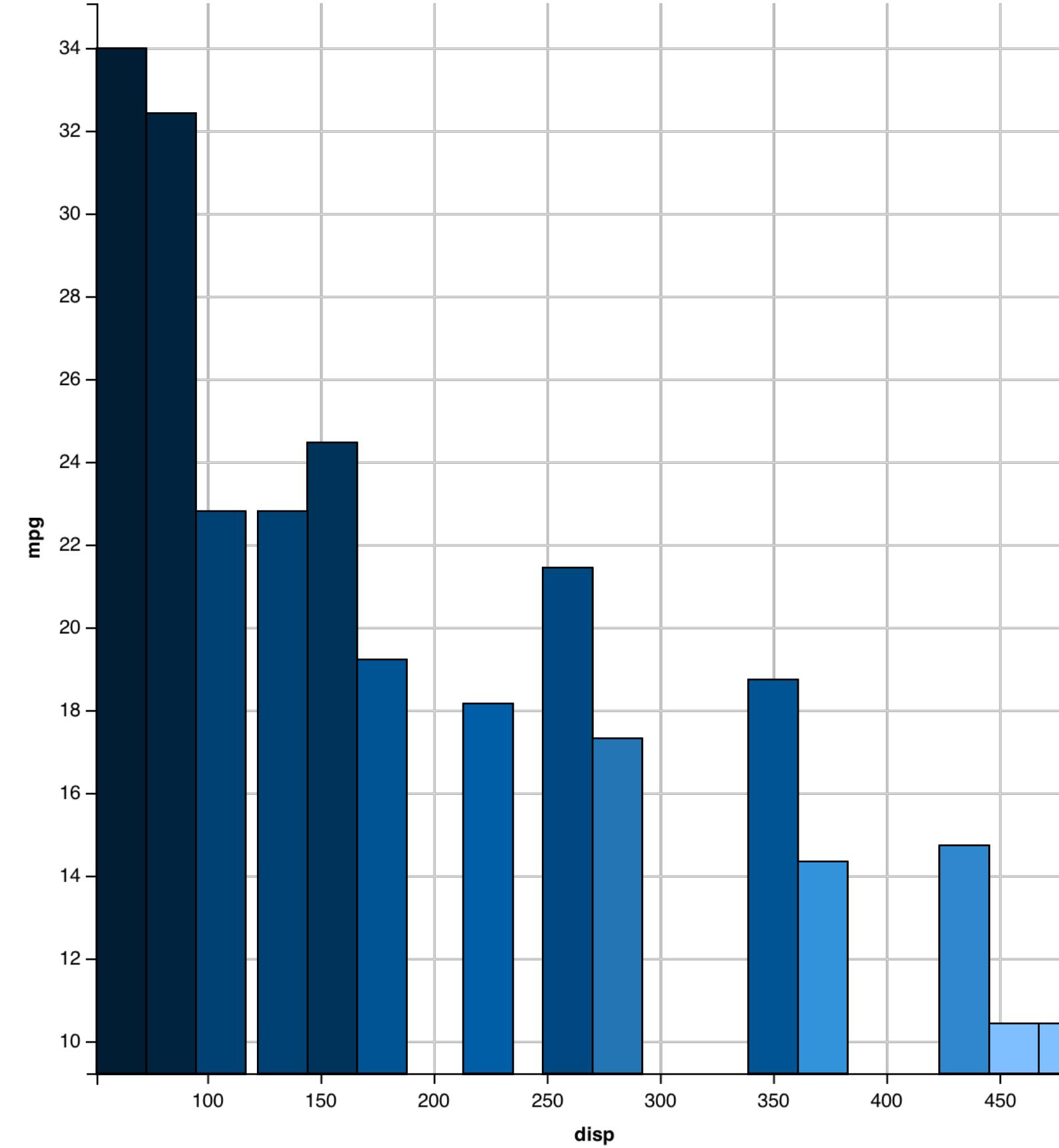
# 1-Visualize-Data

## mappings

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

geom  
points  
lines  
bars

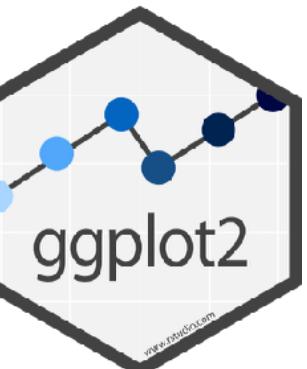
data



# To make a graph

[template]

```
ggplot(data = <DATA>) +  
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```



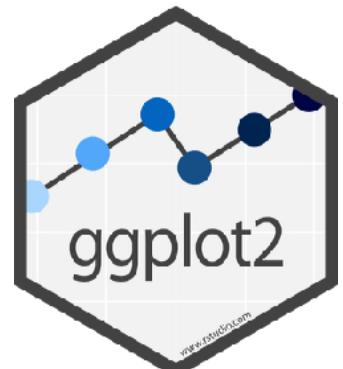
# To make a graph

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

data

## 1. Pick a **data** set

```
ggplot(data = <DATA>) +  
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```



# To make a graph

mpg	cyl	disp	hp	
21.0	6	160.0	2	●
21.0	6	160.0	2	●
22.8	4	108.0	1	●
21.4	6	258.0	2	●
18.7	8	360.0	3	●
18.1	6	225.0	2	●
14.3	8	360.0	5	●
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	●
17.8	6	167.6	2	●
16.4	8	275.8	3	●
17.3	8	275.8	3	●
15.2	8	275.8	3	●
10.4	8	472.0	4	●
10.4	8	460.0	4	●
14.7	8	440.0	4	●
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●

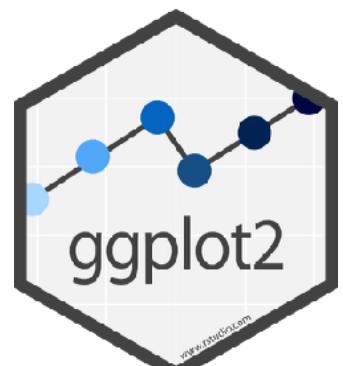
data

geom

1. Pick a **data** set

```
ggplot(data = <DATA>) +  
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

2. Choose a **geom**  
to display cases



## mappings

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

data

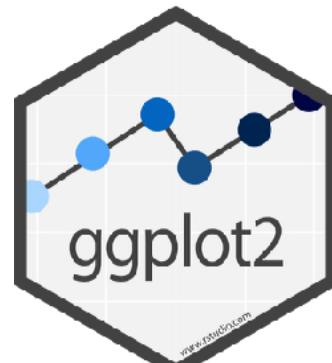
geom

fill  
↑↑

## To make a graph

1. Pick a **data** set

```
ggplot(data = <DATA>) +  
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

2. Choose a **geom**  
to display cases3. **Map** aesthetic  
properties to  
variables

# Your Turn

Add into your concept maps:

1. Your initial mental model
2. Prior knowledge to connect to

Then use the map to outline a simple explanation of your topic.



# What if it doesn't work? - ADEPT

ADEPT Method for Learning	
Analogy	Tell me what it's like.
Diagram	Help me visualize it.
Example	Allow me to experience it.
Plain English	Describe it with everyday words.
Technical Definition	Discuss the formal details.

- <https://betterexplained.com/articles/adept-method/>

# Your Turn

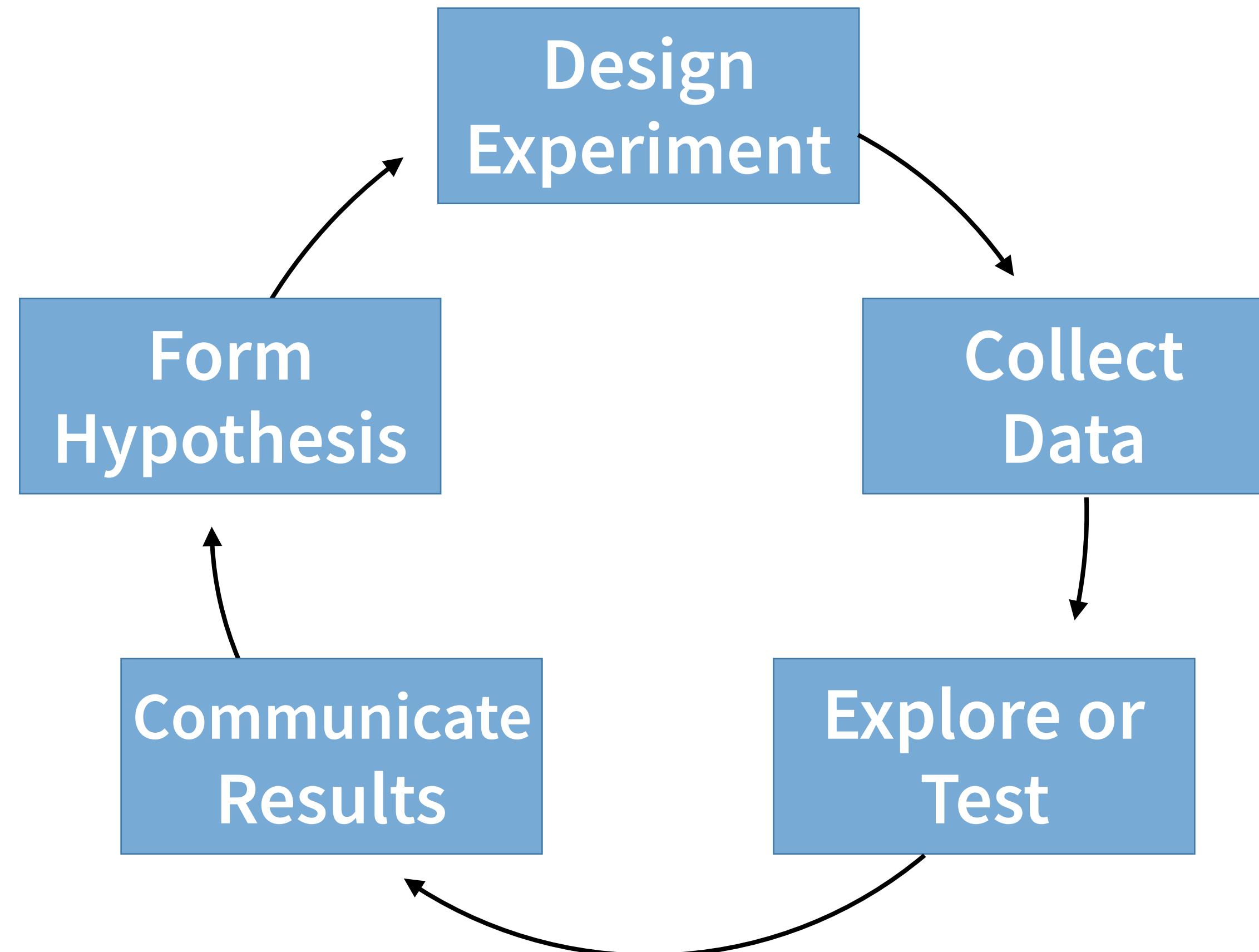
Within your group, use several methods from ADEPT to create a brief explanation of what the tidyverse is.

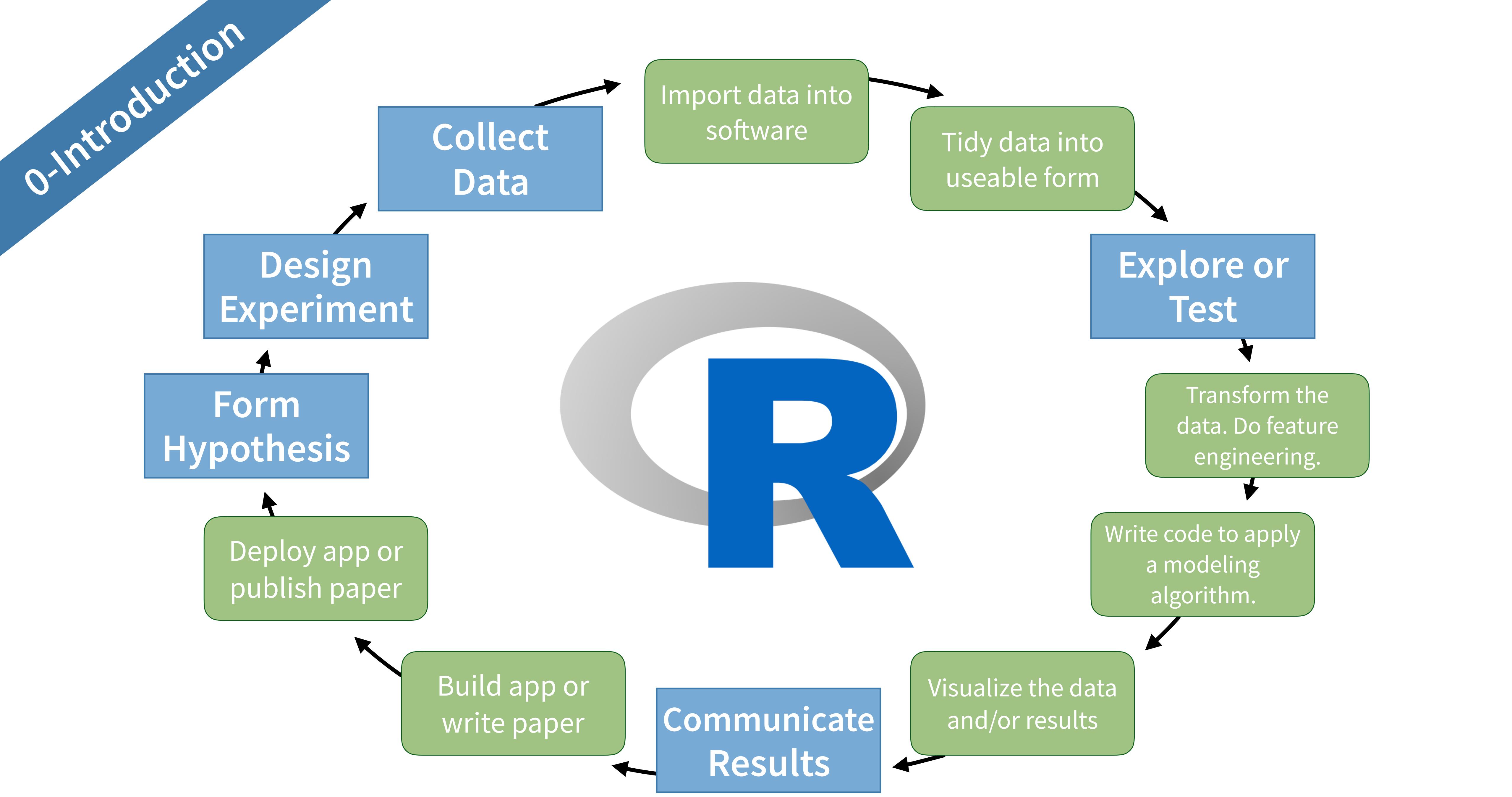
Consider adding motivation to your explanation.

ADEPT Method for Learning	
Analogy	Tell me what it's like.
Diagram	Help me visualize it.
Example	Allow me to experience it.
Plain English	Describe it with everyday words.
Technical Definition	Discuss the formal details.

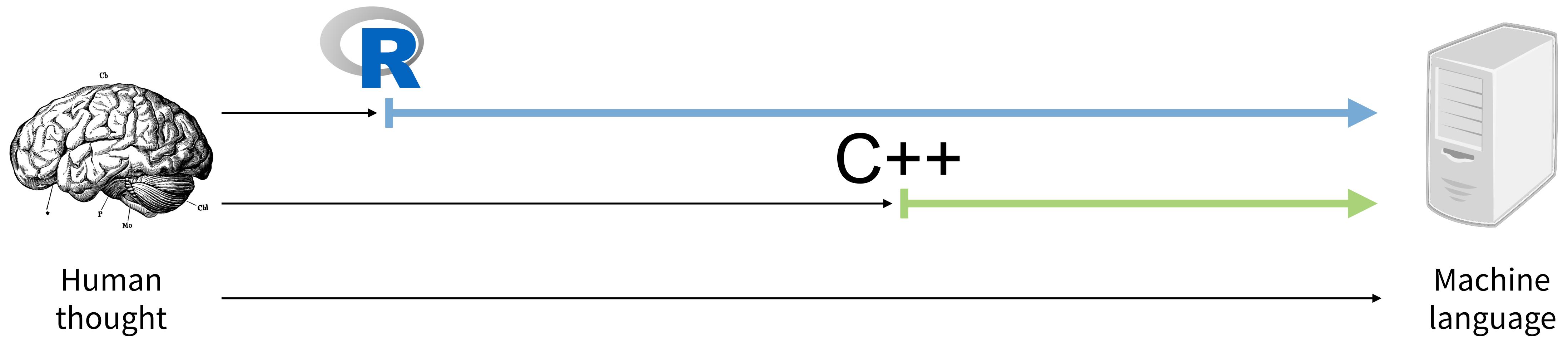


# "Data Science"

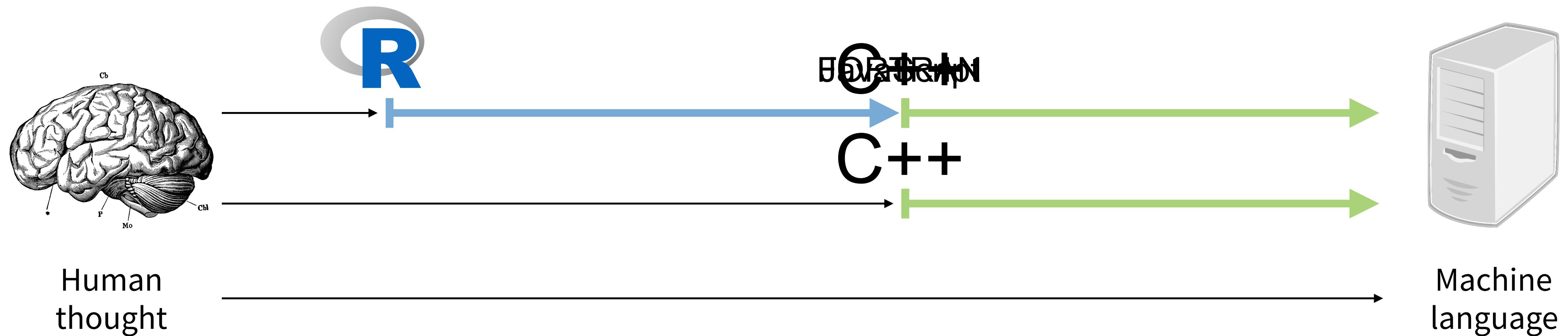




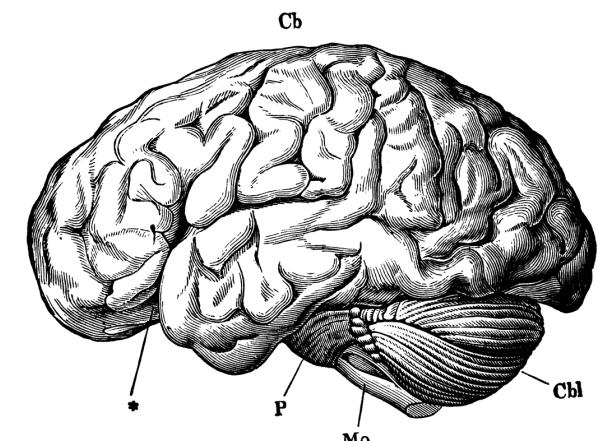
# R - A computer language for scientists



# R - A computer language for scientists



# R - A computer language for scientists



Human  
thought

`map()`

`sapply()`

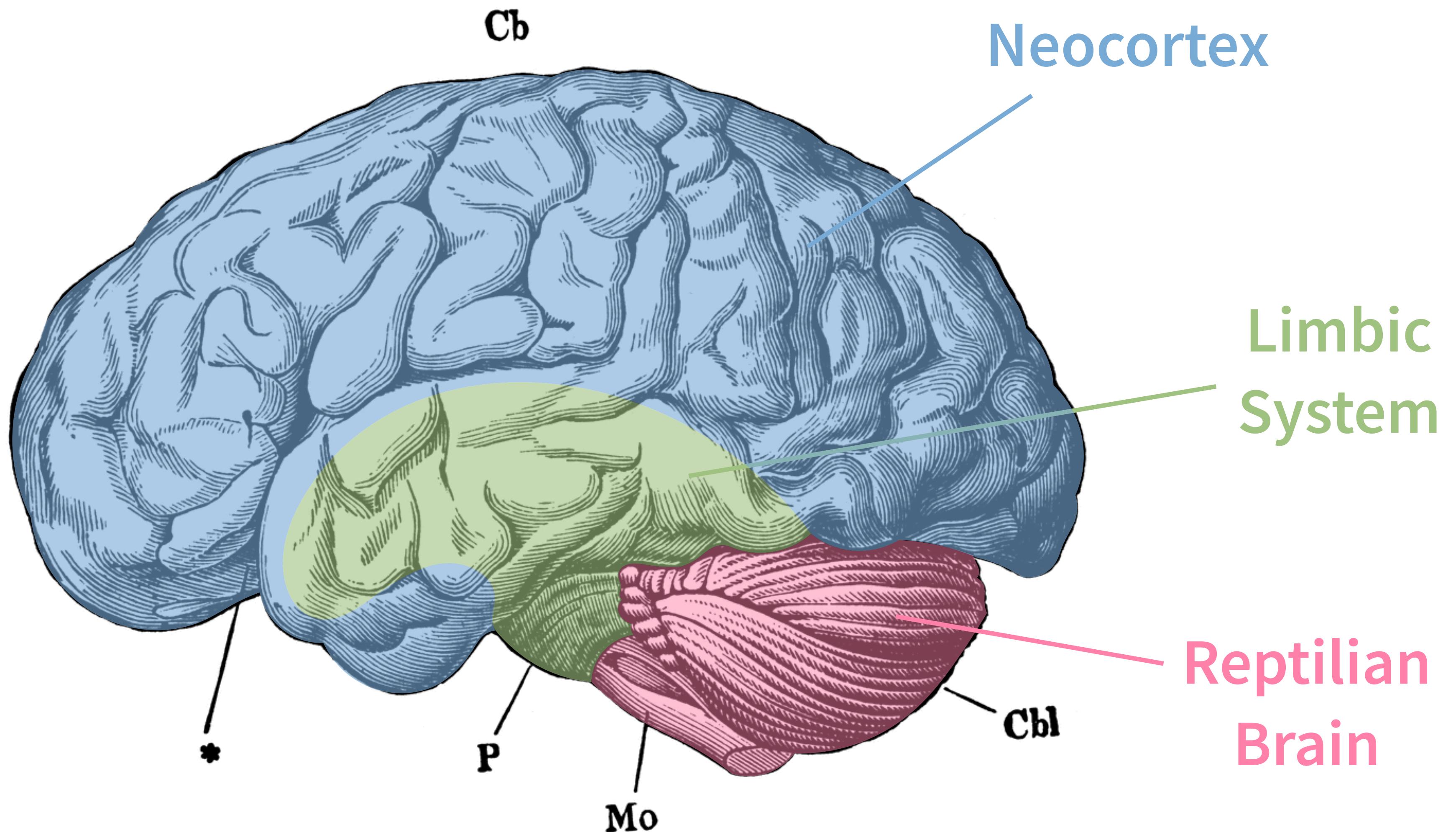
`for()`

`C++`

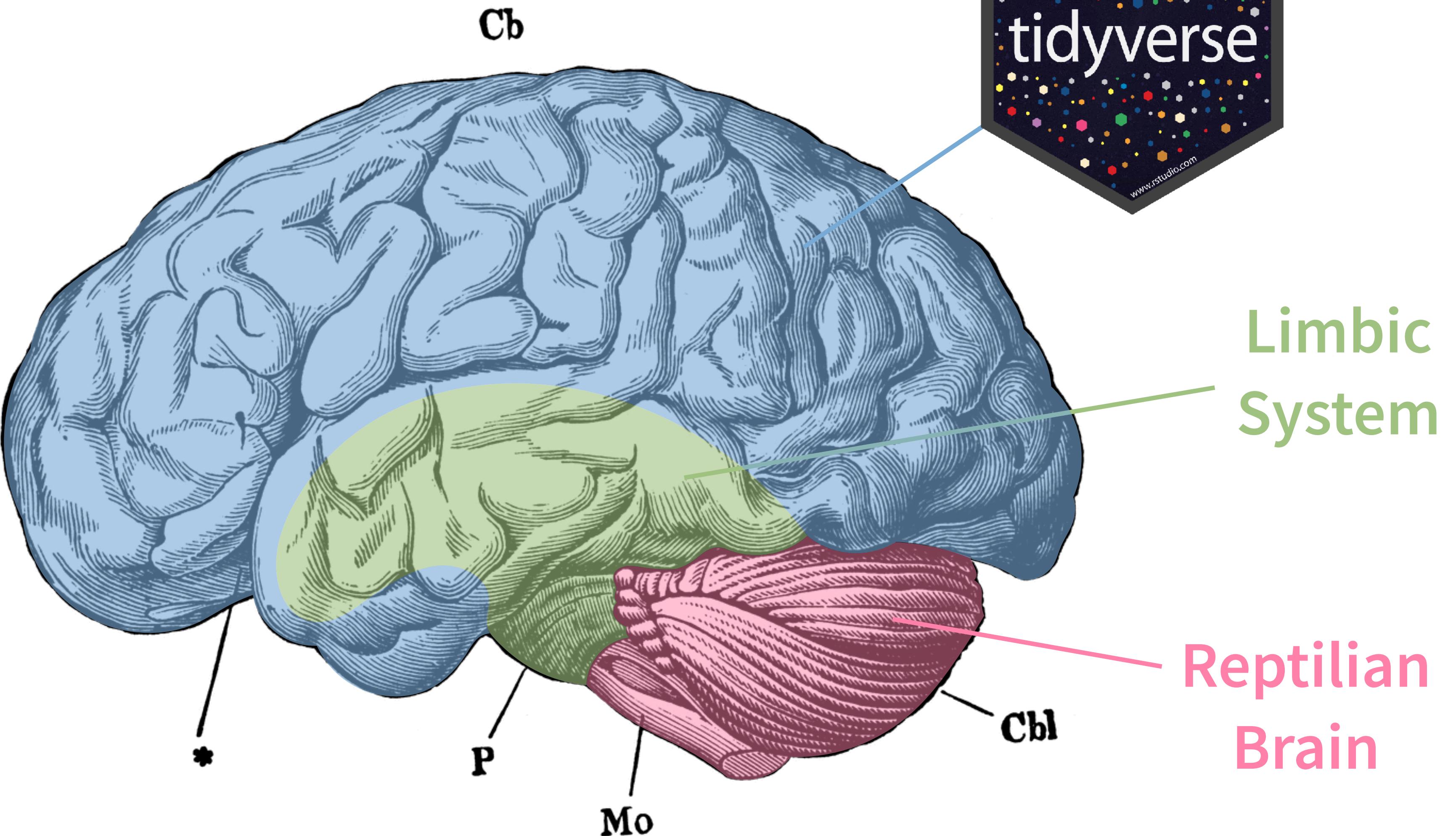


Machine  
language

# O-Introduction



# O-Introduction



# The Tidyverse

A collection of modern R packages that share common philosophies, embed best practices, and are designed to work together.

