

Manipulating Data in R

Reshaping Data

In this module, we will show you how to:

1. Reshape data from wide (fat) to long (tall)
2. Reshape data from long (tall) to wide (fat)
3. Merge Data/Joins

Cheatsheet

<https://raw.githubusercontent.com/rstudio/cheatsheets/main/data-transformation.pdf>

Data transformation with dplyr : : CHEAT SHEET



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



Each **variable** is in its own **column**



Each **observation**, or **case**, is in its own **row**



x %>% f(y) becomes **f(x, y)**

pipes

Summarise Cases

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).

summary function



summarise(.data, ...)
Compute table of summaries.
`summarise(mtcars, avg = mean(mpg))`



count(.data, ..., wt = NULL, sort = FALSE, name = NULL) Count number of rows in each group defined by the variables in ... Also **tally()**.
`count(mtcars, cyl)`

Group Cases

Use **group_by(.data, ..., .add = FALSE, .drop = TRUE)** to create a "grouped" copy of a table grouped by columns in ... dplyr functions will manipulate each "group" separately and combine the results.



`mtcars %>%
group_by(cyl) %>%
summarise(avg = mean(mpg))`

Manipulate Cases

EXTRACT CASES

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



filter(.data, ..., .preserve = FALSE) Extract rows that meet logical criteria.
`filter(mtcars, mpg > 20)`



distinct(.data, ..., .keep_all = FALSE) Remove rows with duplicate values.
`distinct(mtcars, gear)`



slice(.data, ..., .preserve = FALSE) Select rows by position.
`slice(mtcars, 10:15)`



slice_sample(.data, ..., n, prop, weight_by = NULL, replace = FALSE) Randomly select rows. Use `n` to select a number of rows and `prop` to select a fraction of rows.
`slice_sample(mtcars, n = 5, replace = TRUE)`



slice_min(.data, order_by, ..., n, prop, with_ties = TRUE) and **slice_max()** Select rows with the lowest and highest values.
`slice_min(mtcars, mpg, prop = 0.25)`

slice_head(.data, ..., n, prop) and **slice_tail()** Select the first or last rows.
`slice_head(mtcars, n = 5)`

Logical and boolean operators to use with filter()

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

See **?base::Logic** and **?Comparison** for help.

ARRANGE CASES

Manipulate Variables

EXTRACT VARIABLES

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



pull(.data, var = -1, name = NULL, ...) Extract column values as a vector, by name or index.
`pull(mtcars, wt)`



select(.data, ...) Extract columns as a table.
`select(mtcars, mpg, wt)`



relocate(.data, ..., .before = NULL, .after = NULL) Move columns to new position.
`relocate(mtcars, mpg, cyl, .after = last_col())`

Use these helpers with select() and across()

e.g. `select(mtcars, mpg:cyl)`

contains(match)	num_range(prefix, range)	;	e.g. <code>mpg:cyl</code>
ends_with(match)	all_of(x)/any_of(x, ..., vars)	-;	e.g. <code>-gear</code>
starts_with(match)	matches(match)		everything()

MANIPULATE MULTIPLE VARIABLES AT ONCE



across(.cols, .funs, ..., .names = NULL) Summarise or mutate multiple columns in the same way.
`summarise(mtcars, across(everything(), mean))`



c_across(.cols) Compute across columns in row-wise data.
`transmute(rowwise(UKgas), total = sum(c_across(1:2)))`

MAKE NEW VARIABLES

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

What is wide/long data?

<https://github.com/gadenbuie/tidyexplain/blob/main/images/tidyr-pivoting.gif>

wide

id	x	y	z
1	a	c	e
2	b	d	f

What is wide/long data?

Data is stored *differently* in the tibble.

Wide: has many columns

```
# A tibble: 1 × 4
  State    June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>    <chr>          <chr>         <chr>
1 Alabama 37.2%          36.0%         32.4%
```

Long: column names become data

```
# A tibble: 3 × 3
  State    name          value
  <chr>    <chr>         <chr>
1 Alabama June_vacc_rate 37.2%
2 Alabama May_vacc_rate  36.0%
3 Alabama April_vacc_rate 32.4%
```

What is wide/long data?

Wide: multiple columns per individual, values spread across multiple columns

```
# A tibble: 2 × 4
  State    June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>    <chr>           <chr>         <chr>
1 Alabama 37.2%            36.0%         32.4%
2 Alaska 47.5%            46.2%         41.7%
```

Long: multiple rows per observation, a single column contains the values

```
# A tibble: 6 × 3
  State    name          value
  <chr>    <chr>          <chr>
1 Alabama June_vacc_rate 37.2%
2 Alabama May_vacc_rate  36.0%
3 Alabama April_vacc_rate 32.4%
4 Alaska  June_vacc_rate 47.5%
5 Alaska  May_vacc_rate  46.2%
6 Alaska  April_vacc_rate 41.7%
```

What is wide/long data?

Data is wide or long **with respect to** certain variables.

Wide

	Day 1	Day 2	Day 3
Patient 1	A	B	C
Patient 2	D	E	F

Long

	Day	Value
Patient 1	Day 1	A
Patient 1	Day 2	B
Patient 1	Day 3	C
Patient 2	Day 1	D
Patient 2	Day 2	E
Patient 2	Day 3	F

CC-BY jhudatascience.org

Why do we need to switch between wide/long data?

Wide: **Easier for humans to read**

```
# A tibble: 2 × 4
  State    June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>    <chr>           <chr>         <chr>
1 Alabama 37.2%           36.0%         32.4%
2 Alaska 47.5%           46.2%         41.7%
```

Long: **Easier for R to make plots & do analysis**

```
# A tibble: 6 × 3
  State    name          value
  <chr>    <chr>          <chr>
1 Alabama June_vacc_rate 37.2%
2 Alabama May_vacc_rate  36.0%
3 Alabama April_vacc_rate 32.4%
4 Alaska  June_vacc_rate 47.5%
5 Alaska  May_vacc_rate  46.2%
6 Alaska  April_vacc_rate 41.7%
```


tidyr package

tidyr allows you to “tidy” your data. We will be talking about:

- `pivot_longer` - make multiple columns into variables, (wide to long)
- `pivot_wider` - make a variable into multiple columns, (long to wide)
- `separate` - string into multiple columns (review)

The `reshape` command exists. It is a **confusing** function. Don't use it.

pivot_longer...

Reshaping data from wide (fat) to long (tall): tidyr

`tidyr::pivot_longer` - puts column data into rows.

- First describe which columns we want to “pivot_longer”
- `names_to` = gives a new name to the pivoted columns
- `values_to` = gives a new name to the values that used to be in those columns

```
{long_data} <- {wide_data} %>% pivot_longer(cols = {columns to pivot},  
                                           names_to = {New column name: contains old column names},  
                                           values_to = {New column name: contains cell values})
```

Reshaping data from wide (fat) to long (tall): tidyr

wide_data

```
# A tibble: 1 × 3
  June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>          <chr>          <chr>
1 37.2%          36.0%          32.4%
```

```
long_data <- wide_data %>% pivot_longer(cols = everything(),
                                         names_to = "Month",
                                         values_to = "Rate")
```

long_data

```
# A tibble: 3 × 2
  Month      Rate
  <chr>      <chr>
1 June_vacc_rate 37.2%
2 May_vacc_rate  36.0%
3 April_vacc_rate 32.4%
```

Data used: Charm City Circulator

http://jhudatascience.org/intro_to_r/data/Charm_City_Circulator_Ridership.csv

```
circ <- jhur::read_circulator()
head(circ, 5)
```

```
# A tibble: 5 × 15
```

	day	date	orangeBoardings	orangeAlightings	orangeAverage	purpleBoardings
	<chr>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>
1	Monday	01/1...	877	1027	952	NA
2	Tuesday	01/1...	777	815	796	NA
3	Wednesday	01/1...	1203	1220	1212.	NA
4	Thursday	01/1...	1194	1233	1214.	NA
5	Friday	01/1...	1645	1643	1644	NA

```
# ... with 9 more variables: purpleAlightings <dbl>, purpleAverage <dbl>,
#   greenBoardings <dbl>, greenAlightings <dbl>, greenAverage <dbl>,
#   bannerBoardings <dbl>, bannerAlightings <dbl>, bannerAverage <dbl>,
#   daily <dbl>
```

Reshaping data from wide (fat) to long (tall): tidyr

```
long <- circ %>%  
  pivot_longer(starts_with(c("orange", "purple", "green", "banner")),  
               names_to = "var",  
               values_to = "number")
```

long

```
# A tibble: 13,752 × 5
```

	day <chr>	date <chr>	daily <dbl>	var <chr>	number <dbl>
1	Monday	01/11/2010	952	orangeBoardings	877
2	Monday	01/11/2010	952	orangeAlightings	1027
3	Monday	01/11/2010	952	orangeAverage	952
4	Monday	01/11/2010	952	purpleBoardings	NA
5	Monday	01/11/2010	952	purpleAlightings	NA
6	Monday	01/11/2010	952	purpleAverage	NA
7	Monday	01/11/2010	952	greenBoardings	NA
8	Monday	01/11/2010	952	greenAlightings	NA
9	Monday	01/11/2010	952	greenAverage	NA
10	Monday	01/11/2010	952	bannerBoardings	NA

```
# ... with 13,742 more rows
```

Reshaping data from wide (fat) to long (tall): tidyr

There are many ways to select the columns we want. Use `?tidyr_tidy_select` to look at more column selection options.

```
long <- circ %>%  
  pivot_longer( !c(day, date, daily),  
               names_to = "var",  
               values_to = "number")
```

long

```
# A tibble: 13,752 × 5
```

	day <chr>	date <chr>	daily <dbl>	var <chr>	number <dbl>
1	Monday	01/11/2010	952	orangeBoardings	877
2	Monday	01/11/2010	952	orangeAlightings	1027
3	Monday	01/11/2010	952	orangeAverage	952
4	Monday	01/11/2010	952	purpleBoardings	NA
5	Monday	01/11/2010	952	purpleAlightings	NA
6	Monday	01/11/2010	952	purpleAverage	NA
7	Monday	01/11/2010	952	greenBoardings	NA
8	Monday	01/11/2010	952	greenAlightings	NA
9	Monday	01/11/2010	952	greenAverage	NA
10	Monday	01/11/2010	952	bannerBoardings	NA

```
# ... with 13,742 more rows
```

Reshaping data from wide (fat) to long (tall): tidyr

```
long %>% count(var)
```

```
# A tibble: 12 × 2
```

	var <chr>	n <int>
1	bannerAlightings	1146
2	bannerAverage	1146
3	bannerBoardings	1146
4	greenAlightings	1146
5	greenAverage	1146
6	greenBoardings	1146
7	orangeAlightings	1146
8	orangeAverage	1146
9	orangeBoardings	1146
10	purpleAlightings	1146
11	purpleAverage	1146
12	purpleBoardings	1146

Cleaning up long data

We will use `str_replace` from the `stringr` package to put `_` in the names

```
long <- long %>% mutate(  
  var = str_replace(var, "Board", "_Board"),  
  var = str_replace(var, "Alight", "_Alight"),  
  var = str_replace(var, "Average", "_Average")  
)  
long
```

```
# A tibble: 13,752 × 5
```

	day <chr>	date <chr>	daily <dbl>	var <chr>	number <dbl>
1	Monday	01/11/2010	952	orange_Boardings	877
2	Monday	01/11/2010	952	orange_Alightings	1027
3	Monday	01/11/2010	952	orange_Average	952
4	Monday	01/11/2010	952	purple_Boardings	NA
5	Monday	01/11/2010	952	purple_Alightings	NA
6	Monday	01/11/2010	952	purple_Average	NA
7	Monday	01/11/2010	952	green_Boardings	NA
8	Monday	01/11/2010	952	green_Alightings	NA
9	Monday	01/11/2010	952	green_Average	NA
10	Monday	01/11/2010	952	banner_Boardings	NA

```
# ... with 13,742 more rows
```

Cleaning up long data

Now each **var** is Boardings, Averages, or Alightings. We use “**into** =” to name the new columns and “**sep** =” to show where the separation should happen.

```
long <- long %>%  
  separate(var, into = c("line", "type"), sep = "_")  
long
```

```
# A tibble: 13,752 × 6
```

	day <chr>	date <chr>	daily <dbl>	line <chr>	type <chr>	number <dbl>
1	Monday	01/11/2010	952	orange	Boardings	877
2	Monday	01/11/2010	952	orange	Alightings	1027
3	Monday	01/11/2010	952	orange	Average	952
4	Monday	01/11/2010	952	purple	Boardings	NA
5	Monday	01/11/2010	952	purple	Alightings	NA
6	Monday	01/11/2010	952	purple	Average	NA
7	Monday	01/11/2010	952	green	Boardings	NA
8	Monday	01/11/2010	952	green	Alightings	NA
9	Monday	01/11/2010	952	green	Average	NA
10	Monday	01/11/2010	952	banner	Boardings	NA

```
# ... with 13,742 more rows
```

pivot_wider...

Reshaping data from long (tall) to wide (fat): tidyr

`tidyr::pivot_wider` - spreads row data into columns.

- `names_from` = the old column whose contents will be spread into multiple new column names.
- `values_from` = the old column whose contents will fill in the values of those new columns.

```
{wide_data} <- {long_data} %>%  
  pivot_wider(names_from = {Old column name: contains new column names},  
              values_from = {Old column name: contains new cell values})
```

Reshaping data from long (tall) to wide (fat): tidyr

long_data

```
# A tibble: 3 × 2
  Month      Rate
  <chr>    <chr>
1 June_vacc_rate 37.2%
2 May_vacc_rate  36.0%
3 April_vacc_rate 32.4%
```

```
wide_data <- long_data %>% pivot_wider(names_from = "Month",
                                         values_from = "Rate")
```

wide_data

```
# A tibble: 1 × 3
  June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>          <chr>          <chr>
1 37.2%          36.0%          32.4%
```

Reshaping Charm City Circulator

long

A tibble: 13,752 × 6

	day <chr>	date <chr>	daily <dbl>	line <chr>	type <chr>	number <dbl>
1	Monday	01/11/2010	952	orange	Boardings	877
2	Monday	01/11/2010	952	orange	Alightings	1027
3	Monday	01/11/2010	952	orange	Average	952
4	Monday	01/11/2010	952	purple	Boardings	NA
5	Monday	01/11/2010	952	purple	Alightings	NA
6	Monday	01/11/2010	952	purple	Average	NA
7	Monday	01/11/2010	952	green	Boardings	NA
8	Monday	01/11/2010	952	green	Alightings	NA
9	Monday	01/11/2010	952	green	Average	NA
10	Monday	01/11/2010	952	banner	Boardings	NA

... with 13,742 more rows

Reshaping Charm City Circulator

```
wide <- long %>% pivot_wider(names_from = "type",  
                             values_from = "number")
```

wide

```
# A tibble: 4,584 × 7
```

	day <chr>	date <chr>	daily <dbl>	line <chr>	Boardings <dbl>	Alightings <dbl>	Average <dbl>
1	Monday	01/11/2010	952	orange	877	1027	952
2	Monday	01/11/2010	952	purple	NA	NA	NA
3	Monday	01/11/2010	952	green	NA	NA	NA
4	Monday	01/11/2010	952	banner	NA	NA	NA
5	Tuesday	01/12/2010	796	orange	777	815	796
6	Tuesday	01/12/2010	796	purple	NA	NA	NA
7	Tuesday	01/12/2010	796	green	NA	NA	NA
8	Tuesday	01/12/2010	796	banner	NA	NA	NA
9	Wednesday	01/13/2010	1212.	orange	1203	1220	1212.
10	Wednesday	01/13/2010	1212.	purple	NA	NA	NA

... with 4,574 more rows

Lab Part 1

[Website](#)

Joining in `dplyr`

- Merging/joining data sets together - usually on key variables, usually "id"
- `?join` - see different types of joining for `dplyr`
- `inner_join(x, y)` - only rows that match for x and y are kept
- `full_join(x, y)` - all rows of x and y are kept
- `left_join(x, y)` - all rows of x are kept even if not merged with y
- `right_join(x, y)` - all rows of y are kept even if not merged with x
- `anti_join(x, y)` - all rows from x not in y keeping just columns from x.

Merging: Simple Data

data_As

```
# A tibble: 2 × 3
  State      June_vacc_rate May_vacc_rate
  <chr>      <chr>          <chr>
1 Alabama  37.2%             36.0%
2 Alaska   47.5%             46.2%
```

data_cold

```
# A tibble: 2 × 2
  State      April_vacc_rate
  <chr>      <chr>
1 Maine    32.4%
2 Alaska   41.7%
```

Inner Join

<https://github.com/gadenbuie/tidyexplain/blob/main/images/inner-join.gif>

`inner_join(x, y)`



Inner Join

```
ij = inner_join(data_As, data_cold)
```

```
Joining, by = "State"
```

```
ij
```

```
# A tibble: 1 × 4
```

	State	June_vacc_rate	May_vacc_rate	April_vacc_rate
	<chr>	<chr>	<chr>	<chr>
1	Alaska	47.5%	46.2%	41.7%

Left Join

<https://raw.githubusercontent.com/gadenbuie/tidyexplain/main/images/left-join.gif>

`left_join(x, y)`



Left Join

```
lj = left_join(data_As, data_cold)
```

```
Joining, by = "State"
```

```
lj
```

```
# A tibble: 2 × 4
```

	State	June_vacc_rate	May_vacc_rate	April_vacc_rate
	<chr>	<chr>	<chr>	<chr>
1	Alabama	37.2%	36.0%	<NA>
2	Alaska	47.5%	46.2%	41.7%

Install **tidylog** package to log outputs

```
# install.packages("tidylog")
library(tidylog)
left_join(data_As, data_cold)
```

```
Joining, by = "State"
left_join: added one column (April_vacc_rate)
> rows only in x 1
> rows only in y (1)
> matched rows 1
> ===
> rows total 2
```

```
# A tibble: 2 × 4
  State      June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>      <chr>          <chr>          <chr>
1 Alabama  37.2%           36.0%          <NA>
2 Alaska   47.5%           46.2%          41.7%
```

Right Join

<https://raw.githubusercontent.com/gadenbuie/tidyexplain/main/images/right-join.gif>

`right_join(x, y)`



Right Join

```
rj <- right_join(data_As, data_cold)
```

```
Joining, by = "State"
```

```
right_join: added one column (April_vacc_rate)
```

```
> rows only in x (1)
```

```
> rows only in y 1
```

```
> matched rows 1
```

```
> ===
```

```
> rows total 2
```

```
rj
```

```
# A tibble: 2 × 4
```

	State	June_vacc_rate	May_vacc_rate	April_vacc_rate
	<chr>	<chr>	<chr>	<chr>
1	Alaska	47.5%	46.2%	41.7%
2	Maine	<NA>	<NA>	32.4%

Left Join: Switching arguments

```
lj2 <- left_join(data_cold, data_As)
```

```
Joining, by = "State"  
left_join: added 2 columns (June_vacc_rate, May_vacc_rate)  
> rows only in x 1  
> rows only in y (1)  
> matched rows 1  
> ===  
> rows total 2
```

```
lj2
```

```
# A tibble: 2 × 4  
  State April_vacc_rate June_vacc_rate May_vacc_rate  
  <chr>   <chr>           <chr>         <chr>  
1 Maine  32.4%             <NA>          <NA>  
2 Alaska 41.7%             47.5%         46.2%
```

Full Join

<https://raw.githubusercontent.com/gadenbuie/tidyexplain/main/images/full-join.gif>

`full_join(x, y)`



FullJoin

```
fj <- full_join(data_As, data_cold)
```

```
Joining, by = "State"
```

```
full_join: added one column (April_vacc_rate)
```

```
> rows only in x 1
```

```
> rows only in y 1
```

```
> matched rows 1
```

```
> ===
```

```
> rows total 3
```

Full Join

fj

```
# A tibble: 3 × 4
```

	State <chr>	June_vacc_rate <chr>	May_vacc_rate <chr>	April_vacc_rate <chr>
1	Alabama	37.2%	36.0%	<NA>
2	Alaska	47.5%	46.2%	41.7%
3	Maine	<NA>	<NA>	32.4%

Watch out for “includes duplicates”

data_As

```
# A tibble: 2 × 2
  State    state_bird
  <chr>    <chr>
1 Alabama wild turkey
2 Alaska  willow ptarmigan
```

data_cold

```
# A tibble: 3 × 3
  State    vacc_rate month
  <chr>    <chr>    <chr>
1 Maine  32.4%    April
2 Alaska 41.7%    April
3 Alaska 46.2%    May
```

Watch out for “includes duplicates”

```
lj <- left_join(data_As, data_cold)
```

```
Joining, by = "State"  
left_join: added 2 columns (vacc_rate, month)  
> rows only in x 1  
> rows only in y (1)  
> matched rows 2 (includes duplicates)  
> ===  
> rows total 3
```

Watch out for “includes duplicates”

Data including the joining column (“State”) has been duplicated.

lj

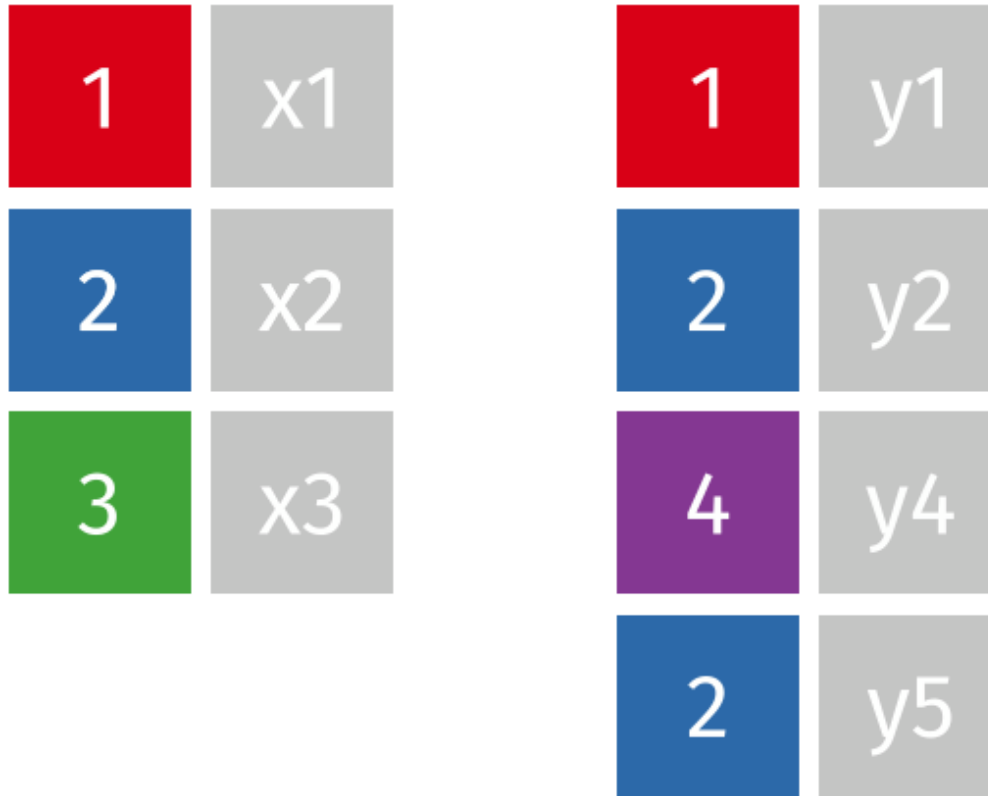
```
# A tibble: 3 × 4
  State    state_bird      vacc_rate month
  <chr>    <chr>          <chr>    <chr>
1 Alabama wild turkey    <NA>     <NA>
2 Alaska  willow ptarmigan 41.7%    April
3 Alaska  willow ptarmigan 46.2%    May
```

Note that “Alaska willow ptarmigan” appears twice.

Watch out for “includes duplicates”

<https://github.com/gadenbuie/tidyexplain/blob/main/images/left-join-extra.gif>

`left_join(x, y)`



Stop tidylog

```
unloadNamespace("tidylog")
```

Duplicated

- The `uplicated` function can give you indications if there are duplicates in a **vector**:

```
duplicated(1:5)
```

```
[1] FALSE FALSE FALSE FALSE FALSE
```

```
duplicated(c(1:5, 1))
```

```
[1] FALSE FALSE FALSE FALSE FALSE TRUE
```

```
lj %>% mutate(dup_State = duplicated(State))
```

```
# A tibble: 3 × 5
```

	State	state_bird	vacc_rate	month	dup_State
	<chr>	<chr>	<chr>	<chr>	<lgl>
1	Alabama	wild turkey	<NA>	<NA>	FALSE
2	Alaska	williow ptarmigan	41.7%	April	FALSE
3	Alaska	williow ptarmigan	46.2%	May	TRUE

Using the **by** argument

By default joins use the intersection of column names. If **by** is specified, it uses that.

```
full_join(data_As, data_cold, by = "State")
```

```
# A tibble: 4 × 4
  State    state_bird      vacc_rate month
  <chr>    <chr>          <chr>    <chr>
1 Alabama wild turkey    <NA>     <NA>
2 Alaska willow ptarmigan 41.7%    April
3 Alaska willow ptarmigan 46.2%    May
4 Maine   <NA>           32.4%    April
```

Using the **by** argument

You can join based on multiple columns by using something like `by = c(col1, col2)`.

If the datasets have two different names for the same data, use:

```
full_join(data_As, data_cold, by = c("a" = "b"))
```

Using “setdiff”

We might want to determine what indexes ARE in the first dataset that AREN'T in the second:

```
data_As
```

```
# A tibble: 2 × 2
  State    state_bird
  <chr>    <chr>
1 Alabama wild turkey
2 Alaska willow ptarmigan
```

```
data_cold
```

```
# A tibble: 3 × 3
  State    vacc_rate month
  <chr>    <chr>    <chr>
1 Maine  32.4%    April
2 Alaska 41.7%    April
3 Alaska 46.2%    May
```

Using “`setdiff`”

Use `setdiff` to determine what indexes ARE in the first dataset that AREN'T in the second:

```
A_states <- data_As %>% pull(State)
cold_states <- data_cold %>% pull(State)
```

```
setdiff(A_states, cold_states)
```

```
[1] "Alabama"
```

```
setdiff(cold_states, A_states)
```

```
[1] "Maine"
```

Lab Part 2

Website