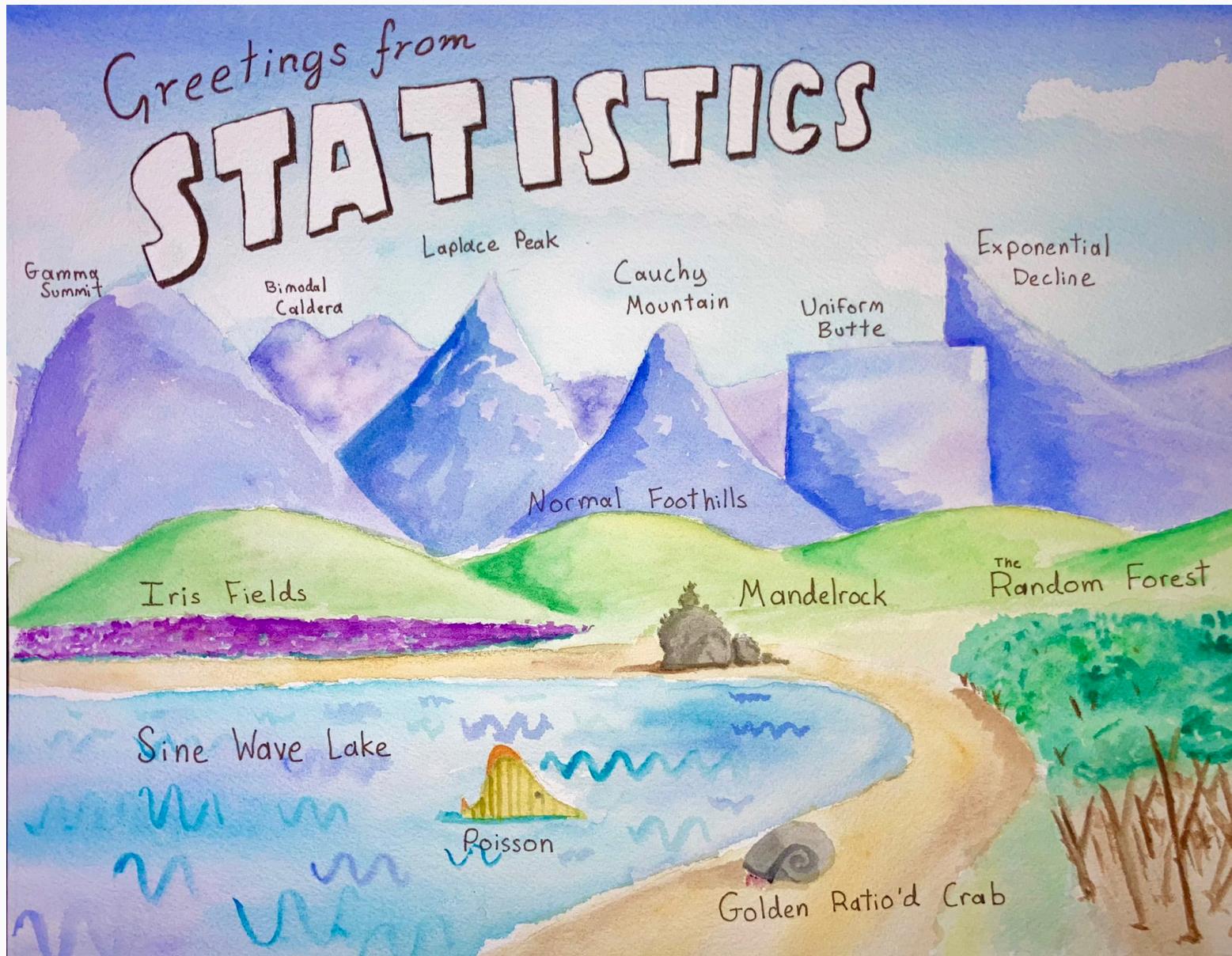


# Introduction to DAV 5300

## Computational Mathematics and Statistics

Jason Bryer, Ph.D.

January 21, 2025



@skyetetra

# Agenda

- Introductions
- Syllabus
- Class meetups
- Course Schedule
- Assignments (how you will be graded)
- Software setup
- Brief introduction to R

While waiting, please complete this formative assessment:



# A little about me...

- Earned my Ph.D. in Educational Psychology and Methodology from the University at Albany.  
Dissertation: [A National Study Comparing Charter and Traditional Public Schools Using Propensity Score Analysis](#)
- Assistant Professor at CUNY in Data Science and Information Systems
- Principal Investigator for a Department of Education Grant to develop and test the Diagnostic Assessment and Achievement of College Skills ([www.DAACS.net](http://www.DAACS.net))
- Authored over a dozen R packages including:
  - [likert](#)
  - [sqlutils](#)
  - [timeline](#)
- Specialize in propensity score methods. Three new methods/R packages developed include:
  - [multilevelPSA](#)
  - [TriMatch](#)
  - [PSAboot](#)

# Also a Father...



# Runner...

---



And photographer.



# Your turn...

What is your name?

What program are you in?

What are your career goals?

Something unique about you (e.g. hobby, interest, favorite movie)?

# Syllabus

Syllabus and course materials are here:

<https://spring2025.dav5300.net>

We will use Canvas primary for submitting assignments only. Please submit PDFs.

PDFs are preferred for the homework as there is some LaTeX formatting in the R markdown files. The `tinytex` R package helps with install LaTeX, but you can also install LaTeX using [MiKTeX](#) (for Windows) and [BasicTeX](#) (for Mac).



# Class Meetings

Class will meet every Tuesday.

In order to get the most out of this class attendance is required.

**One Minute Papers** - Complete the one minute paper after each Meetup (whether you watch live or watch the recordings). It should take approximately one to two minutes to complete.

# Schedule

Start	Topic
Tuesday, August 27, 2024	Intro to the Course
Tuesday, September 03, 2024	Intro to Data
Tuesday, September 10, 2024	Summarizing Data
Tuesday, September 17, 2024	Probability
Tuesday, September 24, 2024	Distributions
Tuesday, October 01, 2024	Foundation for Inference
Tuesday, October 08, 2024	Inference for Categorical Data
Tuesday, October 15, 2024	Inference for Numerical Data
Tuesday, October 22, 2024	Linear Regression
Tuesday, October 29, 2024	Maximum Likelihood Estimation
Tuesday, November 05, 2024	Multiple Regression
Tuesday, November 12, 2024	Conferences (online)
Tuesday, November 19, 2024	Predictive Modeling
Tuesday, November 26, 2024	NO MEETUP - Thanksgiving
Tuesday, December 03, 2024	Bayesian Analysis
Tuesday, December 10, 2024	Presentations
Tuesday, December 17, 2024	Final Exam

Assignments are due on Monday before the next class.

# Textbooks

*OpenIntro Statistics* by David Diaz, Mine Çetinkaya-Rundel, and Christopher D Barr.

*Learning Statistics with R* by Danielle Navaro - We will only use the Bayesian chapter from this book.

## Optional

*R for Data Science* by Hadley Wickham and Garrett Grolemund - Recommended reference for those new to R.

# Assignments

**Labs** (30%) - Labs are designed to provide you an opportunity to apply statistical concepts using statistical software.

**Textbook questions** (15%) - The assigned questions from the textbook provide an opportunity to assess conceptional understandings.

**Participation** (10%) - You are expected to attend every class and to complete a **one minute paper** at the conclusion of class.

**Data Project** (25%) - In a group of 2 to 3 students will present the results of analysis using a data set of your choice. More details will be provided a few weeks into the class.

**Final exam** (20%) - A multiple choice exam will be given on the last day of class.

**All assignments are due on Monday.** Assignments submitted late will be penalized. Assignments will not be accepted more than one week after their due date.

# Academic Integrity

With the exception of the data project, I expect you to complete all assignments (e.g. homework, labs) on your own. It is fine to ask questions of your peers and professor, but working together and/or sharing answers is not allowed.

## Yeshiva's Policy

The submission by a student of any examination, course assignment, or degree requirement is assumed to guarantee that the thoughts and expressions therein not expressly credited to another are literally the student's own. Evidence to the contrary will result in appropriate penalties. For more information, visit <https://www.yu.edu/academic-integrity>.

# Communication

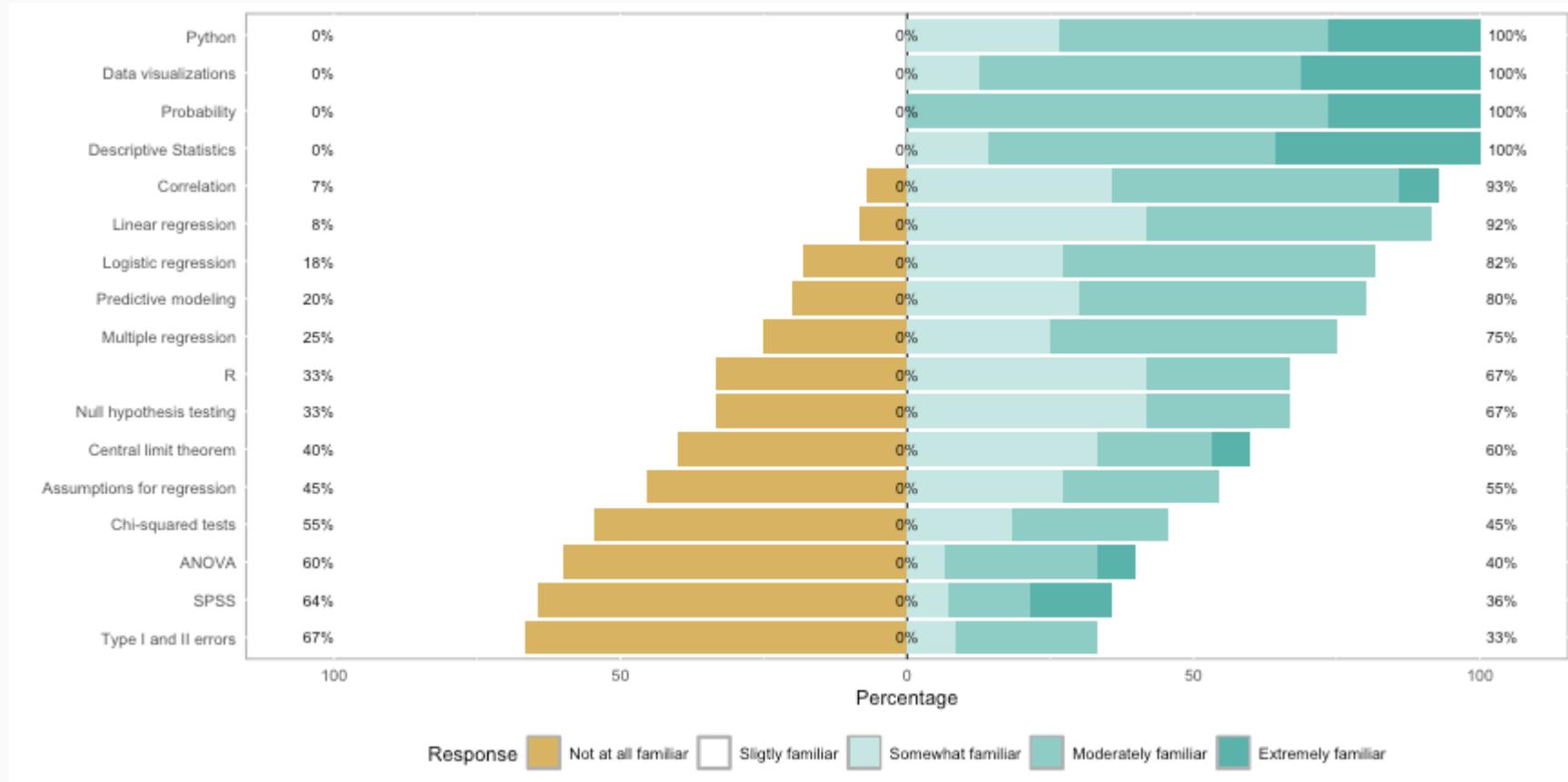
- Email: [jason.bryer@yu.edu](mailto:jason.bryer@yu.edu).
- Canvas
- Office hours before and after class and by appointment.
- Slack  
<https://dav5300spring2025.slack.com>

Scan this QR code to join the Slack workspace:



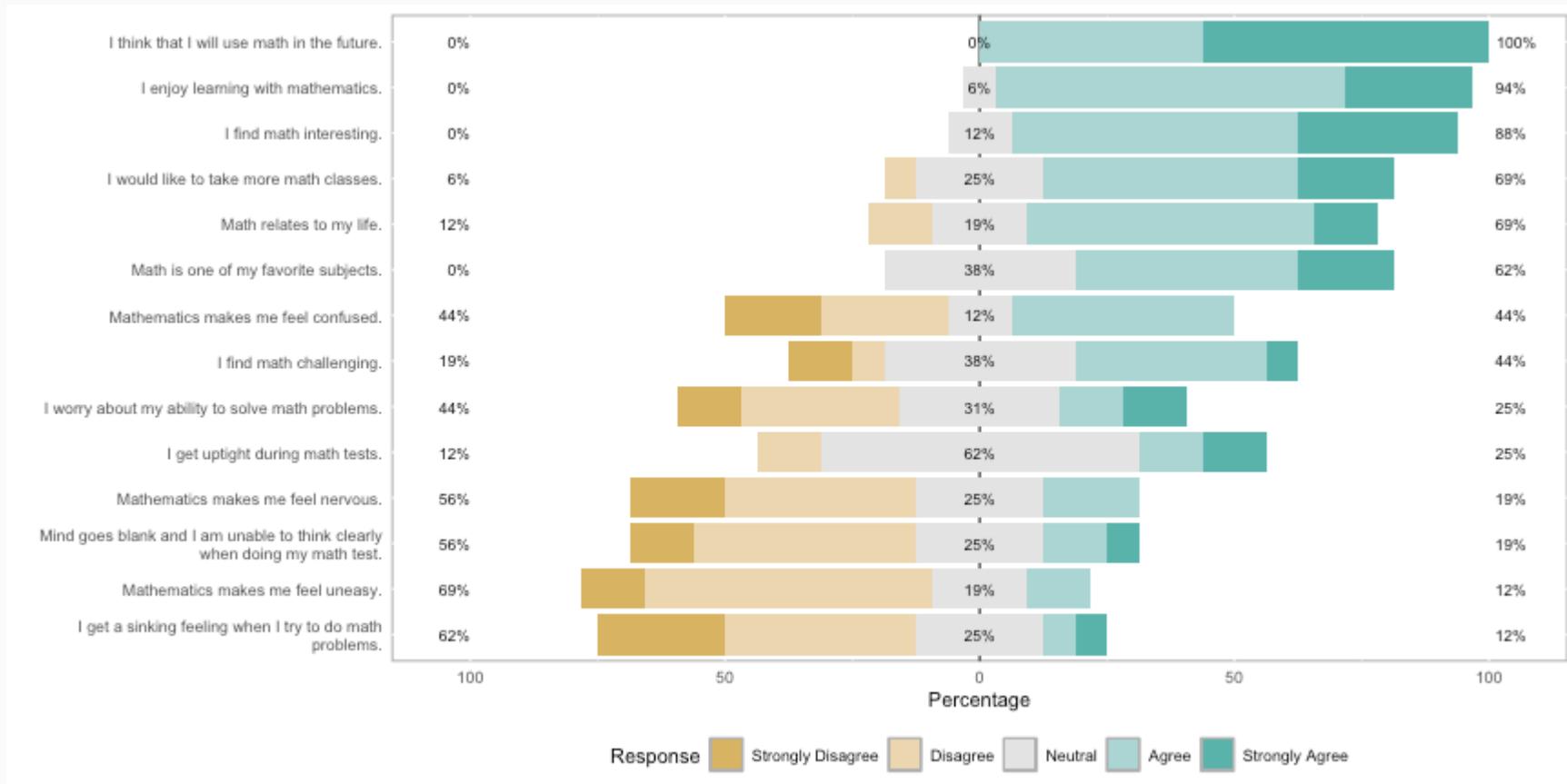
# Familiarity with Statistical Topics

```
likert(stats.results) %>% plot(center = 2.5)
```



# Math Anxiety Survey Scale

```
likert(mass.results) %>% plot()
```



# Software Setup

# Why R?

There are many languages data scientists use. **R** is specifically designed for statistics. We will leverage many R packages that are specifically designed to conduct, teach, and communicate statistical analysis.

To be a well rounded data scientists, I believe you need to have experience in both R and Python. For this course:

- Use R for the labs (they are designed to help you learn the core commands).
- You may use Python or R for the homework and data project.



# Software



This is an applied statistics course so we will make extensive use of the **R statistical programming language**.

- Install **R** and **RStudio** on your own computer. I encourage everyone to do this at some point by the end of the semester.

You will also need to have **LaTeX** installed as well in order to create PDFs. The **tinytex** R package helps with this process:

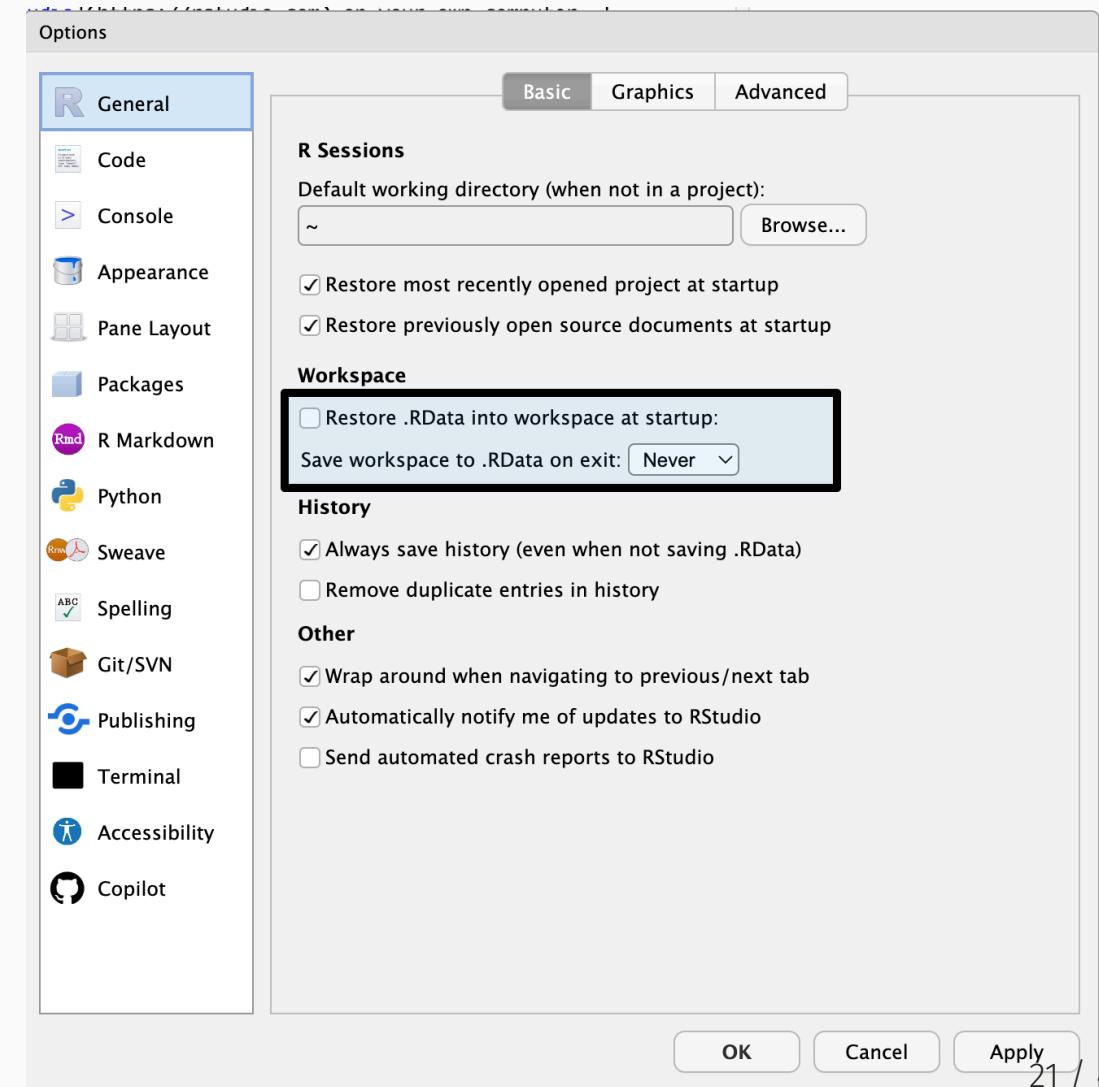
```
install.packages('tinytex')
tinytex::install_tinytex()
```

# Clean Environment Between Sessions

By default RStudio will ask you to save your session when closing the application. Additionally, if the `.RData` file exists in the project directory, data saved in that file will be loaded into your session. *I highly recommend turning this off.* Doing so will ensure you have a clean environment everytime you start RStudio.

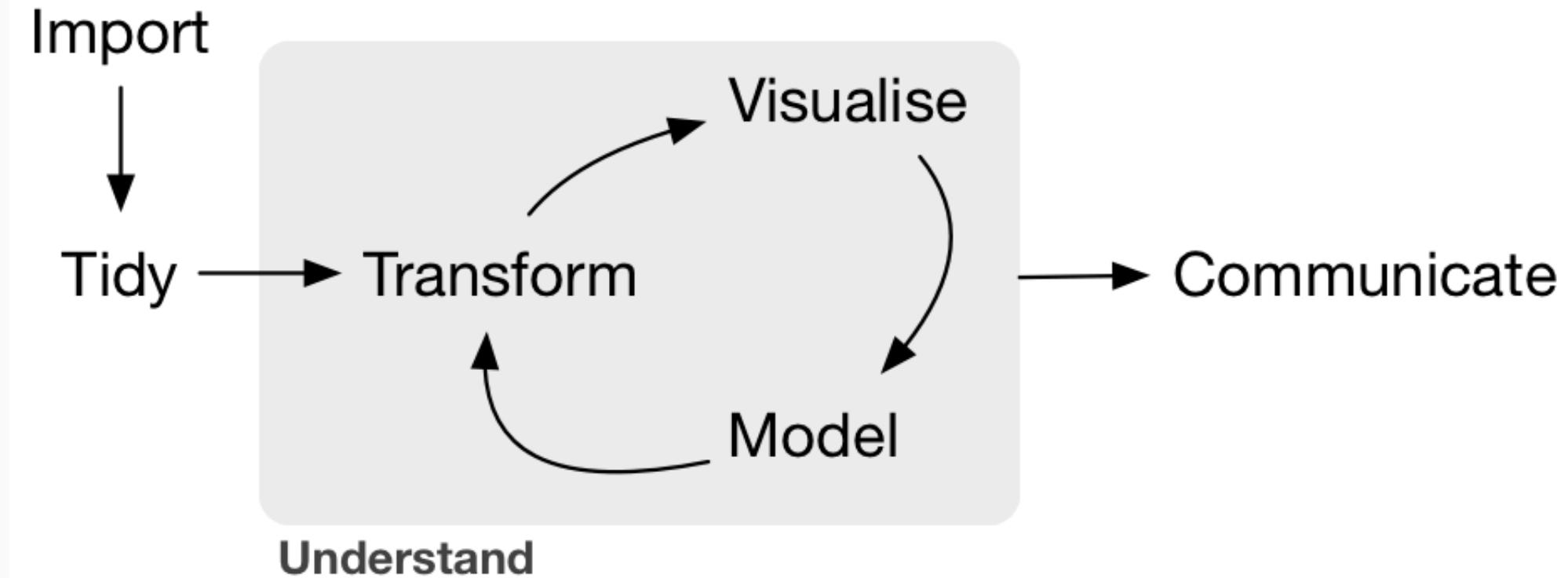
- In RStudio, click the `Tools` menu then `Global Options`
- Uncheck "Restore `.RData` into workspace at startup"
- For "Save workspace to `.RData` on exit" select "Never"

**Why do this?** Whenever you knit a document (e.g. Rmarkdow, Quarto) R will create a new, blank, session to knit the document. When working interactively it is easy to run commands out of order. It is always good to check your work by resetting your environment (click `Session --> Restart R`) and running your commands in order to ensure everything will work as intended.



# Introduction to R

# Workflow



Source: Wickham & Golemud, 2017

# Tidy Data

“**TIDY DATA** is a standard way of mapping the meaning of a dataset to its structure.”

—HADLEY WICKHAM

## In tidy data:

- each variable forms a column
- each observation forms a row
- each cell is a single measurement

each column a variable

each row an observation

id	name	color
1	floof	gray
2	max	black
3	cat	orange
4	donut	gray
5	merlin	black
6	panda	calico

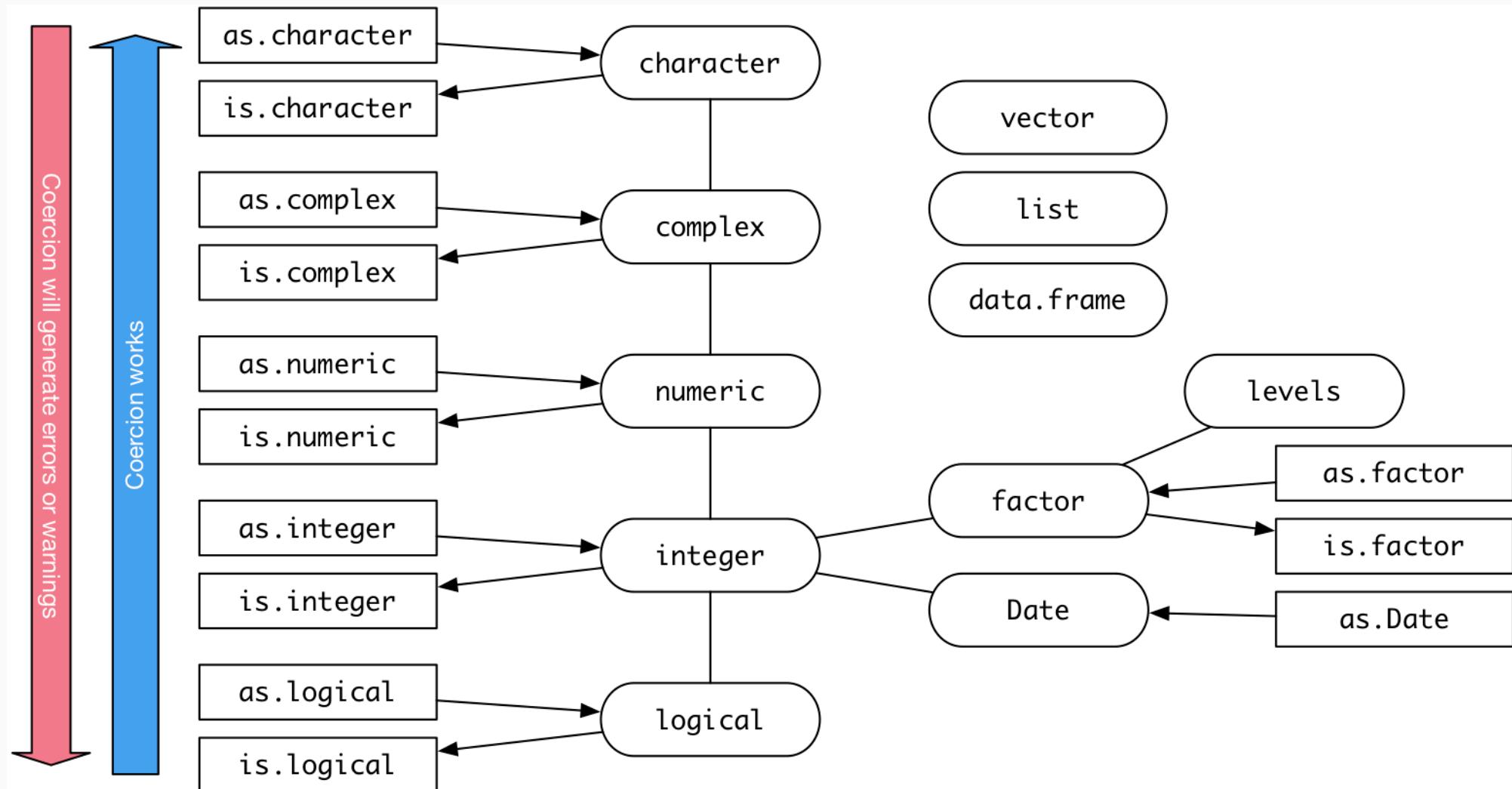
Wickham, H. (2014). Tidy Data. Journal of Statistical Software 59 (10). DOI: 10.18637/jss.v059.i10

# Types of Data

- Numerical (quantitative)
  - Continuous
  - Discrete
- Categorical (qualitative)
  - Regular categorical
  - Ordinal



# Data Types in R





# About legosets

To install the `brickset` package:

```
remotes::install_github('jbryer/brickset')
```

To load the `legosets` dataset.

```
data('legosets', package = 'brickset')
```

The `legosets` data has 20420 observations of 36 variables.

```
names(legosets)
```

```
## [1] "setID"                 "number"                "numberVariant"  
## [4] "name"                  "year"                  "theme"  
## [7] "themeGroup"             "subtheme"              "category"  
## [10] "released"               "pieces"                "minifigs"  
## [13] "bricksetURL"            "rating"                "reviewCount"  
## [16] "packagingType"          "availability"          "agerange_min"  
## [19] "thumbnailURL"           "imageURL"              "US_retailPrice"  
## [22] "US_dateFirstAvailable" "US_dateLastAvailable" "UK_retailPrice"  
## [25] "UK_dateFirstAvailable" "UK_dateLastAvailable" "CA_retailPrice"  
## [28] "CA_dateFirstAvailable" "CA_dateLastAvailable" "DE_retailPrice"  
## [31] "DE_dateFirstAvailable" "DE_dateLastAvailable" "height"  
## [34] "width"                  "depth"                 "weight"
```

# Structure (str)

str(legosets)

```
## 'data.frame': 20420 obs. of 36 variables:
## $ setID      : int 7693 7695 7697 7698 25534 ...
## $ number     : chr "1" "2" "3" "4" ...
## $ numberVariant : int 8 8 6 4 6 1 1 1 3 4 ...
## $ name       : chr "Small house set" "Medium house set" "Medium house set" "Large house set" ...
## $ year        : int 1970 1970 1970 1970 1970 1970 1970 1970 1970 ...
## $ theme      : chr "Minitalia" "Minitalia" "Minitalia" "Minitalia" ...
## $ themeGroup : chr "Vintage" "Vintage" "Vintage" "Vintage" ...
## $ subtheme   : chr NA NA NA NA ...
## $ category   : chr "Normal" "Normal" "Normal" "Normal" ...
## $ released    : logi TRUE TRUE TRUE TRUE TRUE ...
## $ pieces      : int 67 109 158 233 NA 1 1 60 65 NA ...
## $ minifigs   : int NA NA NA NA NA NA NA NA NA ...
## $ bricksetURL: chr "https://brickset.com/sets/1-8" "https://brickset.com/sets/2-8" "https://brickset.com/sets/3-6" "https://brickset.com/sets/4-4" ...
## $ rating      : num 0 0 0 0 0 0 0 0 0 ...
## $ reviewCount: int 0 0 1 0 0 0 0 0 0 ...
## $ packagingType: chr "{Not specified}" "{Not specified}" "{Not specified}" "{Not specified}" ...
## $ availability: chr "{Not specified}" "{Not specified}" "{Not specified}" "{Not specified}" ...
## $ agerange_min: int NA NA NA NA NA NA NA NA NA ...
## $ thumbnailURL: chr "https://images.brickset.com/sets/small/1-8.jpg" "https://images.brickset.com/sets/small/2-8.jpg" "https://images.brickset.com/sets/small/3-6.jpg" "https://images.brickset.com/sets/small/4-4.jpg" ...
## $ imageURL    : chr "https://images.brickset.com/sets/images/1-8.jpg" "https://images.brickset.com/sets/images/2-8.jpg" "https://images.brickset.com/sets/images/3-6.jpg" "https://images.brickset.com/sets/images/4-4.jpg" ...
## $ US_retailPrice: num NA NA NA NA NA NA NA NA NA ...
## $ US_dateFirstAvailable: Date, format: NA NA ...
## $ US_dateLastAvailable: Date, format: NA NA ...
## $ UK_retailPrice   : num NA NA NA NA NA NA NA NA NA ...
## $ UK_dateFirstAvailable: Date, format: NA NA ...
## $ UK_dateLastAvailable: Date, format: NA NA ...
## $ CA_retailPrice   : num NA NA NA NA NA NA NA NA NA ...
## $ CA_dateFirstAvailable: Date, format: NA NA ...
## $ CA_dateLastAvailable: Date, format: NA NA ...
## $ DE_retailPrice   : num NA NA NA NA NA NA NA NA NA ...
## $ DE_dateFirstAvailable: Date, format: NA NA ...
## $ DE_dateLastAvailable: Date, format: NA NA ...
## $ height         : num NA NA NA NA NA ...
## $ width          : num NA NA NA NA NA ...
```

# RStudio Environment tab can help

Screenshot of the RStudio Environment tab showing the Global Environment. The 'legosets' dataset is selected, displaying its structure:

	legosets	16355 obs. of 34 variables
\$ setID	:	int 7693 7695 7697 7698 25534 ...
\$ name	:	chr "Small house set" "Medium house set" "Medium house set" "L...
\$ year	:	int 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 1970 ...
\$ theme	:	chr "Minitalia" "Minitalia" "Minitalia" "Minitalia" ...
\$ themeGroup	:	chr "Vintage" "Vintage" "Vintage" "Vintage" ...
\$ subtheme	:	chr NA NA NA NA ...
\$ category	:	chr "Normal" "Normal" "Normal" "Normal" ...
\$ released	:	logi TRUE TRUE TRUE TRUE TRUE ...
\$ pieces	:	int 67 109 158 233 NA 1 1 60 65 NA ...
\$ minifigs	:	int NA ...
\$ bricksetURL	:	chr "https://brickset.com/sets/1-8" "https://brickset.com/sets..."
\$ rating	:	num 0 0 0 0 0 0 0 0 0 ...
\$ reviewCount	:	int 0 0 1 0 0 0 0 1 0 0 ...
\$ packagingType	:	chr "{Not specified}" "{Not specified}" "{No..."
\$ availability	:	chr "{Not specified}" "{Not specified}" "{No..."
\$ agerange_min	:	int NA NA NA NA NA NA NA NA NA ...
\$ US_retailPrice	:	num NA NA NA NA NA 1.99 NA NA 4.99 NA ...
\$ US_dateFirstAvailable	:	Date, format: NA NA NA NA ...
\$ US_dateLastAvailable	:	Date, format: NA NA NA NA ...
\$ UK_retailPrice	:	num NA ...
\$ UK_dateFirstAvailable	:	Date, format: NA NA NA NA ...
\$ UK_dateLastAvailable	:	Date, format: NA NA NA NA ...
\$ CA_retailPrice	:	num NA ...
\$ CA_dateFirstAvailable	:	Date, format: NA NA NA NA ...
\$ CA_dateLastAvailable	:	Date, format: NA NA NA NA ...
\$ DE_retailPrice	:	num NA ...
\$ DE_dateFirstAvailable	:	Date, format: NA NA NA NA ...
\$ DE_dateLastAvailable	:	Date, format: NA NA NA NA ...
\$ height	:	num NA NA NA NA NA ...
\$ width	:	num NA NA NA NA NA ...
\$ depth	:	num NA NA NA NA NA NA NA 5.08 NA ...
\$ weight	:	num NA ...
\$ thumbnailURL	:	chr "https://images.brickset.com/sets/small/1-8.jpg" "https://..."
\$ imageURL	:	chr "https://images.brickset.com/sets/images/1-8.jpg" "https:/..."

# Table View

Show  entries Search:

	setID	name	year	theme	themeGroup	category	US_retailPrice	pieces	minifigs	rating
1	5074	Heart Carabiner Pen	2005	Gear	Miscellaneous	Gear				0
2	24117	Alien Trooper	2015	Collectable Minifigures	Miscellaneous	Normal		6	1	3.9
3	28398	Air Base	2019	City	Modern day	Normal	89.99	529	6	3.5
4	5768	Model Town House	2007	Creator	Model making	Normal	69.99	1174		4.3
5	23827	Creative Supplement Bright	2015	Classic	Basic	Normal	19.99	303		3.6
6	1760	Workman and Barrow	1985	Fabuland	Junior	Normal		6	1	0
7	5770	Monster Dino	2007	Creator	Model making	Normal	89.99	792		4.3
8	30840	Spider-Man's Monster Truck vs. Mysterio	2021	Marvel Super Heroes	Licensed	Normal	39.99	439	4	3.4
9	47195	Disney 100 Years Celebration	2023	Disney	Licensed	Normal		226	1	4.2
10	26686	The Beatles Yellow Submarine	2016	Ideas	Miscellaneous	Normal	59.99	553	5	4.3

Showing 1 to 10 of 100 entries

Previous 1 2 3 4 5 ... 10 Next



# Data Wrangling Cheat Sheet

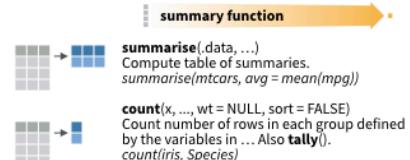
## Data Transformation with dplyr :: CHEAT SHEET

dplyr functions work with pipes and expect **tidy data**. In tidy data:



### Summarise Cases

These apply **summary functions** to columns to create a new table of summary statistics. Summary functions take vectors as input and return one value (see back).

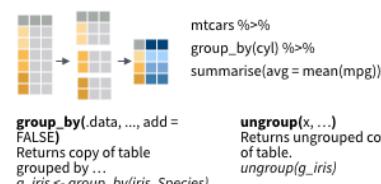


#### VARIATIONS

**summarise\_all()** - Apply funs to every column.  
**summarise\_at()** - Apply funs to specific columns.  
**summarise\_if()** - Apply funs to all cols of one type.

### Group Cases

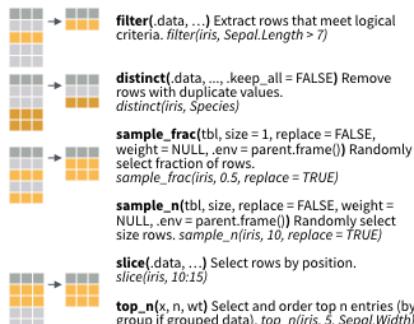
Use **group\_by()** to create a "grouped" copy of a table. dplyr functions will manipulate each "group" separately and then combine the results.



### Manipulate Cases

#### EXTRACT CASES

Row functions return a subset of rows as a new table.

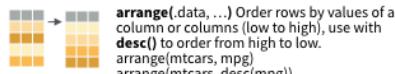


#### Logical and boolean operators to use with filter()

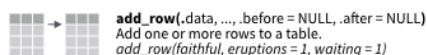
<	=<	is.na()	%in%		xor()
>	=>	is.na()	!	&	

See ?base::logic and ?Comparison for help.

#### ARRANGE CASES



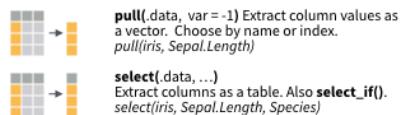
#### ADD CASES



### Manipulate Variables

#### EXTRACT VARIABLES

Column functions return a set of columns as a new vector or table.

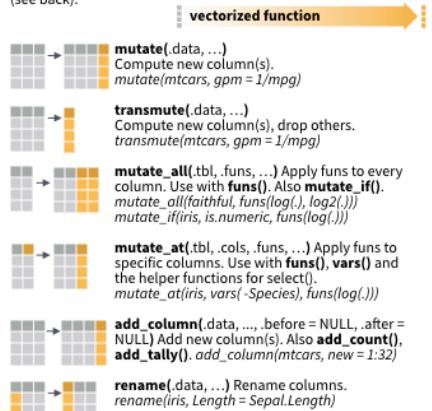


Use these helpers with **select()**, e.g. `select(iris, starts_with("Sepal"))`

<b>contains</b> (match)	<b>num_range</b> (prefix, range)	:	e.g. <code>mpg:cyl</code>
<b>ends_with</b> (match)	<b>one_of</b> (...)	:	e.g. <code>Species</code>
<b>matches</b> (match)	<b>starts_with</b> (match)		

#### MAKE NEW VARIABLES

These apply **vectorized functions** to columns. Vectorized funs take vectors as input and return vectors of the same length as output (see back).



# Tidyverse vs Base R



## R Syntax Comparison :: CHEAT SHEET

### Dollar sign syntax

```
goal(data$x, data$y)
```

#### SUMMARY STATISTICS:

one continuous variable:  
`mean(mtcars$mpg)`

one categorical variable:  
`table(mtcars$cyl)`

two categorical variables:  
`table(mtcars$cyl, mtcars$am)`

one continuous, one categorical:  
`mean(mtcars$mpg[mtcars$cyl==4])`  
`mean(mtcars$mpg[mtcars$cyl==6])`  
`mean(mtcars$mpg[mtcars$cyl==8])`

#### PLOTTING:

one continuous variable:  
`hist(mtcars$disp)`

`boxplot(mtcars$disp)`

one categorical variable:  
`barplot(table(mtcars$cyl))`

two continuous variables:  
`plot(mtcars$disp, mtcars$mpg)`

two categorical variables:  
`mosaicplot(table(mtcars$am, mtcars$cyl))`

one continuous, one categorical:  
`histogram(mtcars$disp[mtcars$cyl==4])`  
`histogram(mtcars$disp[mtcars$cyl==6])`  
`histogram(mtcars$disp[mtcars$cyl==8])`

`boxplot(mtcars$disp[mtcars$cyl==4])`  
`boxplot(mtcars$disp[mtcars$cyl==6])`  
`boxplot(mtcars$disp[mtcars$cyl==8])`

#### WRANGLING:

subsetting:  
`mtcars[mtcars$mpg>30, ]`

making a new variable:  
`mtcars$efficient[mtcars$mpg>30] <- TRUE`  
`mtcars$efficient[mtcars$mpg<30] <- FALSE`

### Formula syntax

```
goal(y~x|z, data=data, group=w)
```

#### SUMMARY STATISTICS:

one continuous variable:  
`mosaic::mean(~mpg, data=mtcars)`

one categorical variable:  
`mosaic::tally(~cyl, data=mtcars)`

two categorical variables:  
`mosaic::tally(cyl~am, data=mtcars)`

one continuous, one categorical:  
`mosaic::mean(mpg~cyl, data=mtcars)`

tilde

#### PLOTTING:

one continuous variable:  
`lattice::histogram(~disp, data=mtcars)`

`lattice::bwplot(~disp, data=mtcars)`

one categorical variable:  
`mosaic::bargraph(~cyl, data=mtcars)`

two continuous variables:  
`lattice::xyplot(mpg~disp, data=mtcars)`

two categorical variables:  
`mosaic::bargraph(~am, data=mtcars, group=cyl)`

one continuous, one categorical:  
`lattice::histogram(~disp|cyl, data=mtcars)`

`lattice::bwplot(cyl~disp, data=mtcars)`

The variety of R syntaxes give  
you many ways to “say” the  
same thing

read across the cheatsheet to see how different  
syntaxes approach the same problem

### Tidyverse syntax

```
data %>% goal(x)
```

#### SUMMARY STATISTICS:

one continuous variable:  
`mtcars %>% dplyr::summarize(mean(mpg))`

the pipe

one categorical variable:  
`mtcars %>% dplyr::group_by(cyl) %>%  
dplyr::summarize(n())`

two categorical variables:  
`mtcars %>% dplyr::group_by(cyl, am) %>%  
dplyr::summarize(n())`

one continuous, one categorical:  
`mtcars %>% dplyr::group_by(cyl) %>%  
dplyr::summarize(mean(mpg))`

PLOTTING:  
one continuous variable:  
`ggplot2::qplot(x=mpg, data=mtcars, geom = "histogram")`

`ggplot2::qplot(y=disp, x=1, data=mtcars, geom="boxplot")`

one categorical variable:  
`ggplot2::qplot(x=cyl, data=mtcars, geom="bar")`

two continuous variables:  
`ggplot2::qplot(x=disp, y=mpg, data=mtcars, geom="point")`

two categorical variables:  
`ggplot2::qplot(x=factor(cyl), data=mtcars, geom="bar") +  
facet_grid(.~cyl)`

one continuous, one categorical:  
`ggplot2::qplot(x=disp, data=mtcars, geom = "histogram") +  
facet_grid(.~cyl)`

`ggplot2::qplot(y=disp, x=factor(cyl), data=mtcars,  
geom="boxplot")`

WRANGLING:  
subsetting:  
`mtcars %>% dplyr::filter(mpg>30)`

making a new variable:  
`mtcars <- mtcars %>%  
dplyr::mutate(efficient = if_else(mpg>30, TRUE, FALSE))`

# Pipes %>% and |>

The pipe operator (`%>%`) introduced with the `magrittr` R package allows for the chaining of R operations. Base R has now added their own pipe operator (`|>`). They take the output from the left-hand side and passes it as the first parameter to the function on the right-hand side.



You can do this in two steps:

```
tab_out <- table(legosets$category)
prop.table(tab_out)
```

Or as nested function calls.

```
prop.table(table(legosets$category))
```

Using the pipe (`|>`) operator we can chain these calls in a what is arguably a more readable format:

```
table(legosets$category) |> prop.table()
```

---

```
##          Book Collection Extended      Gear      Normal       Other
## 0.034818805 0.030509305 0.031586680 0.156513222 0.677864838 0.064985309
```

## dplyr::filter()

KEEP ROWS THAT  
satisfy  
*your CONDITIONS*

keep rows from... this data... ONLY IF... type MATCHES "otter" AND site MATCHES "bay"  
filter(df, type == "otter" & site == "bay")



A cartoon illustration featuring three characters: an orange circle with a smiling face, a purple circle with a question mark, and a green circle with a neutral face. They are positioned around a small map of a coastal area with a blue bay labeled "BAY". The purple character is pointing at a table, while the green character has a red "X" drawn on its body.

	type	food	site
1	otter	urchin	bay
2	Shark	seal	channel
3	otter	abalone	bay
4	otter	crab	wharf

@allisonhorst

# Logical Operators

- `!a` - TRUE if a is FALSE
- `a == b` - TRUE if a and be are equal
- `a != b` - TRUE if a and b are not equal
- `a > b` - TRUE if a is larger than b, but not equal
- `a >= b` - TRUE if a is larger or equal to b
- `a < b` - TRUE if a is smaller than be, but not equal
- `a <= b` - TRUE if a is smaller or equal to b
- `a %in% b` - TRUE if a is in b where b is a vector

```
letters %in% c('a', 'e', 'i', 'o', 'u') |> which()
```

```
## [1] 1 5 9 15 21
```

- `a | b` - TRUE if a or b are TRUE
- `a & b` - TRUE if a and b are TRUE
- `isTRUE(a)` - TRUE if a is TRUE

# Filter



## dplyr

```
mylego <- legosets %>% filter(themeGroup == 'Educational' & year > 2015)
```

## Base R

```
mylego <- legosets[legosets$themeGroups == 'Educational' & legosets$year > 2015,]
```

---

```
nrow(mylego)
```

```
## [1] 103
```

# Select



## dplyr

```
mylego <- mylego %>% select(setID, pieces, theme, availability, US_retailPrice, minifigs)
```

## Base R

```
mylego <- mylego[,c('setID', 'pieces', 'theme', 'availability', 'US_retailPrice', 'minifigs')]
```

---

```
head(mylego, n = 4)
```

	setID	pieces	theme	availability	US_retailPrice	minifigs
## 1	26803	109	Education	{Not specified}	NA	6
## 2	26277	188	Education	Educational	94.95	NA
## 3	27742	160	Education	{Not specified}	NA	NA
## 4	26805	1000	Education	{Not specified}	NA	NA

# Relocate



dplyr::**relocate()**  
move COLUMNS around!

Default: move to FRONT  
or move to  
.before or .after  
A SPECIFIED COLUMN!



# Relocate



## dplyr

```
mylego %>% relocate(where(is.numeric), .after = where(is.character)) %>% head(n = 3)
```

```
##      theme availability setID pieces US_retailPrice minifigs
## 1 Education {Not specified} 26803     109          NA       6
## 2 Education     Educational 26277     188        94.95      NA
## 3 Education {Not specified} 27742     160          NA      NA
```

## Base R

```
mylego2 <- mylego[,c('theme', 'availability', 'setID', 'pieces', 'US_retailPrice', 'minifigs')]
head(mylego2, n = 3)
```

```
##      theme availability setID pieces US_retailPrice minifigs
## 1 Education {Not specified} 26803     109          NA       6
## 2 Education     Educational 26277     188        94.95      NA
## 3 Education {Not specified} 27742     160          NA      NA
```

# Rename



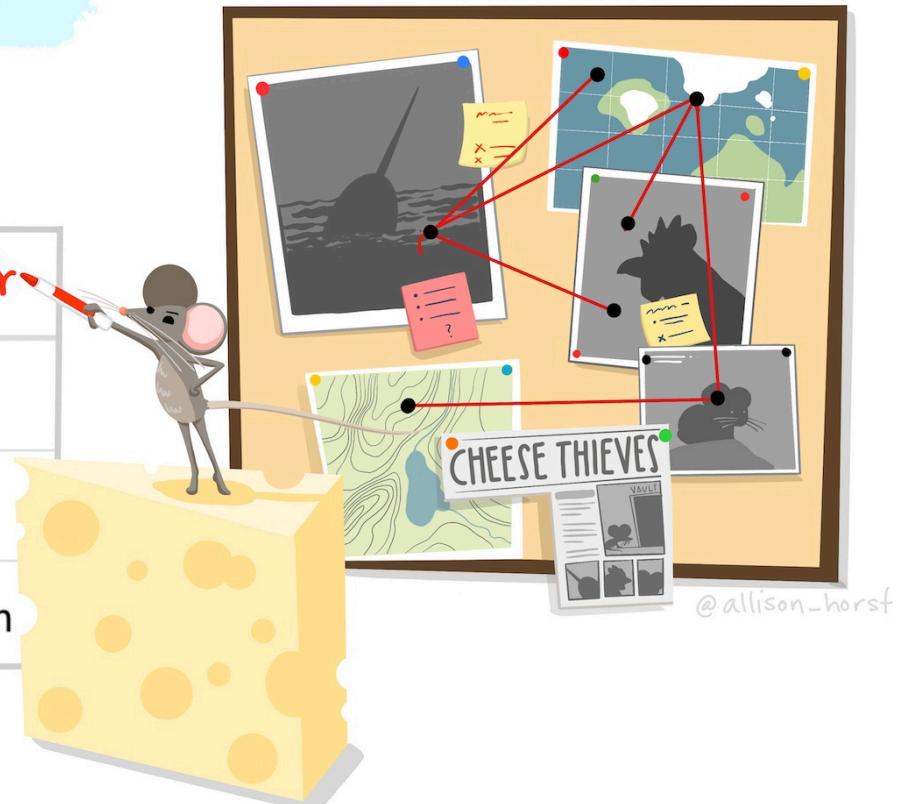
## dplyr::rename()

RENAME COLUMNS\*

df %>% rename(lair=site)

<del>species</del> nemesis	status	<del>site</del> lair
narwhal	unknown	ocean
chicken	active	coop
pika	active	mountain

\*See `rename_with()` to rename using a function.



# Rename



## dplyr

```
mylego %>% dplyr::rename(USD = US_retailPrice) %>% head(n = 3)
```

```
## #> #> #> #>
```

	setID	pieces	theme	availability	USD	minifigs
## 1	26803	109	Education	{Not specified}	NA	6
## 2	26277	188	Education	Educational	94.95	NA
## 3	27742	160	Education	{Not specified}	NA	NA

## Base R

```
names(mylego2)[5] <- 'USD'  
head(mylego2, n = 3)
```

```
## #> #> #> #>
```

	theme	availability	setID	pieces	USD	minifigs
## 1	Education	{Not specified}	26803	109	NA	6
## 2	Education	Educational	26277	188	94.95	NA
## 3	Education	{Not specified}	27742	160	NA	NA

# Mutate



# Mutate



## dplyr

```
mylego %>% filter(!is.na(pieces) & !is.na(US_retailPrice)) %>%  
  mutate(Price_per_piece = US_retailPrice / pieces) %>% head(n = 3)
```

```
## #> #> setID pieces theme availability US_retailPrice minifigs Price_per_piece  
## #> 1 26277 188 Education Educational 94.95 NA 0.5050532  
## #> 2 25949 280 Education Educational 224.95 NA 0.8033929  
## #> 3 25954 1 Education Educational 14.95 NA 14.9500000
```

## Base R

```
mylego2 <- mylego[!is.na(mylego$US_retailPrice) & !is.na(mylego$Price_per_piece),]  
mylego2$Price_per_piece <- mylego2$Price_per_piece / mylego2$US_retailPrice  
head(mylego2, n = 3)
```

```
## [1] setID pieces theme availability  
## [5] US_retailPrice minifigs Price_per_piece  
## <0 rows> (or 0-length row.names)
```



# Group By and Summarize

```
legosets %>% group_by(themeGroup) %>% summarize(mean_price = mean(US_retailPrice, na.rm = TRUE),  
                                sd_price = sd(US_retailPrice, na.rm = TRUE),  
                                median_price = median(US_retailPrice, na.rm = TRUE),  
                                n = n(),  
                                missing = sum(is.na(US_retailPrice)))
```

```
## # A tibble: 17 × 6  
##   themeGroup     mean_price    sd_price median_price      n missing  
##   <chr>          <dbl>       <dbl>      <dbl> <int>     <int>  
## 1 Action/Adventure    41.9        40.8      30.0  1551      813  
## 2 Art and crafts     37.7        50.5      20.0   100       9  
## 3 Basic              22.5        19.6      15.0   879      734  
## 4 Constraction       16.4        12.4      13.0   502      284  
## 5 Educational         184.        188.      138.    520      482  
## 6 Girls               35.8        24.0      23.0   240      227  
## 7 Historical          34.2        32.4      20.0   473      400  
## 8 Junior              22.0        10.1      20.0   228      165  
## 9 Licensed             54.0        70.9      30.0  3054     1160  
## 10 Miscellaneous       21.6        30.4      13.0  6657     4221  
## 11 Model making        78.2        94.1      40.0   832      401  
## 12 Modern day           39.0        36.1      30.0  2577     1567  
## 13 Pre-school            31.0        22.6      25.0  1587     1108  
## 14 Racing                26.8        26.5      15.0   270      176
```

# Describe and Describe By

```
library(psych)
```

```
describe(legosets$US_retailPrice)
```

```
##      vars     n   mean     sd median trimmed    mad    min    max range skew kurtosis
## X1     1 8027 40.33 57.36  19.99   28.86 17.79  1.49  849.99 848.5 5.05     40.51
##           se
## X1 0.64
```

```
describeBy(legosets$US_retailPrice, group = legosets$availability, mat = TRUE, skew = FALSE)
```

	item	group1	vars	n	mean	sd	median	min	max	range	se
## X11	1	{Not specified}	1	1904	27.15558	39.42703	19.99	1.49	789.99	788.5	0.9035676
## X12	2	Educational	1	12	217.03333	108.17617	232.45	14.95	399.95	385.0	31.2277699
## X13	3	Gift with Purchase at LEGO.com	1	0	NaN	NA	NA	Inf	-Inf	-Inf	NA
## X14	4	LEGO exclusive	1	1129	60.45079	108.56718	14.99	1.99	849.99	848.0	3.2311088
## X15	5	LEGOLAND exclusive	1	2	4.99000	0.00000	4.99	4.99	4.99	0.0	0.0000000
## X16	6	Not sold	1	1	12.99000	NA	12.99	12.99	12.99	0.0	NA
## X17	7	Promotional	1	5	4.79000	0.83666	4.99	3.99	5.99	2.0	0.3741657
## X18	8	Promotional (Airline)	1	0	NaN	NA	NA	Inf	-Inf	-Inf	NA
## X19	9	Retail	1	4658	38.88535	39.14642	26.99	1.99	699.99	698.0	0.5735778
## X110	10	Retail - limited	1	315	63.48270	69.97310	39.99	2.49	449.99	447.5	3.9425374
## X111	11	Unknown	1	1	3.99000	NA	3.99	3.99	3.99	0.0	NA

# Additional Resources

For data wrangling:

- `dplyr` website: <https://dplyr.tidyverse.org>
- R for Data Science book: <https://r4ds.had.co.nz/wrangle-intro.html>
- Wrangling penguins tutorial: <https://allisonhorst.shinyapps.io/dplyr-learnr/#section-welcome>
- Data transformation cheat sheet: <https://github.com/rstudio/cheatsheets/raw/master/data-transformation.pdf>

# Good luck with the semester!



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