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HDS Tutorial 4

| Brittany Blankinship | 9 & 10 November 2021 |

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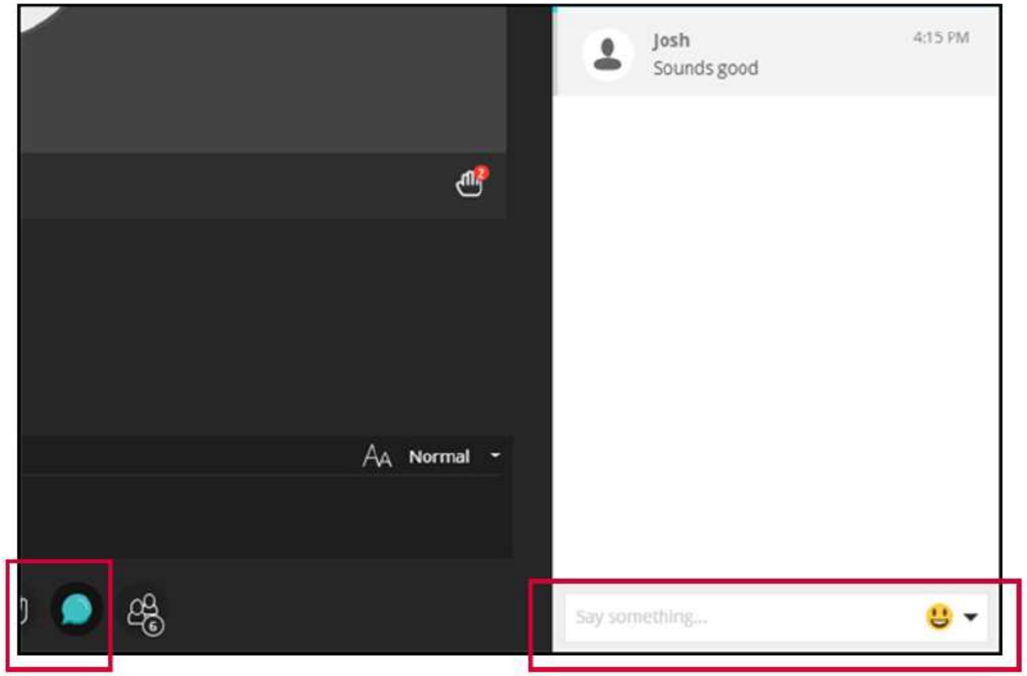

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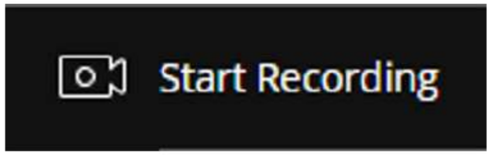

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Agenda

- Interactive overview of key functions discussed in the course
- R Markdown knit to PDF demo
- Q&A

Have you managed to successfully knit an R Markdown document?

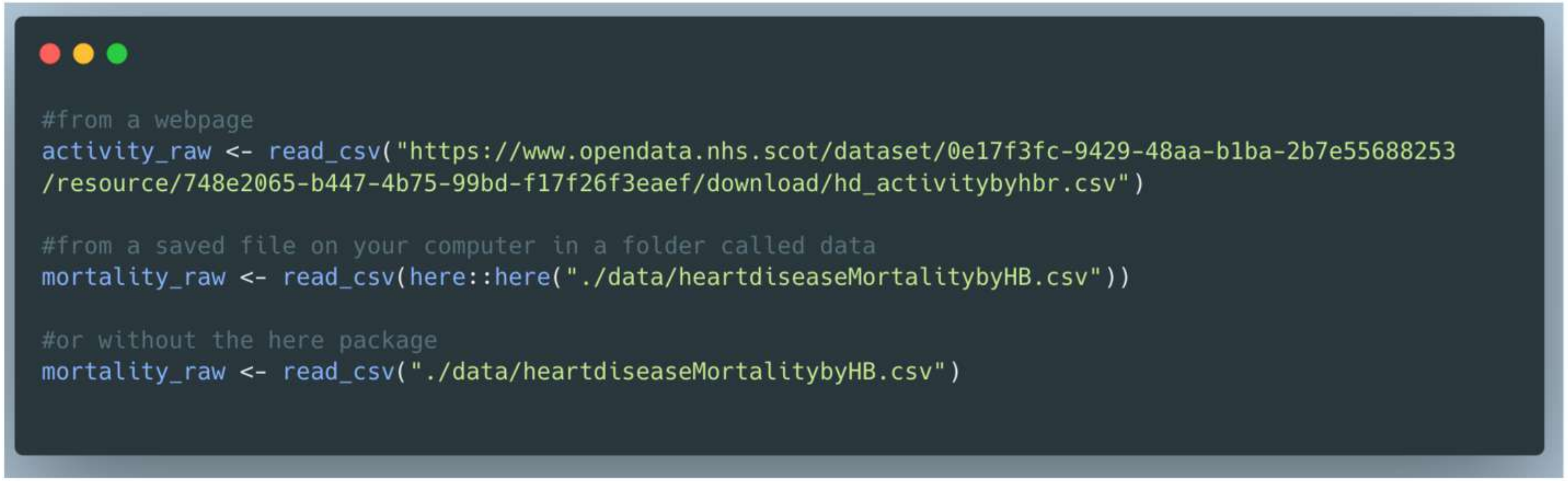
Summary of key functions

Brittany's computer

R hex stickers are so fun!

Importing Data

⭐ `read_csv()`

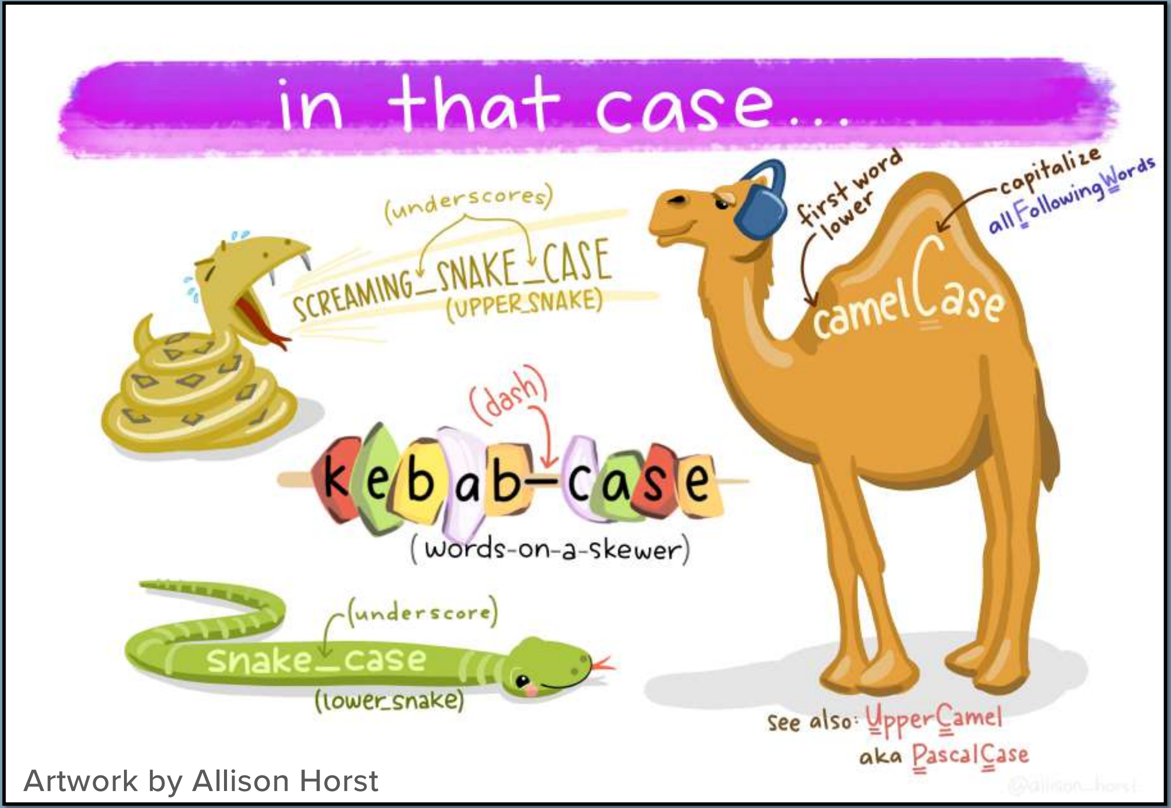


```r
#from a webpage
activity_raw <- read_csv("https://www.opendata.nhs.scot/dataset/0e17f3fc-9429-48aa-b1ba-2b7e55688253
/resource/748e2065-b447-4b75-99bd-f17f26f3eaef/download/hd_activitybyhbr.csv")

#from a saved file on your computer in a folder called data
mortality_raw <- read_csv(here::here("./data/heartdiseaseMortalitybyHB.csv"))

#or without the here package
mortality_raw <- read_csv("./data/heartdiseaseMortalitybyHB.csv")
```

Variable naming conventions

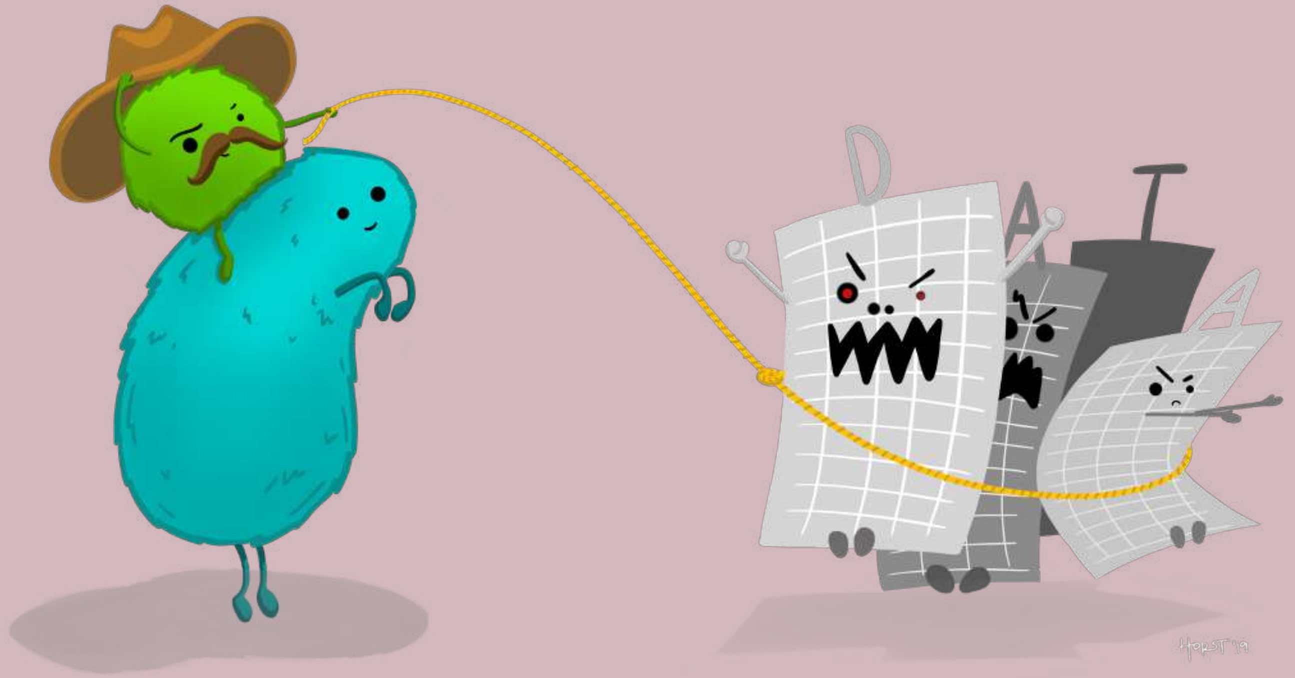
🌟`clean_names()`

Default to snake case, but there are 18 options you can choose from



Artwork by Allison Horst

Wrangling



Artwork by Allison Horst

Logical Operators

<	Less than
>	Greater than
==	Equal to
<=	Less than equal to
>=	Greater than equal to
!=	Not equal to
%in%	Group membership

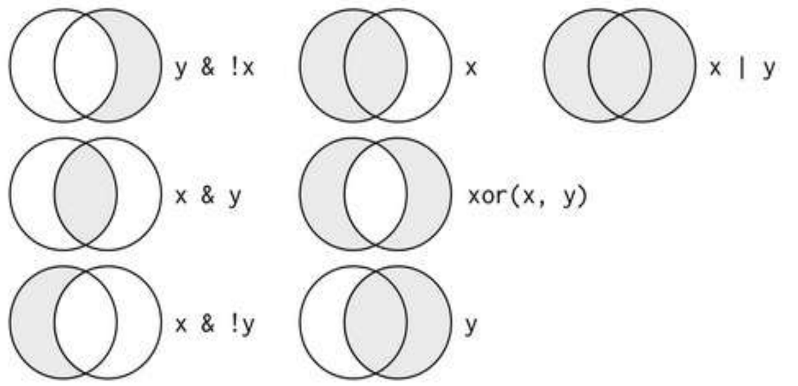


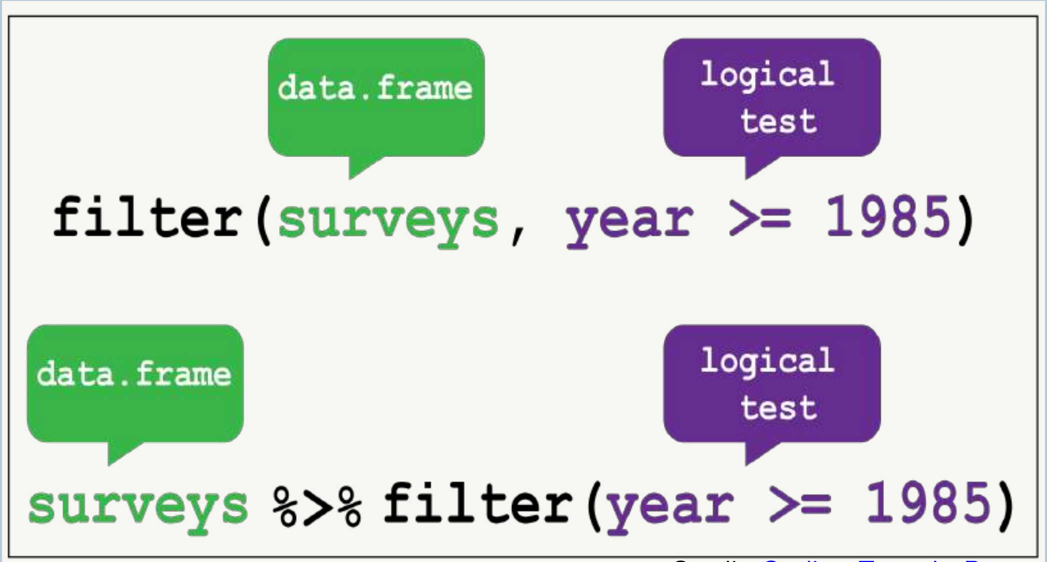
Figure 5.1: Complete set of boolean operations. x is the left-hand circle, y is the right-hand circle, and the shaded region show which parts each operator selects.

Source: R for Data Science book, Figure 5.1

Subsetting Data (observations)

🌟`filter()`

Extract rows of existing data that meeting logical conditions



```
filter(surveys, year >= 1985)

surveys %>% filter(year >= 1985)
```

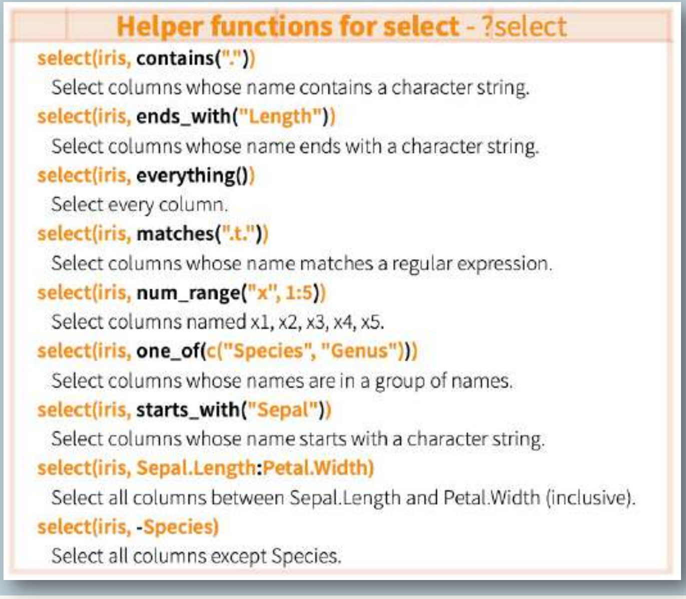
Credit: Coding TogetheR

For more check out this RStudio Data Manipulation video from Garrett Grolemund https://www.youtube.com/watch?v=Zc_ufg4uW4U

Subsetting Data (variables)

🌟`select()`

Select columns by name or helper functions



Helper functions for select - ?select

`select(iris, contains("."))`
Select columns whose name contains a character string.

`select(iris, ends_with("Length"))`
Select columns whose name ends with a character string.

`select(iris, everything())`
Select every column.

`select(iris, matches(".t."))`
Select columns whose name matches a regular expression.

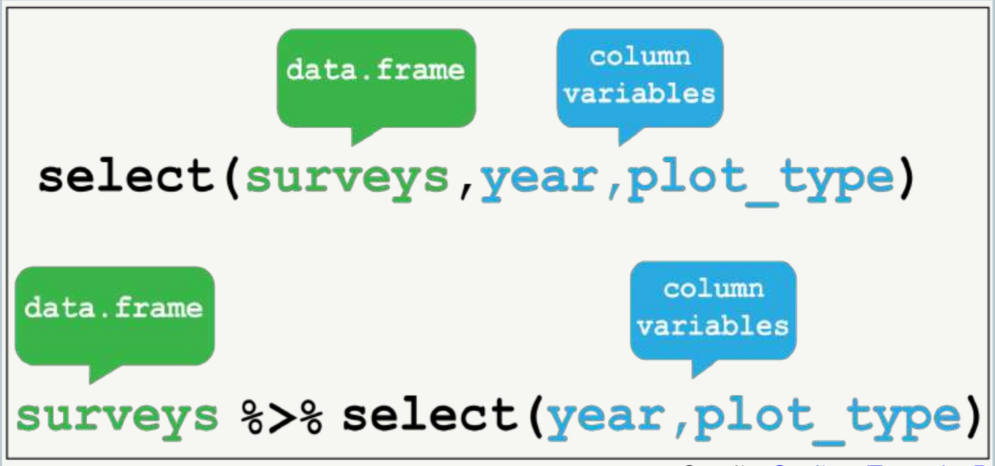
`select(iris, num_range("x", 1:5))`
Select columns named x1, x2, x3, x4, x5.

`select(iris, one_of(c("Species", "Genus")))`
Select columns whose names are in a group of names.

`select(iris, starts_with("Sepal"))`
Select columns whose name starts with a character string.

`select(iris, Sepal.Length:Petal.Width)`
Select all columns between Sepal.Length and Petal.Width (inclusive).

`select(iris, -Species)`
Select all columns except Species.



```
select(surveys,year,plot_type)

surveys %>% select(year,plot_type)
```

Credit: Coding TogetheR

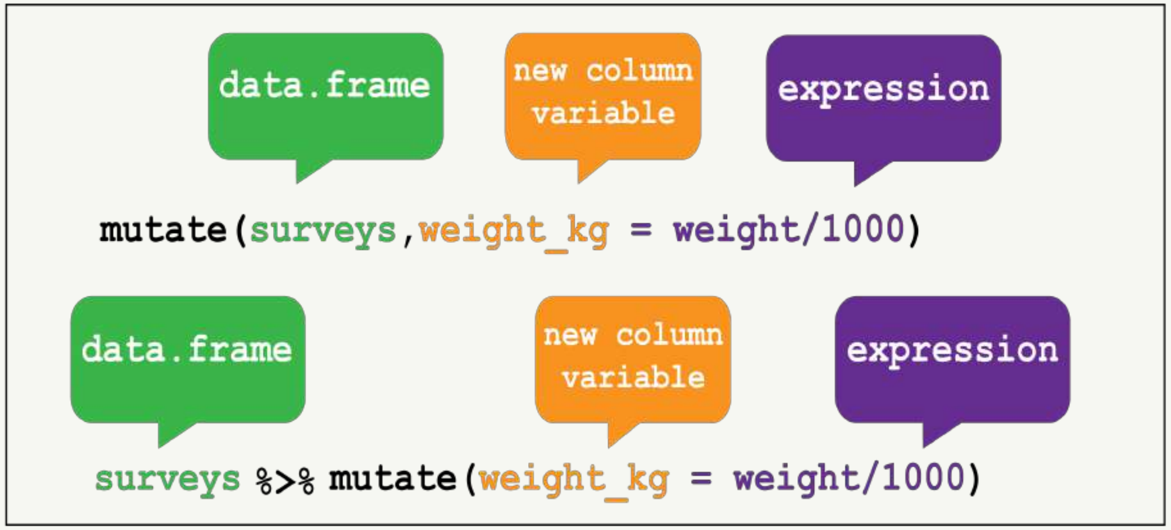
New Variables

🌟`mutate()`

Compute and append one or more new columns – changes an existing column or adds a new one

Works with grouped data or the whole dataset

Original columns remain after being passed to mutate



```
mutate(surveys,weight_kg = weight/1000)
surveys %>% mutate(weight_kg = weight/1000)
```

Credit: [Coding TogetheR]

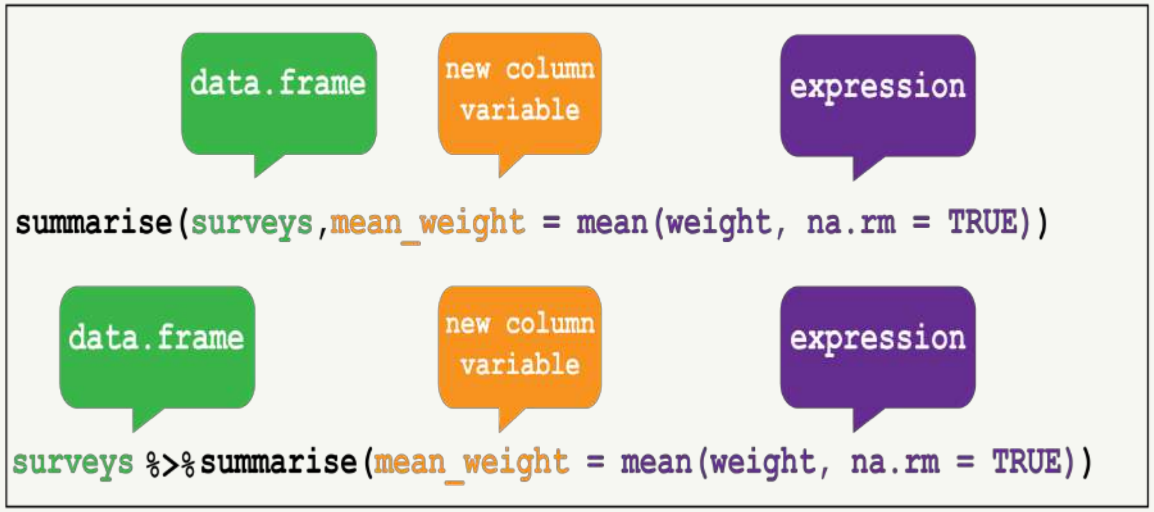
For more check out this RStudio Data Manipluation video from Garrett Grolemund https://www.youtube.com/watch?v=Zc_ufg4uW4U

Summarise

⭐`summarise()`

Summarise data into single row of values

Drops variables not listed in `group_by()` or created inside it, drops columns after calculating the new one



```
summarise(surveys,mean_weight = mean(weight, na.rm = TRUE))
```

```
surveys %>%summarise(mean_weight = mean(weight, na.rm = TRUE))
```

Credit: [Coding TogetheR]

For more check out this RStudio Data Manipluation video from Garrett Grolemund https://www.youtube.com/watch?v=Zc_ufg4uW4U

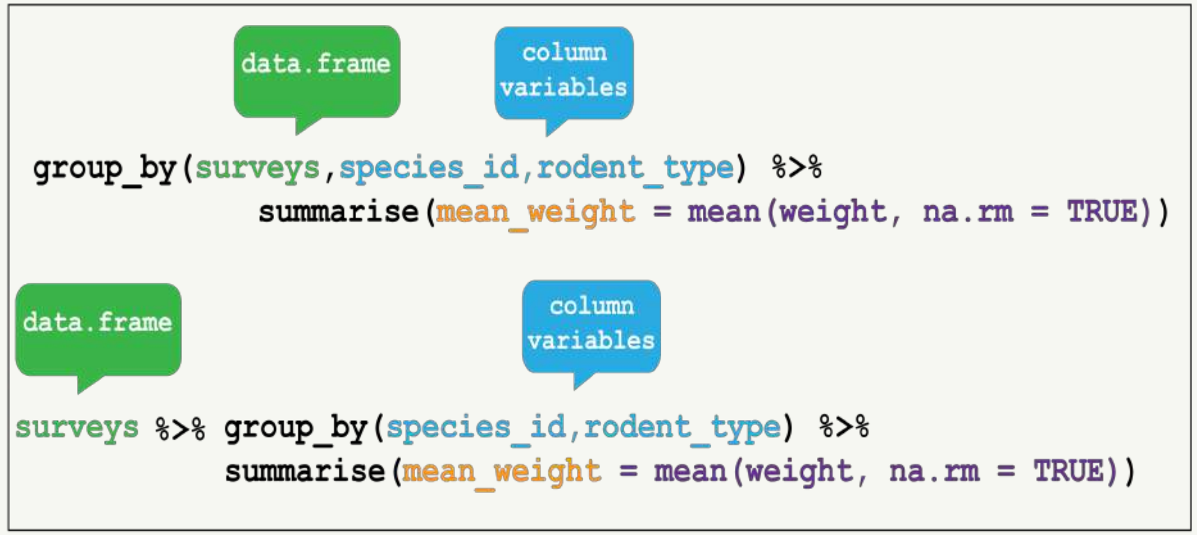
Group Data

🌟`group_by()`

Group data into rows according to column variables

🌟`ungroup()`

Remove grouping information from the data frame

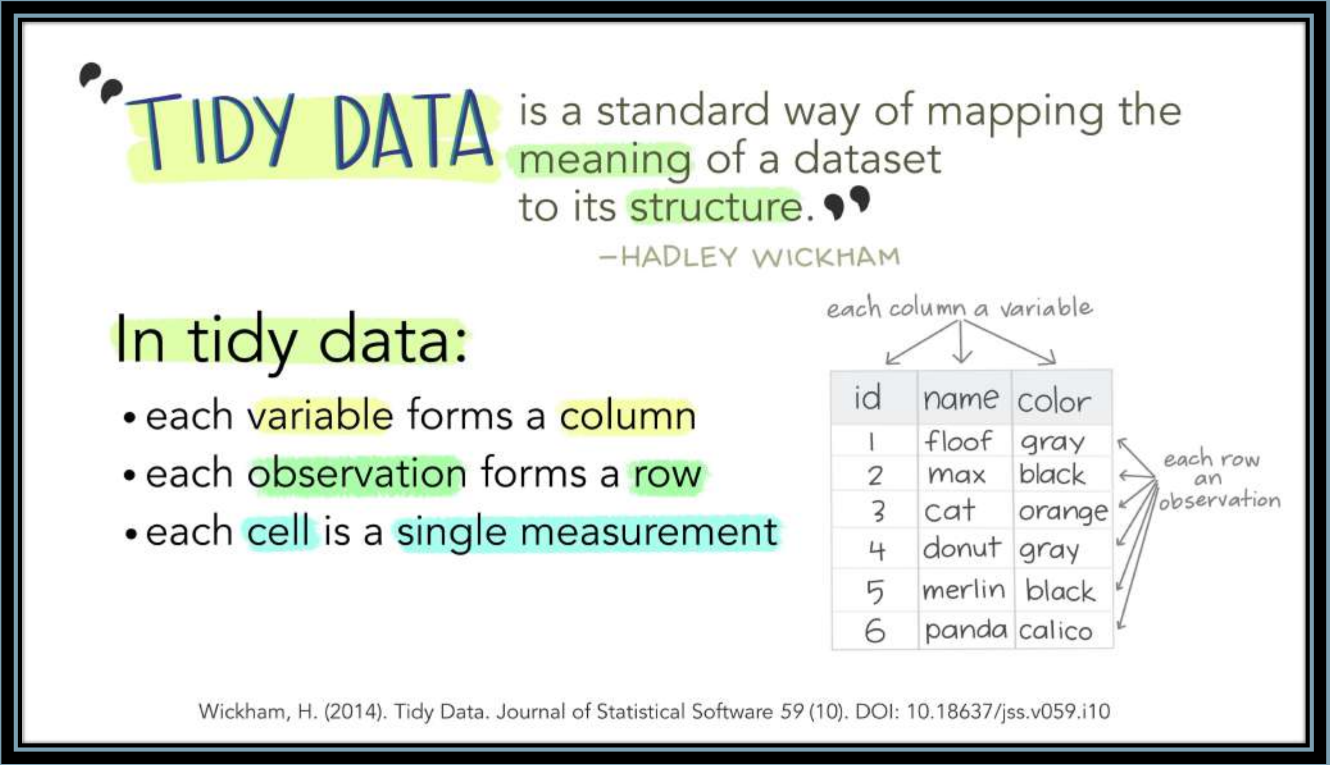


```
group_by(surveys,species_id,rodent_type) %>%
            summarise(mean_weight = mean(weight, na.rm = TRUE))

surveys %>% group_by(species_id,rodent_type) %>%
            summarise(mean_weight = mean(weight, na.rm = TRUE))
```

Credit: Coding TogetheR

For more check out this RStudio Data Manipluation video from Garrett Grolemund https://www.youtube.com/watch?v=Zc_ufg4uW4U

Data formats & Tidy Data



"TIDY DATA is a standard way of mapping the meaning of a dataset to its structure."

—HADLEY WICKHAM

In tidy data:

- each variable forms a column
- each observation forms a row
- each cell is a single measurement

id	name	color
1	floof	gray
2	max	black
3	cat	orange
4	donut	gray
5	merlin	black
6	panda	calico

Wickham, H. (2014). Tidy Data. Journal of Statistical Software 59 (10). DOI: 10.18637/jss.v059.i10

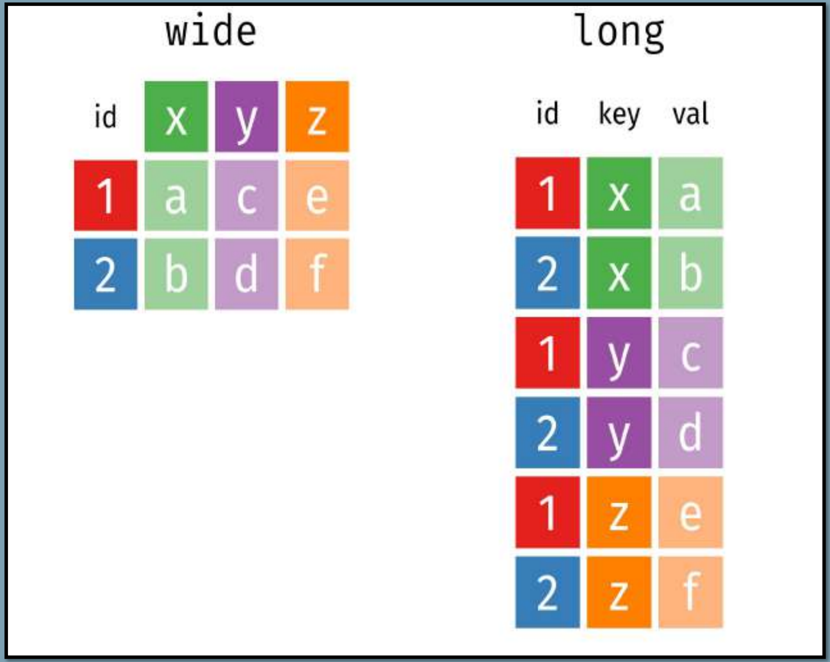
Ways data can become untidy:

- Column headers contain values, rather than names
- Multiple variables are stored in a single column
- Variables are stored in both rows and columns
- Multiple observational types are stored in a single table
- A single observational unit is stored in multiple tables

Wickham, H. (2014). Tidy data. *Journal of statistical software*, *59*(1), 1-23.

For more on tidy data see the above paper & Chapter 12 of the R for Data Science Book

Data formats & Tidy Data

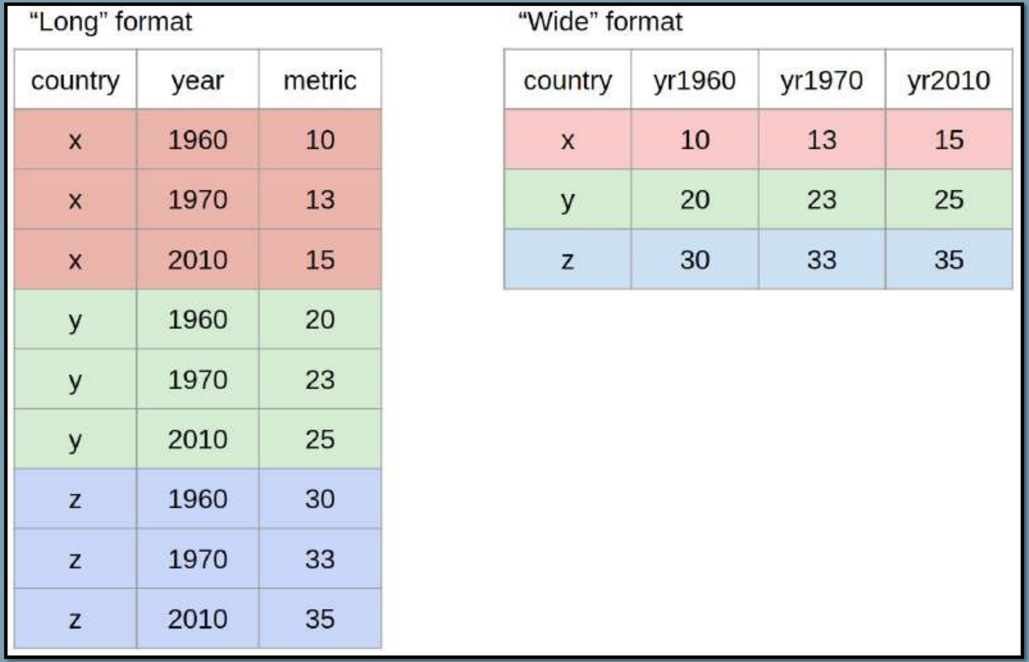


wide

id	x	y	z
1	a	c	e
2	b	d	f

long

id	key	val
1	x	a
2	x	b
1	y	c
2	y	d
1	z	e
2	z	f



"Long" format

country	year	metric
x	1960	10
x	1970	13
x	2010	15
y	1960	20
y	1970	23
y	2010	25
z	1960	30
z	1970	33
z	2010	35

"Wide" format

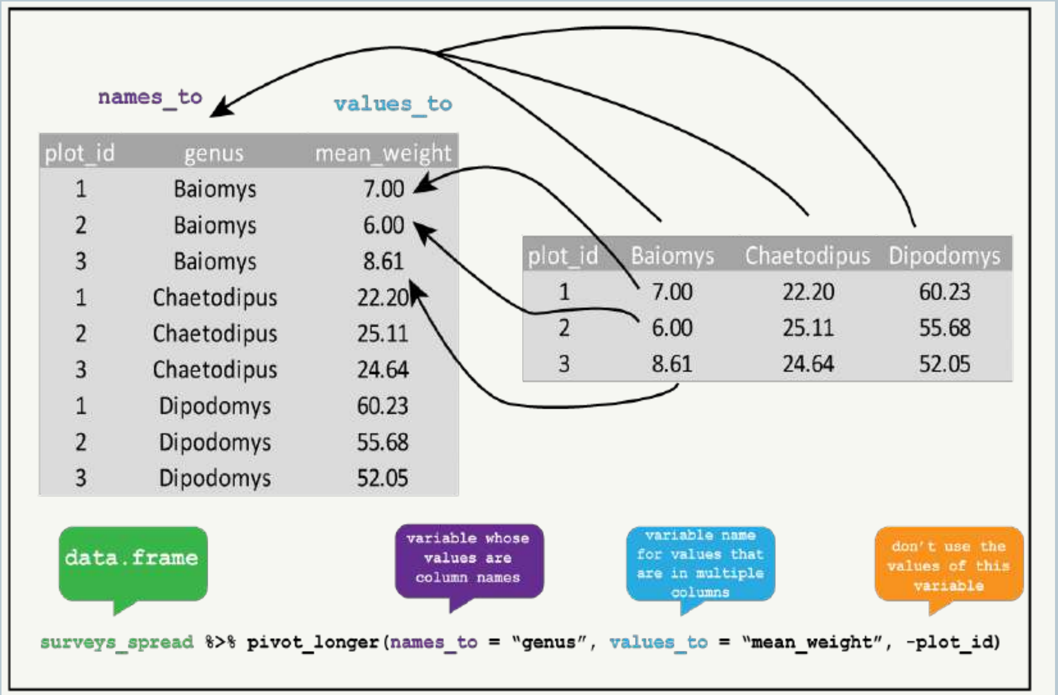
country	yr1960	yr1970	yr2010
x	10	13	15
y	20	23	25
z	30	33	35

Wide format = generally untidy, but found in many datasets

Transforming Data (wide to long)

🌟 `pivot_longer()`

Requires:
1. `data` = data you want to pivot
2. `names_to` = name of the column you <u>want</u> to create to capture condition, requires a character string
3. `values_to` = name of column you <u>want</u> to contain data values, requires a character string
4. `column X:column Y` = range of columns that you <u>have</u> and want to pivot longer, or that you do not want to pivot


names_to
values_to
data.frame
variable whose values are column names
variable name for values that are in multiple columns
don't use the values of this variable

plot_id	genus	mean_weight
1	Baiomys	7.00
2	Baiomys	6.00
3	Baiomys	8.61
1	Chaetodipus	22.20
2	Chaetodipus	25.11
3	Chaetodipus	24.64
1	Dipodomys	60.23
2	Dipodomys	55.68
3	Dipodomys	52.05

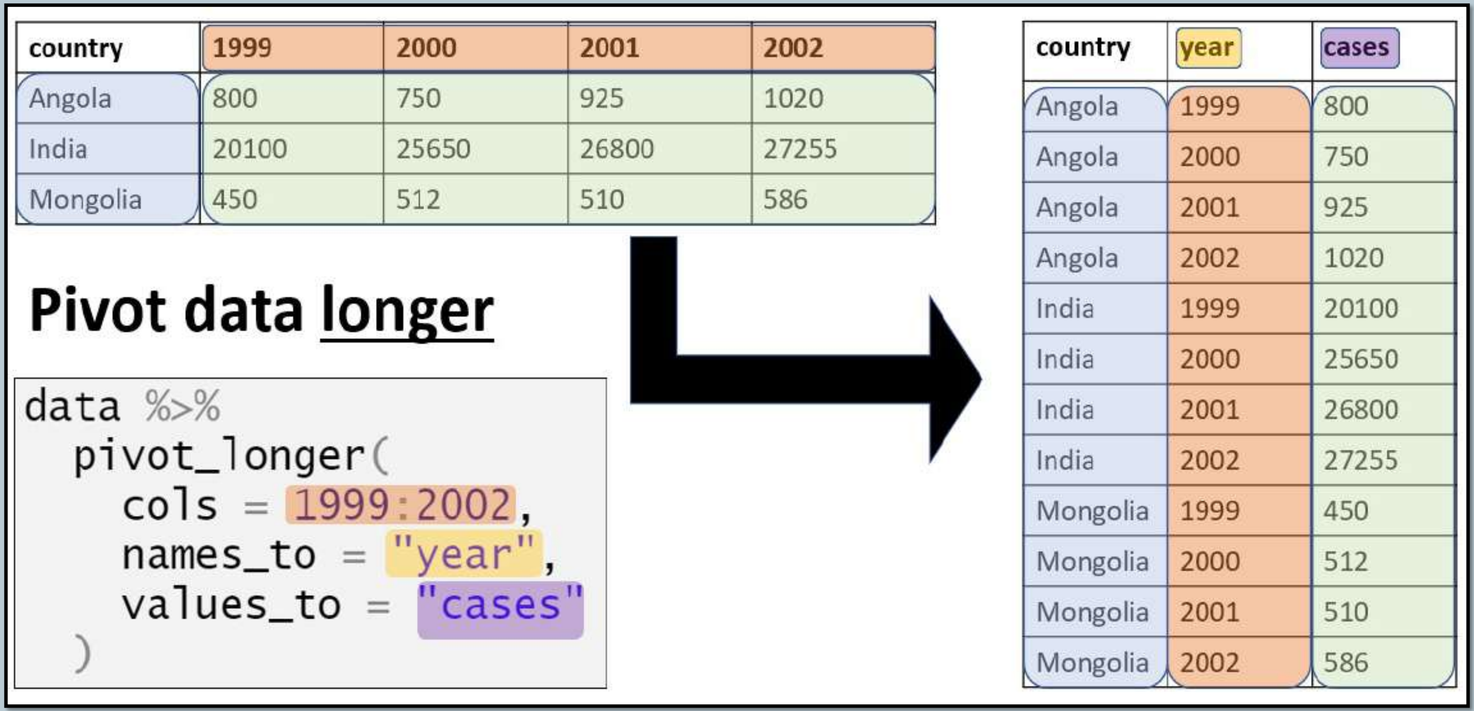
plot_id	Baiomys	Chaetodipus	Dipodomys
1	7.00	22.20	60.23
2	6.00	25.11	55.68
3	8.61	24.64	52.05

```
surveys_spread %>% pivot_longer(names_to = "genus", values_to = "mean_weight", -plot_id)
```

Credit: Alistair Bailey's Coding TogetheR

Transforming Data

🌟 `pivot_longer()` = wide to long



country	1999	2000	2001	2002
Angola	800	750	925	1020
India	20100	25650	26800	27255
Mongolia	450	512	510	586

Pivot data longer

```
data %>%
  pivot_longer(
    cols = 1999:2002,
    names_to = "year",
    values_to = "cases"
  )
```

country	year	cases
Angola	1999	800
Angola	2000	750
Angola	2001	925
Angola	2002	1020
India	1999	20100
India	2000	25650
India	2001	26800
India	2002	27255
Mongolia	1999	450
Mongolia	2000	512
Mongolia	2001	510
Mongolia	2002	586

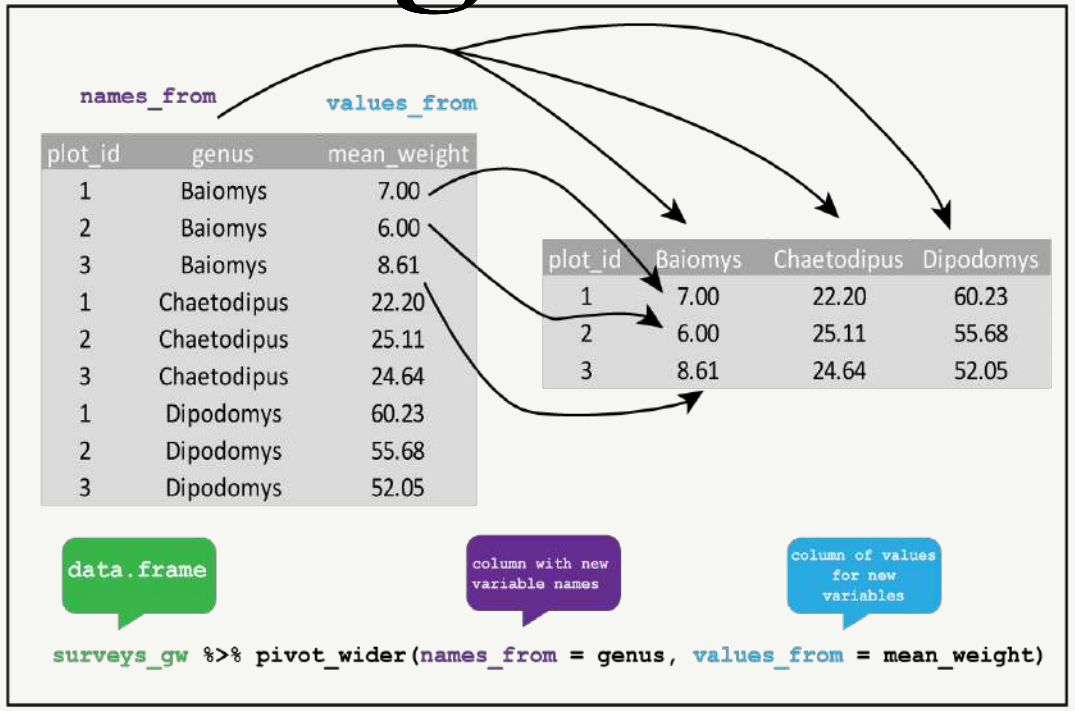
Credit: Epidemiologist R Handbook

Transforming Data (long to wide)

🌟 `pivot_wider()`

Requires:

1. `data` = data you want to pivot
2. `names_from` = name of column you want to end up in several columns
3. `values_from` = name of column that currently contains data values



names_from
values_from
data.frame
column with new variable names
column of values for new variables

plot_id	genus	mean_weight
1	Baiomys	7.00
2	Baiomys	6.00
3	Baiomys	8.61
1	Chaetodipus	22.20
2	Chaetodipus	25.11
3	Chaetodipus	24.64
1	Dipodomys	60.23
2	Dipodomys	55.68
3	Dipodomys	52.05

plot_id	Baiomys	Chaetodipus	Dipodomys
1	7.00	22.20	60.23
2	6.00	25.11	55.68
3	8.61	24.64	52.05

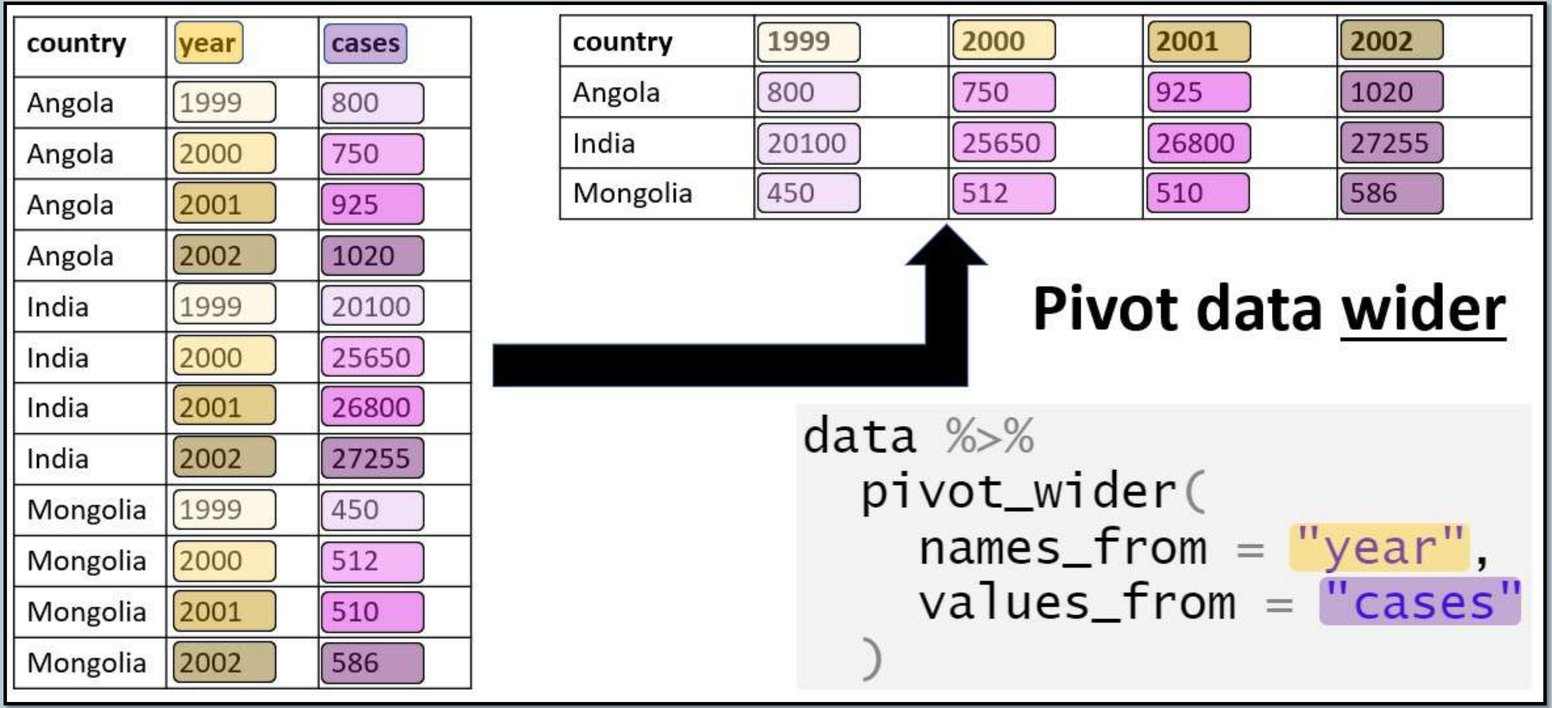
```
surveys_gw %>% pivot_wider(names_from = genus, values_from = mean_weight)
```

Credit: Alistair Bailey's Coding TogetheR

For more check out this RStudio Data Wrangling video from Garrett Grolemund
https://www.youtube.com/watch?v=1ELALQIO-yM - however includes the now superseded functions `gather()` & `spread()`

Transforming Data

🌟`pivot_wider()` = long to wide



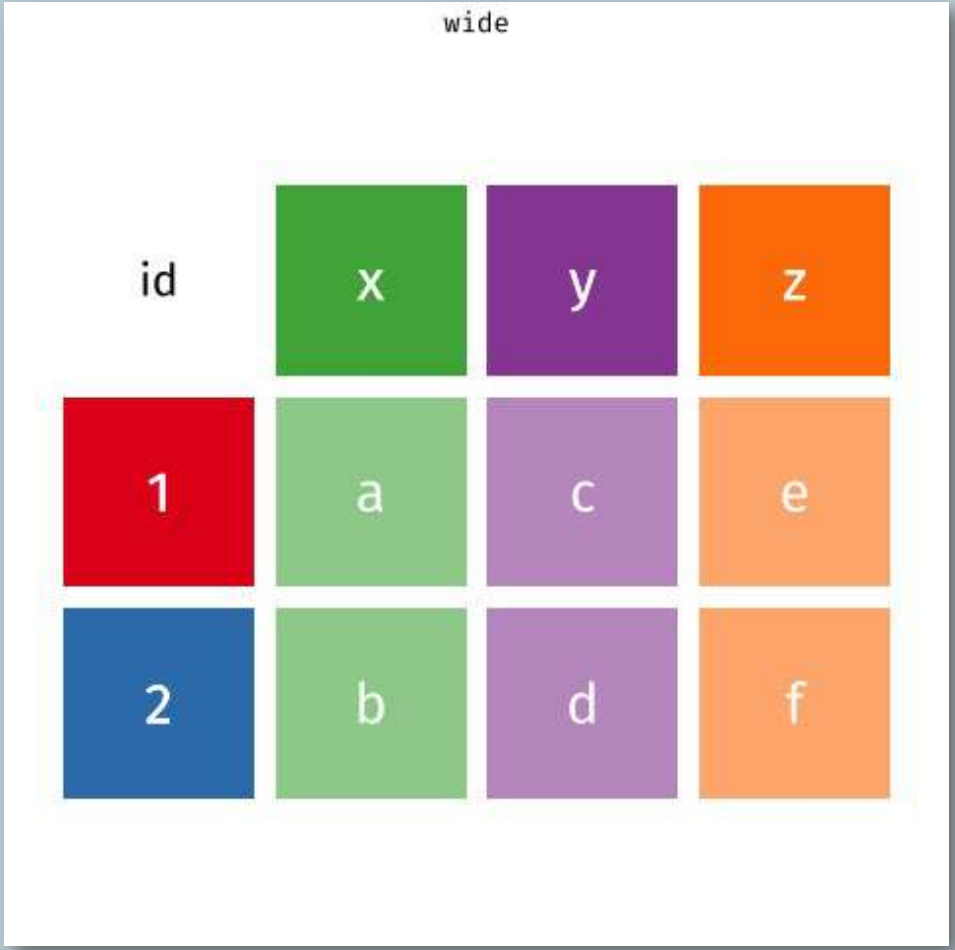
country	year	cases
Angola	1999	800
Angola	2000	750
Angola	2001	925
Angola	2002	1020
India	1999	20100
India	2000	25650
India	2001	26800
India	2002	27255
Mongolia	1999	450
Mongolia	2000	512
Mongolia	2001	510
Mongolia	2002	586

country	1999	2000	2001	2002
Angola	800	750	925	1020
India	20100	25650	26800	27255
Mongolia	450	512	510	586

Pivot data wider

```
data %>%
  pivot_wider(
    names_from = "year",
    values_from = "cases"
  )
```

Credit: Epidemiologist R Handbook



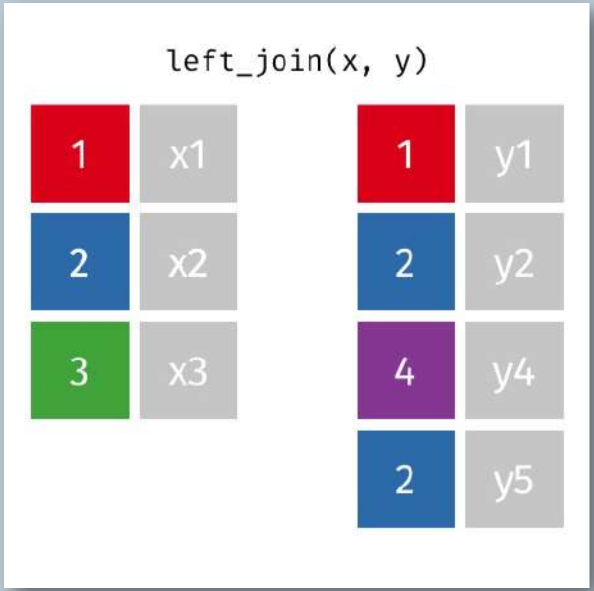
wide

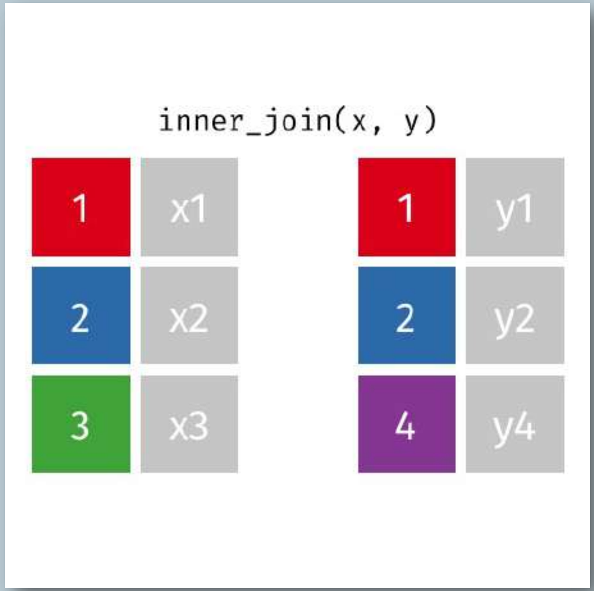
id	x	y	z
1	a	c	e
2	b	d	f

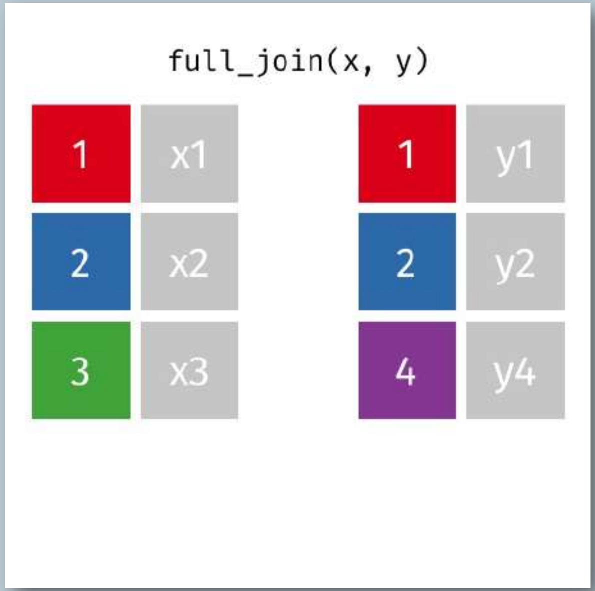
Credit: Garrick Aden-Buie
& Mara Averick

Joins

- ⭐ `left_join()`
- ⭐ `inner_join()`
- ⭐ `full_join()`







For a fun explanation using The Beatles & Rolling Stones see Nic Crane's tweet: https://bit.ly/3qfhBb9

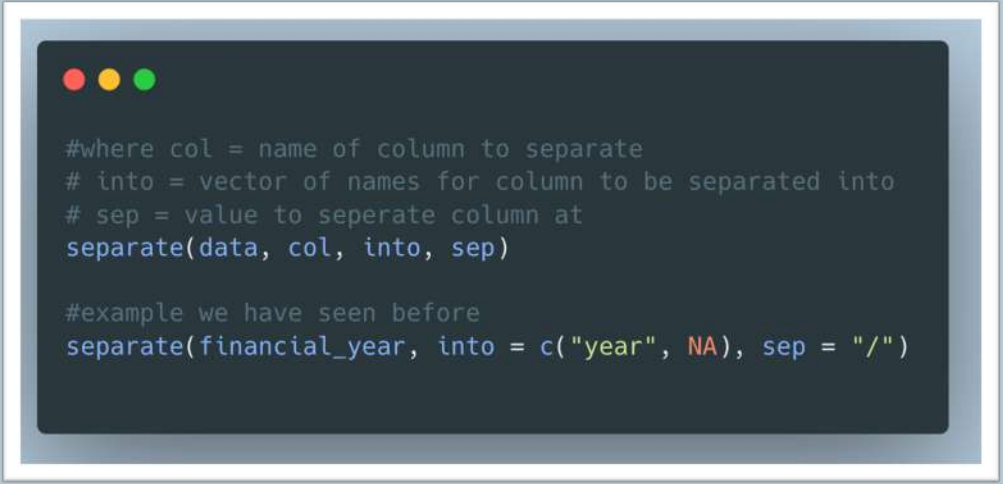
Credit: Garrick Aden-Buie https://www.garrickadenbuie.com/project/tidyexplain/

Dates

Order of elements in date-time	Parse function
year, month, day	⭐ `ymd()`
year, day, month	`ydm()`
month, day, year	`mdy()`
day, month, year	`dmy()`
hour, minute	`hm()`
hour, minute, second	`hms()`
year, month, day, hour, minute, second	`ymd_hms()`

*adapted from *Dates and Times Made Easy with lubridate* (Grolemund & Wickham, 2011)

⭐ `separate()` turns a character column into multiple columns



```
#where col = name of column to separate
# into = vector of names for column to be separated into
# sep = value to seperate column at
separate(data, col, into, sep)

#example we have seen before
separate(financial_year, into = c("year", NA), sep = "/")
```

Factors & Strings

🌟`levels()` to see the set of levels in the factor

🌟`fct_relevel()` to manually reorder factor levels

🌟`fct_recode()` to manually change the levels labels

🌟`fct_collapse()` to collapse levels into manually defined groups

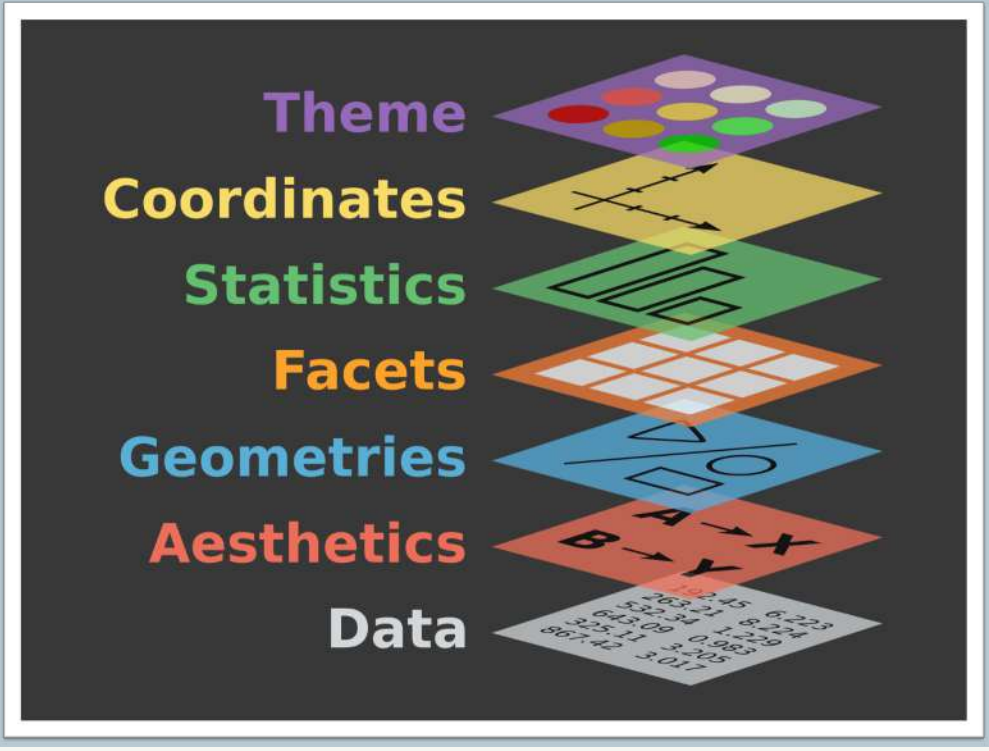
🌟`str_replace()` to change the labels of a string

🌟`str_wrap()` to wrap the text of a string if it is too long into 2+ lines

Plotting

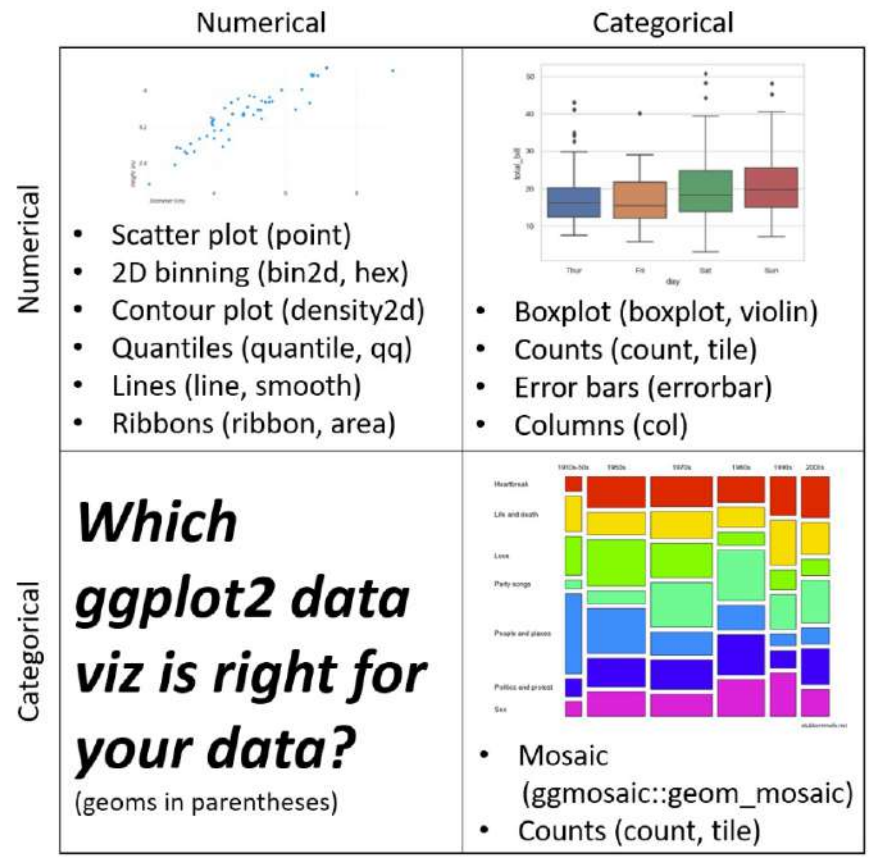
Artwork by Allison Horst

Grammar of Graphics



- ⭐ + theme_bw()
  + theme_classic() etc.
- ⭐ + coord_flip()
  - Example: + stat_summary()
- ⭐ + facet_wrap()
  + facet_grid(x~y)
- ⭐ + geom_line() + geom_bar()
  + geom_jitter() etc.
- ⭐ ggplot(data, aes(x, y, color, shape, fill))
- ⭐ ggplot(data)

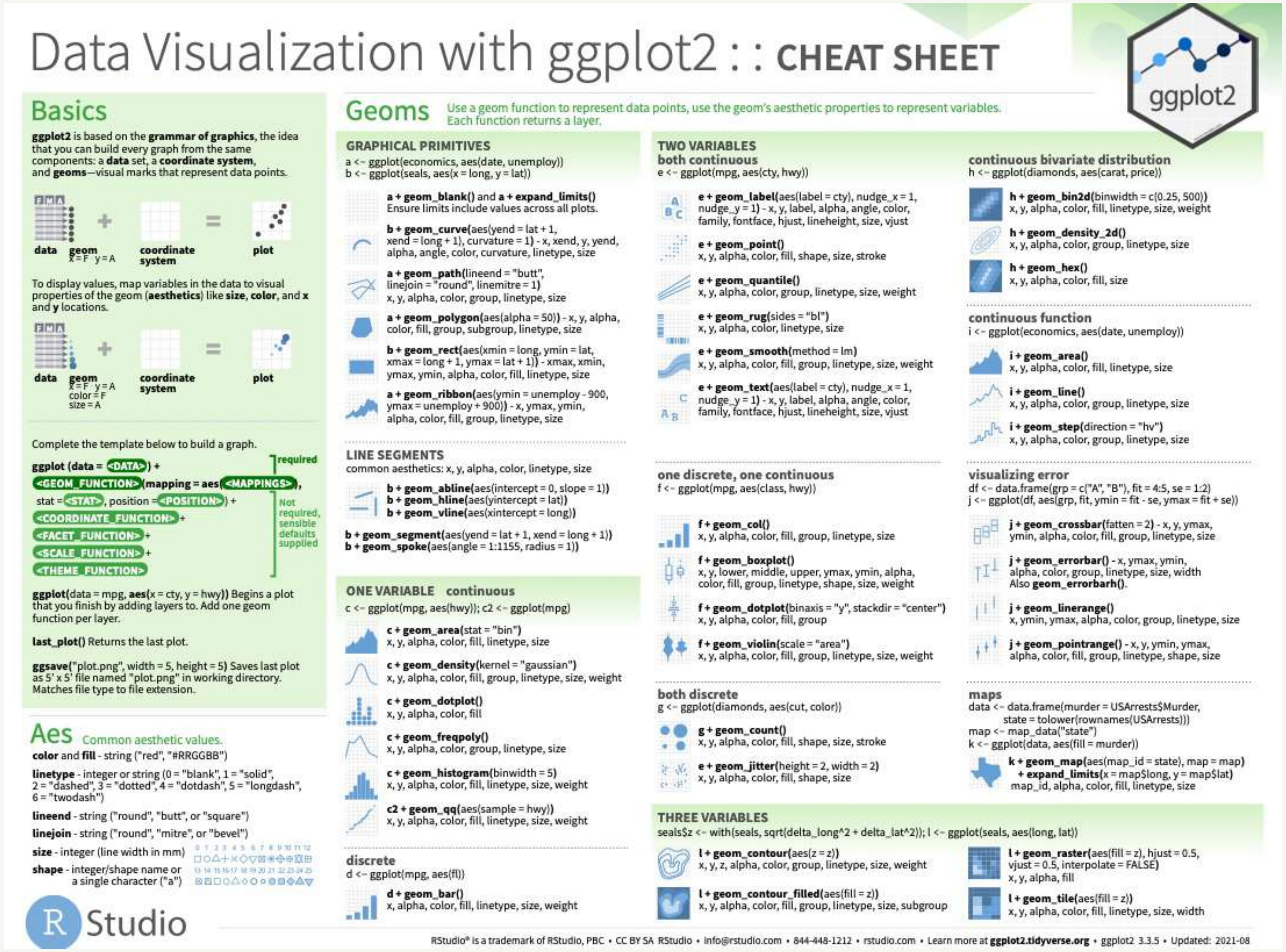
Importance of variable class



	Numerical	Categorical
Numerical	• Scatter plot (point) • 2D binning (bin2d, hex) • Contour plot (density2d) • Quantiles (quantile, qq) • Lines (line, smooth) • Ribbons (ribbon, area)	• Boxplot (boxplot, violin) • Counts (count, tile) • Error bars (errorbar) • Columns (col)
Categorical	***Which ggplot2 data viz is right for your data?*** (geoms in parentheses)	• Mosaic (ggmosaic::geom_mosaic) • Counts (count, tile)

From Dr Sam Tyner's guest lecture in Week 4

ggplot2 Cheatsheet



Data Visualization with ggplot2 : : CHEAT SHEET

ggplot2

Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same components: a **data** set, a **coordinate system**, and **geoms**—visual marks that represent data points.

data + geom (x = F · y = A) + coordinate system = plot

To display values, map variables in the data to visual properties of the geom (**aesthetics**) like **size**, **color**, and **x** and **y** locations.

data + geom (x = F · y = A, color = F, size = A) + coordinate system = plot

Complete the template below to build a graph.

```
ggplot (data = <DATA>) +                                         ] required
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
 stat = <STAT>, position = <POSITION>) +                         ] Not
<COORDINATE_FUNCTION> +                                            required,
<FACET_FUNCTION> +                                                 sensible
<SCALE_FUNCTION> +                                                 defaults
<THEME_FUNCTION>                                                   supplied
```

ggplot(data = mpg, **aes(**x = cty, y = hwy**))** Begins a plot that you finish by adding layers to. Add one geom function per layer.

last_plot() Returns the last plot.

ggsave("plot.png", width = 5, height = 5**)** Saves last plot as 5' x 5' file named "plot.png" in working directory. Matches file type to file extension.

Aes Common aesthetic values.

color and **fill** - string ("red", "#RRGGBB")

linetype - integer or string (0 = "blank", 1 = "solid", 2 = "dashed", 3 = "dotted", 4 = "dotdash", 5 = "longdash", 6 = "twodash")

lineend - string ("round", "butt", or "square")

linejoin - string ("round", "mitre", or "bevel")

size - integer (line width in mm)

shape - integer/shape name or a single character ("a")

0	1	2	3	4	5	6	7	8	9	10	11	12
□	○	△	+	×	◇	▽	⊠	✳	⊕	⊕	⊠	⊞
13	14	15	16	17	18	19	20	21	22	23	24	25
⊠	⊠	□	○	△	◇	○	○	●	■	◆	▲	▼

RStudio

Geoms

Use a geom function to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

GRAPHICAL PRIMITIVES

a <- ggplot(economics, aes(date, unemploy))
b <- ggplot(seals, aes(x = long, y = lat))

a + geom_blank() and **a + expand_limits()** Ensure limits include values across all plots.

b + geom_curve(aes(yend = lat + 1, xend = long + 1), curvature = 1**)** - x, xend, y, yend, alpha, angle, color, curvature, linetype, size

a + geom_path(lineend = "butt", linejoin = "round", linemitre = 1**)** x, y, alpha, color, group, linetype, size

a + geom_polygon(aes(alpha = 50)**)** - x, y, alpha, color, fill, group, subgroup, linetype, size

b + geom_rect(aes(xmin = long, ymin = lat, xmax = long + 1, ymax = lat + 1)**)** - xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

a + geom_ribbon(aes(ymin = unemploy - 900, ymax = unemploy + 900)**)** - x, ymax, ymin, alpha, color, fill, group, linetype, size

LINE SEGMENTS

common aesthetics: x, y, alpha, color, linetype, size

b + geom_abline(aes(intercept = 0, slope = 1)**)**
b + geom_hline(aes(yintercept = lat)**)**
b + geom_vline(aes(xintercept = long)**)**

b + geom_segment(aes(yend = lat + 1, xend = long + 1)**)**
b + geom_spoke(aes(angle = 1:1155, radius = 1)**)**

ONE VARIABLE continuous

c <- ggplot(mpg, aes(hwy)); c2 <- ggplot(mpg)

c + geom_area(stat = "bin"**)** x, y, alpha, color, fill, linetype, size

c + geom_density(kernel = "gaussian"**)** x, y, alpha, color, fill, group, linetype, size, weight

c + geom_dotplot() x, y, alpha, color, fill

c + geom_freqpoly() x, y, alpha, color, group, linetype, size

c + geom_histogram(binwidth = 5**)** x, y, alpha, color, fill, linetype, size, weight

c2 + geom_qq(aes(sample = hwy)**)** x, y, alpha, color, fill, linetype, size, weight

discrete

d <- ggplot(mpg, aes(fl))

d + geom_bar() x, alpha, color, fill, linetype, size, weight

TWO VARIABLES

both continuous

e <- ggplot(mpg, aes(cty, hwy))

e + geom_label(aes(label = cty), nudge_x = 1, nudge_y = 1**)** - x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

e + geom_point() x, y, alpha, color, fill, shape, size, stroke

e + geom_quantile() x, y, alpha, color, group, linetype, size, weight

e + geom_rug(sides = "bl"**)** x, y, alpha, color, linetype, size

e + geom_smooth(method = lm**)** x, y, alpha, color, fill, group, linetype, size, weight

e + geom_text(aes(label = cty), nudge_x = 1, nudge_y = 1**)** - x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

one discrete, one continuous

f <- ggplot(mpg, aes(class, hwy))

f + geom_col() x, y, alpha, color, fill, group, linetype, size

f + geom_boxplot() x, y, lower, middle, upper, ymax, ymin, alpha, color, fill, group, linetype, shape, size, weight

f + geom_dotplot(binaxis = "y", stackdir = "center"**)** x, y, alpha, color, fill, group

f + geom_violin(scale = "area"**)** x, y, alpha, color, fill, group, linetype, size, weight

both discrete

g <- ggplot(diamonds, aes(cut, color))

g + geom_count() x, y, alpha, color, fill, shape, size, stroke

e + geom_jitter(height = 2, width = 2**)** x, y, alpha, color, fill, shape, size

continuous bivariate distribution

h <- ggplot(diamonds, aes(carat, price))

h + geom_bin2d(binwidth = c(0.25, 500)**)** x, y, alpha, color, fill, linetype, size, weight

h + geom_density_2d() x, y, alpha, color, group, linetype, size

h + geom_hex() x, y, alpha, color, fill, size

continuous function

i <- ggplot(economics, aes(date, unemploy))

i + geom_area() x, y, alpha, color, fill, linetype, size

i + geom_line() x, y, alpha, color, group, linetype, size

i + geom_step(direction = "hv"**)** x, y, alpha, color, group, linetype, size

visualizing error

df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
j <- ggplot(df, aes(grp, fit, ymin = fit - se, ymax = fit + se))

j + geom_crossbar(fatten = 2**)** - x, y, ymax, ymin, alpha, color, fill, group, linetype, size

j + geom_errorbar() - x, ymax, ymin, alpha, color, group, linetype, size, width Also **geom_errorbarh()**.

j + geom_linerange() x, ymin, ymax, alpha, color, group, linetype, size

j + geom_pointrange() - x, y, ymin, ymax, alpha, color, fill, group, linetype, shape, size

maps

```
data <- data.frame(murder = USArrests$Murder,
        state = tolower(rownames(USArrests)))
map <- map_data("state")
k <- ggplot(data, aes(fill = murder))
```

k + geom_map(aes(map_id = state), map = map**)** **+ expand_limits(**x = map$long, y = map$lat**)** map_id, alpha, color, fill, linetype, size

THREE VARIABLES

seals$z <- with(seals, sqrt(delta_long^2 + delta_lat^2)); l <- ggplot(seals, aes(long, lat))

l + geom_contour(aes(z = z)**)** x, y, z, alpha, color, group, linetype, size, weight

l + geom_contour_filled(aes(fill = z)**)** x, y, alpha, color, fill, group, linetype, size, subgroup

l + geom_raster(aes(fill = z), hjust = 0.5, vjust = 0.5, interpolate = FALSE**)** x, y, alpha, fill

l + geom_tile(aes(fill = z)**)** x, y, alpha, color, fill, linetype, size, width

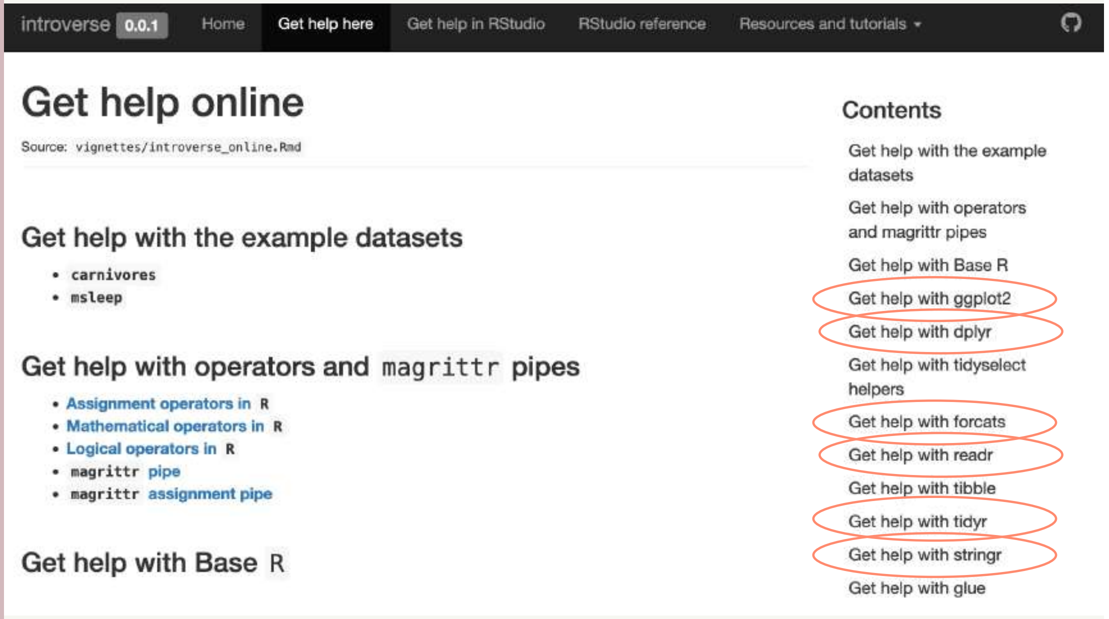
Color palettes

Emil Hvitfeldt has created a “one stop destination for anyone looking for a color palette to use in r.” https://github.com/EmilHvitfeldt/r-color-palettes

Including an interactive color selector! https://emilhvitfeldt.github.io/r-color-palettes/discrete.html

introverse package

https://spielmanlab.github.io/introverse/articles/introverse_online.html



Get help online

Source: `vignettes/introverse_online.Rmd`

Get help with the example datasets

- `carnivores`
- `msleep`

Get help with operators and `magrittr` pipes

- Assignment operators in `R`
- Mathematical operators in `R`
- Logical operators in `R`
- `magrittr` pipe
- `magrittr` assignment pipe

Get help with Base `R`

Contents

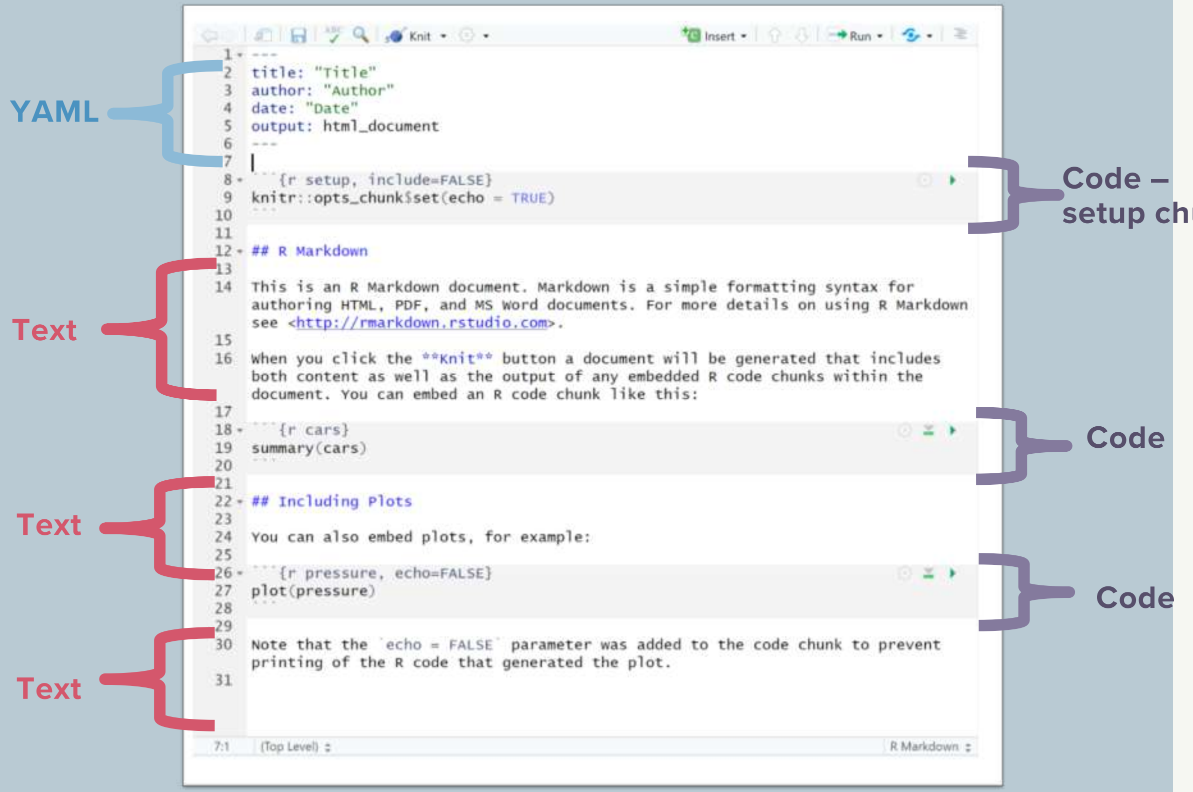
Report generation

Artwork by Allison Horst

R Markdown

- `kable()` for nice tables
- `kable_styling()` for more formatting/styling options

Note: `kableExtra` is *not* a generating package, but an *extra* which can add features to a `kable()` output



~~~
---
title: "Title"
author: "Author"
date: "Date"
output: html_document
---

```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```


## R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for
authoring HTML, PDF, and MS Word documents. For more details on using R Markdown
see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes
both content as well as the output of any embedded R code chunks within the
document. You can embed an R code chunk like this:

```{r cars}
summary(cars)
```

## Including Plots

You can also embed plots, for example:

```{r pressure, echo=FALSE}
plot(pressure)
```

Note that the `echo = FALSE` parameter was added to the code chunk to prevent
printing of the R code that generated the plot.
~~~

A bit more on knitting to PDFs

Questions?

R Programming Assignment

Due: Monday, 29th November at 12 noon GMT

See Learn pages or the repository here for more info

Q&A around the assignment Wednesday 10 November 6pm!