Week 2: *Data Wrangling*

🏛 EMSE 6035: Marketing Analytics for Design Decisions

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Required Packages (check `practice.R` file)

Make sure you have these libraries installed:

```r
install.packages(c("tidyverse", "here"))
```

Remember: you only need to install packages once!

Once installed, you'll need to *load* the libraries every time you open RStudio:

```r
library(tidyverse)
library(here)
```

Week 2: *Data Wrangling*

1. Working with data frames

2. Data wrangling with the *tidyverse*

BREAK

3. Project proposals

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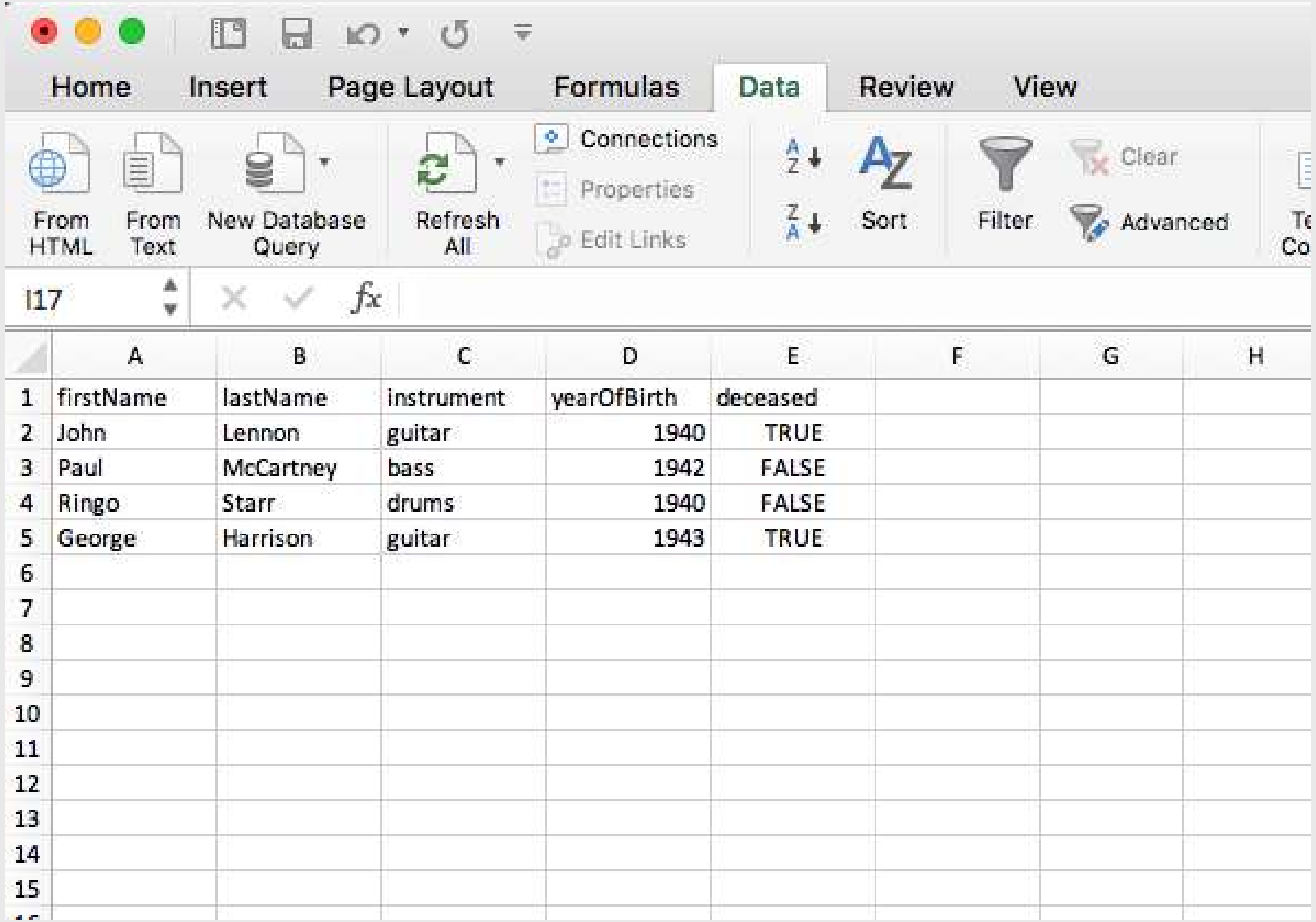
The data frame…in Excel



	A	B	C	D	E
1	firstName	lastName	instrument	yearOfBirth	deceased
2	John	Lennon	guitar	1940	TRUE
3	Paul	McCartney	bass	1942	FALSE
4	Ringo	Starr	drums	1940	FALSE
5	George	Harrison	guitar	1943	TRUE

The data frame...in R

```r
beatles <- tibble(
    firstName   = c("John", "Paul", "Ringo", "George"),
    lastName    = c("Lennon", "McCartney", "Starr", "Harrison"),
    instrument  = c("guitar", "bass", "drums", "guitar"),
    yearOfBirth = c(1940, 1942, 1940, 1943),
    deceased    = c(TRUE, FALSE, FALSE, TRUE)
)

beatles
```

```
#> # A tibble: 4 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 John      Lennon    guitar            1940 TRUE
#> 2 Paul      McCartney bass              1942 FALSE
#> 3 Ringo     Starr     drums             1940 FALSE
#> 4 George    Harrison  guitar            1943 TRUE
```

Columns: *Vectors* of values (must be same data type)

```
beatles
```

```
#> # A tibble: 4 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 John      Lennon    guitar            1940 TRUE
#> 2 Paul      McCartney bass              1942 FALSE
#> 3 Ringo     Starr     drums             1940 FALSE
#> 4 George    Harrison  guitar            1943 TRUE
```

Extract a column using `$`

```
beatles$firstName
```

```
#> [1] "John"   "Paul"   "Ringo"  "George"
```

Rows: Information about individual observations

Information about *John Lennon* is in the first row:

```
beatles[1,]
```

```
#> # A tibble: 1 × 5
#>   firstName lastName instrument yearOfBirth deceased
#>   <chr>     <chr>    <chr>            <dbl> <lgl>
#> 1 John      Lennon   guitar            1940 TRUE
```

Information about *Paul McCartney* is in the second row:

```
beatles[2,]
```

```
#> # A tibble: 1 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 Paul      McCartney bass              1942 FALSE
```

Take a look at the `beatles` data frame in `practice.R`

Getting data into R

1. Load external packages

2. Read in external files (usually a `.csv` file)

NOTE: csv = "comma-separated values"

Data from an R package

```r
library(ggplot2)
```

See which data frames are available in a package:

```r
data(package = "ggplot2")
```

Find out more about a package data set:

```r
?msleep
```

Back to `practice.R`

Importing an external data file

Note the `data.csv` file in your `data` folder.

- **DO NOT** double-click it!
- **DO NOT** open it in Excel!

Excel can **corrupt** your data!

If you **must** open it in Excel:

- Make a copy
- Open the copy

Steps to importing external data files

1. Create a path to the data

```r
library(here)
path_to_data <- here('data', 'data.csv')
path_to_data
```

```
#> [1] "/Users/jhelvy/gh/teaching/MADD/2023-Fall/class/2-data-wrangling/data/data.csv"
```

2. Import the data

```r
library(tidyverse)
data <- read_csv(path_to_data)
```

Using the **here** package to make file paths

The `here()` function builds the path to your **root** to your *working directory* (this is where your `.Rproj` file lives!)

```
here()
```

```
#> [1] "/Users/jhelvy/gh/teaching/MADD/2023-Fall/class/2-data-wrangling"
```

The `here()` function builds the path to files *inside* your working directory

```
path_to_data <- here('data', 'data.csv')
path_to_data
```

```
#> [1] "/Users/jhelvy/gh/teaching/MADD/2023-Fall/class/2-data-wrangling/data/data.csv"
```

Avoid hard-coding file paths!

(they can break on different computers)

```r
path_to_data <- 'data/data.csv'
path_to_data
```

```
#> [1] "data/data.csv"
```

💩 💩

Back to reading in data

```r
path_to_data <- here('data', 'data.csv')
data <- read_csv(path_to_data)
```

Important: Use `read_csv()` instead of `read.csv()`

Your turn

10:00

1) Use the `here()` and `read_csv()` functions to load the `data.csv` file that is in the `data` folder. Name the data frame object `data`.

2) Use the `data` object to answer the following questions:

- How many rows and columns are in the data frame?
- What type of data is each column? (Just look, don't need to type out the answer)
- Preview the different columns - what do you think this data is about? What might one row represent?
- How many unique airports are in the data frame?
- What is the earliest and latest observation in the data frame?
- What is the lowest and highest cost of any one repair in the data frame?

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BREAK

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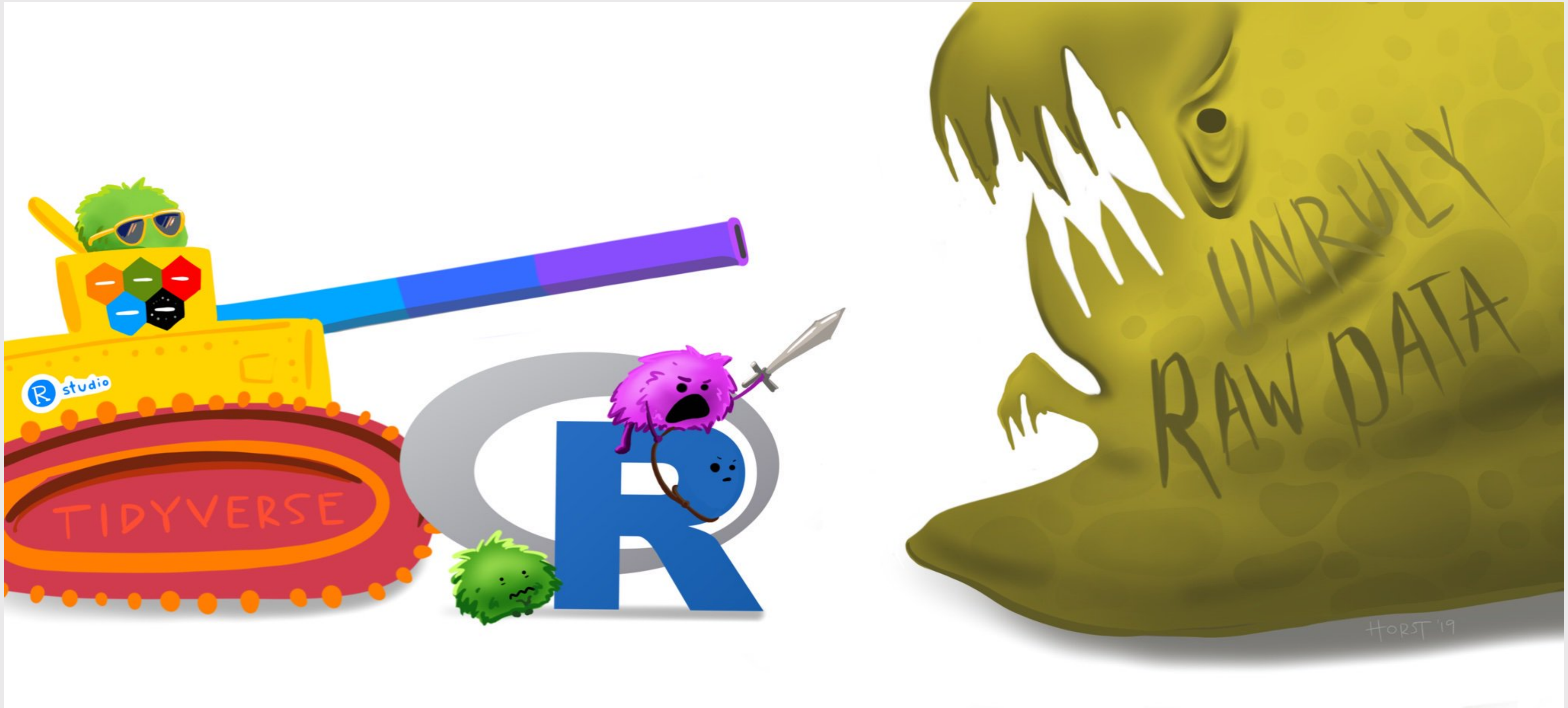
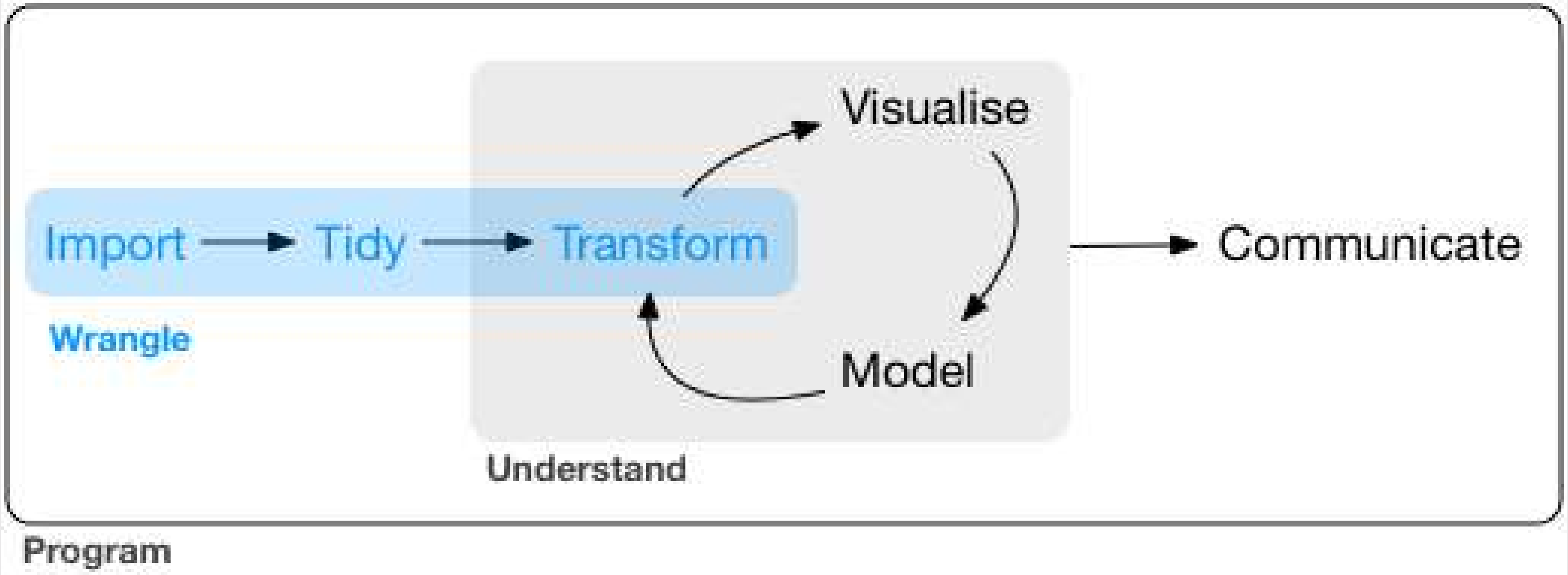
The tidyverse: `stringr` + `dplyr` + `readr` + `ggplot2` + ...



Art by Allison Horst

80% of the job is data wrangling



Today: data wrangling with **dplyr**

Art by Allison Horst

The main `dplyr` "verbs"

"Verb"	What it does
`select()`	Select columns by name
`filter()`	Keep rows that match criteria
`arrange()`	Sort rows based on column(s)
`mutate()`	Create new columns
`summarize()`	Create summary values

Core tidyverse concept:
Chain functions together with "pipes"

%>%

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

```
data %>%
  do_something() %>%
  do_something_else()
```

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

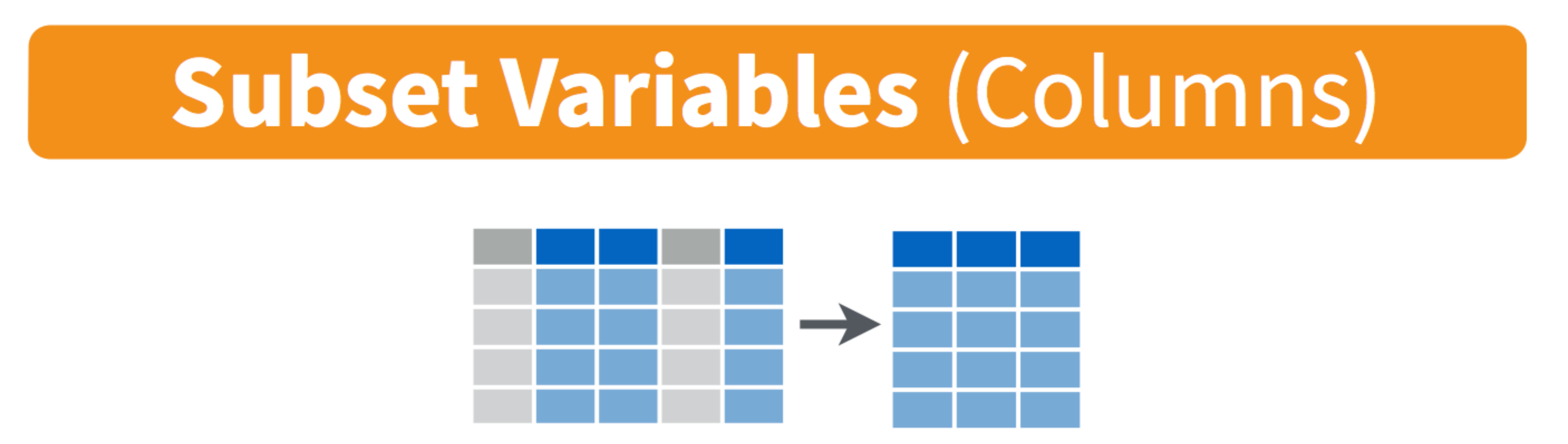
Without Pipes (read from inside-out):

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

With Pipes:

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

Select columns with `select()`



Subset Variables (Columns)

Select columns with `select()`

```r
beatles <- tibble(
    firstName   = c("John", "Paul", "Ringo", "George"),
    lastName    = c("Lennon", "McCartney", "Starr", "Harrison"),
    instrument  = c("guitar", "bass", "drums", "guitar"),
    yearOfBirth = c(1940, 1942, 1940, 1943),
    deceased    = c(TRUE, FALSE, FALSE, TRUE)
)

beatles
```

```
#> # A tibble: 4 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 John      Lennon    guitar            1940 TRUE
#> 2 Paul      McCartney bass              1942 FALSE
#> 3 Ringo     Starr     drums             1940 FALSE
#> 4 George    Harrison  guitar            1943 TRUE
```

Select columns with `select()`

Select the columns `firstName` & `lastName`

```r
beatles %>%
  select(firstName, lastName)
```

```
#> # A tibble: 4 × 2
#>   firstName lastName 
#>   <chr>     <chr>    
#> 1 John      Lennon   
#> 2 Paul      McCartney
#> 3 Ringo     Starr    
#> 4 George    Harrison 
```

Select columns with `select()`

Use the `-` sign to drop columns

```r
beatles %>%
  select(-firstName, -lastName)
```

```
#> # A tibble: 4 × 3
#>   instrument yearOfBirth deceased
#>   <chr>            <dbl> <lgl>
#> 1 guitar            1940 TRUE
#> 2 bass              1942 FALSE
#> 3 drums             1940 FALSE
#> 4 guitar            1943 TRUE
```

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

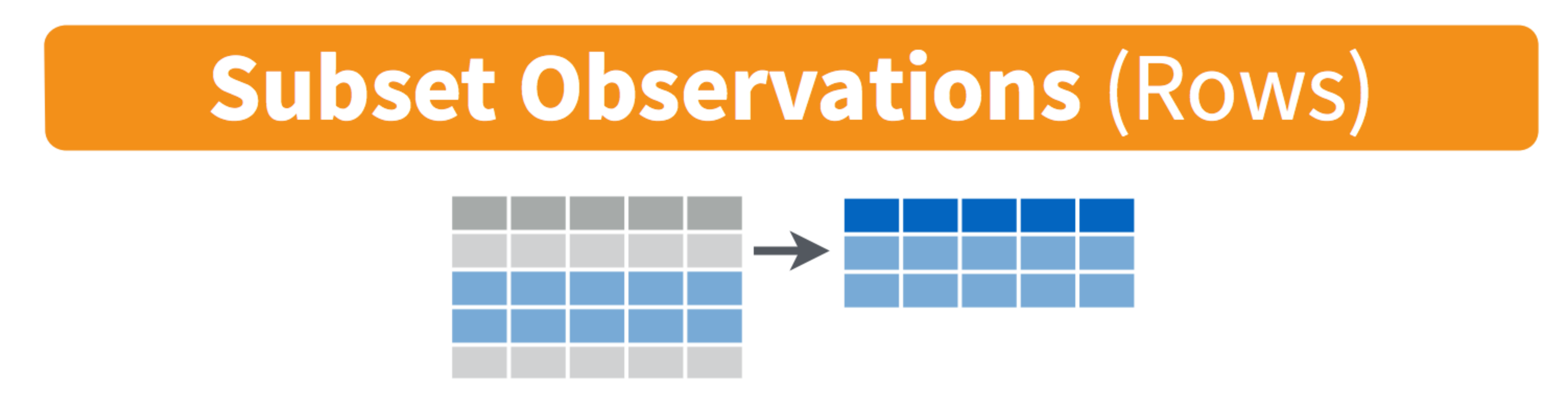
Select columns with `select()`

Select the columns that end with `"Name"`:

```
beatles %>%
  select(ends_with("Name"))
```

```
#> # A tibble: 4 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 John      Lennon
#> 2 Paul      McCartney
#> 3 Ringo     Starr
#> 4 George    Harrison
```

Keep specific rows with `filter()`



Keep specific rows with `filter()`

Keep only the rows with band members born after 1941

```
#> # A tibble: 4 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 John      Lennon    guitar            1940 TRUE
#> 2 Paul      McCartney bass              1942 FALSE
#> 3 Ringo     Starr     drums             1940 FALSE
#> 4 George    Harrison  guitar            1943 TRUE
```

Keep specific rows with `filter()`

Keep only the rows with band members born after 1941

```
beatles %>%
  filter(yearOfBirth > 1941)
```

```
#> # A tibble: 2 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 Paul      McCartney bass              1942 FALSE
#> 2 George    Harrison  guitar            1943 TRUE
```

Keep specific rows with `filter()`

Keep only the rows with band members born after 1941 **& are still living**

```
beatles %>%
  filter(yearOfBirth > 1941, deceased == FALSE)
```

```
#> # A tibble: 1 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 Paul      McCartney bass              1942 FALSE
```

```
beatles %>%
  filter((yearOfBirth > 1941) & (deceased == FALSE))
```

```
#> # A tibble: 1 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 Paul      McCartney bass              1942 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`

```
data %>%
    filter(!is.na(variable))
```

Combine filter() and select()

Get the **first & last name** of members born after 1941 & are still living

```
beatles %>%
  filter(yearOfBirth > 1941, deceased == FALSE) %>%
  select(firstName, lastName)
```

```
#> # A tibble: 1 × 2
#>   firstName lastName
#>   <chr>     <chr>
#> 1 Paul      McCartney
```

Your turn

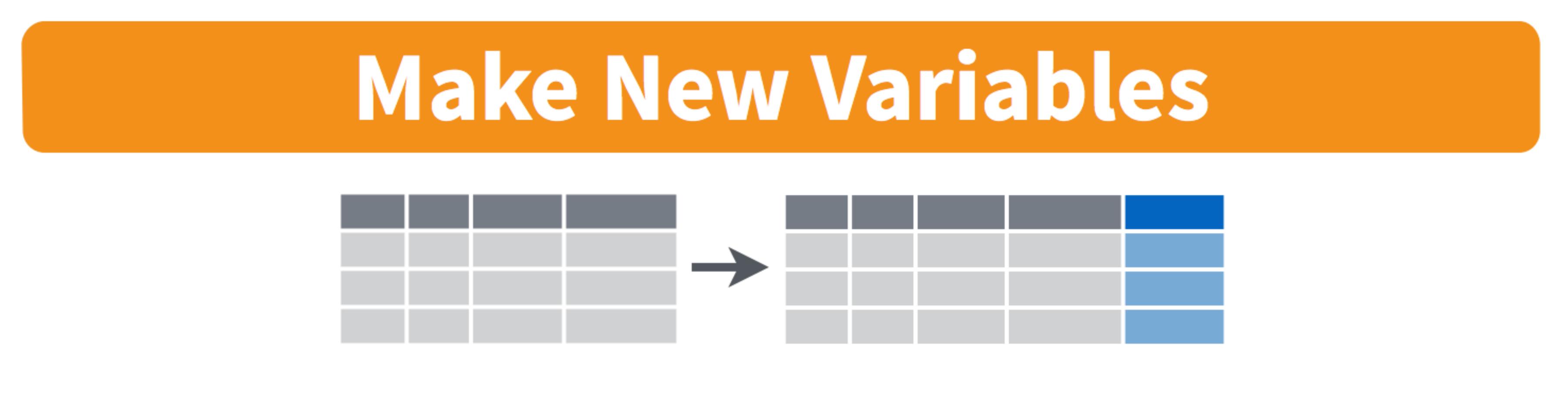
10:00

1) Use the `here()` and `read_csv()` functions to load the `data.csv` file that is in the `data` folder. Name the data frame object `data`.

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

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

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()

Use the yearOfBirth variable to compute the age of each band member

```r
beatles %>%
    mutate(age = 2022 - yearOfBirth)
```

```
#> # A tibble: 4 × 6
#>   firstName lastName  instrument yearOfBirth deceased   age
#>   <chr>     <chr>     <chr>            <dbl> <lgl>    <dbl>
#> 1 John      Lennon    guitar            1940 TRUE        82
#> 2 Paul      McCartney bass              1942 FALSE       80
#> 3 Ringo     Starr     drums             1940 FALSE       82
#> 4 George    Harrison  guitar            1943 TRUE        79
```

You can *immediately* use new variables

```r
beatles %>%
    mutate(
        age = 2022 - yearOfBirth,
        meanAge = mean(age))
```

```
#> # A tibble: 4 × 7
#>   firstName lastName  instrument yearOfBirth deceased   age meanAge
#>   <chr>     <chr>     <chr>            <dbl> <lgl>    <dbl>   <dbl>
#> 1 John      Lennon    guitar            1940 TRUE        82    80.8
#> 2 Paul      McCartney bass              1942 FALSE       80    80.8
#> 3 Ringo     Starr     drums             1940 FALSE       82    80.8
#> 4 George    Harrison  guitar            1943 TRUE        79    80.8
```

Handling if/else conditions

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

```r
beatles %>%
    mutate(playsGuitar = ifelse(instrument == "guitar", TRUE, FALSE))
```

```
#> # A tibble: 4 × 6
#>   firstName lastName  instrument yearOfBirth deceased playsGuitar
#>   <chr>     <chr>     <chr>            <dbl> <lgl>    <lgl>
#> 1 John      Lennon    guitar            1940 TRUE     TRUE
#> 2 Paul      McCartney bass              1942 FALSE    FALSE
#> 3 Ringo     Starr     drums             1940 FALSE    FALSE
#> 4 George    Harrison  guitar            1943 TRUE     TRUE
```

Sort data frame with arrange()

Sort beatles data frame by year of birth

```
beatles %>%
    arrange(yearOfBirth)
```

```
#> # A tibble: 4 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>   
#> 1 John      Lennon    guitar            1940 TRUE    
#> 2 Ringo     Starr     drums             1940 FALSE   
#> 3 Paul      McCartney bass              1942 FALSE   
#> 4 George    Harrison  guitar            1943 TRUE    
```

Sort data frame with arrange()

Use the desc() function to sort in descending order

```
beatles %>%
    arrange(desc(yearOfBirth))
```

```
#> # A tibble: 4 × 5
#>   firstName lastName  instrument yearOfBirth deceased
#>   <chr>     <chr>     <chr>            <dbl> <lgl>
#> 1 George    Harrison  guitar            1943 TRUE
#> 2 Paul      McCartney bass              1942 FALSE
#> 3 John      Lennon    guitar            1940 TRUE
#> 4 Ringo     Starr     drums             1940 FALSE
```

Sort rows with arrange()

Compute the band member age, then sort based on the youngest:

```
beatles %>%
    mutate(age = 2022 - yearOfBirth) %>%
    arrange(age)
```

```
#> # A tibble: 4 × 6
#>   firstName lastName  instrument yearOfBirth deceased   age
#>   <chr>     <chr>     <chr>            <dbl> <lgl>    <dbl>
#> 1 George    Harrison  guitar            1943 TRUE        79
#> 2 Paul      McCartney bass              1942 FALSE       80
#> 3 John      Lennon    guitar            1940 TRUE        82
#> 4 Ringo     Starr     drums             1940 FALSE       82
```

Your turn

10:00

1) Use the `here()` and `read_csv()` functions to load the `data.csv` file that is in the `data` folder. Name the data frame object `data`.

2) Using the `data` object, 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.

3) Remove rows that have NA for `cost_repairs_infl_adj` and re-arrange the resulting data frame based on the highest height and most expensive cost

Break

05:00

Week 2: *Data Wrangling*

1. Working with data frames

2. Data wrangling with the *tidyverse*

BREAK

3. Project proposals

Project Proposal Guidelines

Proposal Items

Item	Description
Abstract	Product / technology in just a few sentences
Introduction	Description, picture, background
Market Opportunity	Identify your customer, competitors, and market size
Product Attributes & Research Questions	2-4 key variables related to product's design and performance
Questions	Major outstanding questions to be resolved

Today

Market Opportunity

- Identify customer
- Identify competitors
- Identify market size

Product Attributes

Features your *customer* cares about

Research Questions

Decisions are trying to inform

Example: **Folding solar panels**

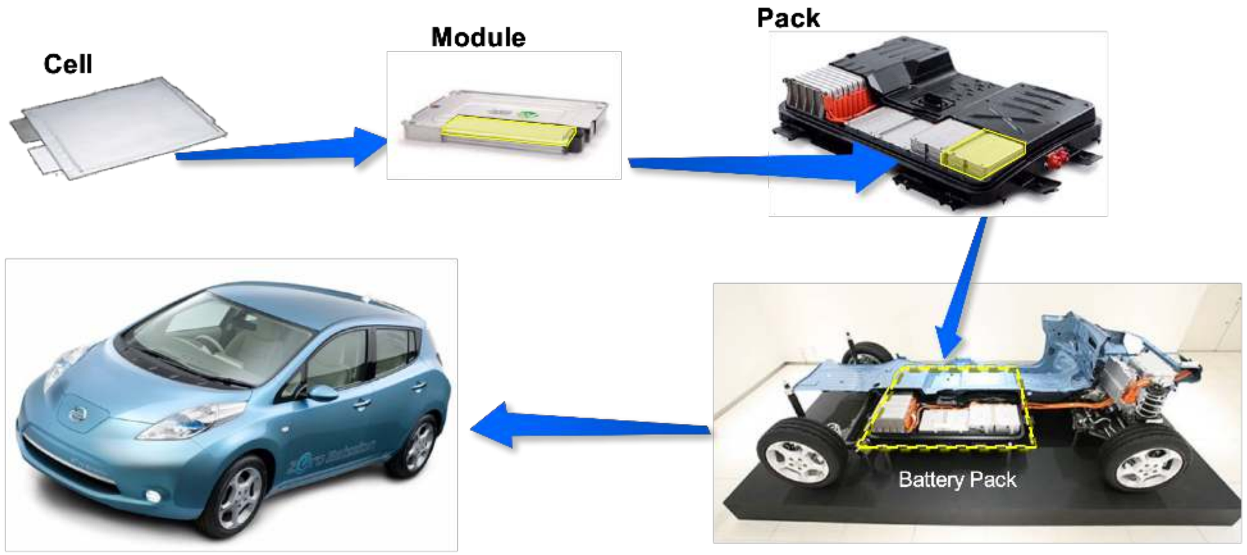
Who is your customer?

- General public?
- Outdoor enthusiasts?
- Emergency gear?

Competitors?

- Similar folding panels
- Batteries?

Example: **Electric vehicle battery**



Who is your customer?

- Car buyers

Competitors?

- Hybrid vehicles?
- Efficient gasoline vehicles?

Product Attributes

Features your *customer* cares about

Research Questions

Decisions you are trying to inform

Product Diagram

Attribute Units

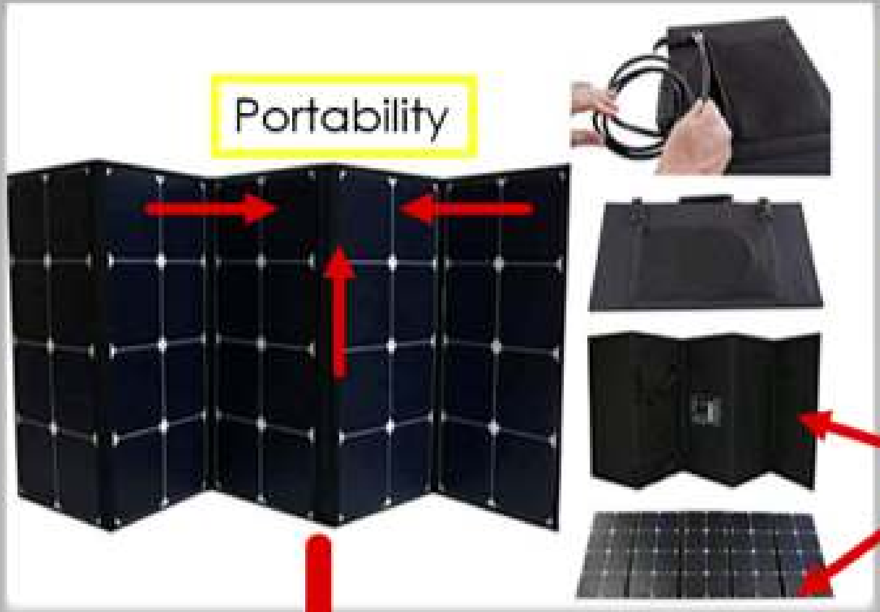
Price– USD
Weight– Kg
Power Output – Watts
Durability – Months
Portability – LxWxH

Decision Variable Units

Power Density – W/Kg
Degradation Rate – Hours
Packing Design – Cm^3

Durability

Degradation Protections



Power Output

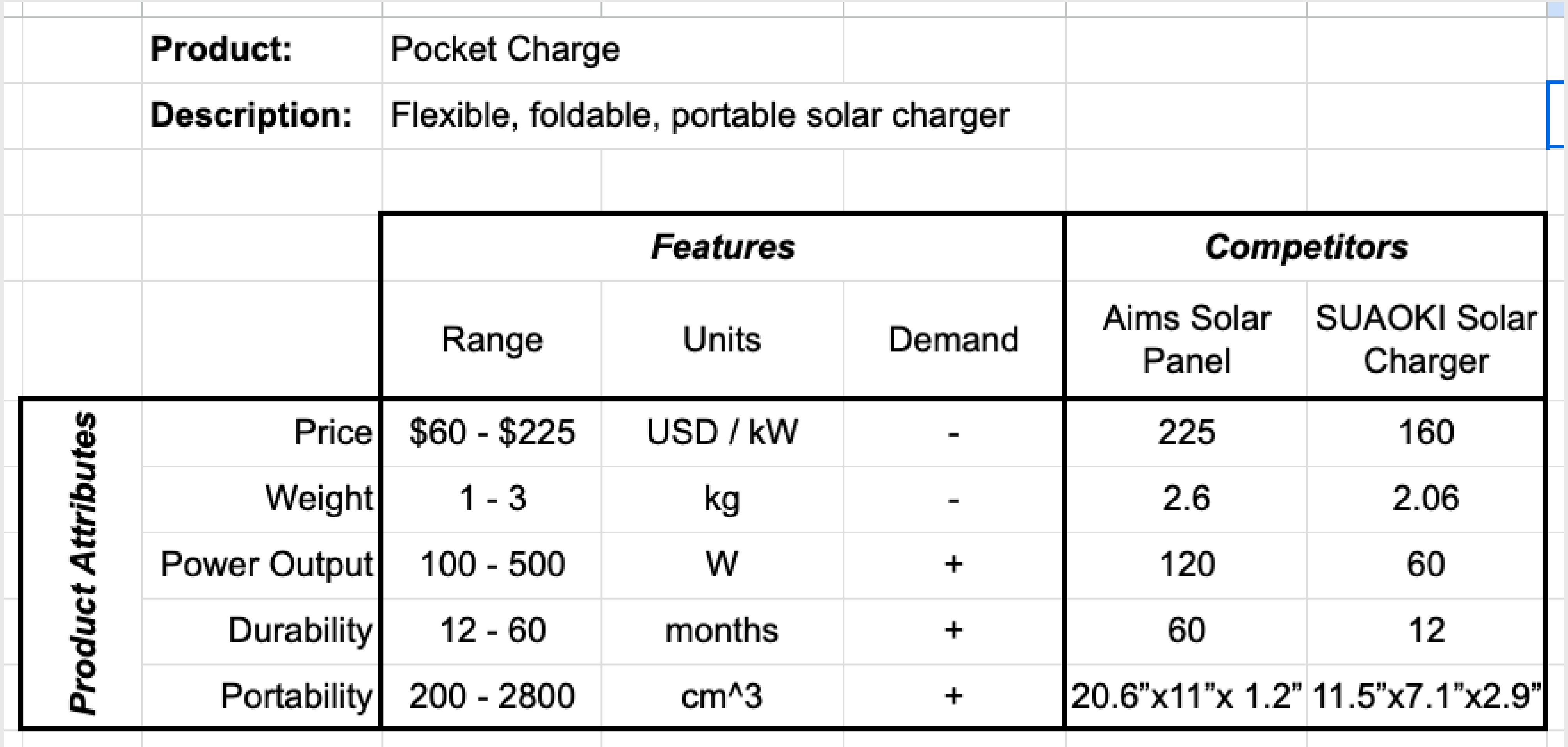
Power Density

Packing Design

Weight

Image Sources:
1.https://www.deviantart.com/kota3214/art/Rainy-Sun-244479413
2.https://www.pennscale.com/products/ntep-certified-scales/label-printing-scales/
3. https://www.thisiswhyimbroke.com/[illegible] foldable-solar-panel-charger/

Product Attributes Table (example)



Product: Pocket Charge

Description: Flexible, foldable, portable solar charger

		Features			***Competitors***	
		Range	Units	Demand	Aims Solar Panel	SUAOKI Solar Charger
Product Attributes	Price	$60 - $225	USD / kW	-	225	160
	Weight	1 - 3	kg	-	2.6	2.06
	Power Output	100 - 500	W	+	120	60
	Durability	12 - 60	months	+	60	12
	Portability	200 - 2800	cm^3	+	20.6”x11”x 1.2”	11.5”x7.1”x2.9”

Team Proposals

15:00

1. Re-arrange tables to sit with your team
2. Discuss & identify your customer & potential competitors
3. Discuss & identify key *Product Attributes* & *Research Questions*
4. Start building out your model relationships table (copy from this example)

Suggestions

- You may want to start with simple bullet lists
- Start with more items rather than fewer (can always cut back later)