Week 9: *Data Wrangling*

EMSE 4571 / 6571: Intro to Programming for Analytics

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March 28, 2024

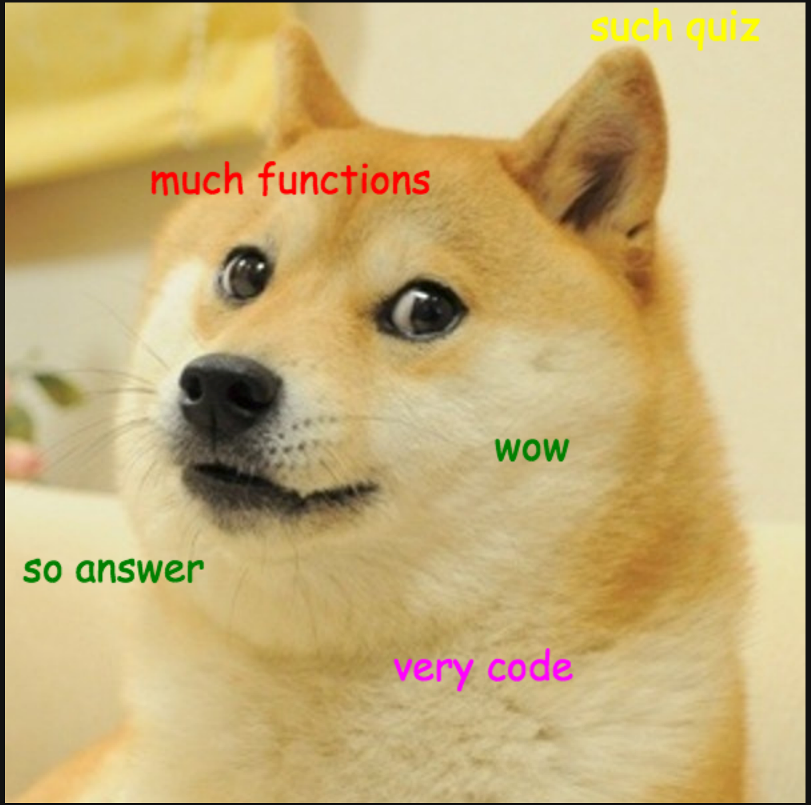
Quiz 5

10:00

Write your name on the quiz!

Rules:

- Work alone; no outside help of any kind is allowed.
- No calculators, no notes, no books, no computers, no phones.



How to fail with ChatGPT

1. Copy-paste the code and never run it.

```
(df$Population / df$State.Population) * 100
```

1. Do things I've explicitly told you not to do.

```
df <- read.csv("data/prisoners2019.csv") # Bad
```

```
df <- read_csv(here("data", "prisoners2019.csv")) # Good
```

1. Use functions we've never covered.

```
total_prison_population <- aggregate(Population ~ State, df, sum)
```

Week 9: *Data Wrangling*

1. Selecting & filtering

2. Sequences with pipes

BREAK

3. Creating new variables

4. Grouped operations

Week 9: *Data Wrangling*

1. Selecting & filtering

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Before we start

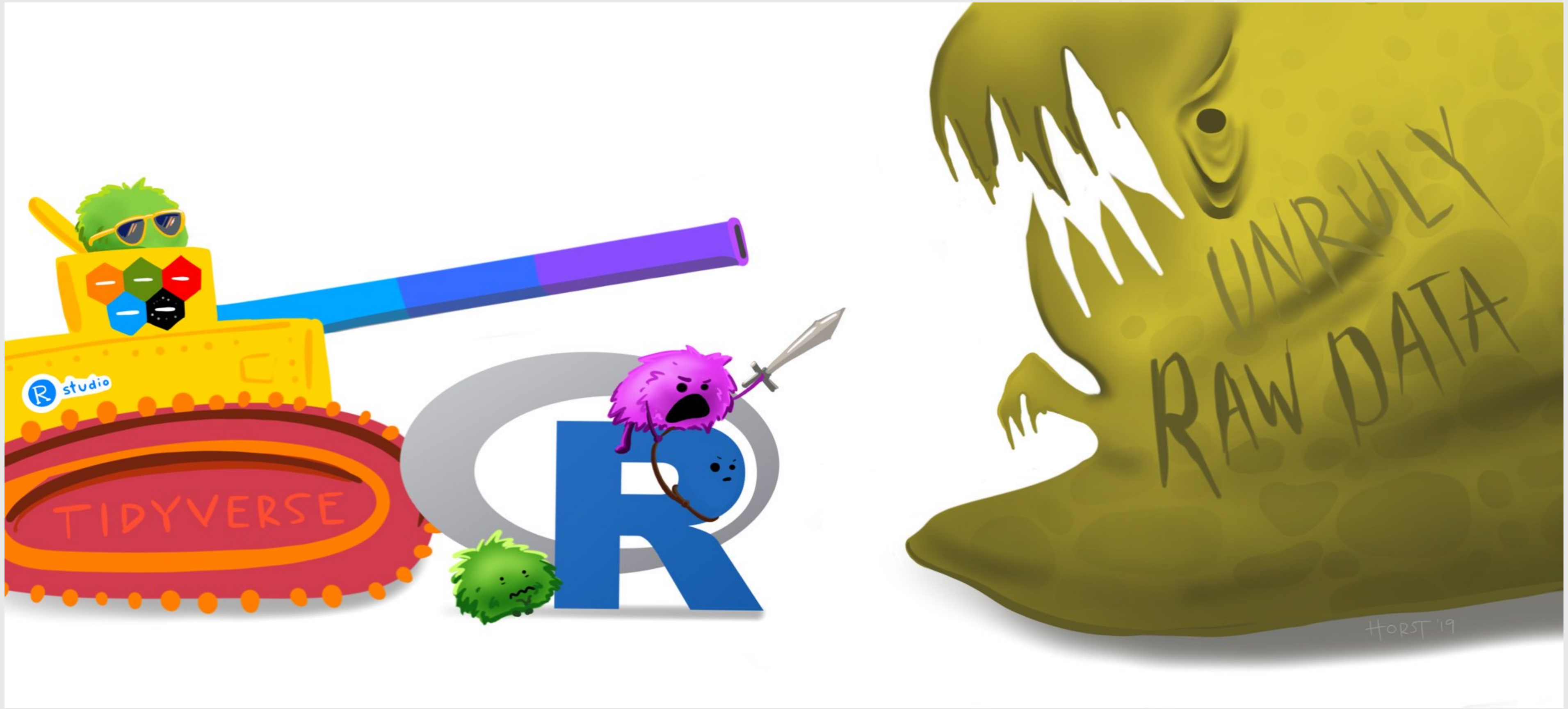
Make sure you have the "tidyverse" installed

```
install.packages('tidyverse')
```

(this is at the top of the `practice.R` file)

Remember: you only need to install packages once!

The tidyverse: `stringr` + `dplyr` + `readr` + `ggplot2` + ...

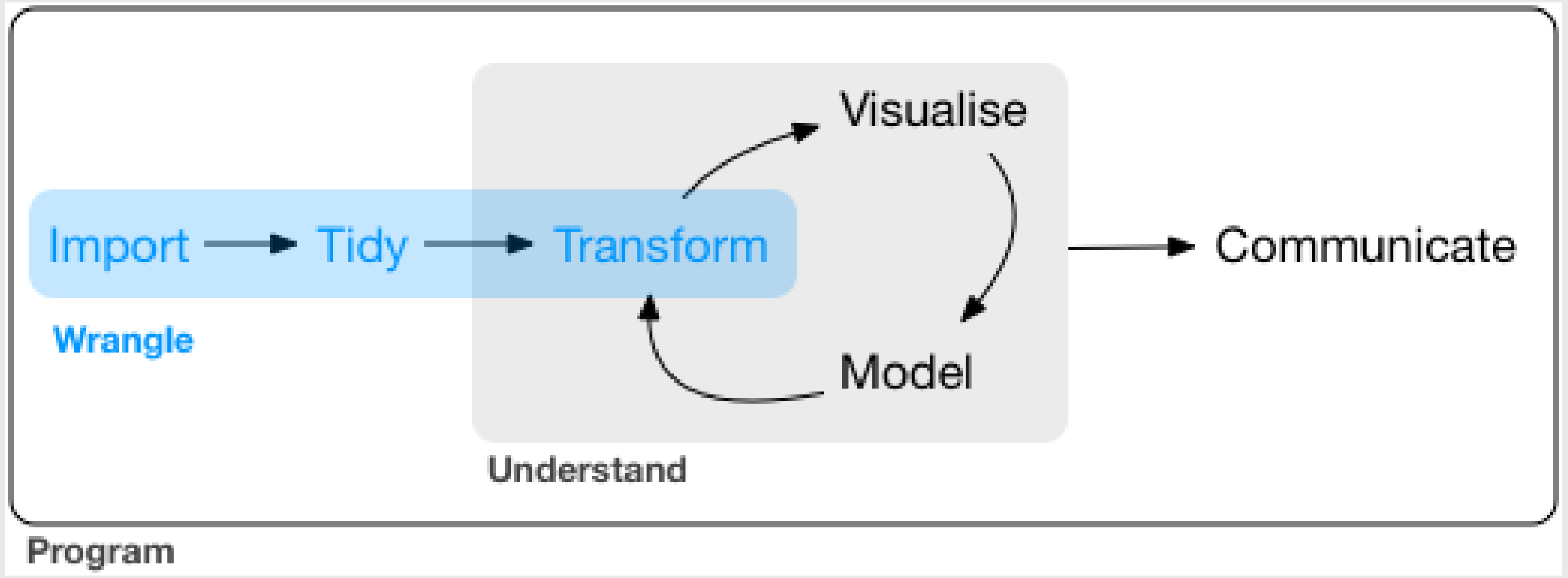


Art by Allison Horst

Today: better data wrangling with **dplyr**

Art by Allison Horst

80% of the job is data wrangling



The main `dplyr` "verbs"

- `select()`: subset columns
- `filter()`: subset rows on conditions
- `arrange()`: sort data frame
- `mutate()`: create new columns by using information from other columns
- `group_by()`: group data to perform grouped operations
- `summarize()`: create summary statistics (usually on grouped data)
- `count()`: count discrete rows

That's a lot to remember!

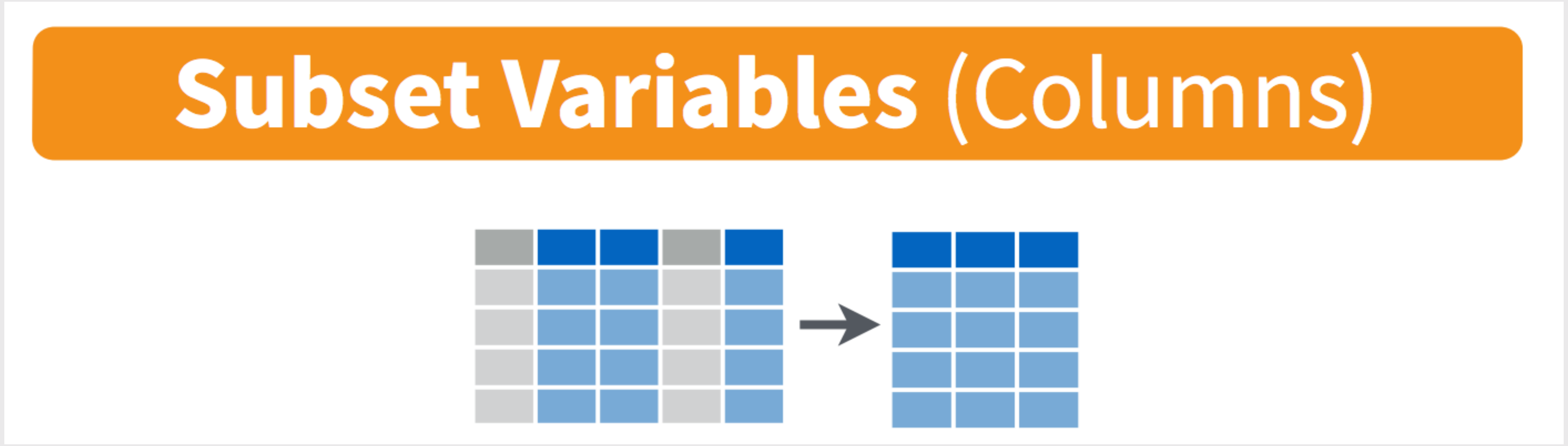
Use this cheatsheet

This week's British Band: **The Spice Girls**

```r
spicegirls <- tibble(
    firstName   = c("Melanie", "Melanie", "Emma", "Geri", "Victoria"),
    lastName    = c("Brown", "Chisholm", "Bunton", "Halliwell", "Beckham"),
    spice       = c("Scary", "Sporty", "Baby", "Ginger", "Posh"),
    yearOfBirth = c(1975, 1974, 1976, 1972, 1974),
    deceased    = c(FALSE, FALSE, FALSE, FALSE, FALSE)
)
spicegirls
```

```
#> # A tibble: 5 × 5
#>   firstName lastName  spice  yearOfBirth deceased
#>   <chr>     <chr>     <chr>        <dbl> <lgl>
#> 1 Melanie   Brown     Scary         1975 FALSE
#> 2 Melanie   Chisholm  Sporty        1974 FALSE
#> 3 Emma      Bunton    Baby          1976 FALSE
#> 4 Geri      Halliwell Ginger        1972 FALSE
#> 5 Victoria  Beckham   Posh          1974 FALSE
```

Select columns with `select()`



Select columns with `select()`

Example: Select the columns `firstName` & `lastName`

Base R:

```
spicegirls[c('firstName', 'lastName')]
```

```
#> # A tibble: 5 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Melanie   Brown
#> 2 Melanie   Chisholm
#> 3 Emma      Bunton
#> 4 Geri      Halliwell
#> 5 Victoria  Beckham
```

Select columns with `select()`

Example: Select the columns `firstName` & `lastName`

dplyr: (note that you don't need `""` around names)

```
select(spicegirls, firstName, lastName)
```

```
#> # A tibble: 5 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Melanie   Brown
#> 2 Melanie   Chisholm
#> 3 Emma      Bunton
#> 4 Geri      Halliwell
#> 5 Victoria  Beckham
```

Select columns with `select()`

Use the `-` sign to drop columns:

```r
select(spicegirls, -firstName, -lastName)
```

```
#> # A tibble: 5 × 3
#>   spice  yearOfBirth deceased
#>   <chr>        <dbl> <lgl>
#> 1 Scary         1975 FALSE
#> 2 Sporty        1974 FALSE
#> 3 Baby          1976 FALSE
#> 4 Ginger        1972 FALSE
#> 5 Posh          1974 FALSE
```

Select columns with `select()`

Select columns based on name criteria:

- `ends_with()` = Select columns that end with a character string
- `contains()` = Select columns that contain a character string
- `matches()` = Select columns that match a regular expression
- `one_of()` = Select column names that are from a group of names

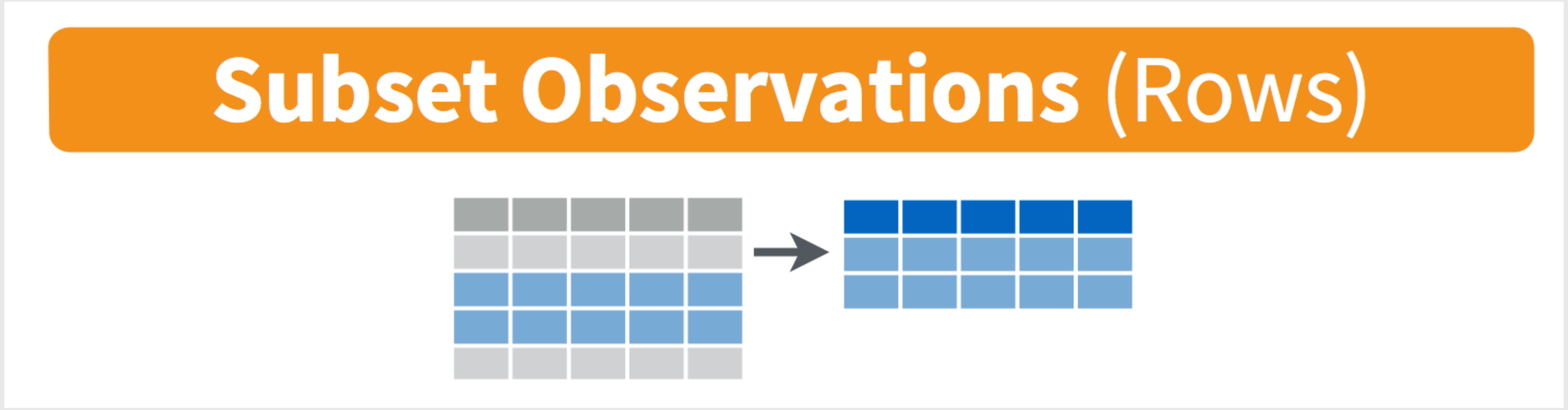
Select columns with `select()`

Select only the "name" columns

```
select(spicegirls, ends_with('name'))
```

```
#> # A tibble: 5 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Melanie   Brown
#> 2 Melanie   Chisholm
#> 3 Emma      Bunton
#> 4 Geri      Halliwell
#> 5 Victoria  Beckham
```

Select rows with `filter()`



Select rows with `filter()`

Example: Filter the band members born after 1974

```
## # A tibble: 5 x 5
##   firstName lastName  spice  yearOfBirth deceased
##   <chr>     <chr>     <chr>        <dbl> <lgl>
## 1 Melanie   Brown     Scary         1975 FALSE
## 2 Melanie   Chisholm  Sporty        1974 FALSE
## 3 Emma      Bunton    Baby          1976 FALSE
## 4 Geri      Halliwell Ginger        1972 FALSE
## 5 Victoria  Beckham   Posh          1974 FALSE
```

Select rows with `filter()`

Example: Filter the band members born after 1974

Base R:

```r
spicegirls[spicegirls$yearOfBirth > 1974,]
```

```
#> # A tibble: 2 × 5
#>   firstName lastName spice yearOfBirth deceased
#>   <chr>     <chr>    <chr>       <dbl> <lgl>   
#> 1 Melanie   Brown    Scary        1975 FALSE   
#> 2 Emma      Bunton   Baby         1976 FALSE   
```

Select rows with `filter()`

Example: Filter the band members born after 1974

dplyr:

```
filter(spicegirls, yearOfBirth > 1974)
```

```
#> # A tibble: 2 × 5
#>   firstName lastName spice yearOfBirth deceased
#>   <chr>     <chr>    <chr>       <dbl> <lgl>
#> 1 Melanie   Brown    Scary        1975 FALSE
#> 2 Emma      Bunton   Baby         1976 FALSE
```

Select rows with `filter()`

Example: Filter the band members born after 1974 **& are named "Melanie"**

dplyr:

```r
filter(spicegirls, yearOfBirth > 1974 & firstName == "Melanie")
```

```
#> # A tibble: 1 × 5
#>   firstName lastName spice yearOfBirth deceased
#>   <chr>     <chr>    <chr>       <dbl> <lgl>
#> 1 Melanie   Brown    Scary        1975 FALSE
```

Logic operators for `filter()`

Description	Example
Values greater than 1	`value > 1`
Values greater than or equal to 1	`value >= 1`
Values less than 1	`value < 1`
Values less than or equal to 1	`value <= 1`
Values equal to 1	`value == 1`
Values not equal to 1	`value != 1`
Values in the set c(1, 4)	`value %in% c(1, 4)`

Removing missing values

Drop all rows where `variable` is `NA`

```
filter(data, !is.na(variable))
```

Your turn: wildlife impacts data

10:00

1) Create the data frame object `df` by using `here()` and `read_csv()` to load the `wildlife_impacts.csv` file in the `data` folder.

2) Use the `df` object and the `select()` and `filter()` functions to answer the following questions:

- Create a new data frame, `df_birds`, that contains only the variables (columns) about the species of bird.
- Create a new data frame, `dc`, that contains only the observations (rows) from DC airports.
- Create a new data frame, `dc_birds_known`, that contains only the observations (rows) from DC airports and those where the species of bird is known.
- How many *known* unique species of birds have been involved in accidents at DC airports?

Week 9: *Data Wrangling*

1. Selecting & filtering
2. Sequences with pipes

BREAK

3. Creating new variables
4. Grouped operations

Create sequences of operations with "pipes"

The Treachery of Images, René Magritte

%>%
Ceci n'est pas un pipe.
www.tidyverse.org

magrittr package

Think of %>% as the words "...and then..."

Without Pipes (read from inside-out):

```
leave_house(get_dressed(get_out_of_bed(wake_up(me))))
```

With Pipes:

```
me %>%
    wake_up() %>%
    get_out_of_bed() %>%
    get_dressed() %>%
    leave_house()
```

Sequence operations with pipes: %>%

1. Filter the band members born after 1974
2. Select only the columns `firstName` & `lastName`

Without Pipes:

```
select(filter(spicegirls, yearOfBirth > 1974), firstName, lastName)
```

```
#> # A tibble: 2 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Melanie   Brown
#> 2 Emma      Bunton
```

Sequence operations with pipes: %>%

1. Filter the band members born after 1974
2. Select only the columns `firstName` & `lastName`

With Pipes:

```r
spicegirls %>%
    filter(yearOfBirth > 1974) %>%
    select(firstName, lastName)
```

```
#> # A tibble: 2 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Melanie   Brown
#> 2 Emma      Bunton
```

Think of the words "...and then..."

Without Pipes:

```
select(filter(spicegirls, yearOfBirth > 1974), firstName, lastName)
```

With Pipes: Note that you don't need to repeat the dataframe name

```
spicegirls %>%
    filter(yearOfBirth > 1974) %>%
    select(firstName, lastName)
```

Sort rows with `arrange()`

Sort the data frame by year of birth:

```
spicegirls %>%
    arrange(yearOfBirth)
```

```
#> # A tibble: 5 × 5
#>   firstName lastName  spice  yearOfBirth deceased
#>   <chr>     <chr>     <chr>        <dbl> <lgl>
#> 1 Geri      Halliwell Ginger        1972 FALSE
#> 2 Melanie   Chisholm  Sporty        1974 FALSE
#> 3 Victoria  Beckham   Posh          1974 FALSE
#> 4 Melanie   Brown     Scary         1975 FALSE
#> 5 Emma      Bunton    Baby          1976 FALSE
```

Sort rows with `arrange()`

Use the `desc()` function to sort in descending order:

```r
spicegirls %>%
    arrange(desc(yearOfBirth))
```

```
#> # A tibble: 5 × 5
#>   firstName lastName  spice  yearOfBirth deceased
#>   <chr>     <chr>     <chr>        <dbl> <lgl>
#> 1 Emma      Bunton    Baby          1976 FALSE
#> 2 Melanie   Brown     Scary         1975 FALSE
#> 3 Melanie   Chisholm  Sporty        1974 FALSE
#> 4 Victoria  Beckham   Posh          1974 FALSE
#> 5 Geri      Halliwell Ginger        1972 FALSE
```

Sort rows with `arrange()`

Example of filtering, arranging, and selecting:

```
spicegirls %>%
    filter(yearOfBirth < 1975) %>%
    arrange(desc(yearOfBirth)) %>%
    select(ends_with('name'))
```

```
#> # A tibble: 3 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Melanie   Chisholm
#> 2 Victoria  Beckham
#> 3 Geri      Halliwell
```

Your turn

10:00

1) Create the data frame object `df` by using `here()` and `read_csv()` to load the `wildlife_impacts.csv` file in the `data` folder.

2) Use the `df` object and `select()`, `filter()`, and `%>%` to answer the following questions:

- Create a new data frame, `dc_dawn`, that contains only the observations (rows) from DC airports that occurred at dawn.
- Create a new data frame, `dc_dawn_birds`, that contains only the observations (rows) from DC airports that occurred at dawn and only the variables (columns) about the species of bird.
- Create a new data frame, `dc_dawn_birds_known`, that contains only the observations (rows) from DC airports that occurred at dawn and only the variables (columns) about the KNOWN species of bird.
- How many *known* unique species of birds have been involved in accidents at DC airports at dawn?

Break

05:00

Week 9: *Data Wrangling*

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BREAK

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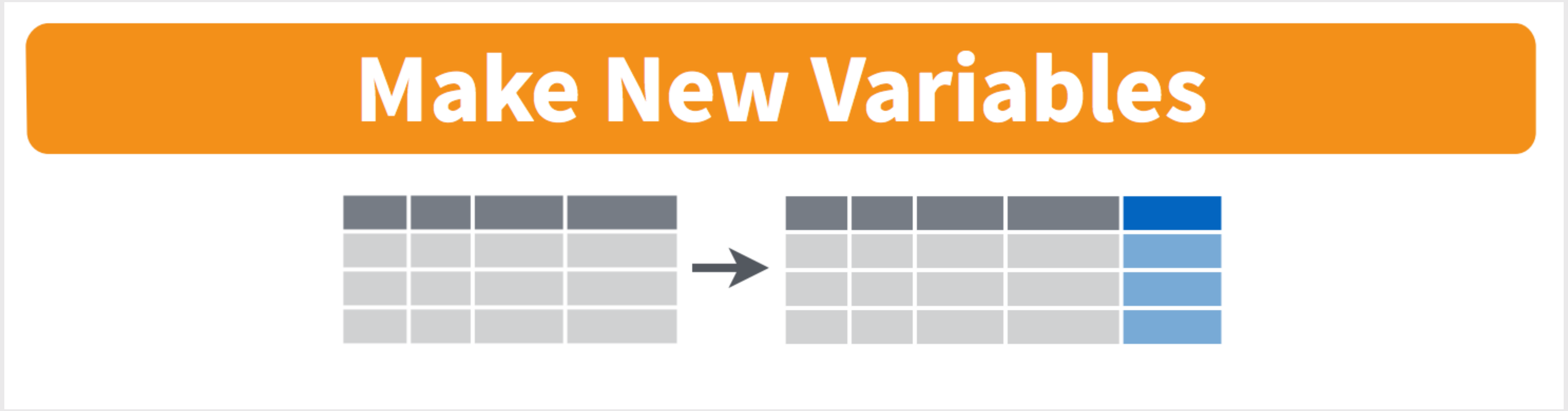
4. Grouped operations

Create new variables with `mutate()`



dplyr::mutate
add column(s), keep existing.
A
B
C
1
5
10
0
2
-3
4
9
6
3
2
14
9
8
THE PLAN:
A
B
C
+
=
HORST '18

Art by Allison Horst

Create new variables with `mutate()`

Example: Use the `yearOfBirth` variable to compute the age of each band member

Base R:

```
spicegirls$age <- 2022 - spicegirls$yearOfBirth
```

dplyr:

```
spicegirls %>%
    mutate(age = 2022 - yearOfBirth)
```

```
#> # A tibble: 5 × 6
#>   firstName lastName  spice  yearOfBirth deceased   age
#>   <chr>     <chr>     <chr>        <dbl> <lgl>    <dbl>
#> 1 Melanie   Brown     Scary         1975 FALSE       47
#> 2 Melanie   Chisholm  Sporty        1974 FALSE       48
#> 3 Emma      Bunton    Baby          1976 FALSE       46
#> 4 Geri      Halliwell Ginger        1972 FALSE       50
#> 5 Victoria  Beckham   Posh          1974 FALSE       48
```

You can *immediately* use new variables

```r
spicegirls %>%
    mutate(
        age = 2022 - yearOfBirth,
        meanAge  = mean(age)) # Immediately using the "age" variable
```

```
#> # A tibble: 5 × 7
#>   firstName lastName  spice  yearOfBirth deceased   age meanAge
#>   <chr>     <chr>     <chr>        <dbl> <lgl>    <dbl>   <dbl>
#> 1 Melanie   Brown     Scary         1975 FALSE       47    47.8
#> 2 Melanie   Chisholm  Sporty        1974 FALSE       48    47.8
#> 3 Emma      Bunton    Baby          1976 FALSE       46    47.8
#> 4 Geri      Halliwell Ginger        1972 FALSE       50    47.8
#> 5 Victoria  Beckham   Posh          1974 FALSE       48    47.8
```

Handling if/else conditions

`ifelse(<condition>, <if TRUE>, <else>)`

```r
spicegirls %>%
    mutate(
        yobAfter74 = ifelse(yearOfBirth > 1974, "yes", "no"))
```

```
#> # A tibble: 5 × 6
#>   firstName lastName  spice  yearOfBirth deceased yobAfter74
#>   <chr>     <chr>     <chr>        <dbl> <lgl>    <chr>
#> 1 Melanie   Brown     Scary         1975 FALSE    yes
#> 2 Melanie   Chisholm  Sporty        1974 FALSE    no
#> 3 Emma      Bunton    Baby          1976 FALSE    yes
#> 4 Geri      Halliwell Ginger        1972 FALSE    no
#> 5 Victoria  Beckham   Posh          1974 FALSE    no
```

Your turn

10:00

1) Create the data frame object `df` by using `here()` and `read_csv()` to load the `wildlife_impacts.csv` file in the `data` folder.

2) Use the `df` object with `%>%` and `mutate()` to create the following new variables:

- `height_miles`: The `height` variable converted to miles (Hint: there are 5,280 feet in a mile).
- `cost_mil`: Is `TRUE` if the repair costs was greater or equal to $1 million, `FALSE` otherwise.

- `season`: One of four seasons based on the `incident_month` variable:

  - `spring`: March, April, May
  - `summer`: June, July, August
  - `fall`: September, October, November
  - `winter`: December, January, February

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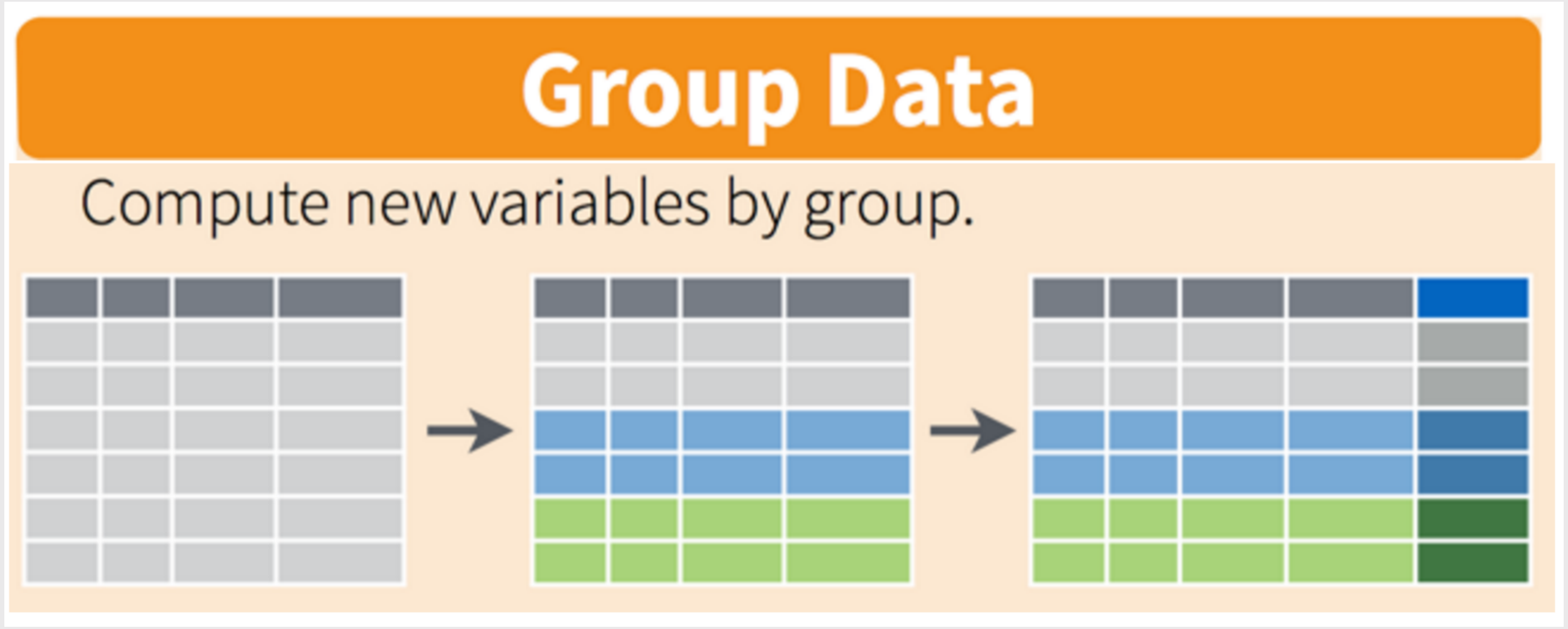
Compute by group with `group_by`



Compute by group with `group_by`

```
bands
```

```
#> # A tibble: 9 × 5
#>   firstName lastName  yearOfBirth deceased band
#>   <chr>     <chr>           <dbl> <lgl>    <chr>
#> 1 Melanie   Brown            1975 FALSE    spicegirls
#> 2 Melanie   Chisholm         1974 FALSE    spicegirls
#> 3 Emma      Bunton           1976 FALSE    spicegirls
#> 4 Geri      Halliwell        1972 FALSE    spicegirls
#> 5 Victoria  Beckham          1974 FALSE    spicegirls
#> 6 John      Lennon           1940 TRUE     beatles
#> 7 Paul      McCartney        1942 FALSE    beatles
#> 8 Ringo     Starr            1940 FALSE    beatles
#> 9 George    Harrison         1943 TRUE     beatles
```

Compute by group with `group_by`

Compute the mean band member age across the whole dataset

```r
bands %>%
    mutate(
        age = 2024 - yearOfBirth,
        mean_age = mean(age) # This is the mean across both bands
    )
```

```
#> # A tibble: 9 × 7
#>   firstName lastName  yearOfBirth deceased band         age mean_age
#>   <chr>     <chr>           <dbl> <lgl>    <chr>      <dbl>    <dbl>
#> 1 Melanie   Brown            1975 FALSE    spicegirls    49     64.4
#> 2 Melanie   Chisholm         1974 FALSE    spicegirls    50     64.4
#> 3 Emma      Bunton           1976 FALSE    spicegirls    48     64.4
#> 4 Geri      Halliwell        1972 FALSE    spicegirls    52     64.4
#> 5 Victoria  Beckham          1974 FALSE    spicegirls    50     64.4
#> 6 John      Lennon           1940 TRUE     beatles       84     64.4
#> 7 Paul      McCartney        1942 FALSE    beatles       82     64.4
#> 8 Ringo     Starr            1940 FALSE    beatles       84     64.4
#> 9 George    Harrison         1943 TRUE     beatles       81     64.4
```

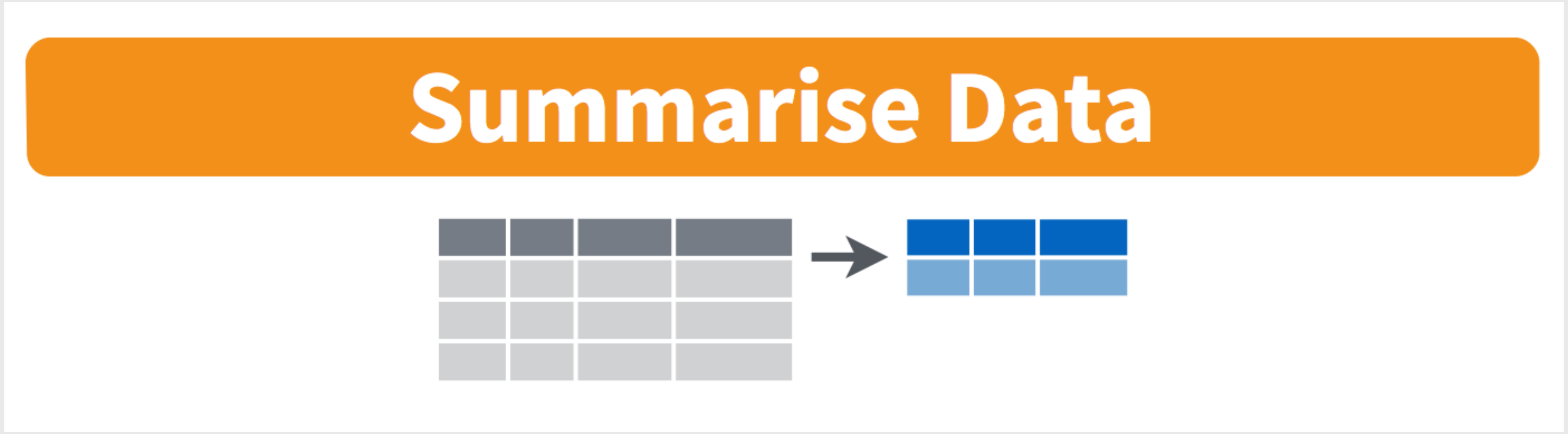
Compute by group with `group_by`

Compute the mean band member age **for each band**

```
bands %>%
    mutate(age = 2024 - yearOfBirth) %>%
    group_by(band) %>% # Everything after this will be done each band
    mutate(mean_age = mean(age))
```

```
#> # A tibble: 9 × 7
#> # Groups:   band [2]
#>   firstName lastName  yearOfBirth deceased band         age mean_age
#>   <chr>     <chr>           <dbl> <lgl>    <chr>      <dbl>    <dbl>
#> 1 Melanie   Brown            1975 FALSE    spicegirls    49     49.8
#> 2 Melanie   Chisholm         1974 FALSE    spicegirls    50     49.8
#> 3 Emma      Bunton           1976 FALSE    spicegirls    48     49.8
#> 4 Geri      Halliwell        1972 FALSE    spicegirls    52     49.8
#> 5 Victoria  Beckham          1974 FALSE    spicegirls    50     49.8
#> 6 John      Lennon           1940 TRUE     beatles       84     82.8
#> 7 Paul      McCartney        1942 FALSE    beatles       82     82.8
#> 8 Ringo     Starr            1940 FALSE    beatles       84     82.8
#> 9 George    Harrison         1943 TRUE     beatles       81     82.8
```

Summarize data frames with `summarise()`



Summarize data frames with `summarise()`

Compute the mean band member age across the whole dataset

```r
bands %>%
    mutate(age = 2024 - yearOfBirth) %>%
    summarise(mean_age = mean(age))
```

```
#> # A tibble: 1 × 1
#>   mean_age
#>      <dbl>
#> 1     64.4
```

Summarize data frames with `summarise()`

Compute the mean band member age for **each band**

```r
bands %>%
    mutate(age = 2024 - yearOfBirth) %>%
    group_by(band) %>%
    summarise(mean_age = mean(age))
```

```
#> # A tibble: 2 × 2
#>   band       mean_age
#>   <chr>         <dbl>
#> 1 beatles        82.8
#> 2 spicegirls     49.8
```

Summarize data frames with `summarise()`

Compute the mean, min, and max band member age for **each band**

```
bands %>%
    mutate(age = 2024 - yearOfBirth) %>%
    group_by(band) %>%
    summarise(
        mean_age = mean(age),
        min_age = min(age),
        max_age = max(age)
    )
```

```
#> # A tibble: 2 × 4
#>   band       mean_age min_age max_age
#>   <chr>         <dbl>   <dbl>   <dbl>
#> 1 beatles        82.8      81      84
#> 2 spicegirls     49.8      48      52
```

Computing counts of observations with `n()`

How many members are in each band?

```
bands %>%
    group_by(band) %>%
    summarise(numMembers = n())
```

```
#> # A tibble: 2 × 2
#>   band       numMembers
#>   <chr>           <int>
#> 1 beatles             4
#> 2 spicegirls          5
```

If you only want a quick count, use `count()`

These do the same thing:

```r
bands %>%
    group_by(band) %>%
    summarise(numMembers = n())
```

```
#> # A tibble: 2 × 2
#>   band       numMembers
#>   <chr>           <int>
#> 1 beatles             4
#> 2 spicegirls          5
```

```r
bands %>%
    count(band)
```

```
#> # A tibble: 2 × 2
#>   band           n
#>   <chr>      <int>
#> 1 beatles        4
#> 2 spicegirls     5
```

If you only want a quick count, use `count()`

You can count by combinations of variables

```
bands %>%
    mutate(nameStartsWithG = str_detect(firstName, '^G')) %>%
    count(band, nameStartsWithG)
```

```
#> # A tibble: 4 × 3
#>   band       nameStartsWithG     n
#>   <chr>      <lgl>           <int>
#> 1 beatles    FALSE               3
#> 2 beatles    TRUE                1
#> 3 spicegirls FALSE               4
#> 4 spicegirls TRUE                1
```

Your turn

10:00

1) Create the data frame object `df` by using `here()` and `read_csv()` to load the `wildlife_impacts.csv` file in the `data` folder.

2) Use the `df` object and `group_by()`, `summarise()`, `count()`, and `%>%` to answer the following questions:

- Create a summary data frame that contains the mean `height` for each different time of day. Then use `write_csv()` to save it as the file "height_summary.csv" in your "data" folder.
- Create a summary data frame that contains the maximum `cost_repairs_infl_adj` for each year. Then use `write_csv()` to save it as the file "cost_summary.csv" in your "data" folder.
- Which *month* has had the greatest number of reported incidents?
- Which *year* has had the greatest number of reported incidents?

HW 9

Make sure you install the package `nycflights13`

```r
install.packages('nycflights13')
```

This package includes **5 data frames**:

```
airlines
airports
flights
planes
weather
```