Reproducible science: Module 3

Dealing with data: Tidyverse

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Acknowledgements

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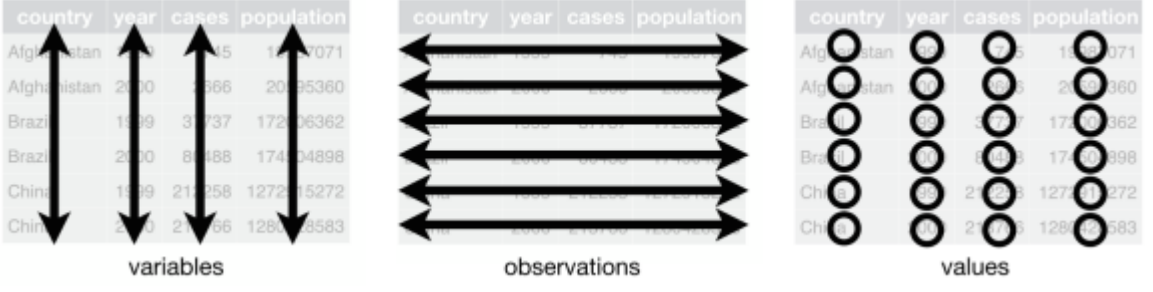
olivier gimenez's materials

What is tidyverse and advantages?

"A framework for managing data that aims at making the cleaning and preparing steps [muuuuuuuch] easier" (Julien Barnier). Main characteristics of a tidy dataset:

- the dataset is tibble;
- measured variable as a column;
- an observation represents a row with each value is in a different cell.

tidyverse consists of a compilation of r packages for data analysis.



Recognizing a tidy dataset

```
#> # A tibble: 12 x 4
#>    country      year type           count
#>    <chr>       <int> <chr>          <int>
#> 1 Afghanistan  1999 cases            745
#> 2 Afghanistan  1999 population  19987071
#> 3 Afghanistan  2000 cases           2666
#> 4 Afghanistan  2000 population  20595360
#> 5 Brazil       1999 cases           37737
#> 6 Brazil       1999 population 172006362
#> # … with 6 more rows
```

Is this a tidy data?

No

Recognizing a tidy dataset

```
#> # A tibble: 6 x 3
#>   country      year rate
#> * <chr>       <int> <chr>
#> 1 Afghanistan  1999 745/19987071
#> 2 Afghanistan  2000 2666/20595360
#> 3 Brazil       1999 37737/172006362
#> 4 Brazil       2000 80488/174504898
#> 5 China        1999 212258/1272915272
#> 6 China        2000 213766/1280428583
```

Is this a tidy data?

No

Recognizing a tidy dataset

```
# Spread across two tibbles
# cases
#> # A tibble: 3 x 3
#>   country     `1999` `2000`
#> * <chr>        <int>  <int>
#> 1 Afghanistan    745   2666
#> 2 Brazil       37737  80488
#> 3 China       212258 213766
# population
#> # A tibble: 3 x 3
#>   country         `1999`     `2000`
#> * <chr>            <int>      <int>
#> 1 Afghanistan   19987071   20595360
#> 2 Brazil       172006362  174504898
#> 3 China       1272915272 1280428583
```

Is this a tidy data?

No

Recognizing a tidy dataset

```
#> # A tibble: 6 x 4
#>   country      year  cases population
#>   <chr>       <int>  <int>      <int>
#> 1 Afghanistan  1999    745   19987071
#> 2 Afghanistan  2000   2666   20595360
#> 3 Brazil       1999  37737  172006362
#> 4 Brazil       2000  80488  174504898
#> 5 China        1999 212258 1272915272
#> 6 China        2000 213766 1280428583
```

Is this a tidy data?

Yes

Tidyverse: Multiple r packages well compiled

Allows using a consistent format for which powerful tools work.

Makes data manipulation pretty natural

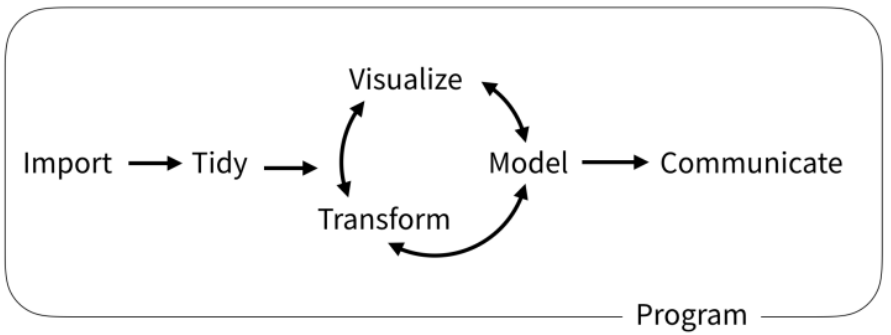
- ggplot2 - visualizing stuff;
- dplyr, tidyr - data manipulation;
- purrr - advanced programming;
- readr - import data;
- tibble - improved data.frame format;
- forcats - working with factors;
- stringr - working with chain of characters.

Simplified flowchart of data science?

Any data analysis follows this typical flow:

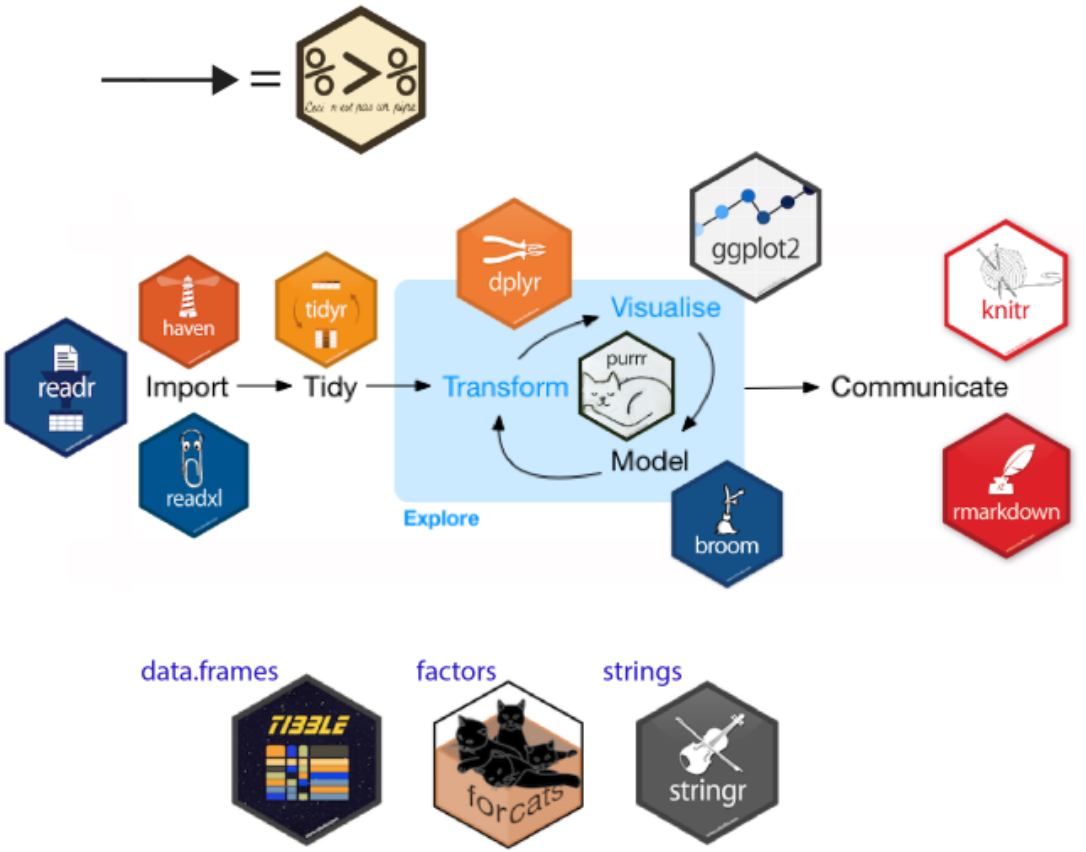
1. Import data;
2. Clean data;
3. Exploratory analysis. A cycle between:
    - Visualization;
    - modeling;
    - Transformation
4. Communicate

If these steps happen at multiple software then errors are highly inevitable.



Reproducibility equals effecient use of time

Tidyverse saves: same flowchart in tidyverse



Reproducibility equals effecient use of time

Practice in tidyverse with *"Twitter predicts citation rates of ecological research"*

We will use an existing data supporting the above publication to learn some functions within **tidyverse**.

Import data

readr::read_csv function:

- creates tibbles instead of data.frame;
- no names to rows;
- allows column names with special characters (see next slide);
- more clever on screen display than w/ data.frames (see next slide);
- no partial matching on column names;
- warning if attempt to access unexisting column;
- is incredibly fast.

Import data

```
# Set the url from where to download the data
url<-"https://doi.org/10.1371/journal.pone.0166570.s001"
# name the file to be downloaded and save as destfile object
destfile <- "twitter_cit_data.csv"
# Apply download.file function in R to download from url
download.file(url, destfile)
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.2.2

## Warning: package 'ggplot2' was built under R version 4.2.2

## Warning: package 'tidyr' was built under R version 4.2.2

## Warning: package 'readr' was built under R version 4.2.2

## Warning: package 'purrr' was built under R version 4.2.2

## Warning: package 'dplyr' was built under R version 4.2.2

## Warning: package 'stringr' was built under R version 4.2.2

## Warning: package 'forcats' was built under R version 4.2.2
```

Import data

```
citations_raw
```

```
## # A tibble: 1,599 × 12
##    `Journal identity` 5-year journal impact fact…¹ `Year published` Volume
##    <chr>                                     <dbl>             <dbl>  <dbl>
##  1 Ecology Letters                            16.7              2014     17
##  2 Ecology Letters                            16.7              2014     17
##  3 Ecology Letters                            16.7              2014     17
##  4 Ecology Letters                            16.7              2014     17
##  5 Ecology Letters                            16.7              2014     17
##  6 Ecology Letters                            16.7              2014     17
##  7 Ecology Letters                            16.7              2014     17
##  8 Ecology Letters                            16.7              2014     17
##  9 Ecology Letters                            16.7              2014     17
## 10 Ecology Letters                            16.7              2014     17
## # ℹ 1,589 more rows
## # ℹ abbreviated name: ¹`5-year journal impact factor`
## # ℹ 7 more variables: Authors <chr>, `Collection date` <chr>,
## #   `Publication date` <chr>, `Number of tweets` <dbl>,
## #   `Number of users` <dbl>, `Twitter reach` <dbl>,
## #   `Number of Web of Science citations` <dbl>
```

Tidy/transform: Rename columns

To rename columns, use function *rename()* new_name=old_name

```
citations_temp <- rename(citations_raw,
       journal = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear = 'Year published',
       colldate = 'Collection date',
       pubdate = 'Publication date',
       nbtweets = 'Number of tweets',
       woscitations = 'Number of Web of Science citations')
head(citations_temp,5,6)
```

```
## # A tibble: 5 × 12
##   journal    impactfactor pubyear Volume Issue Authors colldate pubdate nb
##   <chr>             <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>
## 1 Ecology L…         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…
## 2 Ecology L…         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…
## 3 Ecology L…         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…
## 4 Ecology L…         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…
## 5 Ecology L…         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…
## # ℹ 3 more variables: `Number of users` <dbl>, `Twitter reach` <dbl>,
## #   woscitations <dbl>
```

Tidy: Clean up column names

To clean columns, use function *clean_names()* from the package janitor from it will fill space in column names by "_".

```
janitor::clean_names(citations_raw)
```

```
## # A tibble: 1,599 × 12
##    journal_identity x5_year_journal_impact…¹ year_published volume issue a
##    <chr>                                <dbl>          <dbl>  <dbl> <chr> <
##  1 Ecology Letters                       16.7           2014     17 12    M
##  2 Ecology Letters                       16.7           2014     17 12    J
##  3 Ecology Letters                       16.7           2014     17 12    O
##  4 Ecology Letters                       16.7           2014     17 11    S
##  5 Ecology Letters                       16.7           2014     17 11    K
##  6 Ecology Letters                       16.7           2014     17 10    N
##  7 Ecology Letters                       16.7           2014     17 10    T
##  8 Ecology Letters                       16.7           2014     17 9     B
##  9 Ecology Letters                       16.7           2014     17 9     P
## 10 Ecology Letters                       16.7           2014     17 9     O
## # ℹ 1,589 more rows
## # ℹ abbreviated name: ¹x5_year_journal_impact_factor
## # ℹ 6 more variables: collection_date <chr>, publication_date <chr>,
## #   number_of_tweets <dbl>, number_of_users <dbl>, twitter_reach <dbl>,
## #   number_of_web_of_science_citations <dbl>
```

Tidy: Create and modify columns

The well known function to create and modify columns is *mutate()*, This function takes first the tibble names, the new_name= what you want to do to old column.

```
citations <- mutate(citations_temp, journal = as.factor(journal))
#Pay attention that I store in "citations"
citations
```

```
## # A tibble: 1,599 × 12
##    journal   impactfactor pubyear Volume Issue Authors colldate pubdate nb
##    <fct>            <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>
##  1 Ecology …          16.7    2014     17 12    Morin … 2/1/2016 9/16/2…
##  2 Ecology …          16.7    2014     17 12    Jucker… 2/1/2016 10/13/…
##  3 Ecology …          16.7    2014     17 12    Calcag… 2/1/2016 10/21/…
##  4 Ecology …          16.7    2014     17 11    Segre … 2/1/2016 8/28/2…
##  5 Ecology …          16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…
##  6 Ecology …          16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…
##  7 Ecology …          16.7    2014     17 10    Tschir… 2/2/2016 8/6/20…
##  8 Ecology …          16.7    2014     17 9     Barnec… 2/2/2016 6/17/2…
##  9 Ecology …          16.7    2014     17 9     Pinto-… 2/2/2016 6/12/2…
## 10 Ecology …          16.7    2014     17 9     Clough… 2/2/2016 7/17/2…
## # ℹ 1,589 more rows
## # ℹ 3 more variables: `Number of users` <dbl>, `Twitter reach` <dbl>,
```

Tidy: Create and modify columns

Check now the levels of journal variable

```
levels(citations$journal)
```

```
##  [1] "Animal Conservation"              "Conservation Letters"
##  [3] "Diversity and Distributions"      "Ecological Applications"
##  [5] "Ecology"                          "Ecology Letters"
##  [7] "Evolution"                        "Evolutionary Applications"
##  [9] "Fish and Fisheries"               "Functional Ecology"
## [11] "Global Change Biology"            "Global Ecology and Biogeography"
## [13] "Journal of Animal Ecology"        "Journal of Applied Ecology"
## [15] "Journal of Biogeography"          "Limnology and Oceanography"
## [17] "Mammal Review"                    "Methods in Ecology and Evolution"
## [19] "Molecular Ecology Resources"      "New Phytologist"
```

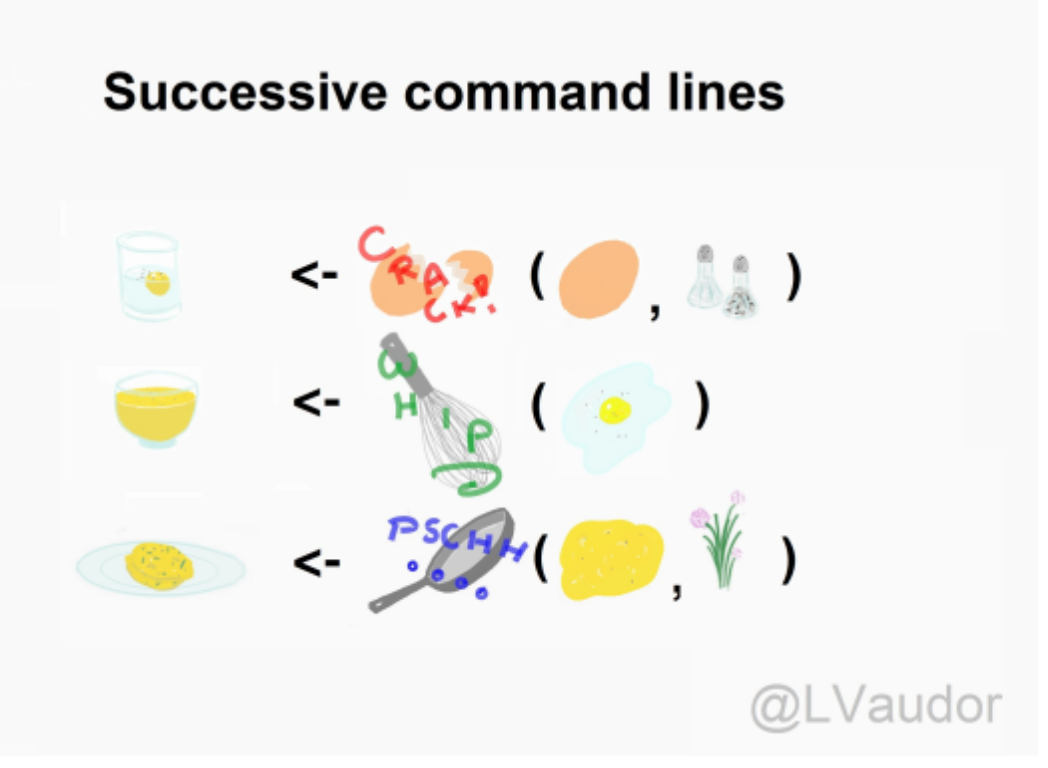
Piping: Make your manipulations easier

Piping was borrowed from other languages, got incorporated into R after a question in Pipe question in 2012. Pipe which is the bar "|" on your keyboard.

Omelette: Base r approach

You need to do complicated programming: create multiple intermediate objects; embed, needs some understanding of coding and is prone to errors.

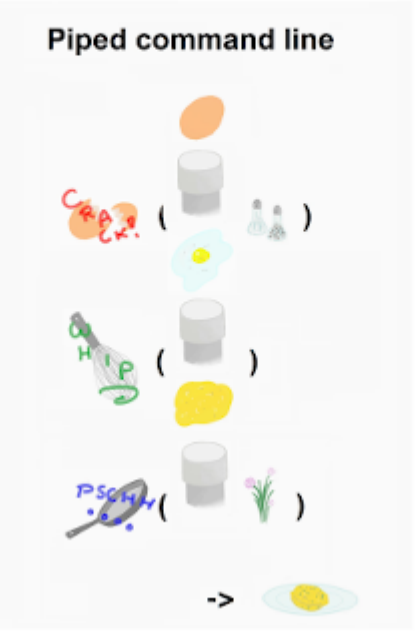
```
white_and_yolk <- crack(egg, add_seasoning)
omelette_batter <- beat(white_and_yolk)
omelette_with_chives <- cook(omelette_batter,add_chives)
```



Omelette: Piping approach

Simpler programming using piping. Piping consists of: taking results from previous function as a starting point of a new function;less prone to errors and consume less memory.

```
egg %>%
  crack(add_seasoning) %>%
  beat() %>%
  cook(add_chives) -> omelette_with_chives
```



Example of piping

Take the tibble "citations_raw" **then** rename some columns then the new tibble containing the renamed tibble and *then* convert the column "journal" from current class ("character") to factor.

```
citations_raw %>%
  rename(journal = 'Journal identity',
         impactfactor = '5-year journal impact factor',
         pubyear = 'Year published',
         colldate = 'Collection date',
         pubdate = 'Publication date',
         nbtweets = 'Number of tweets',
         woscitations = 'Number of Web of Science citations') %>%
  mutate(journal = as.factor(journal))
```

Please notice every time I say **"then"** this is equal to **"%>%"**.

Naming final object of pipe

```
citations <- citations_raw %>%
  rename(journal = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear = 'Year published',
       colldate = 'Collection date',
       pubdate = 'Publication date',
       nbtweets = 'Number of tweets',
       woscitations = 'Number of Web of Science citations') %>%
  mutate(journal = as.factor(journal))
head(citations)
```

```
## # A tibble: 6 × 12
##   journal    impactfactor pubyear Volume Issue Authors colldate pubdate nb
##   <fct>             <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>
## 1 Ecology L…         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…
## 2 Ecology L…         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…
## 3 Ecology L…         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…
## 4 Ecology L…         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…
## 5 Ecology L…         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…
## 6 Ecology L…         16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…
## # ℹ 3 more variables: `Number of users` <dbl>, `Twitter reach` <dbl>,
## #   woscitations <dbl>
```

Naming final object of pipe 2

```
citations_raw %>%
  rename(journal = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear = 'Year published',
       colldate = 'Collection date',
       pubdate = 'Publication date',
       nbtweets = 'Number of tweets',
       woscitations = 'Number of Web of Science citations') %>%
  mutate(journal = as.factor(journal))-> citations2
head(citations2)
```

```
## # A tibble: 6 × 12
##   journal    impactfactor pubyear Volume Issue Authors colldate pubdate nb
##   <fct>             <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>     <chr>
## 1 Ecology L…          16.7    2014     17 12    Morin … 2/1/2016 9/16/2…
## 2 Ecology L…          16.7    2014     17 12    Jucker… 2/1/2016 10/13/…
## 3 Ecology L…          16.7    2014     17 12    Calcag… 2/1/2016 10/21/…
## 4 Ecology L…          16.7    2014     17 11    Segre … 2/1/2016 8/28/2…
## 5 Ecology L…          16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…
## 6 Ecology L…          16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…
## # ℹ 3 more variables: `Number of users` <dbl>, `Twitter reach` <dbl>,
## #   woscitations <dbl>
```

Pipe synthax

- *Verb(Subject,Complement)* replaced by *Subject %>% Verb(Complement)*;
- No need to name unimportant intermediate variables;
- Clear syntax (readability).

If you want you can first write what you want to accomplished in a text with "then" as step wise, then code it by replace "then" by the pipe with its operator "%>%" of course.

Other functions in Tidyverse

Select columns

select() is the function one uses to select different variables i a tibble. You just need to remember that it follows a pipe operator (%>%), and it takes the name of columns one desires to select.

```
citations %>%
  select(journal, impactfactor, nbtweets)
```

```
## # A tibble: 1,599 × 3
##    journal          impactfactor nbtweets
##    <fct>                   <dbl>    <dbl>
##  1 Ecology Letters          16.7       18
##  2 Ecology Letters          16.7       15
##  3 Ecology Letters          16.7        5
##  4 Ecology Letters          16.7        9
##  5 Ecology Letters          16.7        3
##  6 Ecology Letters          16.7       27
##  7 Ecology Letters          16.7        6
##  8 Ecology Letters          16.7       19
##  9 Ecology Letters          16.7       26
## 10 Ecology Letters          16.7       44
## # ℹ 1,589 more rows
```

Drop columns or deselect variables

The opposite of selecting, which is deselecting. One just need to be more logical in the writing. Would you like to guess?

```
citations %>%
  select(-Volume, -Issue, -Authors)
```

```
## # A tibble: 1,599 × 9
##    journal      impactfactor pubyear colldate pubdate nbtweets `Number of
##    <fct>               <dbl>   <dbl> <chr>    <chr>      <dbl>
##  1 Ecology Let…         16.7    2014 2/1/2016 9/16/2…       18
##  2 Ecology Let…         16.7    2014 2/1/2016 10/13/…       15
##  3 Ecology Let…         16.7    2014 2/1/2016 10/21/…        5
##  4 Ecology Let…         16.7    2014 2/1/2016 8/28/2…        9
##  5 Ecology Let…         16.7    2014 2/1/2016 8/28/2…        3
##  6 Ecology Let…         16.7    2014 2/2/2016 7/28/2…       27
##  7 Ecology Let…         16.7    2014 2/2/2016 8/6/20…        6
##  8 Ecology Let…         16.7    2014 2/2/2016 6/17/2…       19
##  9 Ecology Let…         16.7    2014 2/2/2016 6/12/2…       26
## 10 Ecology Let…         16.7    2014 2/2/2016 7/17/2…       44
## # ℹ 1,589 more rows
## # ℹ 2 more variables: `Twitter reach` <dbl>, woscitations <dbl>
```

Split a column in several columns

separate is the function used to split a column into several of course you need to indicate what symbol is the separator (e.g., space, -, /, etc.).

```
head(citations$pubdate)
```

```
## [1] "9/16/2014"  "10/13/2014" "10/21/2014" "8/28/2014"  "8/28/2014"
## [6] "7/28/2014"
```

```
citations %>%
  select(journal, impactfactor, nbtweets, pubdate)%>%
  separate(pubdate,c('month','day','year'),'/')
```

```
## # A tibble: 1,599 × 6
##    journal          impactfactor nbtweets month day   year
##    <fct>                   <dbl>    <dbl> <chr> <chr> <chr>
##  1 Ecology Letters          16.7       18 9     16    2014
##  2 Ecology Letters          16.7       15 10    13    2014
##  3 Ecology Letters          16.7        5 10    21    2014
##  4 Ecology Letters          16.7        9 8     28    2014
##  5 Ecology Letters          16.7        3 8     28    2014
##  6 Ecology Letters          16.7       27 7     28    2014
##  7 Ecology Letters          16.7        6 8     6     2014
```

Transform column in date format

Many of us work with ecological data that record date, and we find it hard to keep these on readable format in R. Within, tidyverse there is a package that specially deals with date formatting variables/columns. The package is called **lubridate**.

```
library(lubridate)
citations %>%
  mutate(pubdate = mdy(pubdate),
         colldate = mdy(colldate))%>%
  select(journal,impactfactor, nbtweets, pubdate, colldate)
```

```
## # A tibble: 1,599 × 5
##    journal         impactfactor nbtweets pubdate    colldate
##    <fct>                  <dbl>    <dbl> <date>     <date>
##  1 Ecology Letters         16.7       18 2014-09-16 2016-02-01
##  2 Ecology Letters         16.7       15 2014-10-13 2016-02-01
##  3 Ecology Letters         16.7        5 2014-10-21 2016-02-01
##  4 Ecology Letters         16.7        9 2014-08-28 2016-02-01
##  5 Ecology Letters         16.7        3 2014-08-28 2016-02-01
##  6 Ecology Letters         16.7       27 2014-07-28 2016-02-02
##  7 Ecology Letters         16.7        6 2014-08-06 2016-02-02
##  8 Ecology Letters         16.7       19 2014-06-17 2016-02-02
```

For easy date format manipulation

Check out ?lubridate::lubridate for more functions

```
library(lubridate)
citations %>%
  mutate(pubdate = mdy(pubdate),
         pubyear2 = year(pubdate))%>%
  select(journal,impactfactor, pubdate, colldate, pubyear2)
```

```
## # A tibble: 1,599 × 5
##    journal          impactfactor pubdate    colldate pubyear2
##    <fct>                   <dbl> <date>     <chr>       <dbl>
##  1 Ecology Letters          16.7 2014-09-16 2/1/2016     2014
##  2 Ecology Letters          16.7 2014-10-13 2/1/2016     2014
##  3 Ecology Letters          16.7 2014-10-21 2/1/2016     2014
##  4 Ecology Letters          16.7 2014-08-28 2/1/2016     2014
##  5 Ecology Letters          16.7 2014-08-28 2/1/2016     2014
##  6 Ecology Letters          16.7 2014-07-28 2/2/2016     2014
##  7 Ecology Letters          16.7 2014-08-06 2/2/2016     2014
##  8 Ecology Letters          16.7 2014-06-17 2/2/2016     2014
##  9 Ecology Letters          16.7 2014-06-12 2/2/2016     2014
## 10 Ecology Letters          16.7 2014-07-17 2/2/2016     2014
## # ℹ 1,589 more rows
```

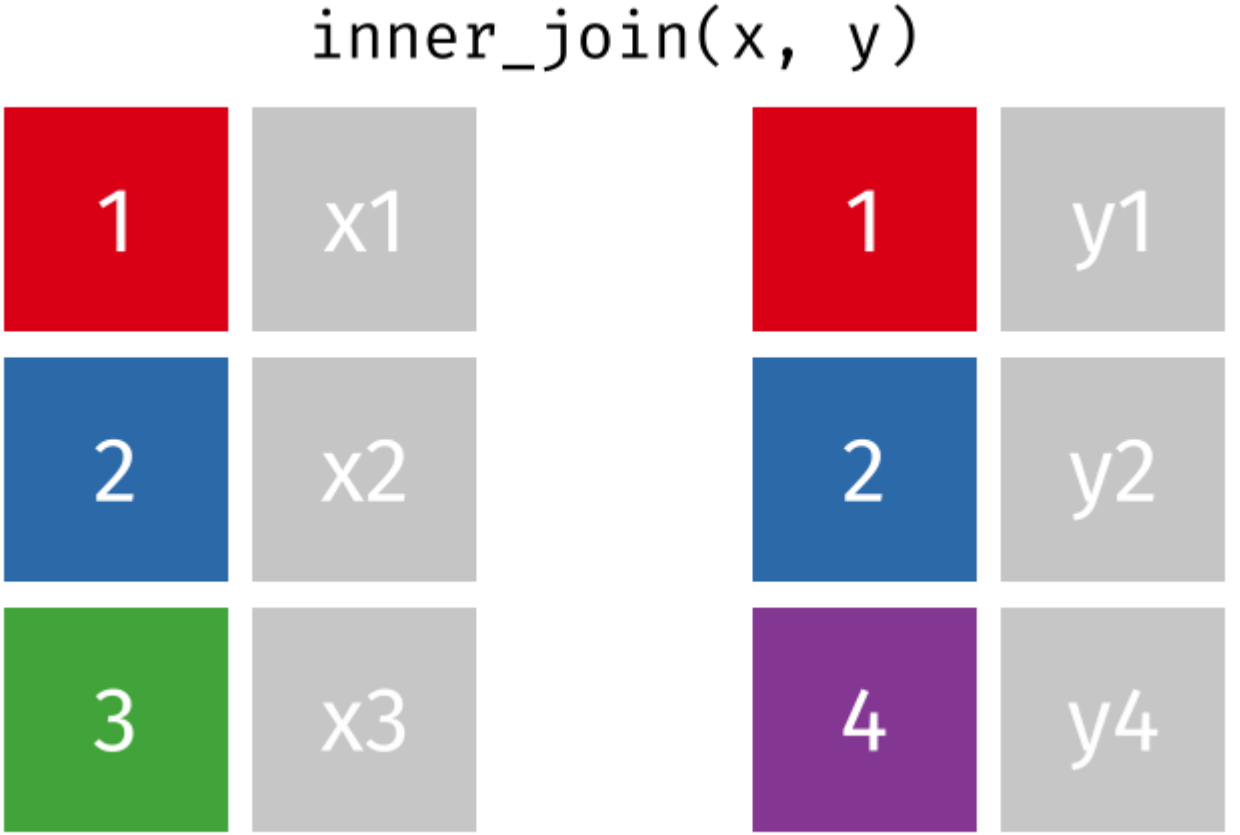
Join tables together

Join two tables

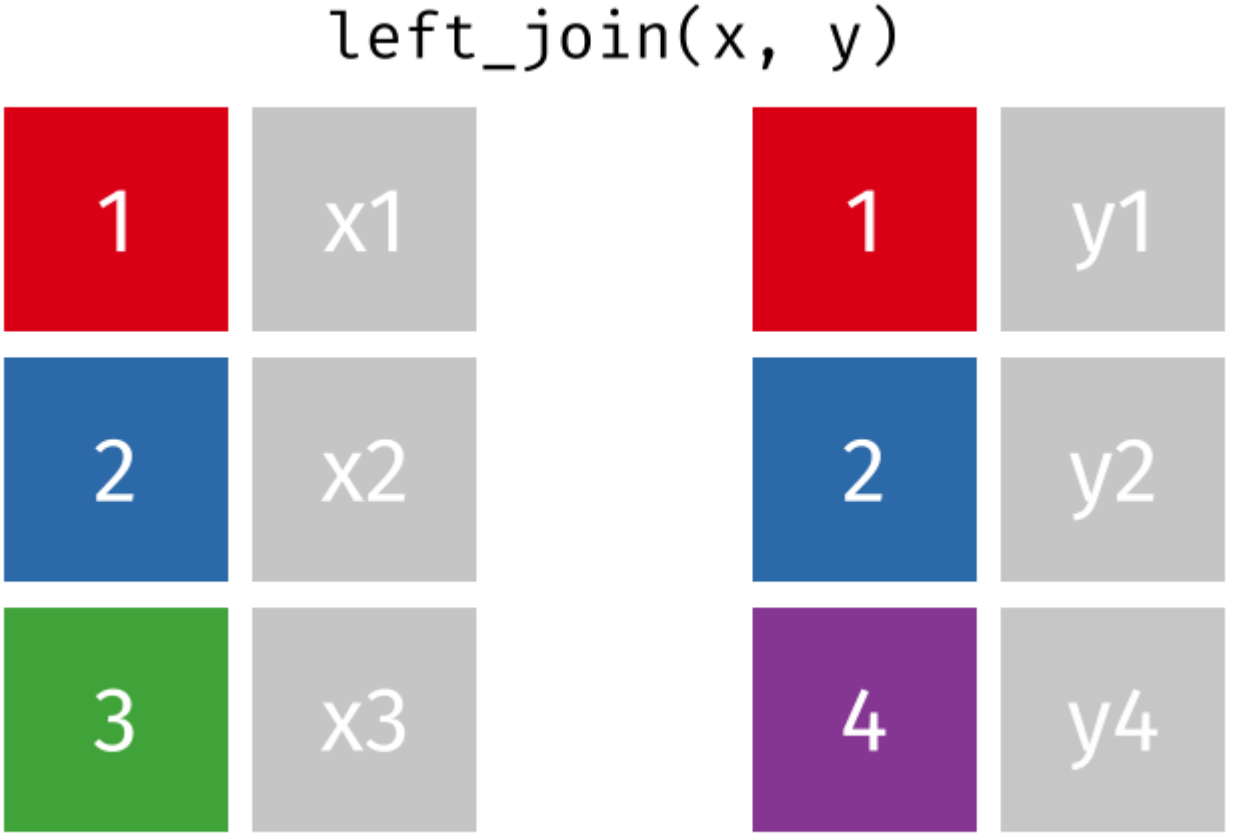
Joining tables are the correspondents of merge function in base R. There is a great tutorial to all sort of joining in tidyverse made available by Garrick Aden-Buie. The joining of tables can be categorized into several types. However, we will only study the following:

- Inner join;
- Left join;
- Right join;
- Semi join;
- Union join;
- Anti join.

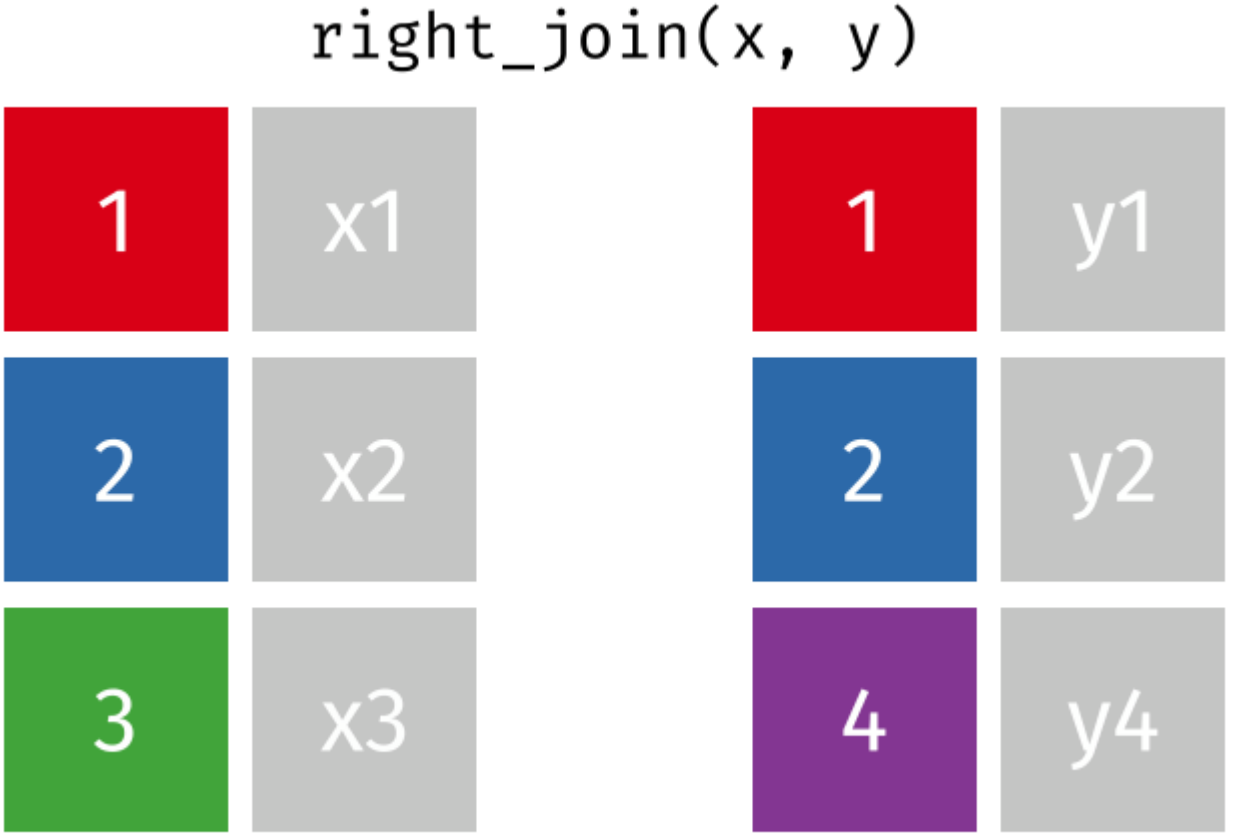
Inner join



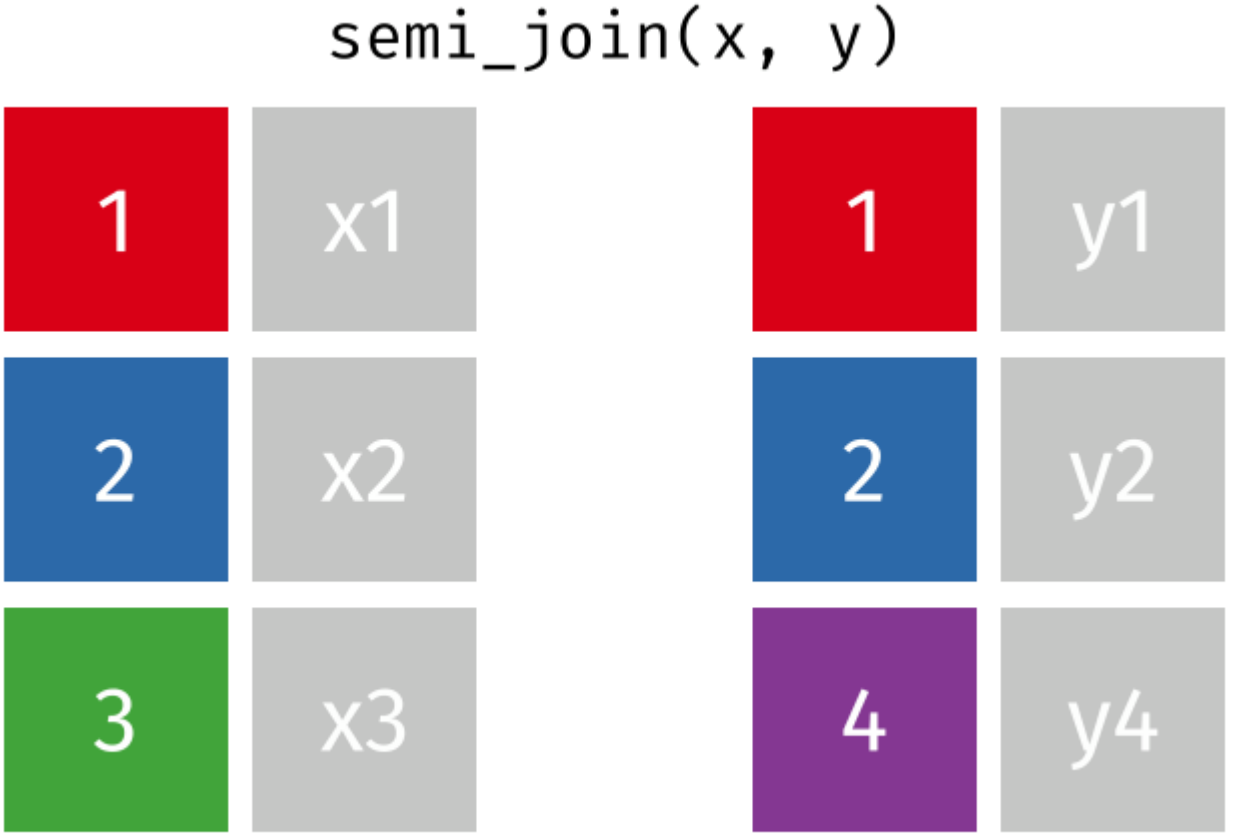
Left join



Right join

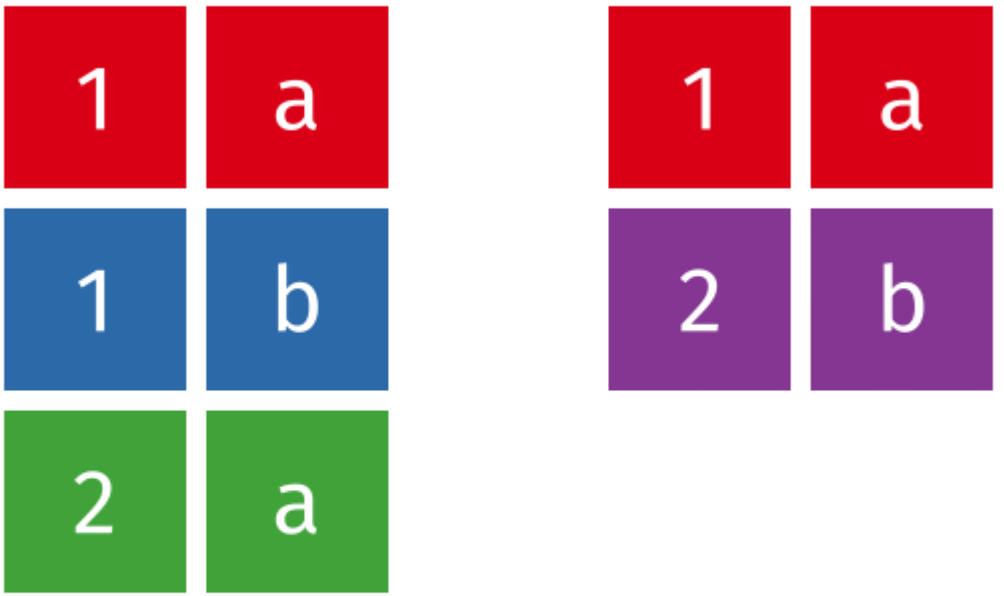


Semi join

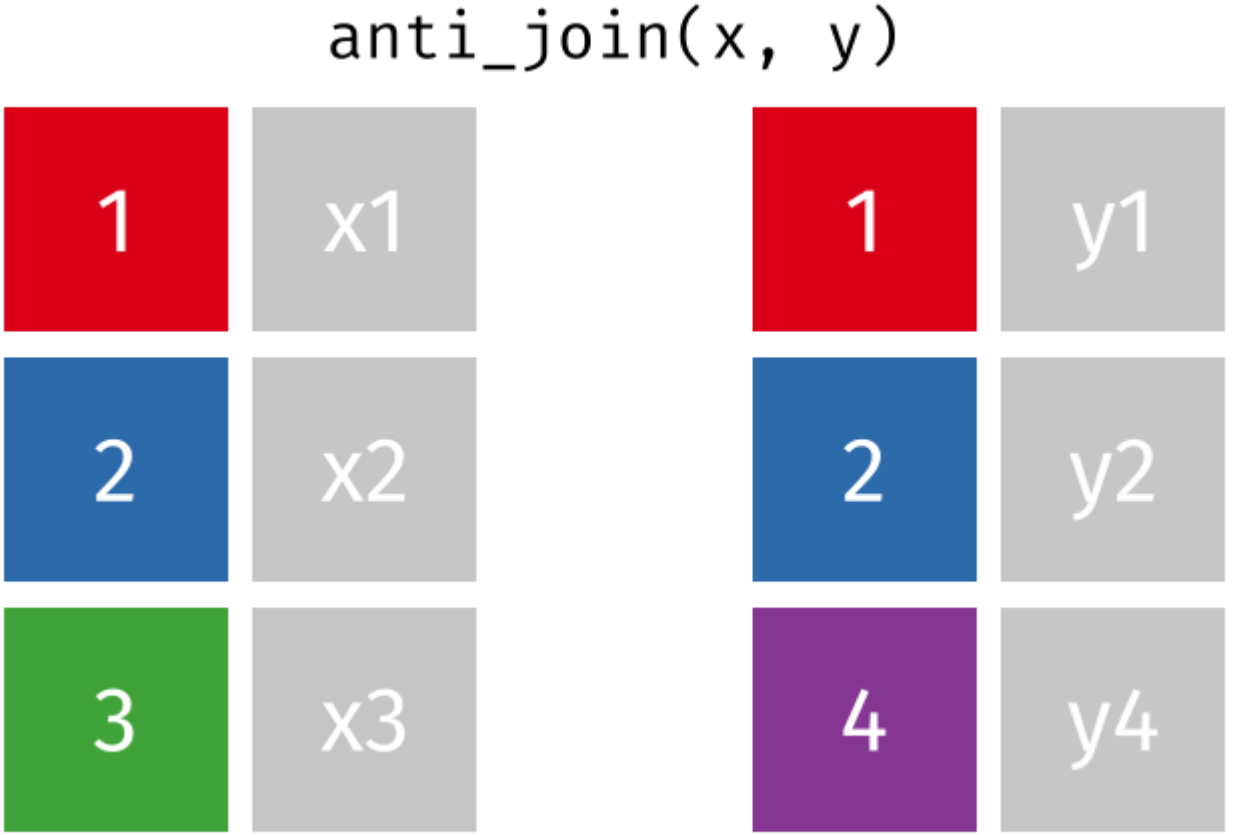


Union join

`union(x, y)`



Anti join



Character manipulation

Select rows of papers with > 3 authors

```
citations %>%
#str_detect() detect characters in a given column
    filter(str_detect(Authors,'et al'))
```

```
## # A tibble: 1,280 × 12
##    journal   impactfactor pubyear Volume Issue Authors colldate pubdate nb
##    <fct>            <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>
##  1 Ecology …         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…
##  2 Ecology …         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…
##  3 Ecology …         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…
##  4 Ecology …         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…
##  5 Ecology …         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…
##  6 Ecology …         16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…
##  7 Ecology …         16.7    2014     17 10    Tschir… 2/2/2016 8/6/20…
##  8 Ecology …         16.7    2014     17 9     Barnec… 2/2/2016 6/17/2…
##  9 Ecology …         16.7    2014     17 9     Pinto-… 2/2/2016 6/12/2…
## 10 Ecology …         16.7    2014     17 9     Clough… 2/2/2016 7/17/2…
## # ℹ 1,270 more rows
## # ℹ 3 more variables: `Number of users` <dbl>, `Twitter reach` <dbl>,
## #   woscitations <dbl>
```

Select columns with rows of papers with > 3 authors

```
citations %>%
  filter(str_detect(Authors,'et al')) %>%
  select(Authors)
```

```
## # A tibble: 1,280 × 1
##    Authors
##    <chr>
##  1 Morin et al
##  2 Jucker et al
##  3 Calcagno et al
##  4 Segre et al
##  5 Kaufman et al
##  6 Nasto et al
##  7 Tschirren et al
##  8 Barnechi et al
##  9 Pinto-Sanchez et al
## 10 Clough et al
## # ℹ 1,270 more rows
```

Select columns with rows of papers with < 3 authors

```
citations %>%
  filter(!str_detect(Authors,'et al')) %>% ##!  for saying "not".
  select(Authors)
```

```
## # A tibble: 319 × 1
##    Authors
##    <chr>
##  1 Neutle and Thorne
##  2 Kellner and Asner
##  3 Griffin and Willi
##  4 Gremer and Venable
##  5 Cavieres
##  6 Haegman and Loreau
##  7 Kearney
##  8 Locey and White
##  9 Quintero and Weins
## 10 Lesser and Jackson
## # ℹ 309 more rows
```

Select authors of columns with rows of papers with < 3 authors

```
citations %>%
  filter(!str_detect(Authors,'et al')) %>% ##!  for saying "not".
pull(Authors) %>%
  head(10)
```

```
##  [1] "Neutle and Thorne"  "Kellner and Asner"  "Griffin and Willi"
##  [4] "Gremer and Venable" "Cavieres"           "Haegman and Loreau"
##  [7] "Kearney"            "Locey and White"    "Quintero and Weins"
## [10] "Lesser and Jackson"
```

Rows of papers with less than 3 authors in journal with IF < 5

```
citations %>%
  filter(!str_detect(Authors,'et al'), impactfactor < 5)
```

```
## # A tibble: 77 × 12
##    journal   impactfactor pubyear Volume Issue Authors colldate pubdate nb
##    <fct>            <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>
##  1 Molecula…          4.9    2014     14 6     Gautier 2/27/20… 5/14/2…
##  2 Molecula…          4.9    2014     14 5     Gambel… 2/27/20… 3/7/20…
##  3 Molecula…          4.9    2014     14 4     Kekkon… 2/27/20… 3/10/2…
##  4 Molecula…          4.9    2014     14 3     Bhatta… 2/27/20… 12/8/2…
##  5 Molecula…          4.9    2014     14 1     Christ… 2/28/20… 10/25/…
##  6 Molecula…          4.9    2013     13 4     Villar… 2/28/20… 5/2/20…
##  7 Molecula…          4.9    2013     13 4     Wang    2/28/20… 4/25/2…
##  8 Molecula…          4.9    2012     12 1     Joly    2/28/20… 9/7/20…
##  9 Animal C…          3.21   2014     17 6     Plavsic 2/9/2016 4/17/2…
## 10 Animal C…          3.21   2014     17 Supp… Knox a… 2/11/20… 11/13/…
## # ℹ 67 more rows
## # ℹ 3 more variables: `Number of users` <dbl>, `Twitter reach` <dbl>,
## #   woscitations <dbl>
```

Convert words to lowercase

```
citations %>%
  mutate(authors_lowercase = str_to_lower(Authors)) %>%
  select(authors_lowercase)
```

```
## # A tibble: 1,599 × 1
##    authors_lowercase
##    <chr>
##  1 morin et al
##  2 jucker et al
##  3 calcagno et al
##  4 segre et al
##  5 kaufman et al
##  6 nasto et al
##  7 tschirren et al
##  8 barnechi et al
##  9 pinto-sanchez et al
## 10 clough et al
## # ℹ 1,589 more rows
```

Remove all spaces in variable names

```
citations%>%
  mutate(journal = str_remove_all(journal," ")) %>%
  select(journal) %>%
  unique() %>%
  head(5)
```

```
## # A tibble: 5 × 1
##   journal
##   <chr>
## 1 EcologyLetters
## 2 GlobalChangeBiology
## 3 GlobalEcologyandBiogeography
## 4 MolecularEcologyResources
## 5 DiversityandDistributions
```

Basic exploratory data analysis

Count ()

This helps to count the number of occurrences.

```
citations %>%
  count(journal, sort = TRUE) ## Embedded sorting within count()
```

```
## # A tibble: 20 × 2
##    journal                                n
##    <fct>                              <int>
##  1 New Phytologist                      144
##  2 Ecology                              108
##  3 Evolution                            108
##  4 Global Change Biology                108
##  5 Global Ecology and Biogeography      108
##  6 Journal of Biogeography              108
##  7 Ecology Letters                      106
##  8 Diversity and Distributions          105
##  9 Animal Conservation                  102
## 10 Methods in Ecology and Evolution      90
## 11 Evolutionary Applications             74
## 12 Functional Ecology                    54
## 13 Journal of Animal Ecology             54
## 14 Journal of Applied Ecology            54
## 15 Limnology and Oceanography            54
```

Count() for multiple variables

```
citations %>%
  count(journal, pubyear)
```

```
## # A tibble: 59 × 3
##    journal                          pubyear     n
##    <fct>                              <dbl> <int>
##  1 Animal Conservation                 2012    18
##  2 Animal Conservation                 2013    18
##  3 Animal Conservation                 2014    66
##  4 Conservation Letters                2012    17
##  5 Conservation Letters                2013    18
##  6 Conservation Letters                2014    18
##  7 Diversity and Distributions         2012    36
##  8 Diversity and Distributions         2013    33
##  9 Diversity and Distributions         2014    36
## 10 Ecological Applications             2012    24
## # ℹ 49 more rows
```

Count sum of tweets per journal

```
citations %>%
  count(journal, wt = nbtweets, sort = TRUE)
```

```
## # A tibble: 20 × 2
##    journal                                n
##    <fct>                              <dbl>
##  1 Ecology Letters                     1538
##  2 Animal Conservation                 1268
##  3 Journal of Applied Ecology          1012
##  4 Methods in Ecology and Evolution     699
##  5 Global Change Biology                613
##  6 Conservation Letters                 542
##  7 New Phytologist                      509
##  8 Global Ecology and Biogeography      379
##  9 Ecology                              335
## 10 Evolution                            335
## 11 Journal of Animal Ecology            323
## 12 Fish and Fisheries                   261
## 13 Evolutionary Applications            238
## 14 Journal of Biogeography              209
## 15 Diversity and Distributions          200
## 16 Mammal Review                        166
## 17 Functional Ecology                   155
```

Group variables to compute stats [summarise()]

```
citations %>%
  group_by(journal) %>%
  summarise(avg_tweets = mean(nbtweets))
```

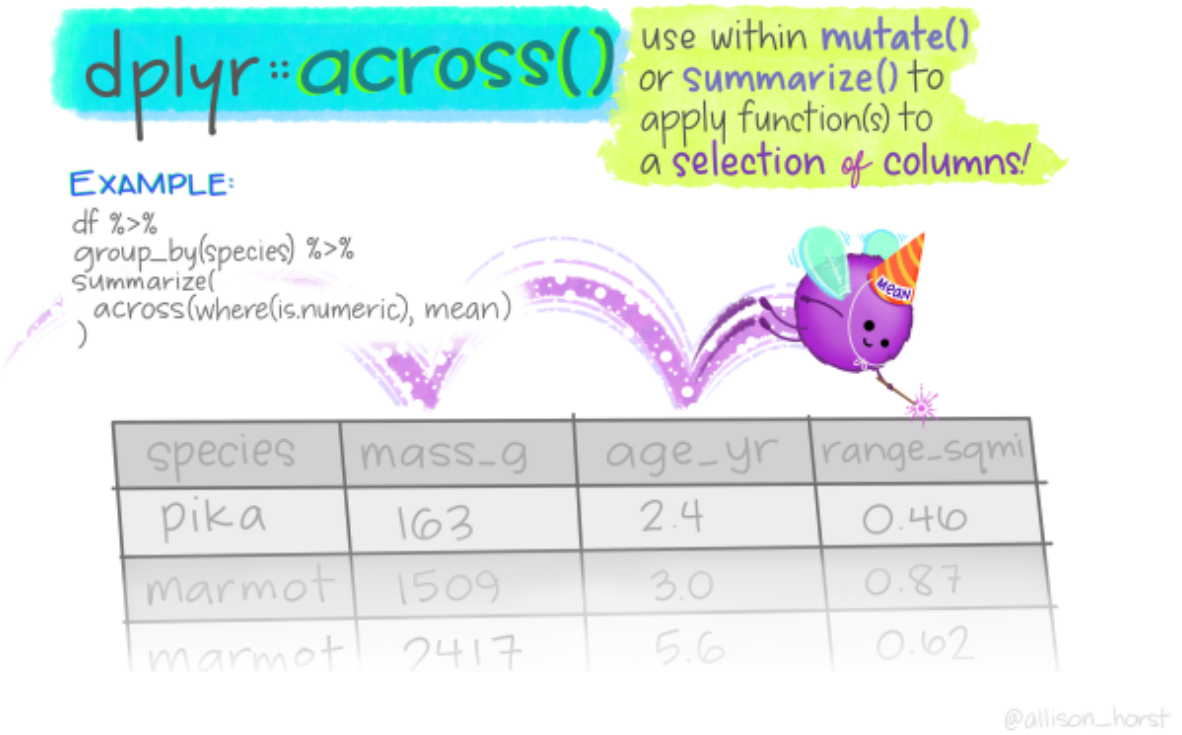
```
## # A tibble: 20 × 2
##    journal                           avg_tweets
##    <fct>                                  <dbl>
##  1 Animal Conservation                    12.4
##  2 Conservation Letters                   10.2
##  3 Diversity and Distributions             1.90
##  4 Ecological Applications                 2.60
##  5 Ecology                                 3.10
##  6 Ecology Letters                        14.5
##  7 Evolution                               3.10
##  8 Evolutionary Applications               3.22
##  9 Fish and Fisheries                      7.25
## 10 Functional Ecology                      2.87
## 11 Global Change Biology                   5.68
## 12 Global Ecology and Biogeography         3.51
## 13 Journal of Animal Ecology               5.98
```

Order stuff [arrange()]

```
citations %>%
  group_by(journal) %>%
  summarise(avg_tweets = mean(nbtweets)) %>%
  # decreasing order but (without desc for increasing)
  arrange(desc(avg_tweets))-> arrangedat
head(arrangedat, 10)
```

```
## # A tibble: 10 × 2
##    journal                              avg_tweets
##    <fct>                                     <dbl>
##  1 Journal of Applied Ecology                18.7
##  2 Ecology Letters                           14.5
##  3 Animal Conservation                       12.4
##  4 Conservation Letters                      10.2
##  5 Methods in Ecology and Evolution           7.77
##  6 Fish and Fisheries                         7.25
##  7 Journal of Animal Ecology                  5.98
##  8 Global Change Biology                      5.68
##  9 Mammal Review                              5.35
## 10 New Phytologist                            3.53
```

Work on several columns [dplyr:::across()]



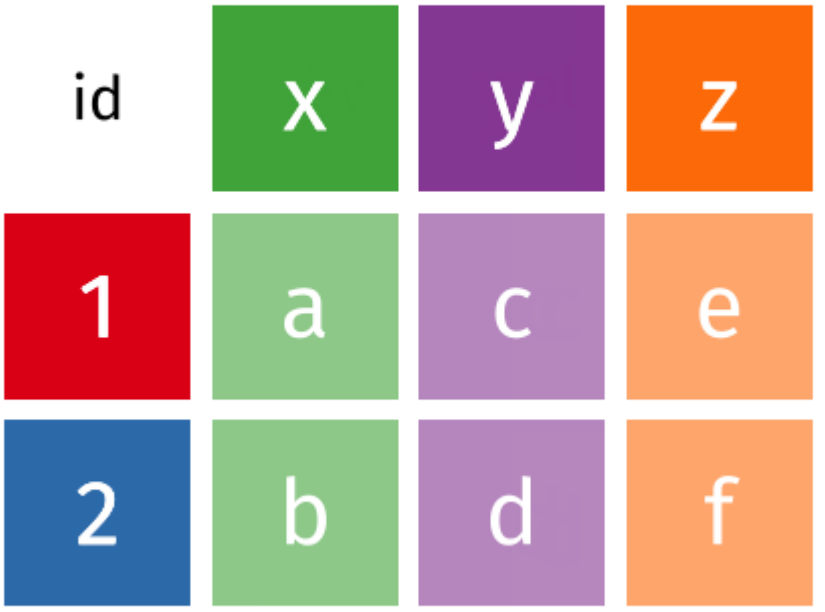
Compute mean across multiple variables

```
citations %>%
  group_by(journal) %>%
  summarize(across(where(is.numeric), mean))
```

```
## # A tibble: 20 × 8
##    journal                impactfactor pubyear Volume nbtweets `Number of
##    <fct>                         <dbl>   <dbl>  <dbl>    <dbl>
##  1 Animal Conservation            3.21   2013.  16.5      12.4
##  2 Conservation Letters           6.4    2013.   6.02     10.2
##  3 Diversity and Distrib…         5.4    2013   19         1.90
##  4 Ecological Applicatio…         5.06   2013   23         2.60
##  5 Ecology                        6.16   2013   94         3.10
##  6 Ecology Letters               16.7    2013.  16.0      14.5
##  7 Evolution                      5.25   2013   67         3.10
##  8 Evolutionary Applicat…         4.6    2013.   6.05      3.22
##  9 Fish and Fisheries             8.1    2013   14         7.25
## 10 Functional Ecology             5.28   2013   27         2.87
## 11 Global Change Biology          8.7    2013   19         5.68
## 12 Global Ecology and Bi…         7.18   2013   22         3.51
## 13 Journal of Animal Eco…         5.32   2013.  81.9       5.98
## 14 Journal of Applied Ec…         5.93   2013   50        18.7
## 15 Journal of Biogeograp…         4.59   2013   40         1.94
## 16 Limnology and Oceanog…         4.4    2013   58         0
```

Tidying tibbles [wide(), long()]

wide



Data manipulation with tidyverse: in depth study

Learn the tidyverse: books, workshops and online courses Selection of books:

- R for Data Science and Advanced R;
- Tidy Tuesdays videos by D. Robinson;
- Material of the stat545 course on Data wrangling, exploration, and analysis with R at the University of British Columbia;
- List of best R packages (with their description) on data import, wrangling and visualization.

Thank you for listening!

Any questions now or email me at **dossa@xtbg.org.cn**

Slides created via the R package **xaringan**.

The chakra comes from remark.js, **knitr**, and R Markdown.