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HDS Tutorial 4
Week 8

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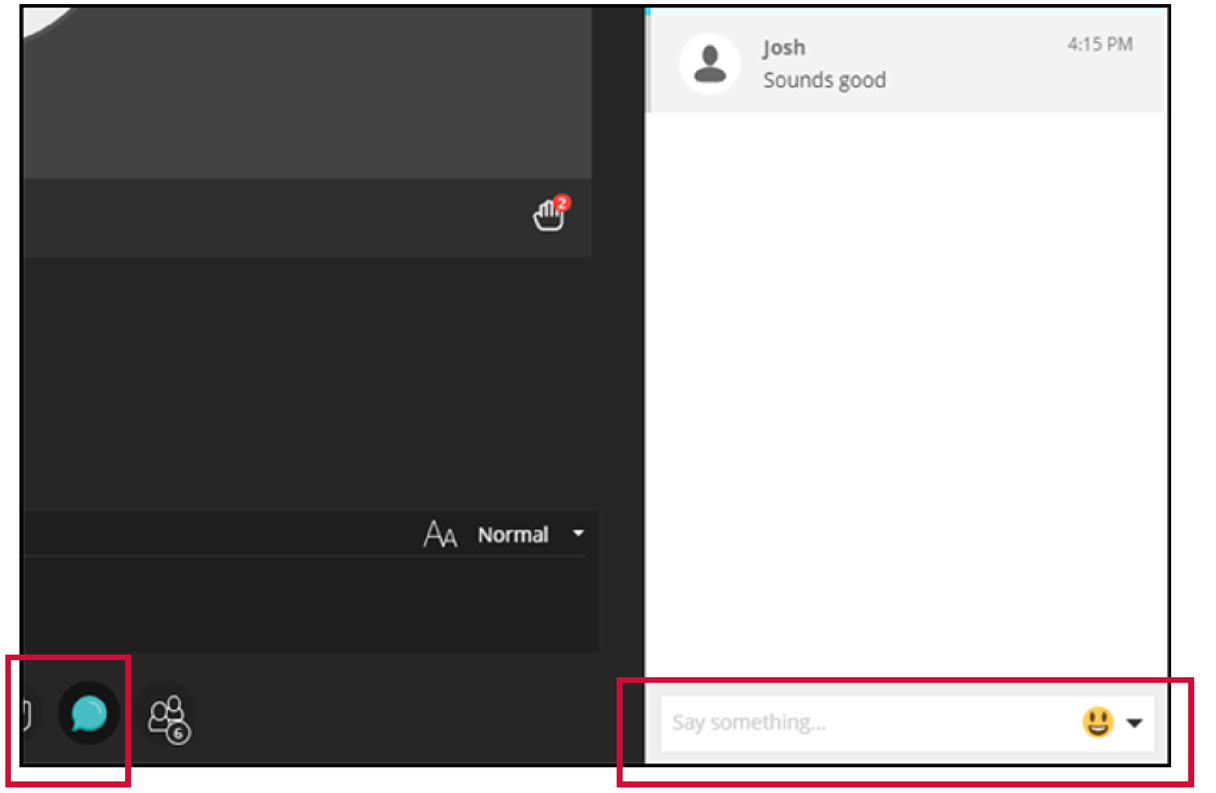

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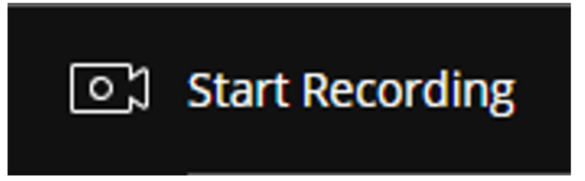

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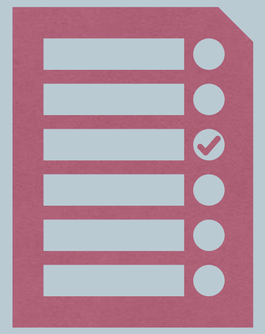
HDS Tutorial 4
Week 8

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 to PDF?

Summary of key functions

Importing Data

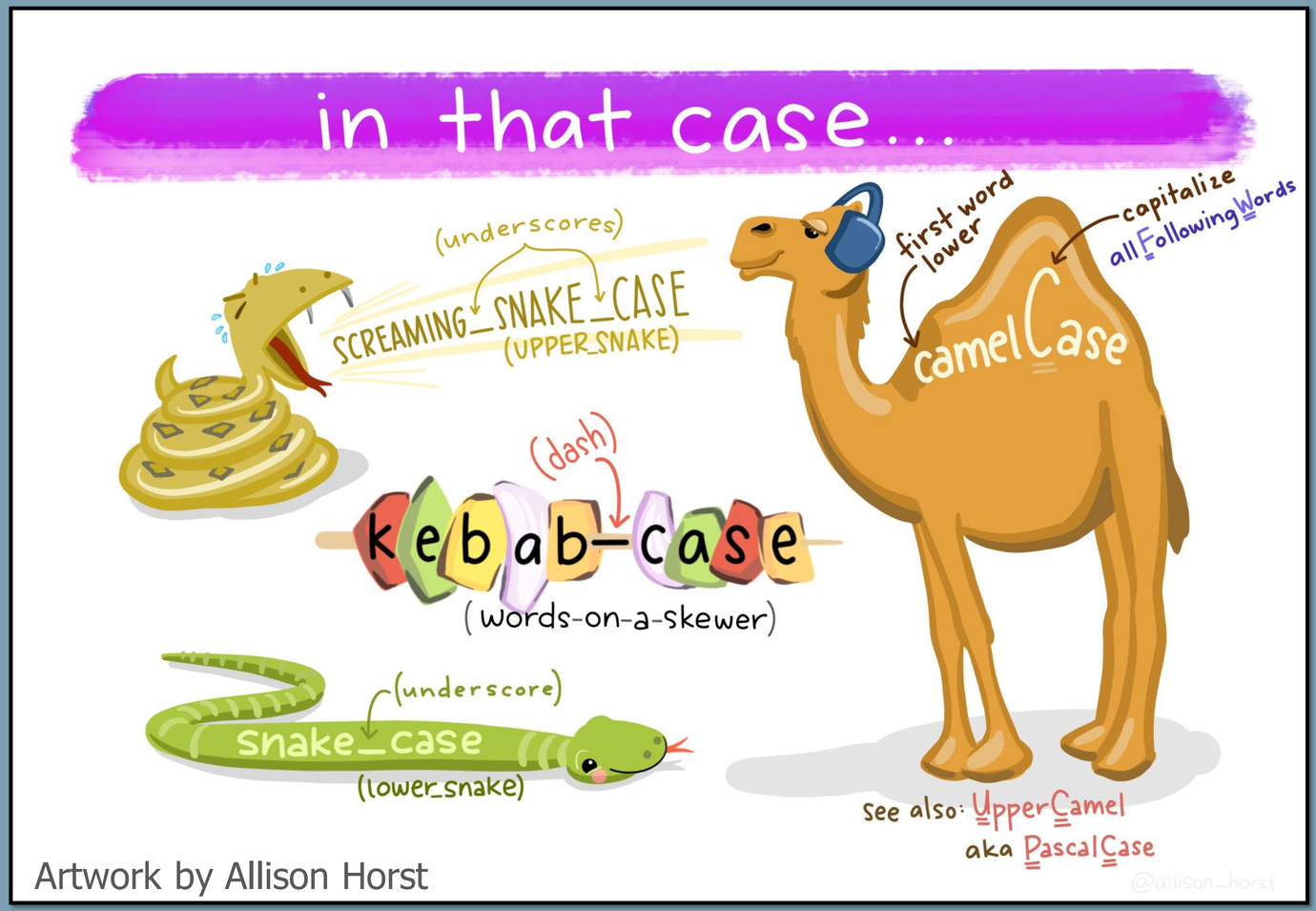
read_csv()

```
#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

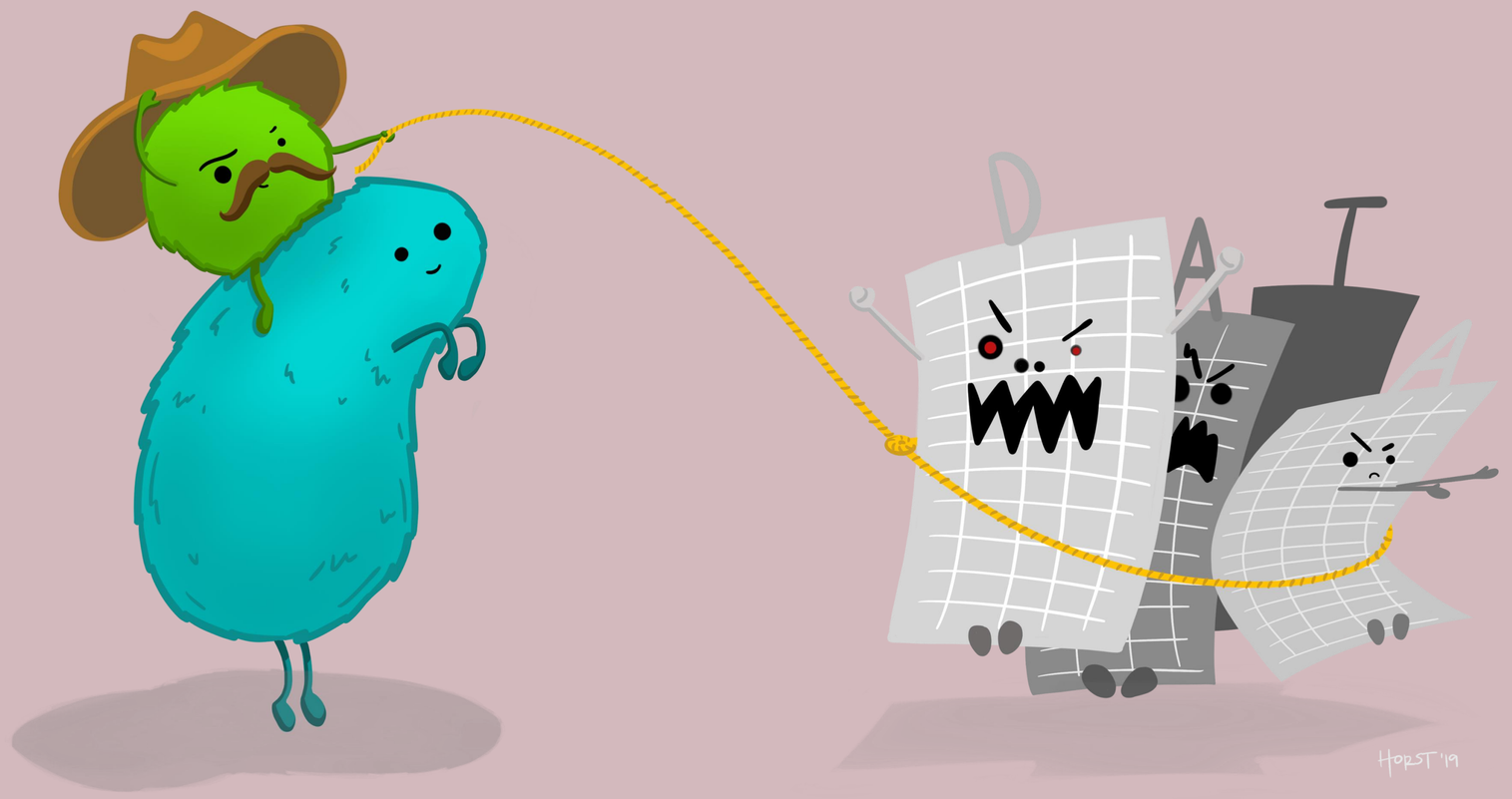
- clean_names()

Defaults 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

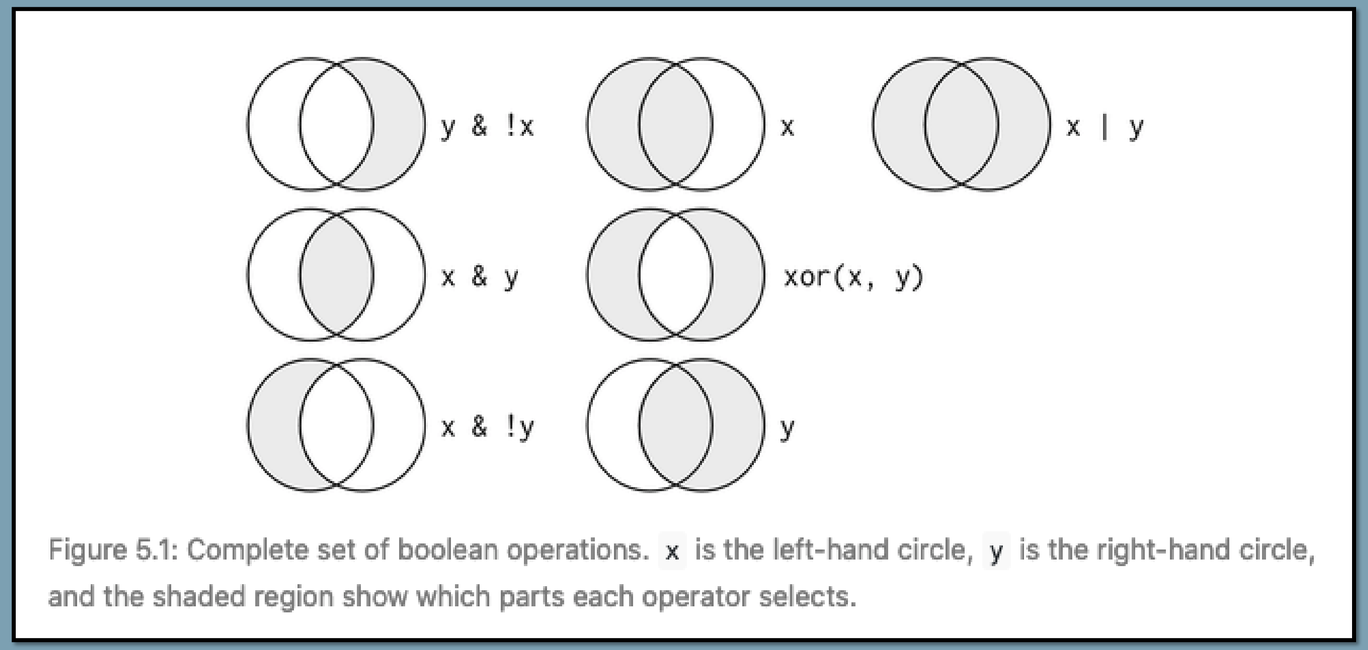


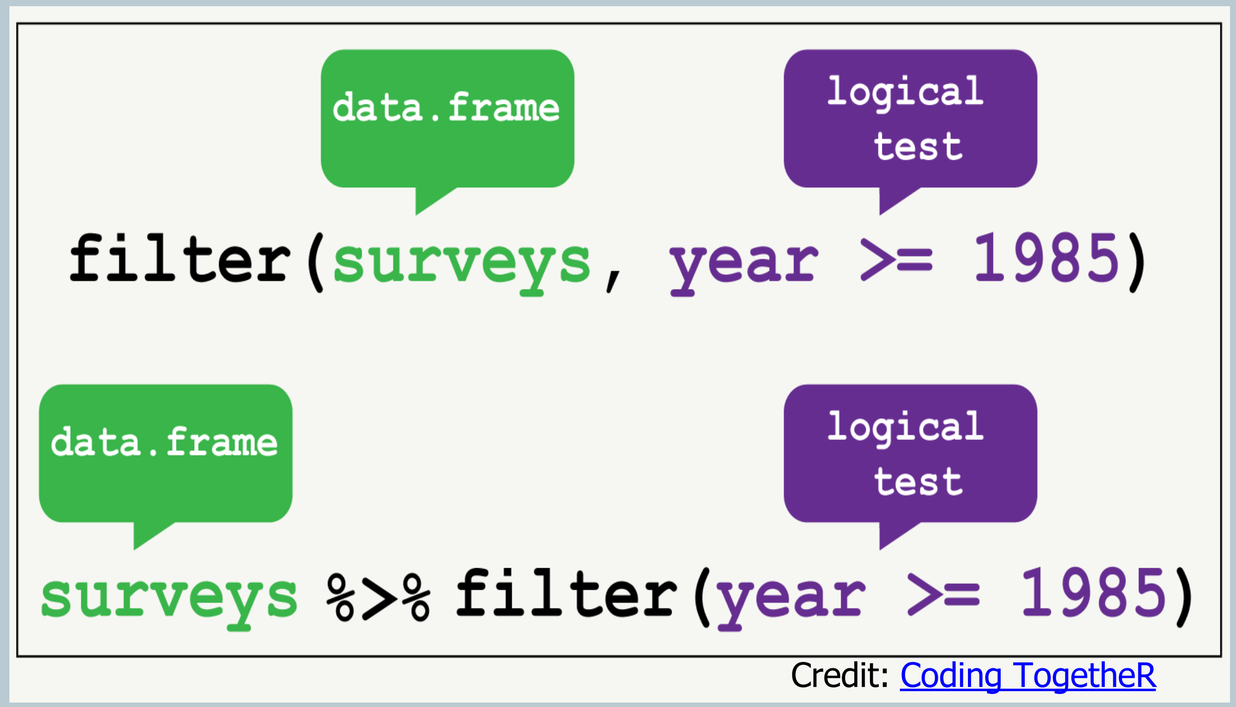
Figure 5.1: Complete set of boolean operations. `x` is the left-hand circle, `y` is the right-hand circle, and the shaded region show which parts each operator selects.

Source: R for Data Science book, Figure 5.1

Subsetting Data (observations)

- filter()

Extract rows of existing data that meeting logical conditions



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.

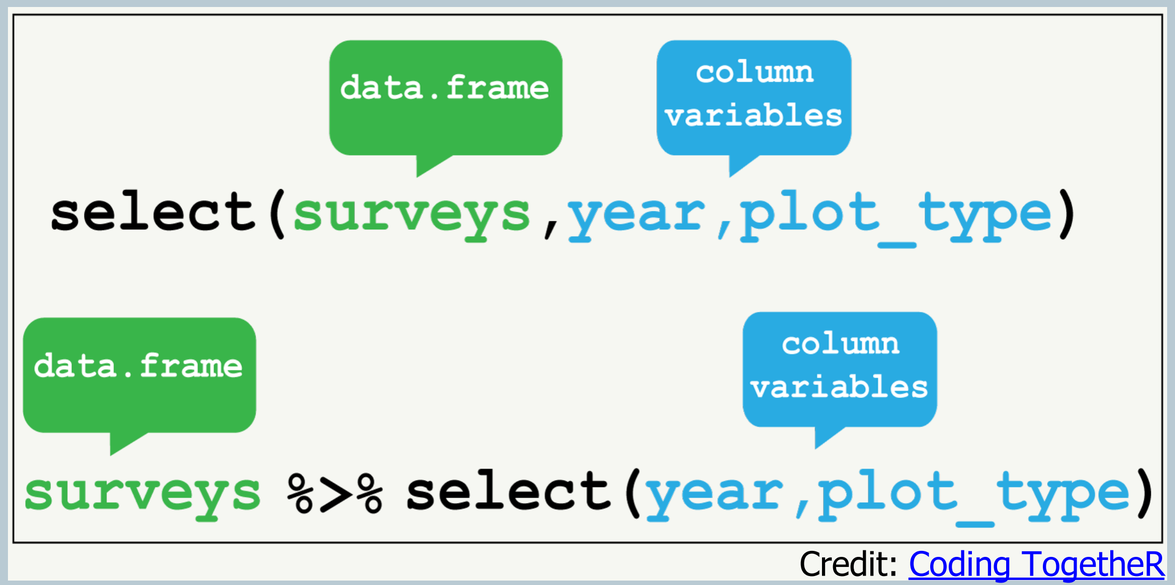
```
select(iris, num_range("x", 1:5))
```
Select columns named x1, x2, x3, x4, x5.

```
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.



Credit: Coding TogetheR

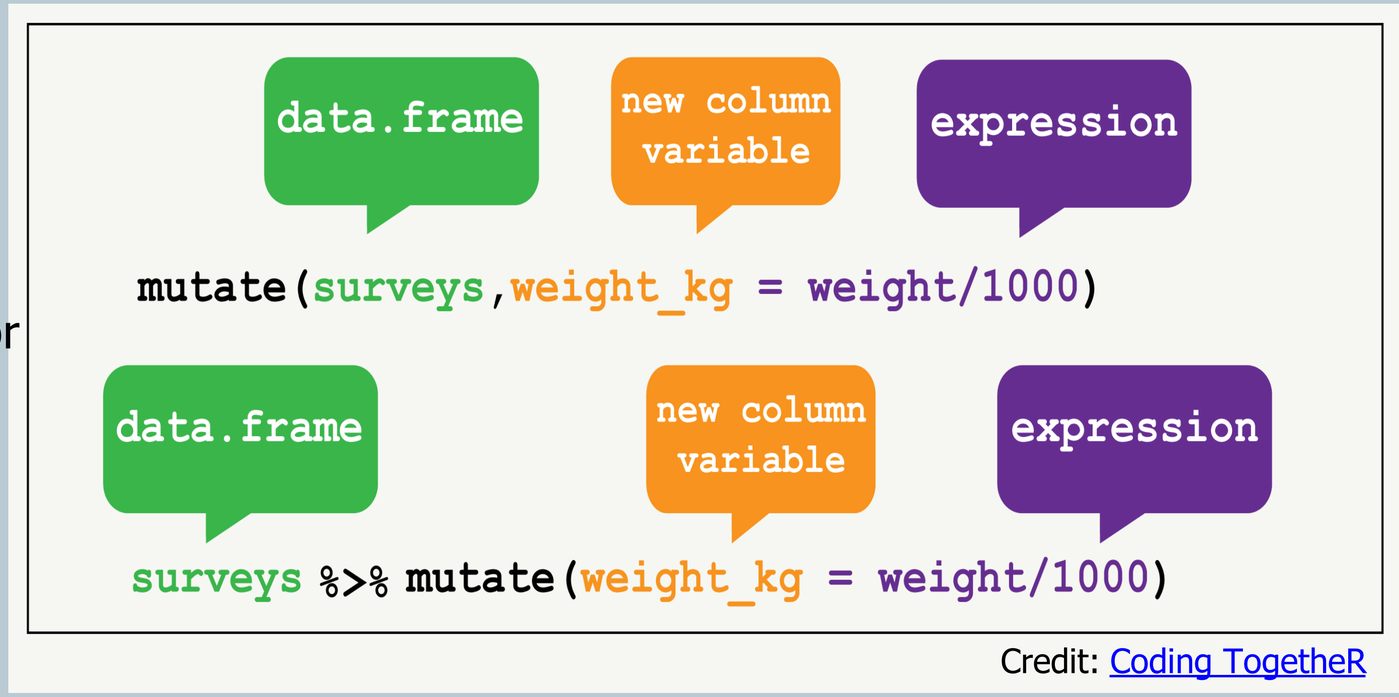
New Variables

- 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



Credit: Coding TogetheR

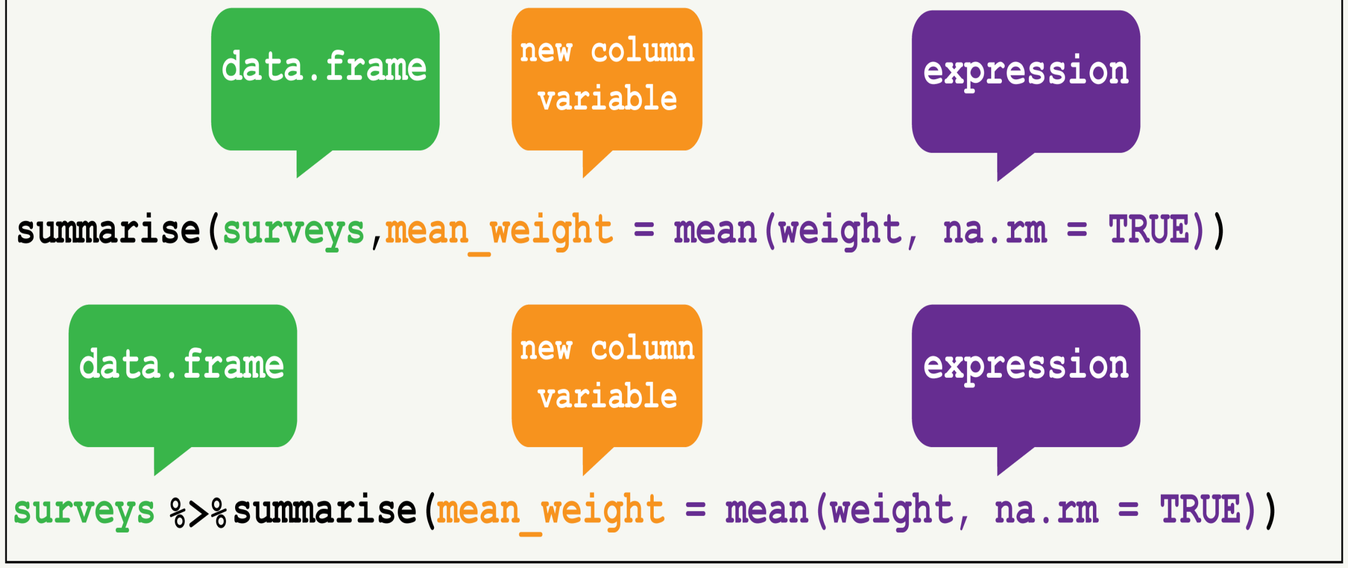
For more check out this RStudio Data Manipluation video from Garrett Grolemund https://www.youtube.com/watch?v=Zc_ufg4uW4U

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



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 – particularly useful when wrangling data for tables

data.frame

column variables

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

data.frame

column variables

```
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

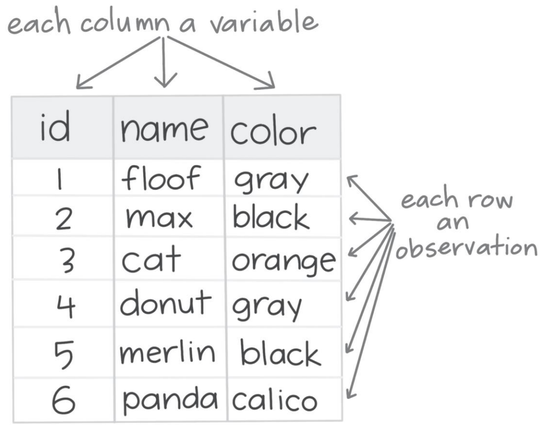
Data formats & Tidy Data

"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



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

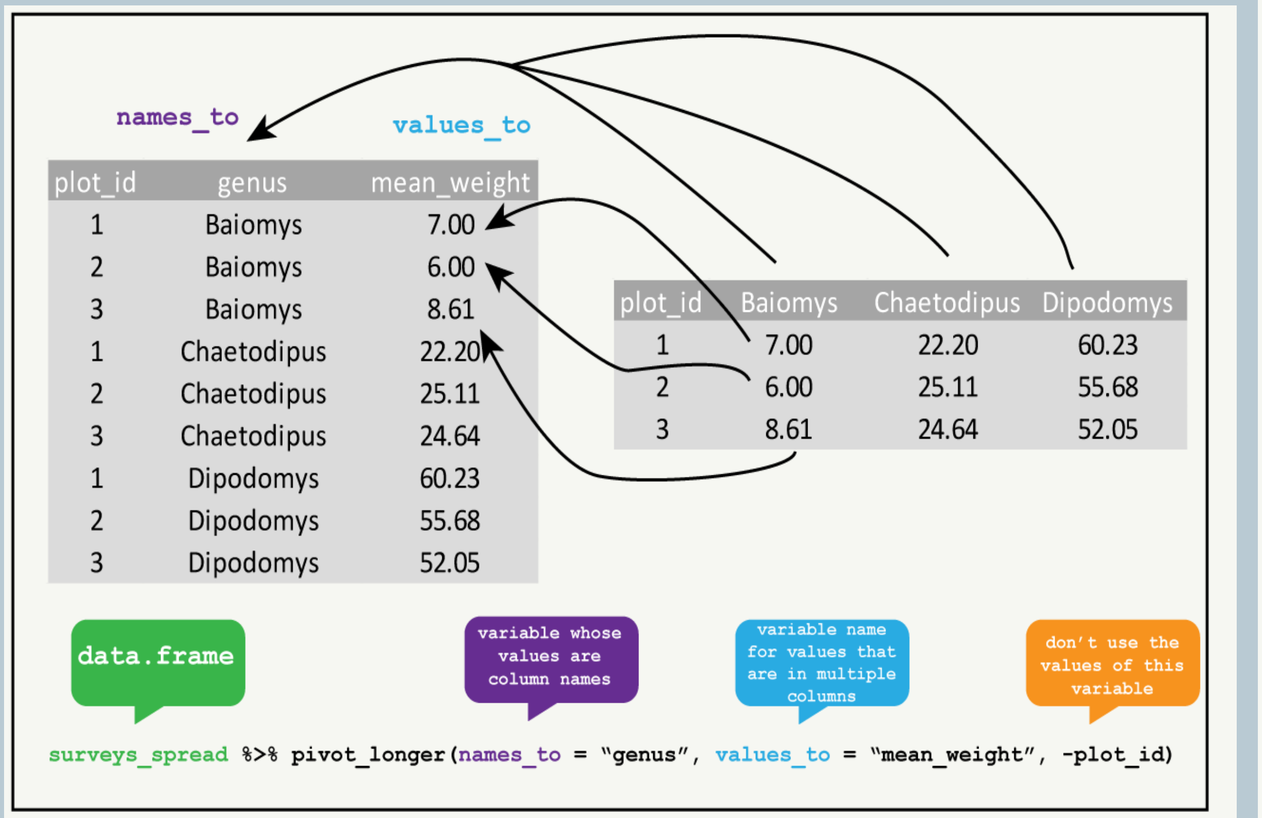
Wide format = generally untidy, but found in many datasets

Transforming Data (wide to long)

- pivot_longer()

Requires:

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



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

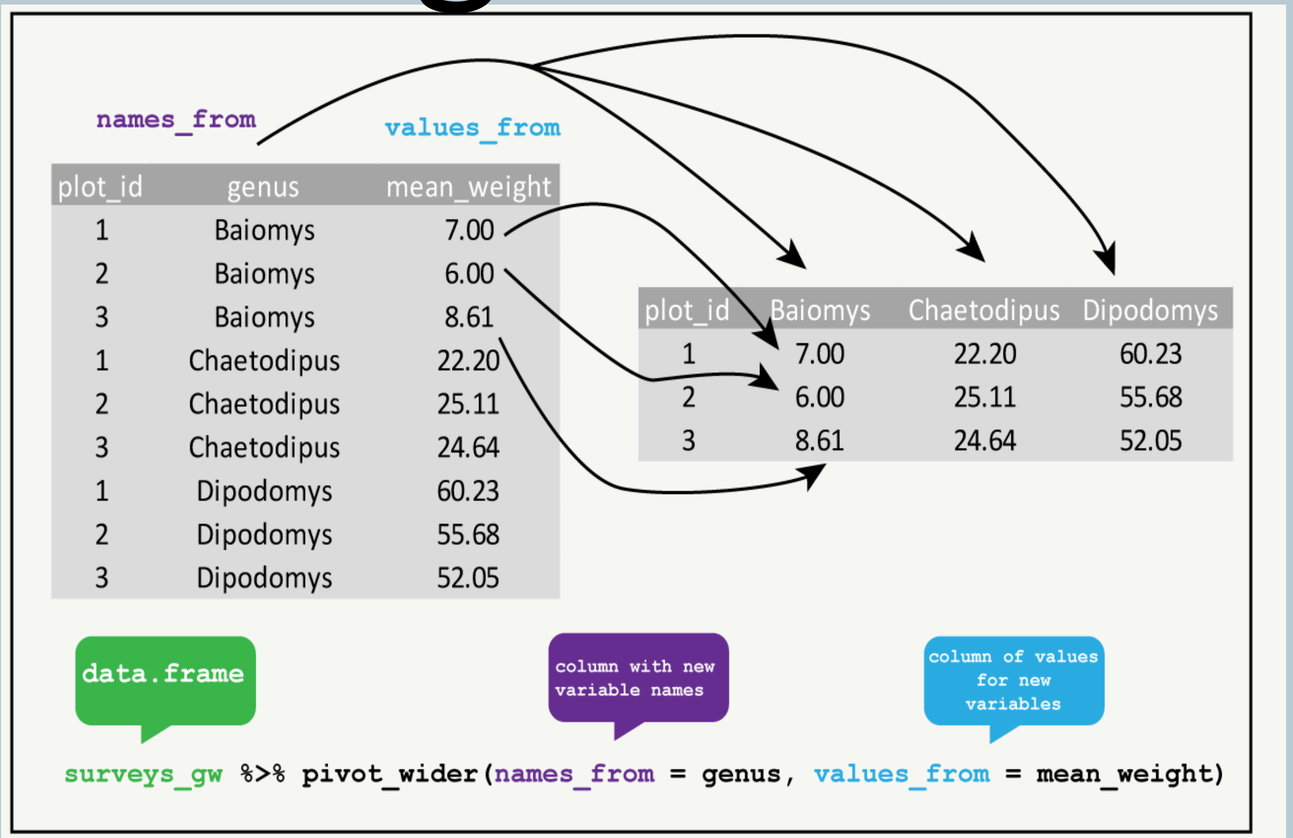
Credit: Epidemiologist R Handbook

Transforming Data
(long to wide)

- pivot_wider()

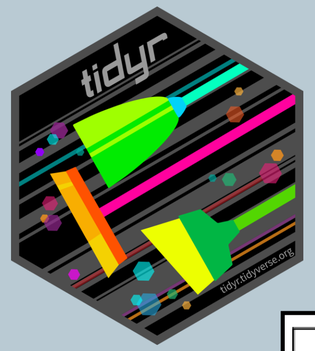
Requires:

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



Credit: Alistair Bailey's Coding TogetheR

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



Transforming Data

- pivot_wider() = long to wide

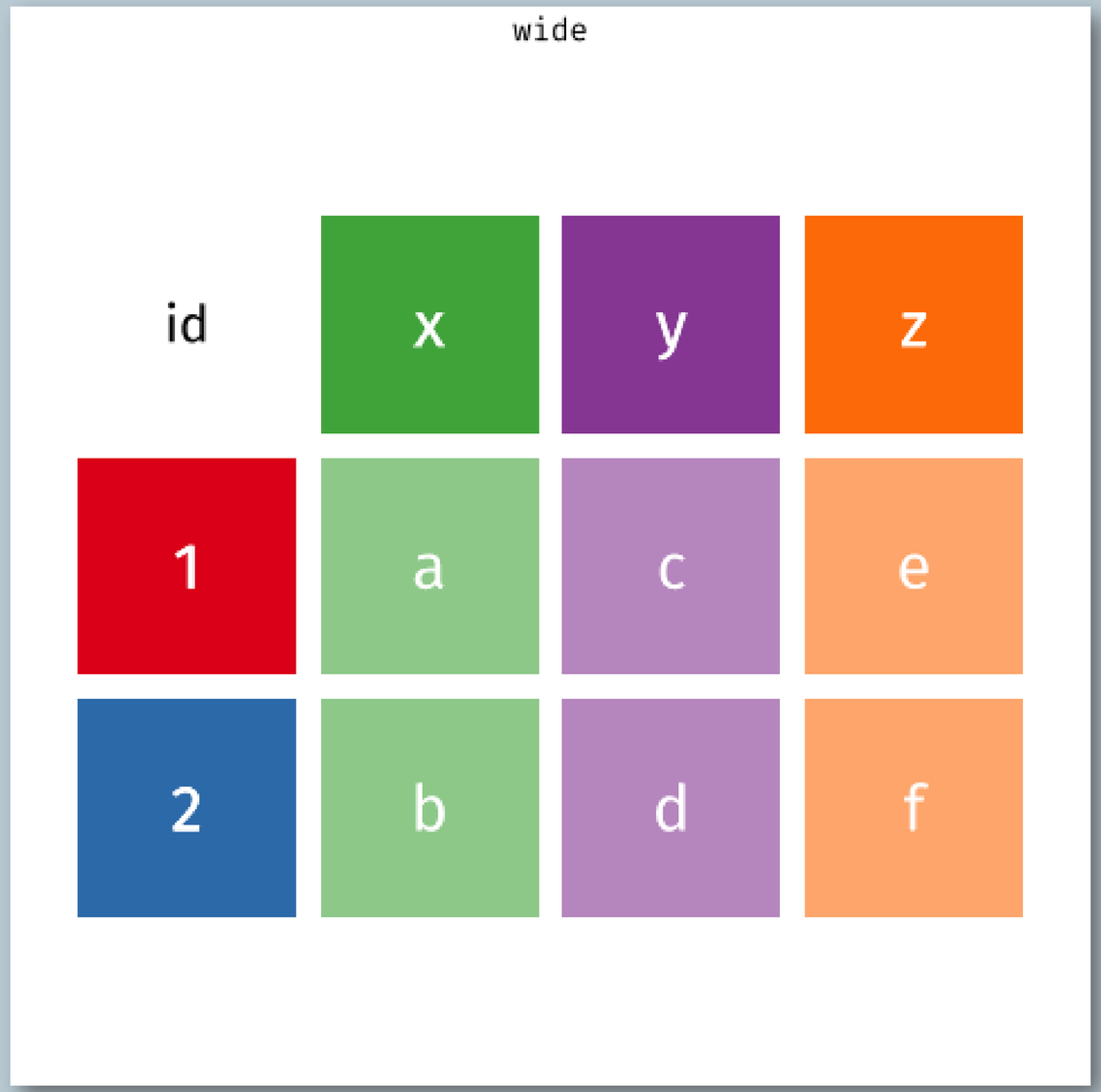
country	year	cases
Angola	1999	800
Angola	2000	750
Angola	2001	925
Angola	2002	1020
India	1999	20100
India	2000	25650
India	2001	26800
India	2002	27255
Mongolia	1999	450
Mongolia	2000	512
Mongolia	2001	510
Mongolia	2002	586

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"
  )
```

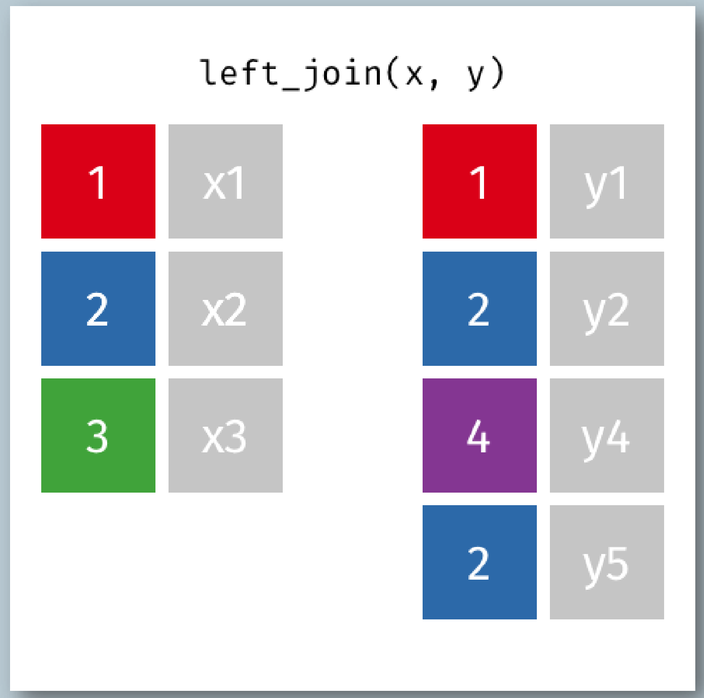
Credit: Epidemiologist R Handbook

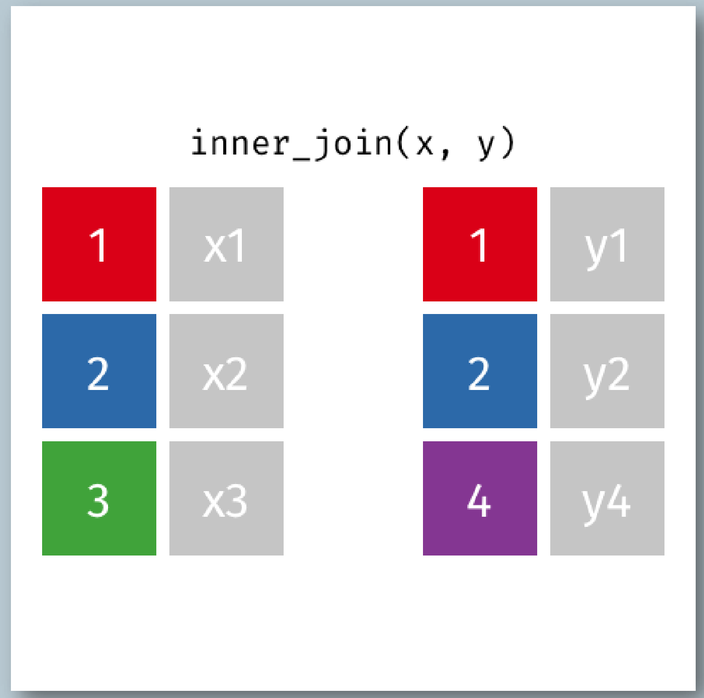


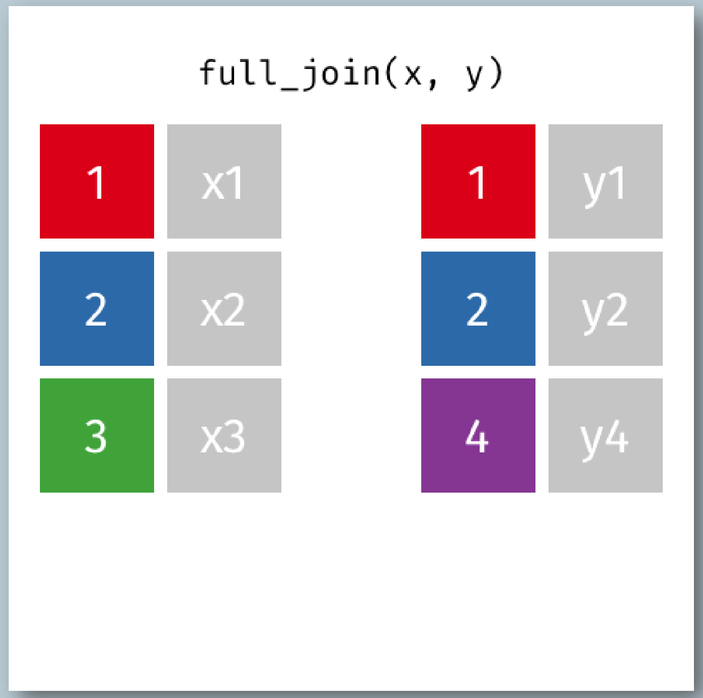
Credit: Garrick Aden-Buie & Mara Averick

Joins

- left_join()
- inner_join()
- full_join()

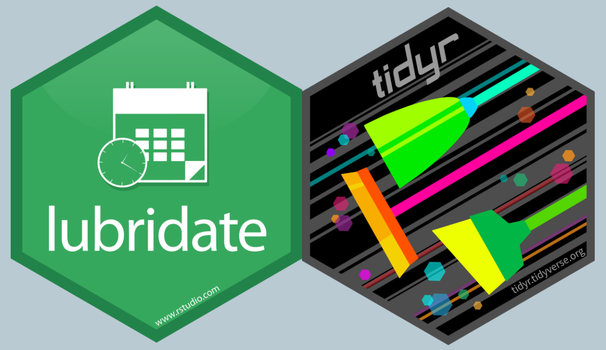






For a fun explanation using The Beatles & Rolling Stones see Nic Crane's tweet:
https://bit.ly/3qfhBb9

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)

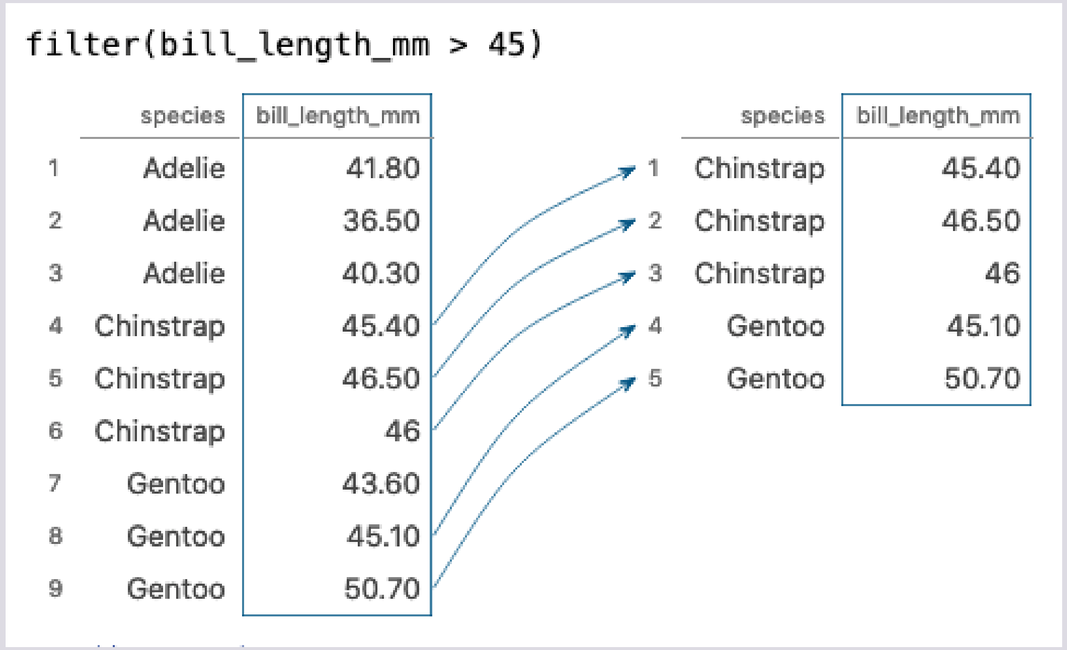
- separate() turns a character column into multiple columns

```
#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

Example: Visualisation of the filter() function



Tidy Data Tutor

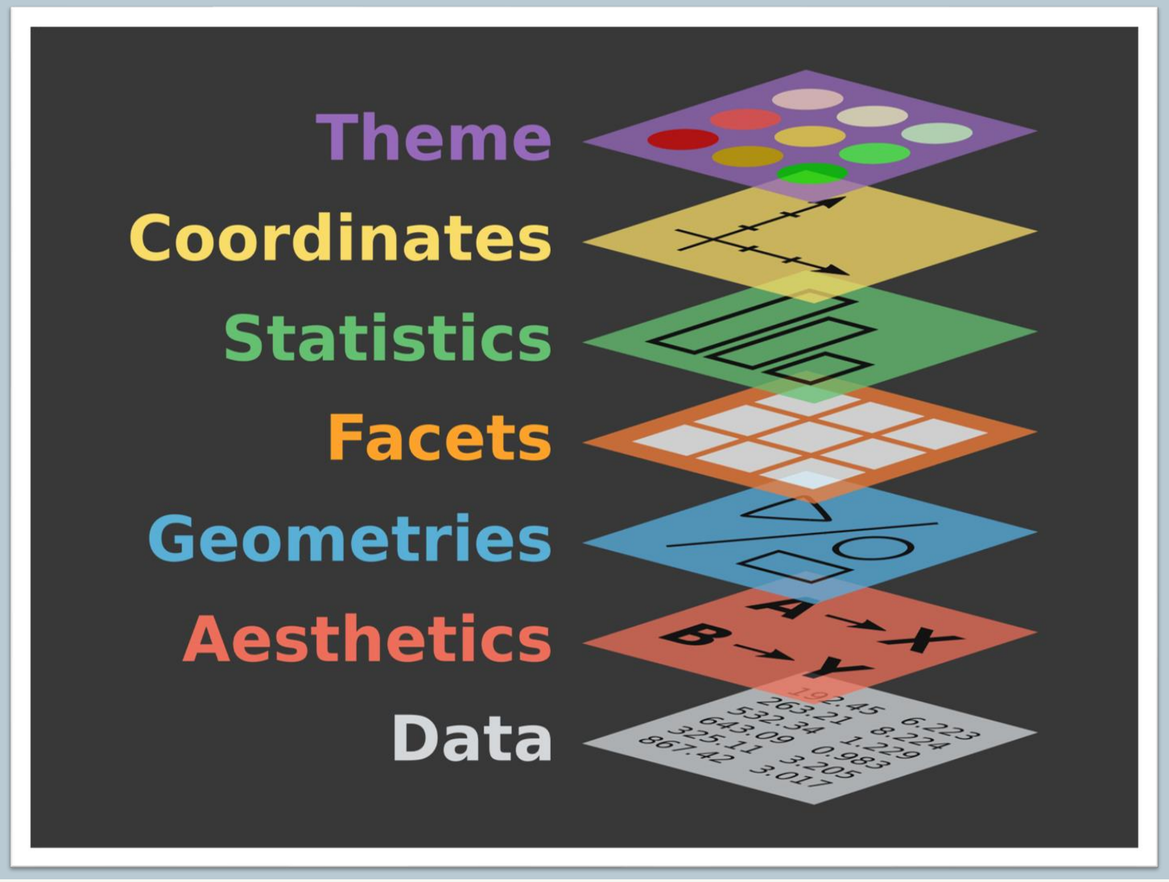
A potentially helpful revision and consolidation tool

https://tidydatatutor.com/

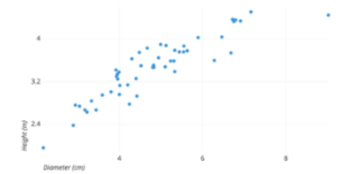
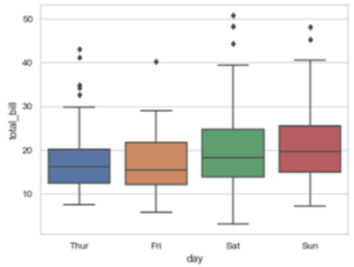
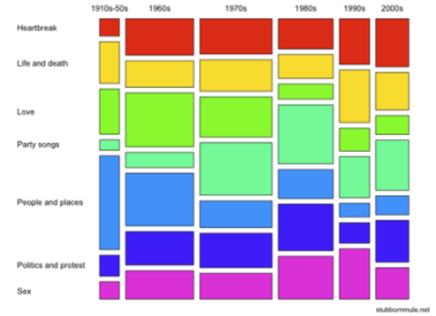
Plotting

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)

	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 recording in Week 4

Importance of variable class

ggplot2 Cheatsheet

Data Visualization with ggplot2 : : CHEAT SHEET

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.

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

Complete the template below to build a graph.

required

```
ggplot (data = <DATA>) +
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
 stat = <STAT>, position = <POSITION>) +
<COORDINATE_FUNCTION> +
<FACET_FUNCTION> +
<SCALE_FUNCTION> +
<THEME_FUNCTION>
```

Not required, sensible defaults 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")

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

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

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

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

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

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://sjspielman.github.io/introverse/articles/introverse_online.html

introverse 0.0.1 | Home | Get help here | Get help in RStudio | RStudio reference | Resources and tutorials

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`

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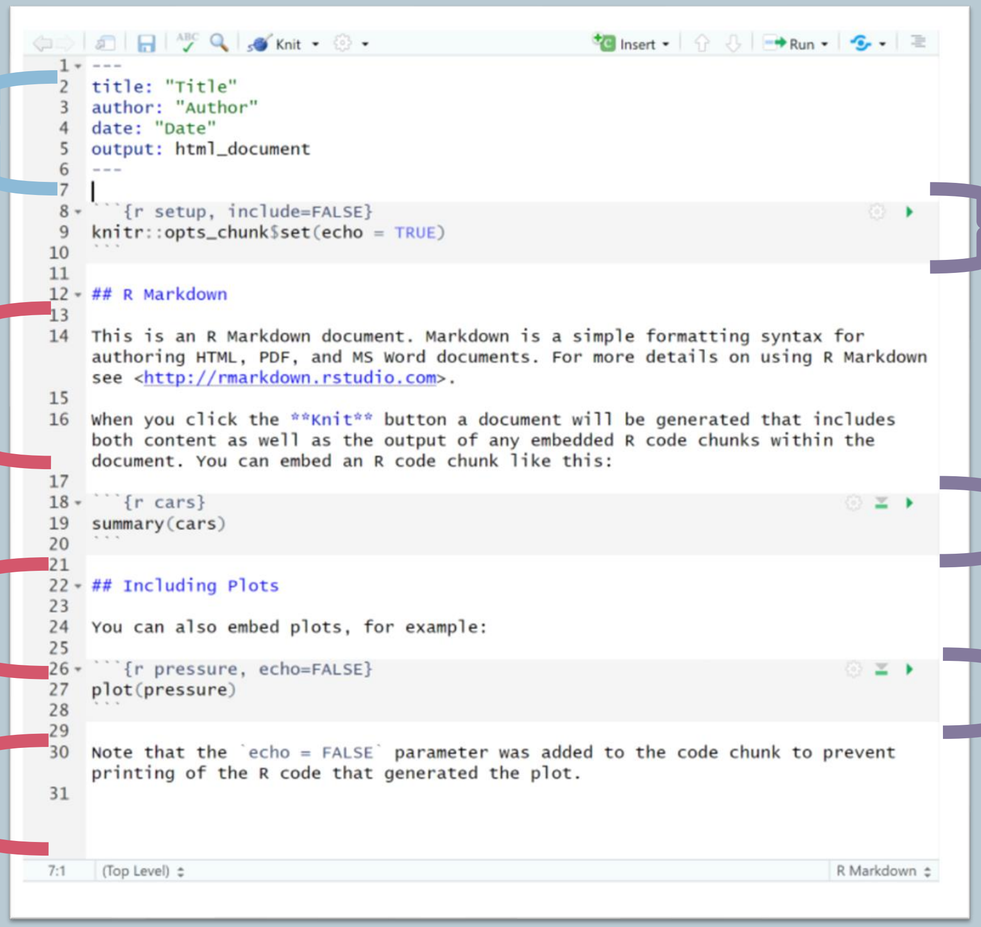
Report generation

Artwork by Allison Horst

R Markdown

- kbl() for nice tables



A bit more on knitting to PDFs

Questions?

R Programming Assignment

Due: Monday, 20th March at 12 noon GMT

See Learn pages "*Assessments*" for more info

Q&A around the assignment Wednesday 1st March 6pm!