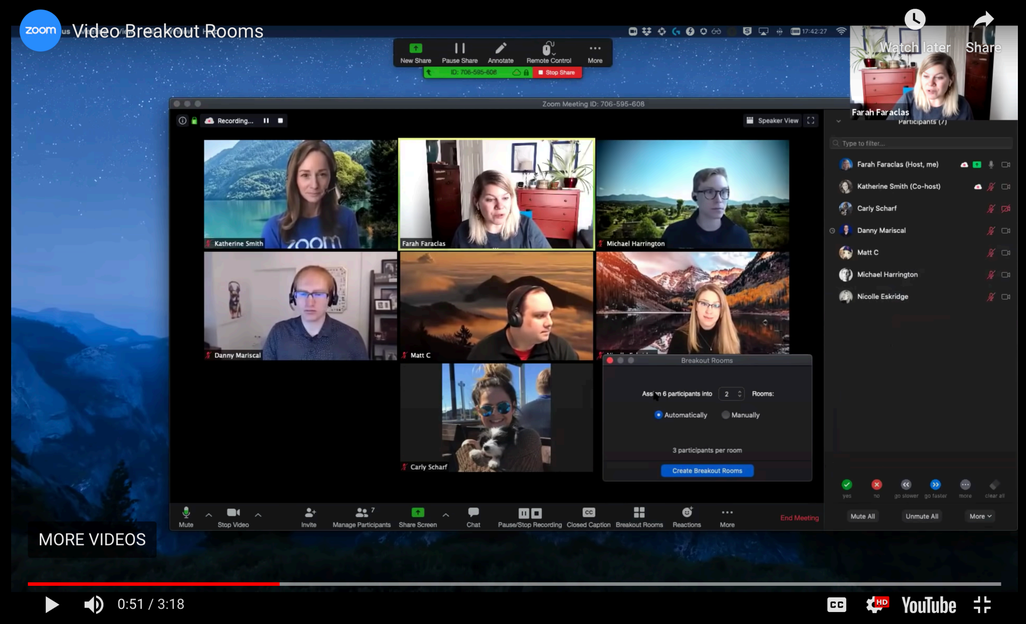
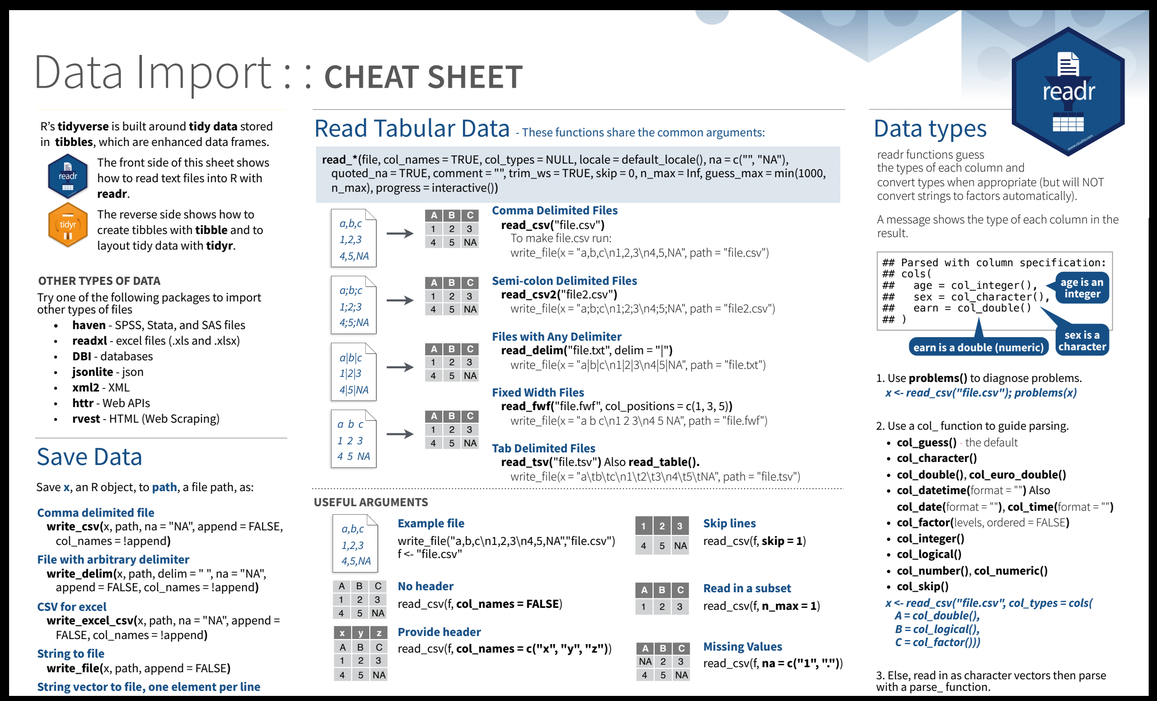
# Import Data with

# Exercise: What do you already know?

- I will use Zoom to split you into groups of two.
- Ask you partner:
  - *What sort of data do you need to get into R?*
  - *Where does it currently reside?*
  - *What problems have you run into importing data into R before?*
- 5 minutes

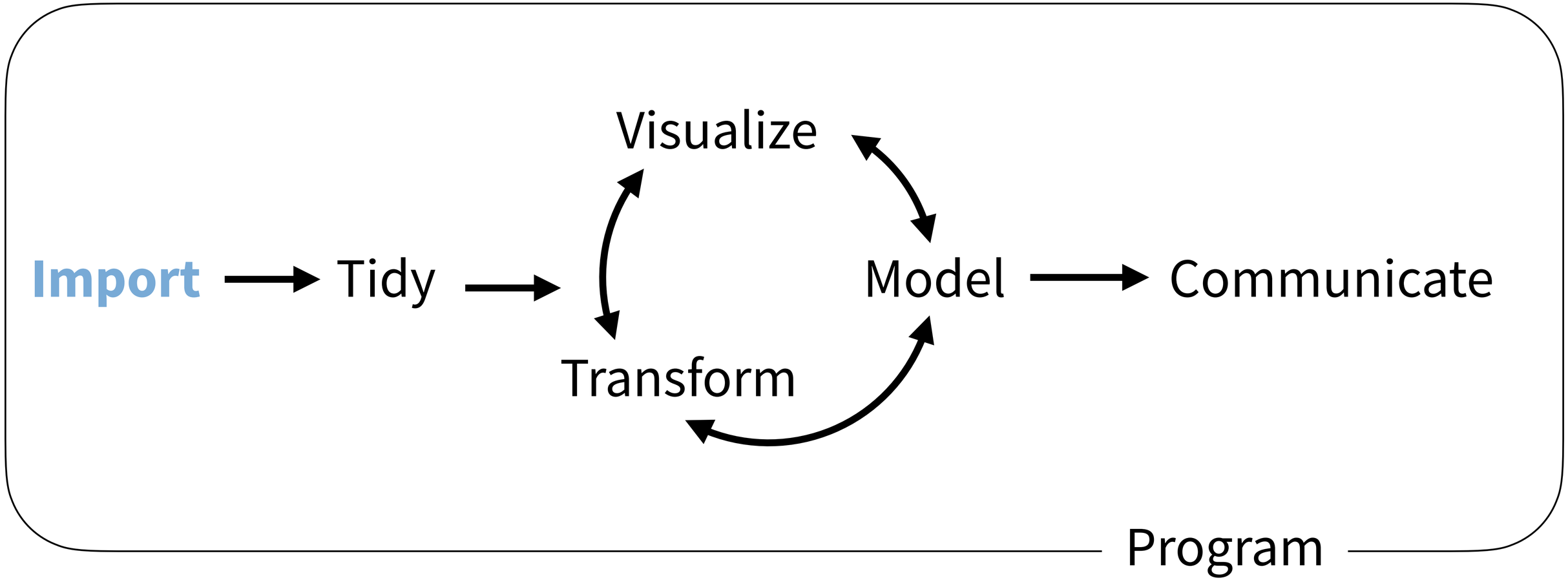



# Notes form & Cheat Sheet

Please take out

# (Applied) **Data Science**



# Data Import in the Tidyverse
# A package for each storage type!

| package | accesses |
|---|---|
| readr | csv, tsv, etc. |
| haven | SPSS, Stata, and SAS files |
| readxl | excel files (.xls, .xlsx) |
| jsonlite | json |
| xml2 | xml |
| httr | web API's |
| rvest | web pages (web scraping) |
| DBI | databases |
| sparklyr | data loaded into spark |

Open **exercises/03-Import-Data-Exercises.Rmd**

# Importing Data

# readr


Simple, consistent functions for working with strings / csv data.

```
# install.packages("tidyverse")
library(readr)
```

Compared to **read.table** and its derivatives, readr functions are:

1. ~ 10 times faster
2. Return tibbles
3. Have more intuitive defaults. No row names, no strings as factors.

# readr functions

| function | reads |
|---|---|
| read_csv() | Comma separated values |
| read_csv2() | Semi-colon separated values |
| read_delim() | General delimited files |
| read_fwf() | Fixed width files |
| read_log() | Apache log files |
| read_table() | Space separated |
| read_tsv() | Tab delimited values |

# readr functions

| function | reads |
|---|---|
| **read_csv()** | **Comma separated values** |
| read_csv2() | Semi-colon separated values |
| read_delim() | General delimited files |
| read_fwf() | Fixed width files |
| read_log() | Apache log files |
| read_table() | Space separated |
| read_tsv() | Tab delimited values |

# nimbus.csv

```
date,longitude,latitude,ozone
1985-10-01T00:00:00Z,-179.375,-87.5,.
1985-10-01T00:00:00Z,-178.125,-87.5,.
1985-10-01T00:00:00Z,-176.875,-87.5,.
1985-10-01T00:00:00Z,-175.625,-87.5,.
1985-10-01T00:00:00Z,-174.375,-87.5,.
1985-10-01T00:00:00Z,-173.125,-87.5,.
1985-10-01T00:00:00Z,-171.875,-87.5,.
1985-10-01T00:00:00Z,-170.625,-87.5,.
1985-10-01T00:00:00Z,-169.375,-87.5,.
```

# nimbus.csv

```
date,longitude,latitude,ozone
1985-10-01T00:00:00Z,-179.375,-87.5,.
1985-10-01T00:00:00Z,-178.125,-87.5,.
1985-10-01T00:00:00Z,-176.875,-87.5,.
1985-10-01T00:00:00Z,-175.625,-87.5,.
1985-10-01T00:00:00Z,-174.375,-87.5,.
1985-10-01T00:00:00Z,-173.125,-87.5,.
1985-10-01T00:00:00Z,-171.875,-87.5,.
1985-10-01T00:00:00Z,-170.625,-87.5,.
1985-10-01T00:00:00Z,-169.375,-87.5,.
```

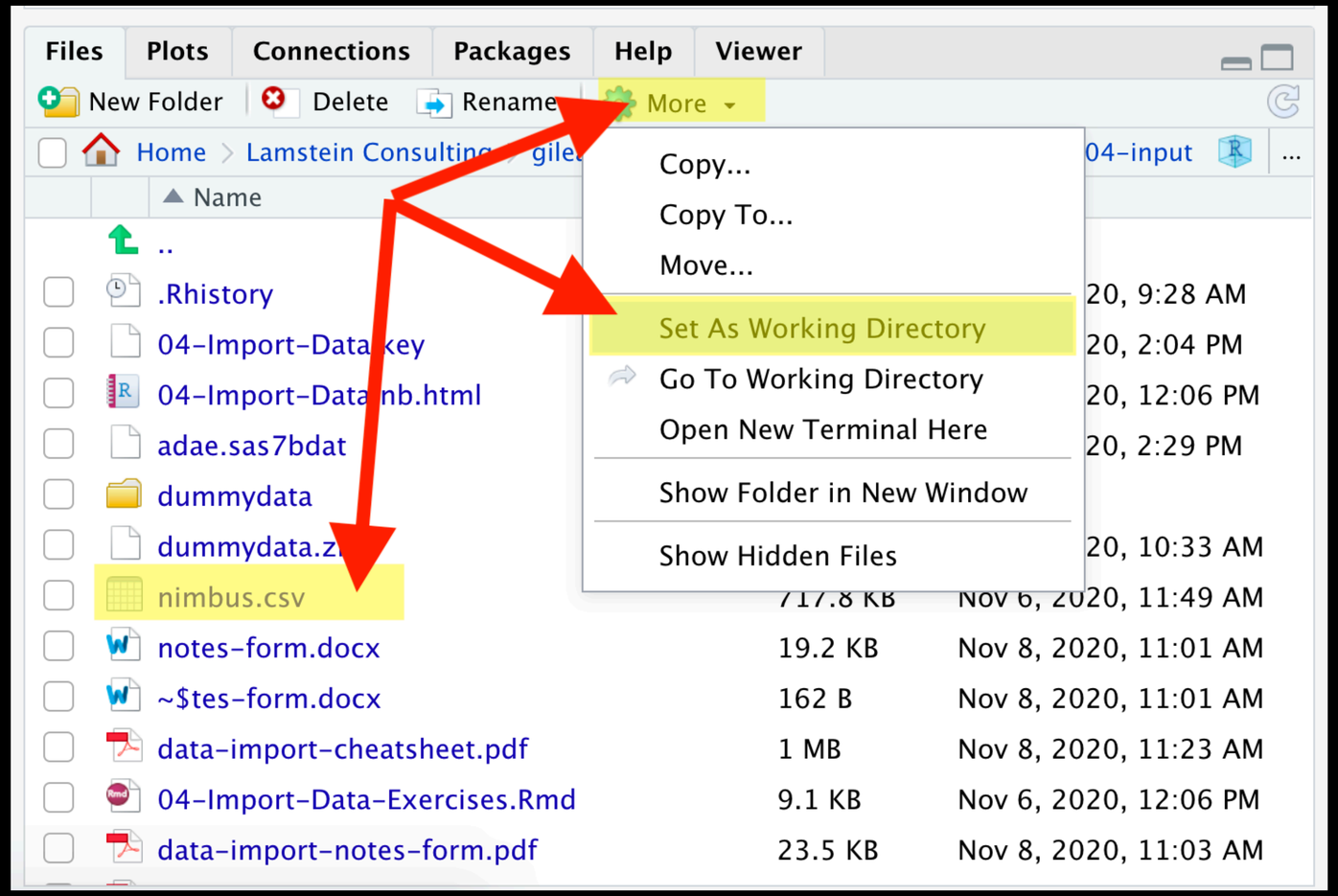
# read_csv()

readr functions share a common syntax

```
df <- read_csv("path/to/file.csv", …)
```

**object to save output into**

**path from working directory to file**




# Set Your Working Directory

# Your Turn 1

Find **nimbus.csv** (in your working directory). Then read it into an object. Then view the results.

# Your Turn 1

Find **nimbus.csv** (in your working directory). Then read it into an object. Then view the results.

```
nimbus <- read_csv("nimbus.csv")
```

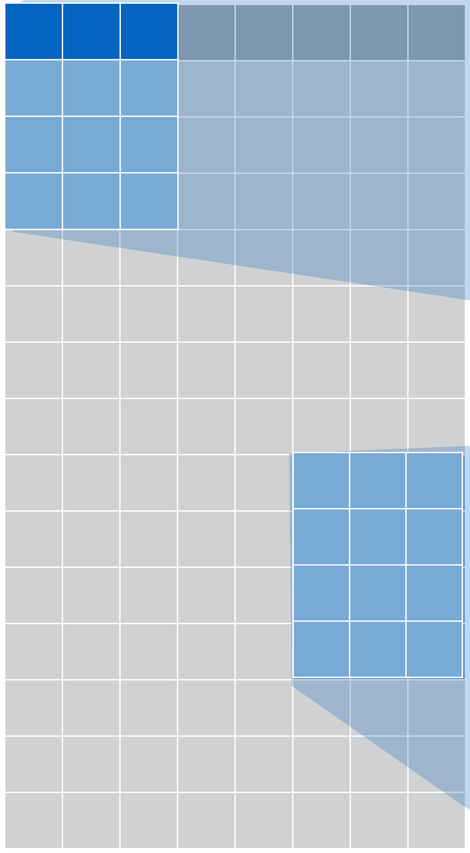
```
nimbus
```

# tibbles

# read.csv() vs. read_csv()

```
Console ~/Dropbox (RStudio)/RStudio/training/U-Master-the-tidyverse/0-course-developm
217   1985-10-01  -144.375    -86.5     .
218   1985-10-01  -143.125    -86.5     .
219   1985-10-01  -141.875    -86.5     .
220   1985-10-01  -140.625    -86.5     .
221   1985-10-01  -139.375    -86.5     .
222   1985-10-01  -138.125    -86.5     .
223   1985-10-01  -136.875    -86.5     .
224   1985-10-01  -135.625    -86.5     .
225   1985-10-01  -134.375    -86.5     .
226   1985-10-01  -133.125    -86.5     .
227   1985-10-01  -131.875    -86.5     .
228   1985-10-01  -130.625    -86.5     .
229   1985-10-01  -129.375    -86.5     .
230   1985-10-01  -128.125    -86.5     .
231   1985-10-01  -126.875    -86.5     .
232   1985-10-01  -125.625    -86.5     .
233   1985-10-01  -124.375    -86.5     .
234   1985-10-01  -123.125    -86.5     .
235   1985-10-01  -121.875    -86.5     .
236   1985-10-01  -120.625    -86.5     .
237   1985-10-01  -119.375    -86.5     .
238   1985-10-01  -118.125    -86.5     .
239   1985-10-01  -116.875    -86.5     .
240   1985-10-01  -115.625    -86.5     .
241   1985-10-01  -114.375    -86.5     .
242   1985-10-01  -113.125    -86.5     .
243   1985-10-01  -111.875    -86.5     .
244   1985-10-01  -110.625    -86.5     .
245   1985-10-01  -109.375    -86.5     .
246   1985-10-01  -108.125    -86.5     .
247   1985-10-01  -106.875    -86.5     .
248   1985-10-01  -105.625    -86.5     .
249   1985-10-01  -104.375    -86.5     .
250   1985-10-01  -103.125    -86.5     .
 [ reached getOption("max.print") -- omitted 24974 rows ]
>
```

```
Console ~/Dropbox (RStudio)/RStudio/training/U-Master-the-tidyverse/0-course-developm
> nimbus
# A tibble: 25,224 x 4
         date longitude latitude ozone
       <dttm>     <dbl>    <dbl> <chr>
 1 1985-10-01  -179.375    -87.5     .
 2 1985-10-01  -178.125    -87.5     .
 3 1985-10-01  -176.875    -87.5     .
 4 1985-10-01  -175.625    -87.5     .
 5 1985-10-01  -174.375    -87.5     .
 6 1985-10-01  -173.125    -87.5     .
 7 1985-10-01  -171.875    -87.5     .
 8 1985-10-01  -170.625    -87.5     .
 9 1985-10-01  -169.375    -87.5     .
10 1985-10-01  -168.125    -87.5     .
# ... with 25,214 more rows
>
```



A large table to display

```
# A tibble: 234 × 6
   manufacturer      model displ
          <chr>      <chr> <dbl>
1          audi         a4   1.8
2          audi         a4   1.8
3          audi         a4   2.0
4          audi         a4   2.0
5          audi         a4   2.8
6          audi         a4   2.8
7          audi         a4   3.1
8          audi a4 quattro   1.8
9          audi a4 quattro   1.8
10         audi a4 quattro   2.0
# ... with 224 more rows, and 3
#   more variables: year <int>,
#   cyl <int>, trans <chr>
```

tibble display

```
156 1999   6   auto(l4)
157 1999   6   auto(l4)
158 2008   6   auto(l4)
159 2008   8   auto(s4)
160 1999   4 manual(m5)
161 1999   4   auto(l4)
162 2008   4 manual(m5)
163 2008   4 manual(m5)
164 2008   4   auto(l4)
165 2008   4   auto(l4)
166 1999   4   auto(l4)
 [ reached getOption("max.print") --
omitted 68 rows ]
```

data frame display

# tibbles

A type of data frame common throughout tidyverse packages.
Tibbles enhance data frames in three ways:

1. **Subsetting** - [ always returns a new tibble, [[ and $ always return a new vector
2. **No partial matching** - You must use full column names when subsetting
3. **Display** - When you print a tibble, R provides a concise view of the data that fits on one screen


# tibble

A package with several helper functions for tibbles:

- **as_tibble()** - convert a data frame to a tibble
- **as.data.frame()** - convert a tibble to a data frame
- **tribble()** - make a tibble (transversed)

```
tribble(
   ~x,  ~y,
    1, "a",
    2, "b",
    3, "c")
```

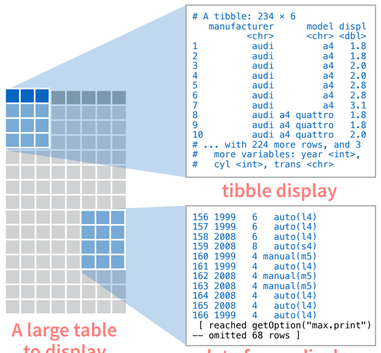
| x | y |
|---|---|
| 1 | a |
| 2 | b |
| 3 | c |

# tibbles

## Tibbles - an enhanced data frame

The **tibble** package provides a new S3 class for storing tabular data, the tibble. Tibbles inherit the data frame class, but improve two behaviors:

- **Display** - When you print a tibble, R provides a concise view of the data that fits on one screen.
- **Subsetting** - [ always returns a new tibble, [[ and $ always return a vector.
- **No partial matching** - You must use full column names when subsetting




- Control the default appearance with options:
  **options**(tibble.print_max = n, tibble.print_min = m, tibble.width = Inf)
- View entire data set with **View**(x, title) or **glimpse**(x, width = NULL, …)
- Revert to data frame with **as.data.frame**() (required for some older packages)

### Construct a tibble in two ways

Both make this tibble

**tibble**(…)
Construct by columns.

```
tibble(x = 1:3,
       y = c("a", "b", "c"))
```

**tribble**(…)
Construct by rows.

```
tribble(
  ~x, ~y,
   1, "a",
   2, "b",
   3, "c")
```

```
A tibble: 3 × 2
      x     y
  <int> <dbl>
1     1     a
2     2     b
3     3     c
```

**as_tibble**(x, …) Convert data frame to tibble.

**enframe**(x, name = "name", value = "value")
Converts named vector to a tibble with a names column and a values column.

**is_tibble**(x) Test whether x is a tibble.

# Parsing

# Quiz

What class is ozone?

```
nimbus %>% pluck("ozone") %>% class()
```

```
nimbus %>% pluck("ozone") %>% class()
```

```
[1] "character"
```

```
nimbus %>% pluck("ozone") %>% unique()
```

```
  [1] "302" "304" "287" "274" "264" "242" "211" "195" "197" "196" "198" "193" "187"
 [14] "190" "199" "194" "213" "218" "221" "229" "209" "186" "188" "191" "189" "184"
 [27] "180" "183" "215" "312" "319" "320" "311" "300" "290" "267" "226" "210" "200"
 [40] "203" "201" "192" "204" "206" "208" "205" "223" "232" "238" "243" "220" "202"
 [53] "185" "219" "222" "216" "324" "336" "333" "323" "308" "295" "244" "212" "237"
 [66] "248" "239" "241" "250" "249" "252" "234" "318" "313" "326" "335" "337" "316"
 [79] "266" "207" "227" "251" "253" "257" "261" "214" "228" "273" "285" "288" "291"
 [92] "270" "254" "317" "325" "332" "340" "344" "338" "297" "247" "217" "225" "231"
[105] "235" "236" "262" "260" "265" "272" "278" "280" "279" "255" "245" "224" "181"
[118] "240" "269" "296" "307" "315" "321" "306" "299" "298" "283" "327" "322" "328"
[131] "331" "310" "275" "233" "258" "276" "281" "289" "330" "346" "305" "334" "359"
[144] "347" "314" "301" "256" "263" "277" "284" "282" "271" "246" "183" "182" "230"
[157] "349" "351" "350" "342" "329" "355" "371" "309" "303" "292" "259" "268" "341"
[170] "343" "348" "345" "354" "361" "372" "382" "376" "356" "293" "286" "353" "355"
[183] "358" "360" "363" "370" "384" "380" "294" "339" "362" "352" "368" "373" "377"
```


# . = NA

```
nimbus
```

| date <S3: POSIXct> | longitude <dbl> | latitude <dbl> | ozone <chr> |
|---|---|---|---|
| 1985-10-01 | -179.375 | -87.5 | . |
| 1985-10-01 | -178.125 | -87.5 | . |
| 1985-10-01 | -176.875 | -87.5 | . |
| 1985-10-01 | -175.625 | -87.5 | . |
| 1985-10-01 | -174.375 | -87.5 | . |
| 1985-10-01 | -173.125 | -87.5 | . |
| 1985-10-01 | -171.875 | -87.5 | . |
| 1985-10-01 | -170.625 | -87.5 | . |
| 1985-10-01 | -169.375 | -87.5 | . |

# read_csv()

readr functions share a common syntax

```
nimbus <- read_csv("nimbus.csv", na = ".")
```

**object to save output into**

**path from working directory to file**

**Value(s) to convert to NA**

```
nimbus <- read_csv("nimbus.csv", na = ".")
```

| | date | longitude | latitude | ozone |
|---|---|---|---|---|
| | <dttm> | <dbl> | <dbl> | <dbl> |
| 1 | 1985-10-01 00:00:00 | -179. | -73.5 | 302 |
| 2 | 1985-10-01 00:00:00 | -178. | -73.5 | 302 |
| 3 | 1985-10-01 00:00:00 | -177. | -73.5 | 3 |
| 4 | 1985-10-01 00:00:00 | -176. | -73.5 | 3 |
| 5 | 1985-10-01 00:00:00 | -174. | -73.5 | 3 |
| 6 | 1985-10-01 00:00:00 | -173. | -73.5 | 3 |
| 7 | 1985-10-01 00:00:00 | -172. | -73.5 | 304 |
| 8 | 1985-10-01 00:00:00 | -171. | -73.5 | 304 |
| 9 | 1985-10-01 00:00:00 | -164. | -73.5 | 287 |
| 10 | 1985-10-01 00:00:00 | -163. | -73.5 | 287 |

… with 18,953 more rows

**<dbl> stands for "double"**

suppose

```
nimbus <- read_csv("nimbus.csv", na = ".")
```

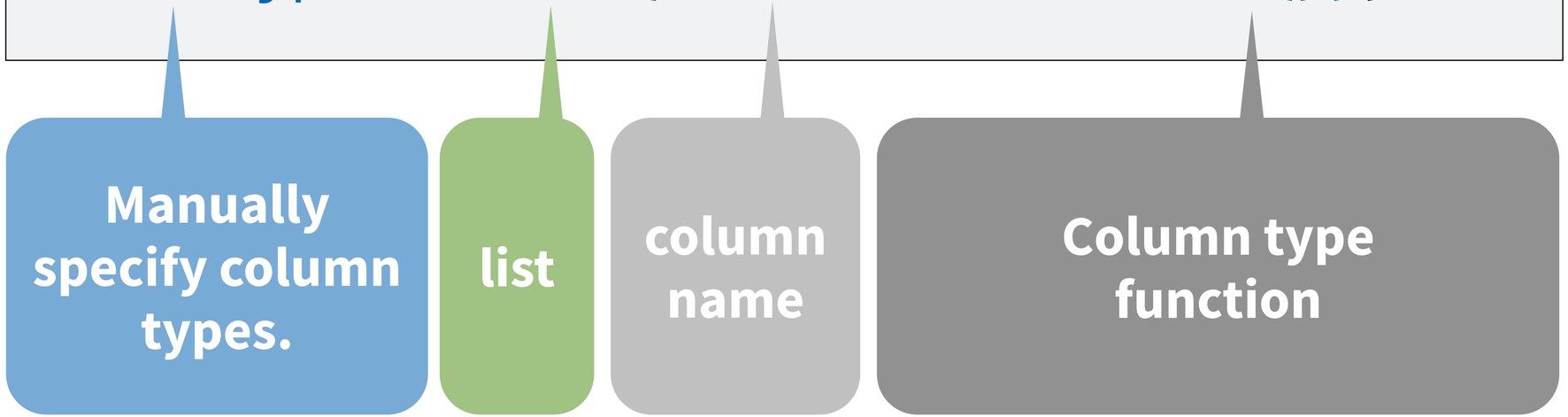
| date <S3: POSIXct> | longitude <dbl> | latitude <dbl> | ozone <chr> |
|---|---|---|---|
| 1985-10-01 | -179.375 | -87.5 | *NA* |
| 1985-10-01 | -178.125 | -87.5 | *NA* |
| 1985-10-01 | -176.875 | -87.5 | *NA* |
| 1985-10-01 | -175.625 | -87.5 | *NA* |
| 1985-10-01 | -174.375 | -87.5 | *NA* |
| 1985-10-01 | -173.125 | -87.5 | *NA* |
| 1985-10-01 | -171.875 | -87.5 | *NA* |
| 1985-10-01 | -170.625 | -87.5 | *NA* |
| 1985-10-01 | -169.375 | -87.5 | *NA* |
| 1985-10-01 | -168.125 | -87.5 | *NA* |

**<chr> stands for character string** (not a number)

# read_csv()

readr functions share a common syntax

```
nimbus <- read_csv("nimbus.csv", na = ".",
  col_types = list(ozone = col_double()))
```

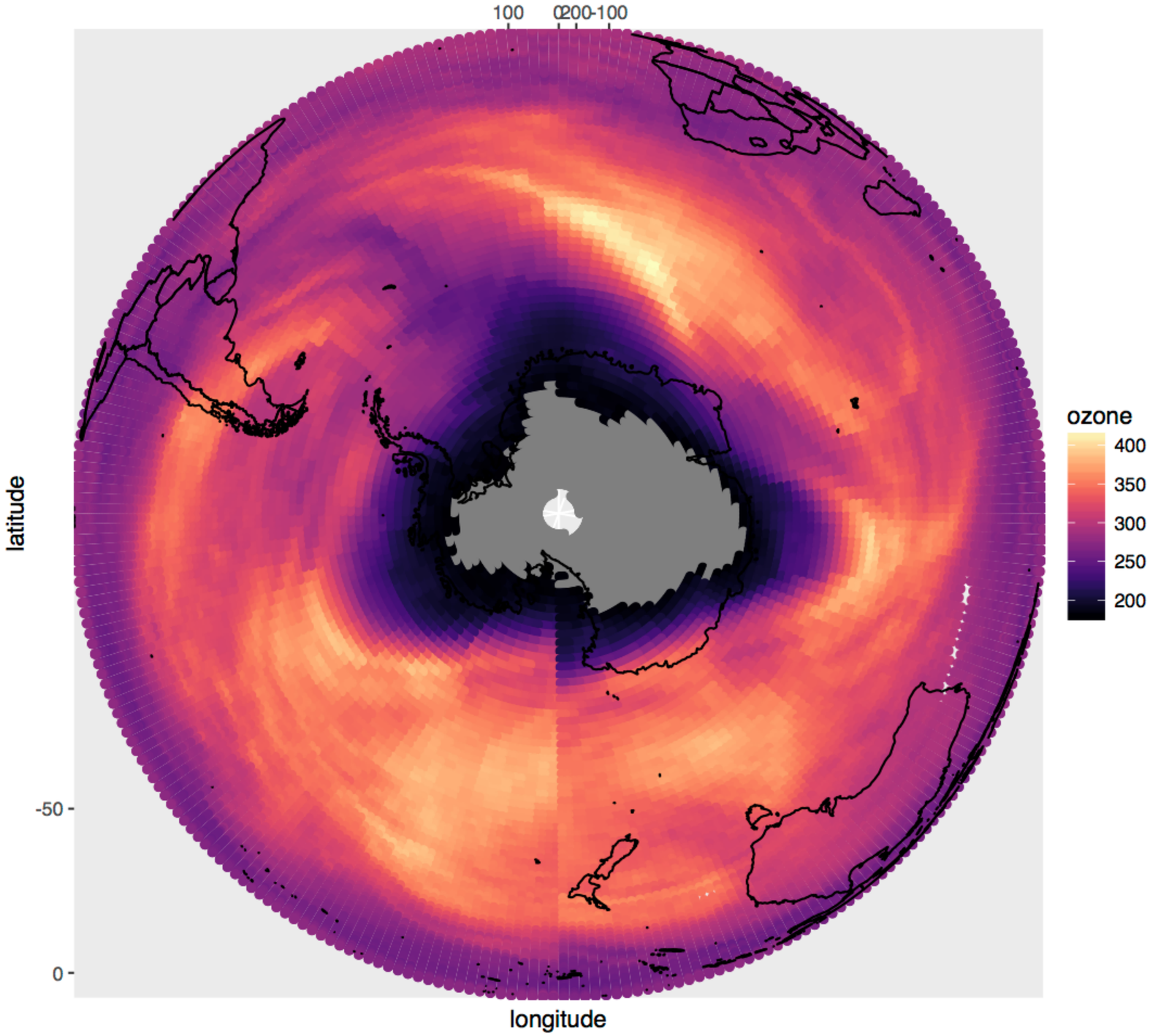


| type function | data type |
|---|---|
| col_character() | character |
| col_date() | Date |
| col_datetime() | POSIXct (date-time) |
| col_double() | double (numeric) |
| col_factor() | factor |
| col_guess() | let readr guess (default) |
| col_integer() | integer |
| col_logical() | logical |
| col_number() | numbers mixed with non-number characters |
| col_numeric() | double or integer |
| col_skip() | do not read |
| col_time() | time |

| type function | data type |
|---|---|
| col_character() | character |
| col_date() | Date |
| col_datetime() | POSIXct (date-time) |
| **col_double()** | **double (numeric)** |
| col_factor() | factor |
| col_guess() | let readr guess (default) |
| col_integer() | integer |
| col_logical() | logical |
| col_number() | numbers mixed with non-number characters |
| col_numeric() | double or integer |
| col_skip() | do not read |
| col_time() | time |

```
nimbus <- read_csv("nimbus.csv", na = ".",
  col_types = list(ozone = col_double()))

library(viridis)
world <- map_data(map = "world")
nimbus %>%
  ggplot() +
    geom_point(aes(longitude, latitude, color = ozone)) +
    geom_path(aes(long, lat, group = group), data = world) +
    coord_map("ortho", orientation=c(-90, 0, 0)) +
    scale_color_viridis(option = "A")
```


100
0
200
-100
latitude
-50
0
longitude
ozone
400
350
300
250
200

# Writing

# readr functions

| function | writes |
|---|---|
| write_csv() | Comma separated values |
| write_excel_csv() | CSV intended for opening in Excel |
| write_delim() | General delimited files |
| write_file() | Single string, written as is |
| write_lines() | Vector of strings, one element per line |
| write_tsv() | Tab delimited values |

# write_csv()

Saves data set as a csv on your computer.

```
write_csv(nimbus, file = "nimbus2.csv")
```

**Table to save**

**file**
**path to save at**

# Reading SAS files

# haven


functions for reading in SAS, SPSS and Stata files

```
# install.packages("tidyverse")
library(haven)
```

# read_sas()

haven functions share a common syntax

```
df <- read_sas("path/to/file.csv", …)
```

**object to save output into**

**path from working directory to file**

# Your Turn

The file **adae.sas7bdat** contains randomly generated data meant to mimic clinical trial data.

Load the data using **read_sas** from the **haven** package.

View the resulting tibble both on the command line and by using the built-in Viewer (i.e. with **View(df)**). Are there any differences?

```
library(haven)
df = read_sas("adae.sas7bdat")
df
```

A tibble: 38 x 95

| | STUDYID | SUBJID | SITEID | AGE | SEX | RACE | SAFFL | ARM | ARMCD | ACTARM |
|---|---|---|---|---|---|---|---|---|---|---|
| | <chr> | <chr> | <dbl> | <dbl> | <chr> | <chr> | <chr> | <chr> | <chr> | <chr> |
| 1 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 2 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 3 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 4 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 5 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 6 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 7 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 8 | GS-US-… | 1001 | 1000 | 20 | F | WHITE | Y | [Pla… | P | [Plac… |
| 9 | GS-US-… | 1002 | 1000 | 21 | M | OTHER | Y | [20 … | 1 | [20 m… |
| 0 | GS-US-… | 1002 | 1000 | 21 | M | OTHER | Y | [20 … | 1 | [20 m… |

… with 28 more rows, and 85 more variables: ACTARMCD <chr>, COHORT <chr>, COHORTN <dbl>, TRT01P <chr>, TRT01PN <dbl>,

04-Import-Data-Exercises.Rmd | df

Filter | Cols: « ‹ 1 – 50 › »

| | STUDYID<br>Study Identifier | SUBJID<br>Subject Identifier | SITEID<br>Study Site Identifier | AGE<br>Age | SEX<br>Sex | RACE<br>Race | SAFFL<br>Safety Population Flag |
|---|---|---|---|---|---|---|---|
| 1 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 2 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 3 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 4 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 5 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 6 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 7 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 8 | GS-US-xxx-xxxx | 1001 | 1000 | 20 | F | WHITE | Y |
| 9 | GS-US-xxx-xxxx | 1002 | 1000 | 21 | M | OTHER | Y |
| 10 | GS-US-xxx-xxxx | 1002 | 1000 | 21 | M | OTHER | Y |
| 11 | GS-US-xxx-xxxx | 1002 | 1000 | 21 | M | OTHER | Y |
| 12 | GS-US-xxx-xxxx | 1003 | 1000 | 20 | M | WHITE | Y |
| 13 | GS-US-xxx-xxxx | 1003 | 1000 | 20 | M | WHITE | Y |
| 14 | GS-US-xxx-xxxx | 1003 | 1000 | 20 | M | WHITE | Y |
| 15 | GS-US-xxx-xxxx | 1003 | 1000 | 20 | M | WHITE | Y |

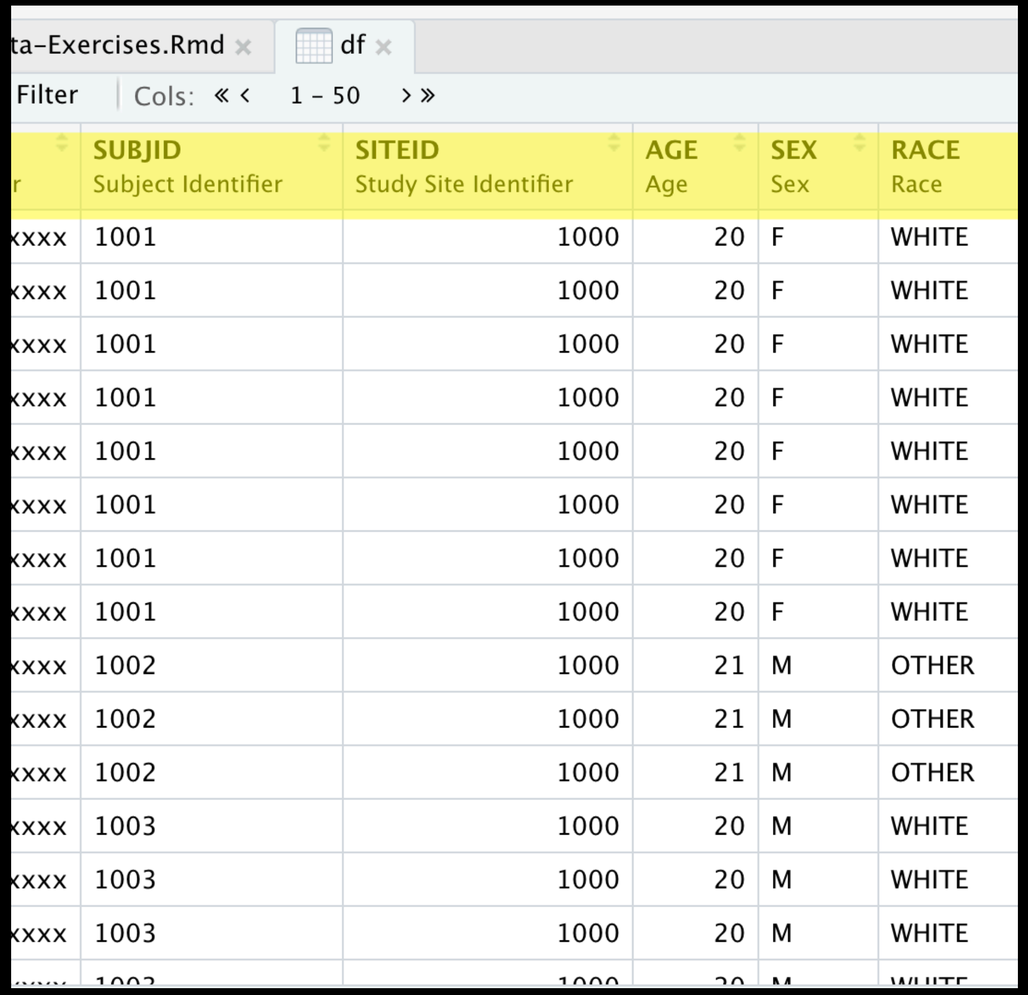
# Final Exam!

ggplot Exercises

1. Create a histogram of patient ages
2. Create a bar chart of patient races.

dplyr exercises

3. How many males and females were in the study?
4. What is the average age of females in each cohort?



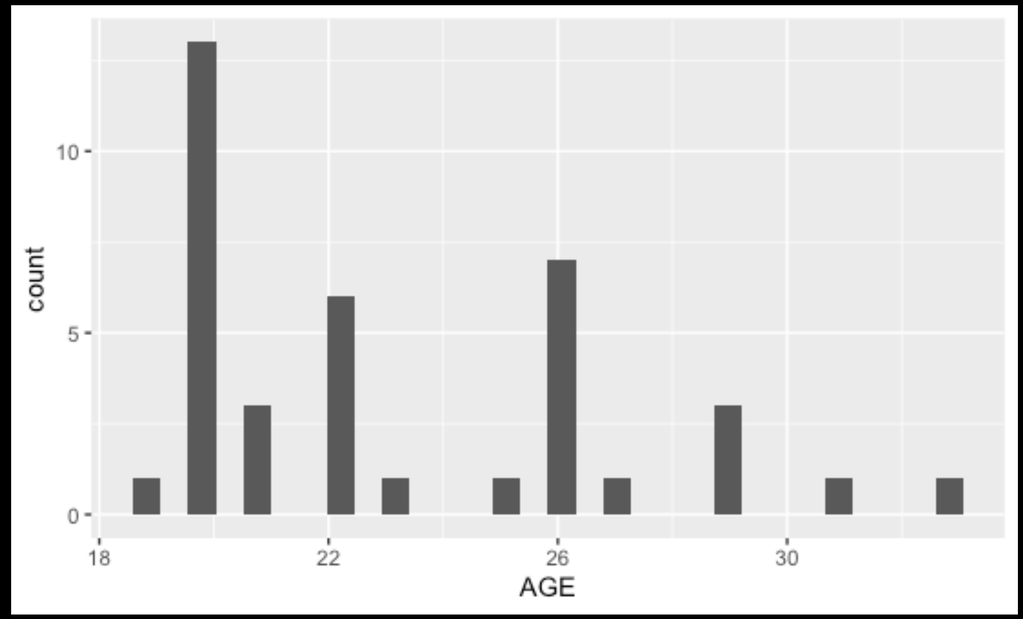
ta-Exercises.Rmd × | df ×

Filter | Cols: « ‹ 1 – 50 › »

| r | SUBJID Subject Identifier | SITEID Study Site Identifier | AGE Age | SEX Sex | RACE Race |
|---|---|---|---|---|---|
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1001 | 1000 | 20 | F | WHITE |
| xxxx | 1002 | 1000 | 21 | M | OTHER |
| xxxx | 1002 | 1000 | 21 | M | OTHER |
| xxxx | 1002 | 1000 | 21 | M | OTHER |
| xxxx | 1003 | 1000 | 20 | M | WHITE |
| xxxx | 1003 | 1000 | 20 | M | WHITE |
| xxxx | 1003 | 1000 | 20 | M | WHITE |

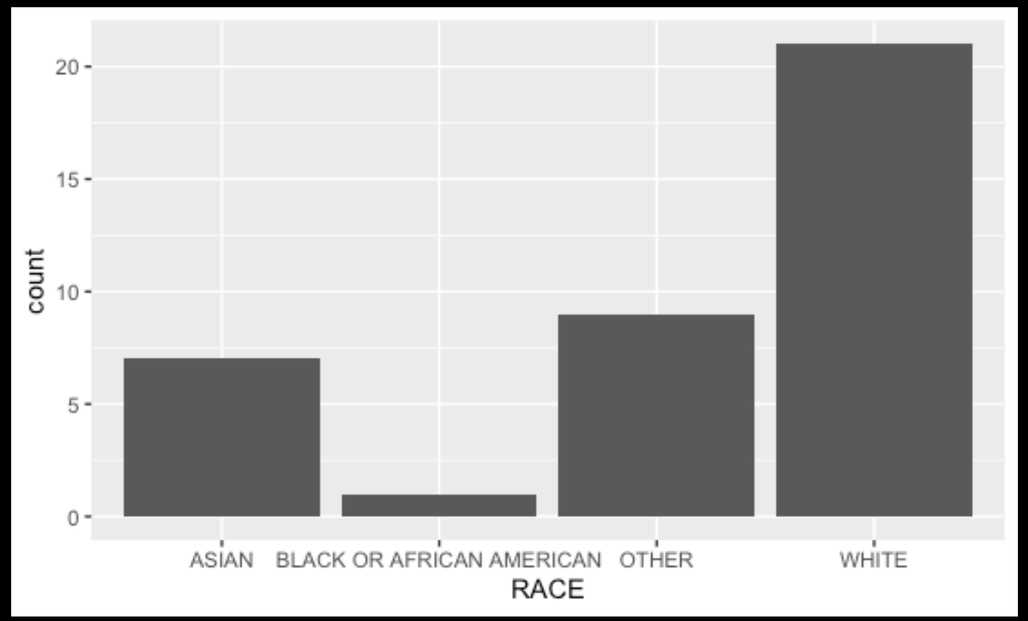
# Histogram of Ages

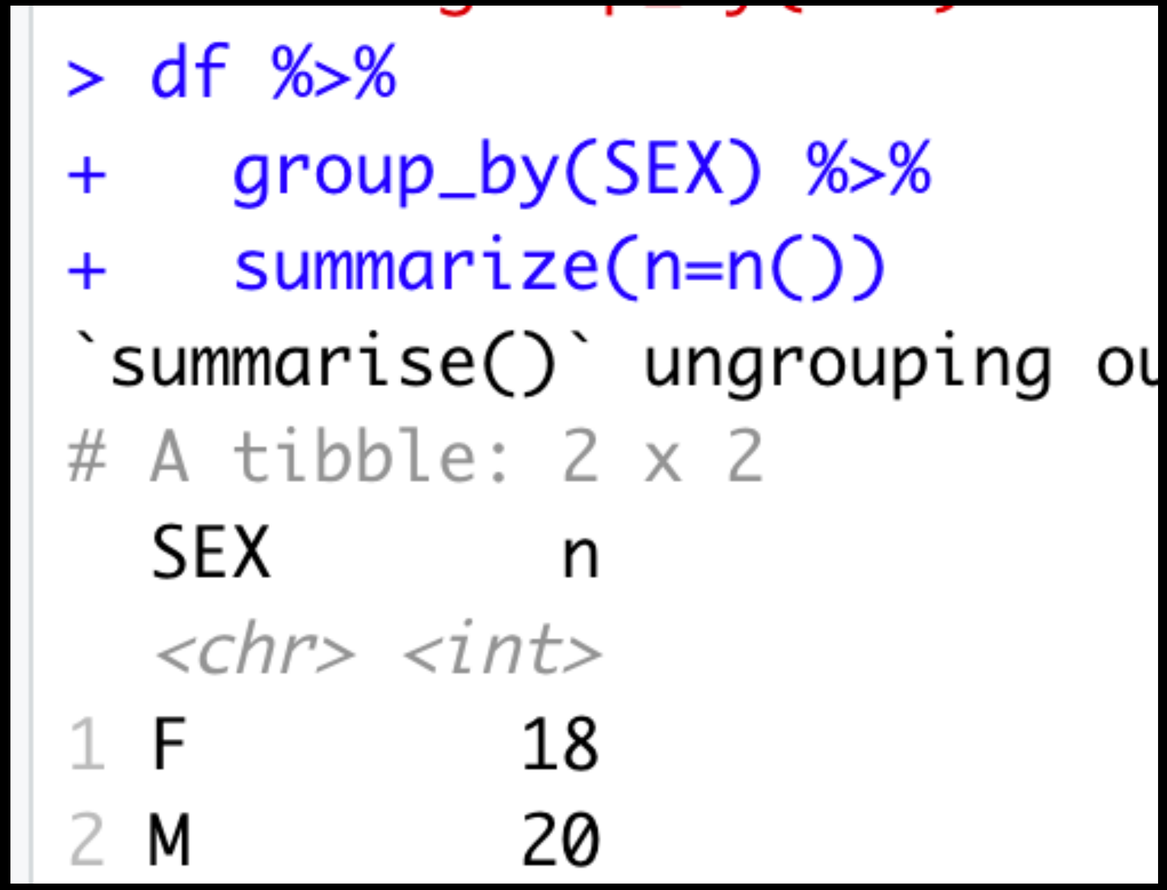
```
ggplot(df, aes(AGE)) +
  geom_histogram()
```



# Bar Chart of Race

```
ggplot(df, aes(RACE)) +
  geom_bar()
```



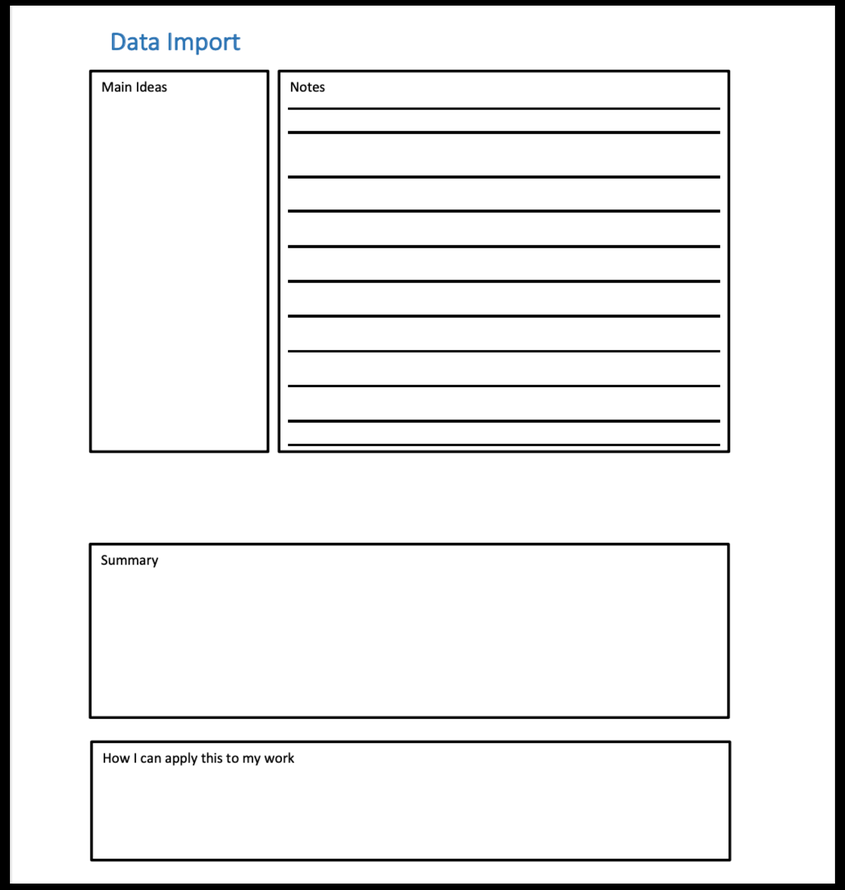


```
> df %>%
+   group_by(SEX) %>%
+   summarize(n=n())
`summarise()` ungrouping ou
# A tibble: 2 x 2
  SEX       n
  <chr> <int>
1 F        18
2 M        20
```

# Patients by Gender

```
> df %>%
+   filter(SEX=="F") %>%
+   group_by(COHORT) %>%
+   summarize(av_age=mean(AGE))
`summarise()` ungrouping output (
# A tibble: 2 x 2
  COHORT   av_age
  <chr>      <dbl>
1 Cohort 1    22.8
2 Cohort 2    22
```

# Mean Female Age by Cohort




# Notes form - please complete

# Homework

- Please practice reading in SAS files into R with haven ...
  - ... and visualizing the data with ggplot2
  - ... and transforming the data with dplyr
- Get stuck?
  - Refer to the Notebooks and Notes you completed
  - And the Cheatsheets you have
  - Ask Google!


# Post-Course Support

# Import Data with