Welcome to the tidyverse

Week 3

AEM 2850: R for Business Analytics

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Spring 2022

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Announcements

If you are new to the class, please review canvas announcements

Reminders:

- Bookmark aem2850.toddgerarden.com/schedule and visit often
- Submit assignments via canvas
  - Lab 2 was due yesterday (Monday) at 11:59pm
  - Reflection - Week 3 is due Wednesday at 11:59pm

Bring your laptop to class on Thursday!

Questions before we get started?

Plan for today

Prologue

Tidyverse basics

Data transformation with dplyr

- filter
- arrange
- select
- mutate
- summarize
- other goodies

Prologue

What sports do we watch?

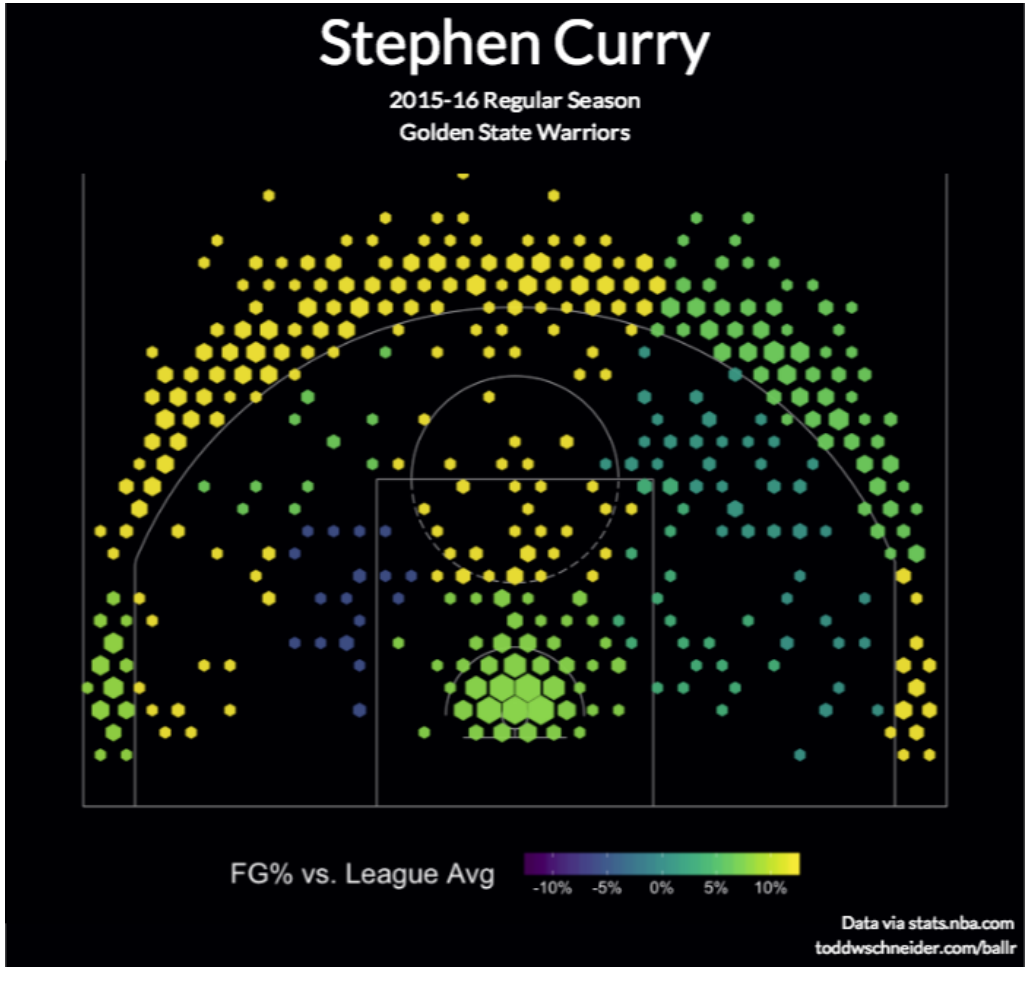
Take a guess: what's the most popular spectator sport among classmates?

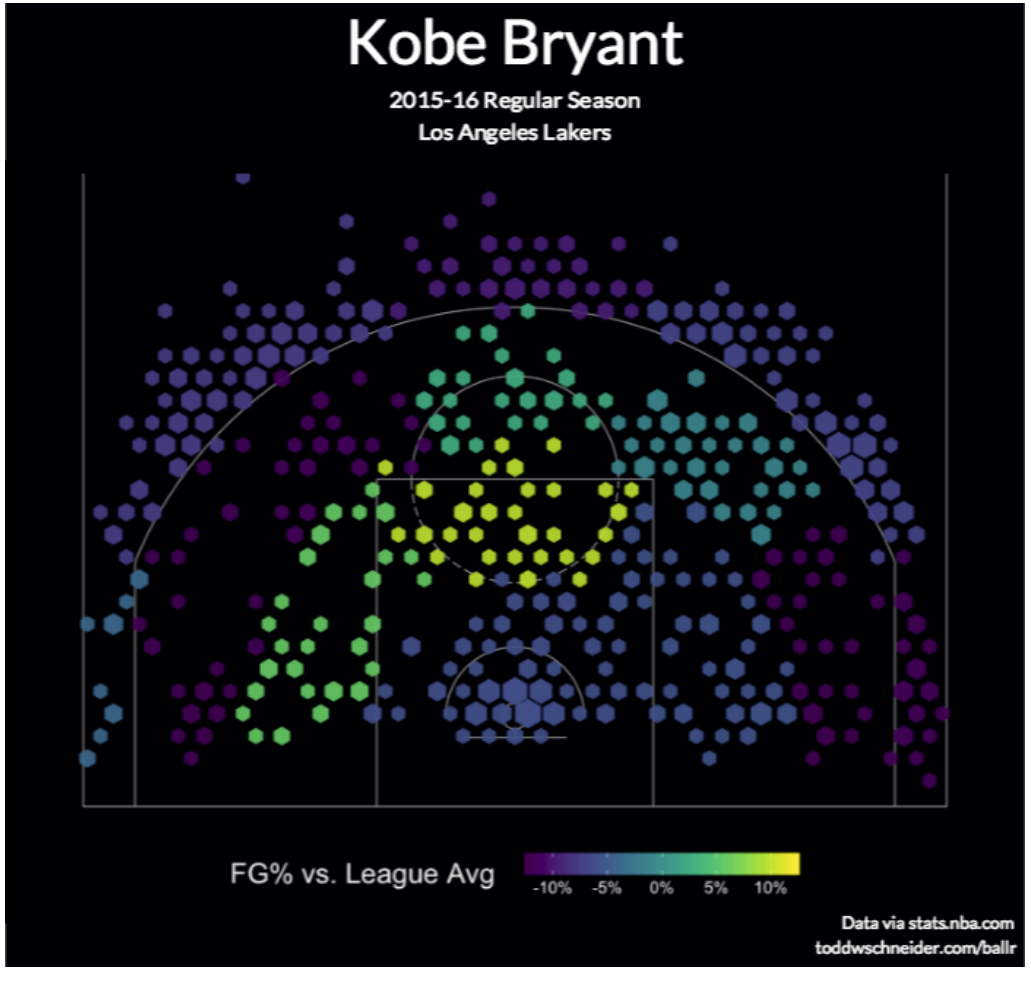
```
##  [1] "football"   "basketball" "volleyball" "soccer"     NA
##  [6] "baseball"   "football"   "basketball" "basketball" "football"
## [11] "gymnastics" "gymnastics" "squash"     NA           "basketball"
## [16] "gymnastics" "tennis"     "baseball"   "basketball" "basketball"
## [21] NA           "soccer"     "basketball" "baseball"   "tennis"
## [26] "polo"       "hockey"     "basketball" "gymnastics" "soccer"
## [31] "tennis"     NA           "soccer"     "cricket"    "tennis"
## [36] "tennis"     "badminton"  "football"   "football"
```

Let's `count` and `arrange` to get the top 3:

```
## # A tibble: 3 × 2
##   sport          n
##   <chr>      <int>
## 1 basketball     8
## 2 football       5
## 3 tennis         5
```

R can be used for sports analytics, too!





R "dialects"

Last week we introduced several R programming concepts:

- logical expressions
- assignment
- object types
- object names, namespace conflicts
- indexing

We did this using base R

- **pro:** comes in the box, close parallels to other programming languages
- **con:** can be confusing for new programmers (esp. indexing operations)

R "dialects"

This week we will start using the tidyverse

You can think of it as a different "dialect" of R

This dialect is more like human language

More intuitive if you're new to programming

So if Lab 2 was confusing, don't get discouraged!

Tidyverse basics

Tidyverse vs. base R

Lots of debate over tidyverse vs. base R

Why we're using the tidyverse:

- Consistent philosophy and syntax
- Great documentation and community support
- For data wrangling and plotting, tidyverse is 🔥

Base R is still great, can do some things tidyverse can't

data.table is another great alternative for data wrangling

Tidyverse vs. base R

Often a correspondence between tidyverse and base R commands:

tidyverse	base
`?readr::read_csv`	`?utils::read.csv`
`?dplyr::if_else`	`?base::ifelse`
`?tibble::tibble`	`?base::data.frame`

Tidyverse alternatives typically offer extra features

Remember: There are always multiple ways to do something in R

Let's load the tidyverse meta-package

```
library(tidyverse)
```

```
## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.1 ──

## ✓ ggplot2 3.3.5     ✓ purrr   0.3.4
## ✓ tibble  3.1.6     ✓ dplyr   1.0.7
## ✓ tidyr   1.1.4     ✓ stringr 1.4.0
## ✓ readr   2.1.1     ✓ forcats 0.5.1

## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## x tidyr::extract()   masks magrittr::extract()
## x dplyr::filter()    masks stats::filter()
## x dplyr::lag()       masks stats::lag()
## x purrr::set_names() masks magrittr::set_names()
```

We just loaded a bunch of packages: **ggplot2**, **tibble**, **dplyr**, etc.

We also see some **namespace conflicts**

Tidyverse packages

When you install the tidyverse, you actually get a lot more packages:

```
tidyverse_packages()
```

```
##  [1] "broom"        "cli"          "crayon"       "dbplyr"
##  [5] "dplyr"        "dtplyr"       "forcats"      "googledrive"
##  [9] "googlesheets4" "ggplot2"      "haven"        "hms"
## [13] "httr"         "jsonlite"     "lubridate"    "magrittr"
## [17] "modelr"       "pillar"       "purrr"        "readr"
## [21] "readxl"       "reprex"       "rlang"        "rstudioapi"
## [25] "rvest"        "stringr"      "tibble"       "tidyr"
## [29] "xml2"         "tidyverse"
```

These other packages have to be loaded separately

Tidyverse packages

Today we'll focus on **dplyr**

But first let's talk about tibbles and pipes

Review: What are objects?

There are many different *types* (or *classes*) of objects

Here are some objects that we'll be working with regularly:

- vectors
- matrices
- data frames
- lists
- functions

Review: Data frames

The most important object we'll work with is the **data frame**

You can think of it as an Excel spreadsheet

```
# Create a small data frame called "d"
d <- data.frame(x = 1:2, y = 3:4)
d
```

```
##   x y
## 1 1 3
## 2 2 4
```

This is essentially just a table with columns named x and y

Each row is an observation telling us the values of both x and y

Tibbles are data frames with opinions

For this class you can think of tibbles and data frames as synonymous

Tibbles have some advantages, such as pretty printing

We will primarily use tibbles in this course

Two functions may come in handy:

- `as_tibble()` converts data frames to tibbles
- `tibble()` creates new tibbles from scratch

See `vignette("tibble")` for more

Printing a data.frame

```
as.data.frame(starwars)
```

```
##                    name height   mass    hair_color          skin_color
## 1           Luke Skywalker    172   77.0         blond                fair
## 2                  C-3PO    167   75.0          <NA>                gold
## 3                  R2-D2     96   32.0          <NA>         white, blue
## 4              Darth Vader    202  136.0          none               white
## 5              Leia Organa    150   49.0         brown               light
## 6                Owen Lars    178  120.0   brown, grey               light
## 7       Beru Whitesun lars    165   75.0         brown               light
## 8                  R5-D4     97   32.0          <NA>          white, red
## 9        Biggs Darklighter    183   84.0         black               light
## 10         Obi-Wan Kenobi    182   77.0 auburn, white                fair
## 11       Anakin Skywalker    188   84.0         blond                fair
## 12         Wilhuff Tarkin    180     NA  auburn, grey                fair
## 13              Chewbacca    228  112.0         brown             unknown
## 14               Han Solo    180   80.0         brown                fair
## 15                 Greedo    173   74.0          <NA>               green
## 16 Jabba Desilijic Tiure    175 1358.0          <NA>   green-tan, brown
## 17        Wedge Antilles    170   77.0         brown                fair
## 18      Jek Tono Porkins    180  110.0         brown                fair
```

How could we make this look nicer?

```
as.data.frame(starwars)
```

```
##                    name height   mass    hair_color          skin_color
## 1           Luke Skywalker    172   77.0         blond                fair
## 2                  C-3PO    167   75.0          <NA>                gold
## 3                  R2-D2     96   32.0          <NA>         white, blue
## 4              Darth Vader    202  136.0          none               white
## 5              Leia Organa    150   49.0         brown               light
## 6                Owen Lars    178  120.0   brown, grey               light
## 7       Beru Whitesun lars    165   75.0         brown               light
## 8                  R5-D4     97   32.0          <NA>          white, red
## 9        Biggs Darklighter    183   84.0         black               light
## 10         Obi-Wan Kenobi    182   77.0 auburn, white                fair
## 11       Anakin Skywalker    188   84.0         blond                fair
## 12         Wilhuff Tarkin    180     NA  auburn, grey                fair
## 13              Chewbacca    228  112.0         brown             unknown
## 14              Han Solo    180   80.0         brown                fair
## 15                 Greedo    173   74.0          <NA>               green
## 16 Jabba Desilijic Tiure    175 1358.0          <NA>   green-tan, brown
## 17        Wedge Antilles    170   77.0         brown                fair
## 18      Jek Tono Porkins    180  110.0         brown                fair
```

Printing a data.frame with head()

```
head(as.data.frame(starwars))
```

```
##             name height mass  hair_color  skin_color eye_color birth_year
## 1 Luke Skywalker    172   77       blond        fair      blue       19.0
## 2          C-3PO    167   75        <NA>        gold    yellow      112.0
## 3          R2-D2     96   32        <NA> white, blue       red       33.0
## 4    Darth Vader    202  136        none       white    yellow       41.9
## 5    Leia Organa    150   49       brown       light     brown       19.0
## 6      Owen Lars    178  120 brown, grey       light      blue       52.0
##      sex    gender homeworld species
## 1   male masculine  Tatooine   Human
## 2   none masculine  Tatooine   Droid
## 3   none masculine     Naboo   Droid
## 4   male masculine  Tatooine   Human
## 5 female  feminine  Alderaan   Human
## 6   male masculine  Tatooine   Human
##
## 1                                          The Empire Strikes Back, Revenge of the Sith, Return of the
## 2                    The Empire Strikes Back, Attack of the Clones, The Phantom Menace, Revenge of the
## 3 The Empire Strikes Back, Attack of the Clones, The Phantom Menace, Revenge of the Sith, Return of the
## 4                                                                The Empire Strikes Back, Revenge of the
```

Printing a tibble

```
starwars
```

```
## # A tibble: 87 × 14
##    name    height  mass hair_color  skin_color eye_color birth_year sex   gender
##    <chr>    <int> <dbl> <chr>       <chr>      <chr>           <dbl> <chr> <chr>
##  1 Luke S…    172    77 blond       fair       blue             19   male  mascu…
##  2 C-3PO      167    75 <NA>        gold       yellow          112   none  mascu…
##  3 R2-D2       96    32 <NA>        white, bl… red              33   none  mascu…
##  4 Darth …    202   136 none        white      yellow           41.9 male  mascu…
##  5 Leia O…    150    49 brown       light      brown            19   fema… femin…
##  6 Owen L…    178   120 brown, grey light      blue             52   male  mascu…
##  7 Beru W…    165    75 brown       light      blue             47   fema… femin…
##  8 R5-D4       97    32 <NA>        white, red red              NA   none  mascu…
##  9 Biggs …    183    84 black       light      brown            24   male  mascu…
## 10 Obi-Wa…    182    77 auburn, wh… fair       blue-gray        57   male  mascu…
## # … with 77 more rows, and 5 more variables: homeworld <chr>, species <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

Pipes

Generic programming question: Does anyone know what pipes do?

Pipes allow us to pass information through a sequence of operations

The tidyverse loads its own pipe operator, denoted `%>%`

Keyboard shortcut: use `Ctrl/Cmd+Shift+m` to insert `%>%` (with spaces)

Pipe usage

To see why using pipes is so powerful, consider this contrived example based on what we did this morning:

1. Wake up
2. Get out of bed
3. Get dressed
4. Drink coffee
5. Go to class

A day without pipes

You could code this through a series of assignment operations:

```
me <- wake_up(me)
me <- get_out_of_bed(me)
me <- get_dressed(me)
me <- drink(me, "coffee")
me <- go(me, "class")
```

Or by putting all these operations in a single line of code:

```
me <- go(drink(get_dressed(get_out_of_bed(wake_up(me))), "coffee"), "class")
```

Neither is ideal

Pipes are the best of both worlds

We can do everything at once, in order:

```
me %>%
  wake_up() %>%
  get_out_of_bed() %>%
  get_dressed() %>%
  drink("coffee") %>%
  go("class")
```

Emphasis is on verbs (e.g., `wake_up`, `get_out_of_bed`, etc.), not nouns (i.e., `me`)

Pipes: Best practices

Write linear code

Spread code out for readability: use one line per verb

Don't use pipes...

- when you need more than 10 (use intermediate objects instead)
- for multiple inputs or outputs
- for non-linear relationships

Aside: due to the popularity of %>%, base R now includes a native pipe |> with slightly different properties. We will use %>% in this class.

dplyr

What is dplyr?

What is dplyr?

The dplyr package provides a **grammar of data manipulation**

dplyr's functions are **verbs** that correspond to things we want to **do**

dplyr functions all have these things in common:

1. their first argument is a data frame
2. their other arguments describe what you want to do
3. their output is a new data frame

1 + 3 + %>% allow us to combine simple steps to achieve complex results

dplyr has five key verbs we will use

1. `filter`: subset rows based on their values
2. `arrange`: reorder rows based on their values
3. `select`: select columns (i.e., variables)
4. `mutate`: create new columns
5. `summarize`: collapse multiple rows into a single summary value

dplyr verbs operate on different things

- Rows:
  - `filter`: subset rows based on their values
  - `arrange`: reorder rows based on their values
- Columns:
  - `select`: select columns (i.e., variables)
  - `mutate`: create new columns
- Groups of rows:
  - `summarize`: collapse multiple rows into a single summary value

Let's study these commands together using the `starwars` data frame that comes pre-packaged with dplyr

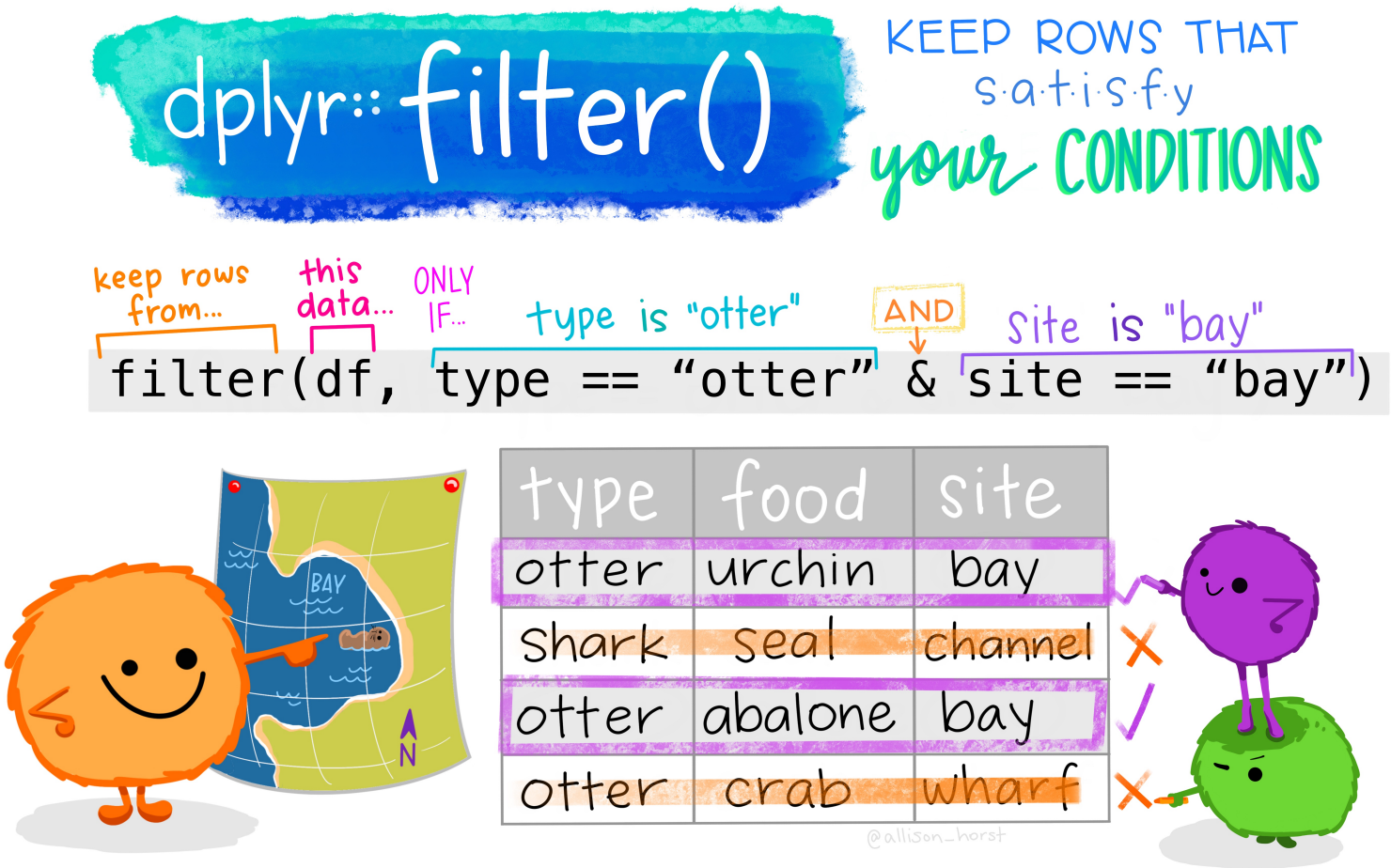
Starwars

As a reminder, this is what the `starwars` dataset looks like:

```
starwars
```

```
## # A tibble: 87 × 14
##    name    height  mass hair_color  skin_color eye_color birth_year sex   gender
##    <chr>    <int> <dbl> <chr>       <chr>      <chr>           <dbl> <chr> <chr>
##  1 Luke S…    172    77 blond       fair       blue             19   male  mascu…
##  2 C-3PO      167    75 <NA>        gold       yellow          112   none  mascu…
##  3 R2-D2       96    32 <NA>        white, bl… red              33   none  mascu…
##  4 Darth …    202   136 none        white      yellow           41.9 male  mascu…
##  5 Leia O…    150    49 brown       light      brown            19   fema… femin…
##  6 Owen L…    178   120 brown, grey light      blue             52   male  mascu…
##  7 Beru W…    165    75 brown       light      blue             47   fema… femin…
##  8 R5-D4       97    32 <NA>        white, red red              NA   none  mascu…
##  9 Biggs …    183    84 black       light      brown            24   male  mascu…
## 10 Obi-Wa…    182    77 auburn, wh… fair       blue-gray        57   male  mascu…
## # … with 77 more rows, and 5 more variables: homeworld <chr>, species <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

1) dplyr::filter



1) dplyr::filter

`filter` allows us to focus on certain rows / observations

For example, you may only be interested in droids:

```
starwars %>%
  filter(species == "Droid")
```

```
## # A tibble: 6 × 14
##   name   height  mass hair_color skin_color  eye_color birth_year sex   gender
##   <chr>   <int> <dbl> <chr>      <chr>       <chr>           <dbl> <chr> <chr>
## 1 C-3PO     167    75 <NA>       gold        yellow            112 none  masculi…
## 2 R2-D2      96    32 <NA>       white, blue red                33 none  masculi…
## 3 R5-D4      97    32 <NA>       white, red  red                NA none  masculi…
## 4 IG-88     200   140 none       metal       red                15 none  masculi…
## 5 R4-P17     96    NA none       silver, red red, blue          NA none  feminine
## 6 BB8        NA    NA none       none        black              NA none  masculi…
## # … with 5 more variables: homeworld <chr>, species <chr>, films <list>,
## #   vehicles <list>, starships <list>
```

1) dplyr::filter

Or perhaps you want to subset the humans that are taller than I am:

```
starwars %>%
  filter(
    species == "Human",
    height >= 194
    )
```

Can you name one? *Hint: there's only one*

```
## # A tibble: 1 × 14
##   name     height  mass hair_color skin_color eye_color birth_year sex   gender
##   <chr>     <int> <dbl> <chr>      <chr>      <chr>           <dbl> <chr> <chr>
## 1 Darth V…    202   136 none       white      yellow           41.9 male  mascul…
## # … with 5 more variables: homeworld <chr>, species <chr>, films <list>,
## #   vehicles <list>, starships <list>
```

1) dplyr::filter

Regular expressions work here too, with the help of the `stringr` package:

```
starwars %>%
  filter(stringr::str_detect(name, "Skywalker"))
```

```
## # A tibble: 3 × 14
##   name     height  mass hair_color skin_color eye_color birth_year sex    gender
##   <chr>     <int> <dbl> <chr>      <chr>      <chr>           <dbl> <chr>  <chr>
## 1 Luke Sk…    172    77 blond      fair       blue             19   male   mascu…
## 2 Anakin …    188    84 blond      fair       blue             41.9 male   mascu…
## 3 Shmi Sk…    163    NA black      fair       brown            72   female femin…
## # … with 5 more variables: homeworld <chr>, species <chr>, films <list>,
## #   vehicles <list>, starships <list>
```

Or you can use `grepl` to achieve the same goal:

```
starwars %>%
  filter(grepl("Skywalker", name))
```

1) dplyr::filter

A very common `filter` use case is identifying/removing missing data:

```
starwars %>%
  filter(is.na(height))
```

```
## # A tibble: 6 × 14
##   name     height  mass hair_color skin_color eye_color birth_year sex    gender
##   <chr>     <int> <dbl> <chr>      <chr>      <chr>           <dbl> <chr>  <chr>
## 1 Arvel C…     NA    NA brown      fair       brown              NA male   mascu…
## 2 Finn         NA    NA black      dark       dark               NA male   mascu…
## 3 Rey          NA    NA brown      light      hazel              NA female femin…
## 4 Poe Dam…     NA    NA brown      light      brown              NA male   mascu…
## 5 BB8          NA    NA none       none       black              NA none   mascu…
## 6 Captain…     NA    NA unknown    unknown    unknown            NA <NA>   <NA>
## # … with 5 more variables: homeworld <chr>, species <chr>, films <list>,
## #   vehicles <list>, starships <list>
```

1) dplyr::filter

How could you build on this to remove missing observations?

```
starwars %>%
  filter(!is.na(height)) # use ! for negation
```

```
## # A tibble: 81 × 14
##    name    height  mass hair_color  skin_color eye_color birth_year sex   gender
##    <chr>    <int> <dbl> <chr>       <chr>      <chr>           <dbl> <chr> <chr>
##  1 Luke S…    172    77 blond       fair       blue             19   male  mascu…
##  2 C-3PO      167    75 <NA>        gold       yellow          112   none  mascu…
##  3 R2-D2       96    32 <NA>        white, bl… red              33   none  mascu…
##  4 Darth …    202   136 none        white      yellow           41.9 male  mascu…
##  5 Leia O…    150    49 brown       light      brown            19   fema… femin…
##  6 Owen L…    178   120 brown, grey light      blue             52   male  mascu…
##  7 Beru W…    165    75 brown       light      blue             47   fema… femin…
##  8 R5-D4       97    32 <NA>        white, red red              NA   none  mascu…
##  9 Biggs …    183    84 black       light      brown            24   male  mascu…
## 10 Obi-Wa…    182    77 auburn, wh… fair       blue-gray        57   male  mascu…
## # … with 71 more rows, and 5 more variables: homeworld <chr>, species <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

2) dplyr::arrange

`arrange` sorts the data frame based on the variable(s) you supply:

```
starwars %>%
  arrange(birth_year)
```

```
## # A tibble: 87 × 14
##    name     height  mass hair_color skin_color eye_color birth_year sex   gender
##    <chr>     <int> <dbl> <chr>      <chr>      <chr>           <dbl> <chr> <chr>
##  1 Wicket …     88  20   brown      brown      brown             8   male  mascu…
##  2 IG-88       200 140   none       metal      red              15   none  mascu…
##  3 Luke Sk…    172  77   blond      fair       blue             19   male  mascu…
##  4 Leia Or…    150  49   brown      light      brown            19   fema… femin…
##  5 Wedge A…    170  77   brown      fair       hazel            21   male  mascu…
##  6 Plo Koon    188  80   none       orange     black            22   male  mascu…
##  7 Biggs D…    183  84   black      light      brown            24   male  mascu…
##  8 Han Solo    180  80   brown      fair       brown            29   male  mascu…
##  9 Lando C…    177  79   black      dark       brown            31   male  mascu…
## 10 Boba Fe…    183  78.2 black      fair       brown            31.5 male  mascu…
## # … with 77 more rows, and 5 more variables: homeworld <chr>, species <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

2) dplyr::arrange

We can also arrange items in descending order using `arrange(desc())`:

```
starwars %>%
  arrange(desc(birth_year))
```

```
## # A tibble: 87 × 14
##    name    height  mass hair_color skin_color  eye_color birth_year sex   gender
##    <chr>    <int> <dbl> <chr>      <chr>       <chr>           <dbl> <chr> <chr>
##  1 Yoda        66    17 white      green       brown             896 male  mascu…
##  2 Jabba …    175  1358 <NA>       green-tan,… orange            600 herm… mascu…
##  3 Chewba…    228   112 brown      unknown     blue              200 male  mascu…
##  4 C-3PO      167    75 <NA>       gold        yellow            112 none  mascu…
##  5 Dooku      193    80 white      fair        brown             102 male  mascu…
##  6 Qui-Go…    193    89 brown      fair        blue               92 male  mascu…
##  7 Ki-Adi…    198    82 white      pale        yellow             92 male  mascu…
##  8 Finis …    170    NA blond      fair        blue               91 male  mascu…
##  9 Palpat…    170    75 grey       pale        yellow             82 male  mascu…
## 10 Cliegg…    183    NA brown      fair        blue               82 male  mascu…
## # … with 77 more rows, and 5 more variables: homeworld <chr>, species <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

3) dplyr::select

`select` allows us to select columns / variables:

```
starwars %>% select(name)
```

```
## # A tibble: 87 × 1
##    name
##    <chr>
##  1 Luke Skywalker
##  2 C-3PO
##  3 R2-D2
##  4 Darth Vader
##  5 Leia Organa
##  6 Owen Lars
##  7 Beru Whitesun lars
##  8 R5-D4
##  9 Biggs Darklighter
## 10 Obi-Wan Kenobi
## # … with 77 more rows
```

`select` returns a tibble even though you only asked for one variable

To get a vector, you can use:

- `starwars %>% pull(name)`

Or, from base R:

- `starwars %>% .$name`
- `starwars %>% .[["name"]]`

3) dplyr::select

You can get fancy: use commas to select multiple columns, deselect a column using "-", and select consecutive columns using "first:last"

```
starwars %>%
  select(name:skin_color, species, -height)
```

```
## # A tibble: 87 × 5
##    name                mass hair_color    skin_color  species
##    <chr>              <dbl> <chr>         <chr>       <chr>
##  1 Luke Skywalker        77 blond         fair        Human
##  2 C-3PO                 75 <NA>          gold        Droid
##  3 R2-D2                 32 <NA>          white, blue Droid
##  4 Darth Vader          136 none          white       Human
##  5 Leia Organa           49 brown         light       Human
##  6 Owen Lars            120 brown, grey   light       Human
##  7 Beru Whitesun lars    75 brown         light       Human
##  8 R5-D4                 32 <NA>          white, red  Droid
##  9 Biggs Darklighter     84 black         light       Human
## 10 Obi-Wan Kenobi        77 auburn, white fair        Human
## # … with 77 more rows
```

3) dplyr::select

You can also rename your selected variables at the same time:

```
starwars %>%
  select(alias = name, crib = homeworld)
```

```
## # A tibble: 87 × 2
##    alias              crib
##    <chr>              <chr>
##  1 Luke Skywalker     Tatooine
##  2 C-3PO              Tatooine
##  3 R2-D2              Naboo
##  4 Darth Vader        Tatooine
##  5 Leia Organa        Alderaan
##  6 Owen Lars          Tatooine
##  7 Beru Whitesun lars Tatooine
##  8 R5-D4              Tatooine
##  9 Biggs Darklighter  Tatooine
## 10 Obi-Wan Kenobi     Stewjon
## # … with 77 more rows
```

3) dplyr::select

If you just want to rename columns without subsetting them, use `rename`:

```
starwars %>%
  rename(alias = name, crib = homeworld)
```

```
## # A tibble: 87 × 14
##    alias   height  mass hair_color  skin_color eye_color birth_year sex   gender
##    <chr>    <int> <dbl> <chr>       <chr>      <chr>           <dbl> <chr> <chr>
##  1 Luke S…    172    77 blond       fair       blue             19   male  mascu…
##  2 C-3PO      167    75 <NA>        gold       yellow          112   none  mascu…
##  3 R2-D2       96    32 <NA>        white, bl… red              33   none  mascu…
##  4 Darth …    202   136 none        white      yellow           41.9 male  mascu…
##  5 Leia O…    150    49 brown       light      brown            19   fema… femin…
##  6 Owen L…    178   120 brown, grey light      blue             52   male  mascu…
##  7 Beru W…    165    75 brown       light      blue             47   fema… femin…
##  8 R5-D4       97    32 <NA>        white, red red              NA   none  mascu…
##  9 Biggs …    183    84 black       light      brown            24   male  mascu…
## 10 Obi-Wa…    182    77 auburn, wh… fair       blue-gray        57   male  mascu…
## # … with 77 more rows, and 5 more variables: crib <chr>, species <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

3) dplyr::select

`select(contains(PATTERN))` provides a handy shortcut:

```
starwars %>%
  select(name, contains("color"))
```

```
## # A tibble: 87 × 4
##    name               hair_color    skin_color  eye_color
##    <chr>              <chr>         <chr>       <chr>
##  1 Luke Skywalker     blond         fair        blue
##  2 C-3PO              <NA>          gold        yellow
##  3 R2-D2              <NA>          white, blue red
##  4 Darth Vader        none          white       yellow
##  5 Leia Organa        brown         light       brown
##  6 Owen Lars          brown, grey   light       blue
##  7 Beru Whitesun lars brown         light       blue
##  8 R5-D4              <NA>          white, red  red
##  9 Biggs Darklighter  black         light       brown
## 10 Obi-Wan Kenobi     auburn, white fair        blue-gray
## # … with 77 more rows
```

3) dplyr::select

`select(..., everything())` is another useful shortcut to move important variables to the "front" of a data frame

```
starwars %>%
  select(species, homeworld, everything()) %>%
  head(5)
```

```
## # A tibble: 5 × 14
##   species homeworld name           height  mass hair_color skin_color  eye_color
##   <chr>   <chr>     <chr>           <int> <dbl> <chr>      <chr>       <chr>
## 1 Human   Tatooine  Luke Skywalker    172    77 blond      fair        blue
## 2 Droid   Tatooine  C-3PO             167    75 <NA>       gold        yellow
## 3 Droid   Naboo     R2-D2              96    32 <NA>       white, blue red
## 4 Human   Tatooine  Darth Vader       202   136 none       white       yellow
## 5 Human   Alderaan  Leia Organa       150    49 brown      light       brown
## # … with 6 more variables: birth_year <dbl>, sex <chr>, gender <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

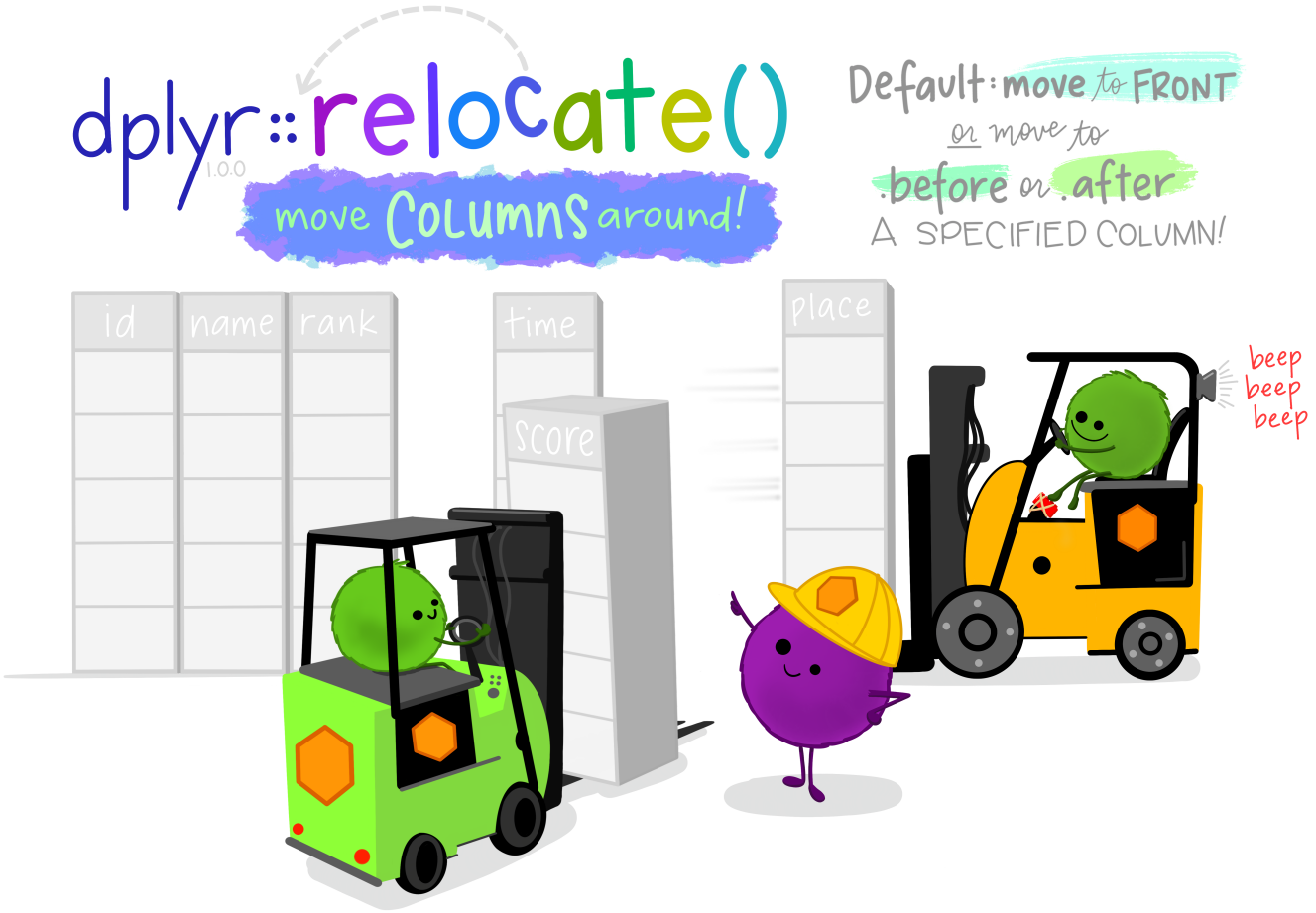
3) dplyr::~~select~~ relocate

You can also use `relocate` to reorder columns without subsetting:

```
starwars %>%
  relocate(species, homeworld) %>%
  head(5)
```

```
## # A tibble: 5 × 14
##   species homeworld name           height  mass hair_color skin_color  eye_color
##   <chr>   <chr>     <chr>           <int> <dbl> <chr>      <chr>       <chr>
## 1 Human   Tatooine  Luke Skywalker    172    77 blond      fair        blue
## 2 Droid   Tatooine  C-3PO             167    75 <NA>       gold        yellow
## 3 Droid   Naboo     R2-D2              96    32 <NA>       white, blue red
## 4 Human   Tatooine  Darth Vader       202   136 none       white       yellow
## 5 Human   Alderaan  Leia Organa       150    49 brown      light       brown
## # … with 6 more variables: birth_year <dbl>, sex <chr>, gender <chr>,
## #   films <list>, vehicles <list>, starships <list>
```

3) dplyr::~~select~~ relocate



4) dplyr::mutate

4) dplyr::mutate

You can create new columns from scratch or by transforming existing columns:

```
starwars %>%
  select(name, birth_year) %>%
  mutate(dog_years = birth_year * 7) %>%
  mutate(comment = paste0(name, " is ", dog_years, " in dog years."))
```

```
## # A tibble: 87 × 4
##    name               birth_year dog_years comment
##    <chr>                   <dbl>     <dbl> <chr>
##  1 Luke Skywalker           19        133  Luke Skywalker is 133 in dog years.
##  2 C-3PO                   112        784  C-3PO is 784 in dog years.
##  3 R2-D2                    33        231  R2-D2 is 231 in dog years.
##  4 Darth Vader              41.9      293. Darth Vader is 293.3 in dog years.
##  5 Leia Organa              19        133  Leia Organa is 133 in dog years.
##  6 Owen Lars                52        364  Owen Lars is 364 in dog years.
##  7 Beru Whitesun lars       47        329  Beru Whitesun lars is 329 in dog yea…
##  8 R5-D4                    NA         NA  R5-D4 is NA in dog years.
##  9 Biggs Darklighter        24        168  Biggs Darklighter is 168 in dog year…
## 10 Obi-Wan Kenobi           57        399  Obi-Wan Kenobi is 399 in dog years.
```

4) dplyr::mutate

`mutate` creates variables in order, so we can chain them together in a single call:

```
starwars %>%
  select(name, birth_year) %>%
  mutate(dog_years = birth_year * 7, # separate with a comma
         comment = paste0(name, " is ", dog_years, " in dog years."))
```

```
## # A tibble: 87 × 4
##    name               birth_year dog_years comment
##    <chr>                   <dbl>     <dbl> <chr>
##  1 Luke Skywalker           19        133  Luke Skywalker is 133 in dog years.
##  2 C-3PO                   112        784  C-3PO is 784 in dog years.
##  3 R2-D2                    33        231  R2-D2 is 231 in dog years.
##  4 Darth Vader              41.9      293. Darth Vader is 293.3 in dog years.
##  5 Leia Organa              19        133  Leia Organa is 133 in dog years.
##  6 Owen Lars                52        364  Owen Lars is 364 in dog years.
##  7 Beru Whitesun lars       47        329  Beru Whitesun lars is 329 in dog yea…
##  8 R5-D4                    NA         NA  R5-D4 is NA in dog years.
##  9 Biggs Darklighter        24        168  Biggs Darklighter is 168 in dog year…
## 10 Obi-Wan Kenobi           57        399  Obi-Wan Kenobi is 399 in dog years.
```

4) dplyr::mutate

Boolean, logical, and conditional operators all work well with `mutate`:

```
starwars %>%
  select(name, height) %>%
  filter(name %in% c("Luke Skywalker", "Anakin Skywalker")) %>%
  mutate(tall1 = height > 180) %>%
  mutate(tall2 = ifelse(height > 180, "Tall", "Short")) # same effect, but can choose labels
```

How many rows do you think this will return? How many columns?

```
## # A tibble: 2 × 4
##   name             height tall1 tall2
##   <chr>             <int> <lgl> <chr>
## 1 Luke Skywalker      172 FALSE Short
## 2 Anakin Skywalker    188 TRUE  Tall
```

5) dplyr::summarize

Often we want to get summary statistics or *collapse* our data

`summarize` provides an easy way to do this

Example from Lab 2: "What are the mininum, maximum, and average prices of the diamonds?"

```
diamonds %>%
  summarize(min = min(price),      # calculate the min price
            max = max(price),      # calculate the max price
            average = mean(price)) # calculate the mean price
```

```
## # A tibble: 1 × 3
##     min   max average
##   <int> <int>   <dbl>
## 1   326 18823   3933.
```

5) dplyr::summarize

Including "na.rm = TRUE" keeps NAs from propagating to the end result:

```
# Probably not what we want
starwars %>%
  summarize(mh = mean(height))
```

```
## # A tibble: 1 × 1
##      mh
##   <dbl>
## 1    NA
```

```
# Much better
starwars %>%
  summarize(mh = mean(height, na.rm = TRUE))
```

```
## # A tibble: 1 × 1
##      mh
##   <dbl>
## 1  174.
```

Is this a feature or a bug?

It depends on the context!

Bonus: dplyr::group_by

`summarize` is particularly useful in combination with `group_by`:

```
starwars %>%
  group_by(species, gender) %>% # for each species-gender combo
  summarize(mean_height = mean(height, na.rm = TRUE)) # calculate the mean height
```

```
## `summarise()` has grouped output by 'species'. You can override using the `.groups` argument.
```

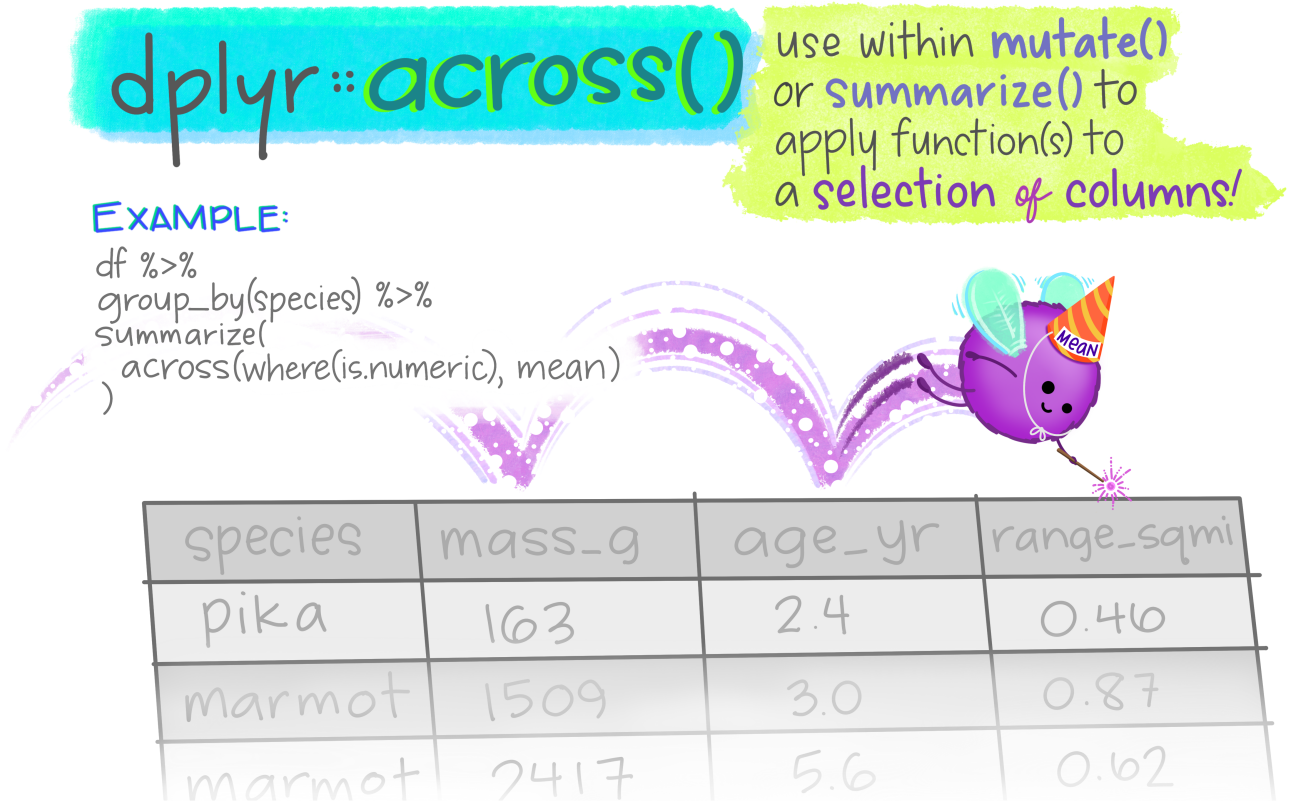
```
## # A tibble: 42 × 3
## # Groups:   species [38]
##    species   gender    mean_height
##    <chr>     <chr>           <dbl>
##  1 Aleena    masculine          79
##  2 Besalisk  masculine         198
##  3 Cerean    masculine         198
##  4 Chagrian  masculine         196
##  5 Clawdite  feminine          168
##  6 Droid     feminine           96
##  7 Droid     masculine         140
##  8 Dug       masculine         112
```

Bonus: dplyr::ungroup

Groups are persistent, `ungroup` removes them

Other dplyr goodies for your reference

Other dplyr goodies: across



Other dplyr goodies: across

Combining `mutate` with `across` allows you to work on a subset of variables:

```
starwars %>%
  select(name:eye_color) %>%
  mutate(across(where(is.character), toupper)) %>% # capitalize all character variables
  head(5)
```

```
## # A tibble: 5 × 6
##   name           height  mass hair_color skin_color  eye_color
##   <chr>           <int> <dbl> <chr>      <chr>       <chr>
## 1 LUKE SKYWALKER    172    77 BLOND      FAIR        BLUE
## 2 C-3PO             167    75 <NA>       GOLD        YELLOW
## 3 R2-D2              96    32 <NA>       WHITE, BLUE RED
## 4 DARTH VADER       202   136 NONE       WHITE       YELLOW
## 5 LEIA ORGANA       150    49 BROWN      LIGHT       BROWN
```

Other dplyr goodies: across

We can also use `across` within `summarize`:

```
starwars %>%
  group_by(species) %>%
  summarize(across(where(is.numeric), mean, na.rm=T)) %>% # take the mean of all numeric variables
  head(5)
```

```
## # A tibble: 5 × 4
##   species  height  mass birth_year
##   <chr>     <dbl> <dbl>      <dbl>
## 1 Aleena       79    15        NaN
## 2 Besalisk    198   102        NaN
## 3 Cerean      198    82         92
## 4 Chagrian    196   NaN        NaN
## 5 Clawdite    168    55        NaN
```

Other dplyr goodies: count

`count` to get the number of observations:

```
starwars %>%
  count(species)
```

```
## # A tibble: 38 × 2
##    species       n
##    <chr>     <int>
##  1 Aleena        1
##  2 Besalisk      1
##  3 Cerean        1
##  4 Chagrian      1
##  5 Clawdite      1
##  6 Droid         6
##  7 Dug           1
##  8 Ewok          1
##  9 Geonosian     1
## 10 Gungan        3
## # … with 28 more rows
```

```
starwars %>%
  group_by(species) %>% summarize(num = n())
```

```
## # A tibble: 38 × 2
##    species     num
##    <chr>     <int>
##  1 Aleena        1
##  2 Besalisk      1
##  3 Cerean        1
##  4 Chagrian      1
##  5 Clawdite      1
##  6 Droid         6
##  7 Dug           1
##  8 Ewok          1
##  9 Geonosian     1
## 10 Gungan        3
## # … with 28 more rows
```

Other dplyr goodies: distinct

`distinct` to isolate unique observations:

```
starwars %>% distinct(species)
```

```
## # A tibble: 38 × 1
##    species
##    <chr>
##  1 Human
##  2 Droid
##  3 Wookiee
##  4 Rodian
##  5 Hutt
##  6 Yoda's species
##  7 Trandoshan
##  8 Mon Calamari
##  9 Ewok
## 10 Sullustan
## # … with 28 more rows
```

Other dplyr goodies: window functions

Window functions make it easy to get leads and lags, percentiles, cumulative sums, etc.

- See `vignette("window-functions")`

The final set of dplyr "goodies" worth mentioning are the family of join operations, but we'll come back to those later