

# Programming in R Workshop

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## Load packages

Load purrr, tidyverse and dplyr packages.

```
library(purrr)
library(tidyverse)
library(conflicted)
library(dplyr)
```

Load the Eukaryotes dataset - only have to run this once to get the data

```
eukaryotes <- read_tsv(
  file = "ftp://ftp.ncbi.nlm.nih.gov/genomes/GENOME_REPORTS/eukaryotes.txt",
  na = c("", "na", "-")
)

# Reformat dataset headers
names_new <- names(eukaryotes) |>
  str_replace_all("#%()", "") |>
  str_replace_all("[ /]", "_") |>
  str_to_lower()
```

```
eukaryotes <- eukaryotes |>
  set_names(names_new)

# Save tibble
write_tsv(eukaryotes, "eukaryotes.tsv")
```

Load the saved dataset

```
eukaryotes <- read_tsv("https://raw.githubusercontent.com/swuyts/purrr_tutorial/master/data/
```

```
Rows: 11508 Columns: 19
```

```
-- Column specification -----
```

```
Delimiter: "\t"
```

```
chr   (10): organism_name, bioproject_accession, group, subgroup, assembly_ac...
```

```
dbl   (7): taxid, bioproject_id, size_mb, gc, scaffolds, genes, proteins
```

```
date  (2): release_date, modify_date
```

```
i Use `spec()` to retrieve the full column specification for this data.
```

```
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

How many different organisms are there in our dataset?

```
eukaryotes |>
  pull(organism_name) |>
  n_distinct()
```

```
[1] 6111
```

Subset dataframe by selecting variables for the analysis:

```
eukaryotes_subset <- eukaryotes |>
  select(organism_name, group, subgroup)
```

Using `n_distinct` to each variable of `eukaryotes_subset`

```
map(eukaryotes_subset, n_distinct)
```

```
$organism_name  
[1] 6111
```

```
$group  
[1] 5
```

```
$subgroup  
[1] 19
```

```
eukaryotes_subset |>  
  map(n_distinct)
```

```
$organism_name  
[1] 6111
```

```
$group  
[1] 5
```

```
$subgroup  
[1] 19
```

## Nested Tibbles

Split the eukaryotes dataset according to groups defined in the group variable:

```
eukaryotes |> pull(group) |> unique()
```

```
[1] "Other"      "Protists" "Plants"    "Fungi"     "Animals"
```

```
eukaryotes_nested <- eukaryotes |>  
  group_by(group) |>  
  nest()
```

```
eukaryotes_nested
```

```
# A tibble: 5 x 2  
# Groups:   group [5]  
  group    data  
  <chr>   <list>
```

```

1 Other      <tibble [51 x 18]>
2 Protists   <tibble [888 x 18]>
3 Plants     <tibble [1,304 x 18]>
4 Fungi      <tibble [6,064 x 18]>
5 Animals    <tibble [3,201 x 18]>

```

Split the “eukaryotes\_nested” into 5 smaller dataframes.

```
eukaryotes_nested |> pull(data)
```

```
[[1]]
```

```
# A tibble: 51 x 18
```

|    | organism_name<br><chr> | taxid<br><dbl> | bioproject_accession<br><chr> | bioproject_id<br><dbl> | subgroup<br><chr> | size_mb<br><dbl> |
|----|------------------------|----------------|-------------------------------|------------------------|-------------------|------------------|
| 1  | Pyropia yezoensis      | 2788           | PRJNA589917                   | 589917                 | Other             | 108.             |
| 2  | Thalassiosira pse~     | 296543         | PRJNA191                      | 191                    | Other             | 32.4             |
| 3  | Guillardia theta ~     | 905079         | PRJNA53577                    | 53577                  | Other             | 87.1             |
| 4  | Cyanidioschyzon m~     | 280699         | PRJNA10792                    | 10792                  | Other             | 16.5             |
| 5  | Galdieria sulphur~     | 130081         | PRJNA13023                    | 13023                  | Other             | 13.7             |
| 6  | Phaeodactylum tri~     | 556484         | PRJNA13152                    | 13152                  | Other             | 27.5             |
| 7  | Bigelowiella nata~     | 753081         | PRJNA47111                    | 47111                  | Other             | 91.4             |
| 8  | Ectocarpus silicu~     | 2880           | PRJEA42625                    | 42625                  | Other             | 196.             |
| 9  | Thalassiosira oce~     | 159749         | PRJNA36595                    | 36595                  | Other             | 92.2             |
| 10 | Fragilariopsis cy~     | 635003         | PRJNA32761                    | 32761                  | Other             | 80.5             |

```
# i 41 more rows
```

```
# i 12 more variables: gc <dbl>, assembly_accession <chr>, replicons <chr>,
#   wgs <chr>, scaffolds <dbl>, genes <dbl>, proteins <dbl>,
#   release_date <date>, modify_date <date>, status <chr>, center <chr>,
#   biosample_accession <chr>
```

```
[[2]]
```

```
# A tibble: 888 x 18
```

|   | organism_name<br><chr> | taxid<br><dbl> | bioproject_accession<br><chr> | bioproject_id<br><dbl> | subgroup<br><chr> | size_mb<br><dbl> |
|---|------------------------|----------------|-------------------------------|------------------------|-------------------|------------------|
| 1 | Emiliana huxleyi~      | 280463         | PRJNA77753                    | 77753                  | Other P~          | 168.             |
| 2 | Leishmania major ~     | 347515         | PRJNA10724                    | 10724                  | Kinetop~          | 32.9             |
| 3 | Trypanosoma bruce~     | 679716         | PRJEA40697                    | 40697                  | Kinetop~          | 22.1             |
| 4 | Trypanosoma cruzi      | 5693           | PRJNA11755                    | 11755                  | Kinetop~          | 89.9             |
| 5 | Entamoeba histoly~     | 294381         | PRJNA142                      | 142                    | Other P~          | 20.8             |
| 6 | Giardia intestina~     | 5741           | PRJNA561185                   | 561185                 | Other P~          | 11.5             |
| 7 | Eimeria tenella        | 5802           | PRJEB4863                     | 224694                 | Apicomp~          | 51.9             |
| 8 | Cryptosporidium p~     | 353152         | PRJNA144                      | 144                    | Apicomp~          | 9.10             |

```

 9 Toxoplasma gondii~ 508771 PRJNA28893          28893 Apicomp~ 65.7
10 Plasmodium berghei 5821 PRJEB11993          305111 Apicomp~ 18.8
# i 878 more rows
# i 12 more variables: gc <dbl>, assembly_accession <chr>, replicons <chr>,
#   wgs <chr>, scaffolds <dbl>, genes <dbl>, proteins <dbl>,
#   release_date <date>, modify_date <date>, status <chr>, center <chr>,
#   biosample_accession <chr>

```

[[3]]

```

# A tibble: 1,304 x 18
  organism_name      taxid bioproject_accession bioproject_id subgroup size_mb
  <chr>             <dbl> <chr>                <dbl> <chr>      <dbl>
1 Arabidopsis thali~ 3702 PRJNA10719          10719 Land Pl~ 120.
2 Glycine max        3847 PRJNA19861          19861 Land Pl~ 979.
3 Medicago truncatu~ 3880 PRJNA10791          10791 Land Pl~ 413.
4 Solanum lycopersi~ 4081 PRJNA119           119 Land Pl~ 828.
5 Hordeum vulgare s~ 112509 PRJEB34217        576847 Land Pl~ 4341.
6 Oryza sativa Japo~ 39947 PRJNA12269          12269 Land Pl~ 374.
7 Triticum aestivum  4565 PRJNA392179        392179 Land Pl~ 15419.
8 Zea mays           4577 PRJNA10769          10769 Land Pl~ 2135.
9 Coffea arabica     13443 PRJNA506972        506972 Land Pl~ 1094.
10 Lotus japonicus   34305 PRJDA28941          28941 Land Pl~ 394.
# i 1,294 more rows
# i 12 more variables: gc <dbl>, assembly_accession <chr>, replicons <chr>,
#   wgs <chr>, scaffolds <dbl>, genes <dbl>, proteins <dbl>,
#   release_date <date>, modify_date <date>, status <chr>, center <chr>,
#   biosample_accession <chr>

```

[[4]]

```

# A tibble: 6,064 x 18
  organism_name      taxid bioproject_accession bioproject_id subgroup size_mb
  <chr>             <dbl> <chr>                <dbl> <chr>      <dbl>
1 Pneumocystis cari~ 1.41e6 PRJNA223511        223511 Ascomyc~ 7.66
2 Schizosaccharomyc~ 4.90e3 PRJNA13836          13836 Ascomyc~ 12.6
3 Saccharomyces cer~ 5.59e5 PRJNA43747          43747 Ascomyc~ 12.2
4 Aspergillus nidul~ 2.27e5 PRJNA130           130 Ascomyc~ 30.3
5 Aspergillus fumig~ 3.31e5 PRJNA131           131 Ascomyc~ 29.4
6 Neurospora crassa~ 3.67e5 PRJNA13841          13841 Ascomyc~ 41.1
7 Phanerochaete chr~ 5.31e3 PRJNA343563        343563 Basidio~ 39.2
8 Candida albicans ~ 2.38e5 PRJNA10701          10701 Ascomyc~ 14.3
9 Encephalitozoon c~ 2.85e5 PRJNA13833          13833 Other F~ 2.50
10 Aspergillus terre~ 3.42e5 PRJNA15631          15631 Ascomyc~ 29.4
# i 6,054 more rows

```

```

# i 12 more variables: gc <dbl>, assembly_accession <chr>, replicons <chr>,
#   wgs <chr>, scaffolds <dbl>, genes <dbl>, proteins <dbl>,
#   release_date <date>, modify_date <date>, status <chr>, center <chr>,
#   biosample_accession <chr>

[[5]]
# A tibble: 3,201 x 18
  organism_name      taxid bioproject_accession bioproject_id subgroup size_mb
  <chr>             <dbl> <chr>                                <dbl> <chr>      <dbl>
1 Caenorhabditis br~  6238 PRJNA10731                        10731 Roundwo~   108.
2 Caenorhabditis el~  6239 PRJNA13758                        13758 Roundwo~   100.
3 Brugia malayi      6279 PRJNA10729                        10729 Roundwo~    93.7
4 Aedes aegypti      7159 PRJNA392114                    392114 Insects    1279.
5 Aedes albopictus   7160 PRJNA552090                    552090 Insects    2538.
6 Anopheles gambiae~ 180454 PRJNA1438                        1438 Insects     265.
7 Drosophila melano~  7227 PRJNA13669                        13669 Insects     144.
8 Apis mellifera     7460 PRJNA477511                    477511 Insects     225.
9 Ciona intestinalis  7719 PRJDA65419                        65419 Other A~    115.
10 Danio rerio       7955 PRJNA11776                       11776 Fishes    1679.
# i 3,191 more rows
# i 12 more variables: gc <dbl>, assembly_accession <chr>, replicons <chr>,
#   wgs <chr>, scaffolds <dbl>, genes <dbl>, proteins <dbl>,
#   release_date <date>, modify_date <date>, status <chr>, center <chr>,
#   biosample_accession <chr>

```

## Combine nested tibbles and map

Count number of rows for each sub data frames

```
map(eukaryotes_nested$data, nrow)
```

```

[[1]]
[1] 51

[[2]]
[1] 888

[[3]]
[1] 1304

[[4]]

```

```
[1] 6064
```

```
[[5]]
```

```
[1] 3201
```

Create a new column using `mutate()`

```
eukaryotes_nested |>
  mutate(n_row = map_int(data, nrow))
```

```
# A tibble: 5 x 3
# Groups:   group [5]
  group      data              n_row
  <chr>    <list>              <int>
1 Other   <tibble [51 x 18]>         51
2 Protists <tibble [888 x 18]>       888
3 Plants  <tibble [1,304 x 18]>    1304
4 Fungi   <tibble [6,064 x 18]>   6064
5 Animals <tibble [3,201 x 18]>   3201
```

How many different organisms are there per group ?

There are two different ways:

```
# Define a custom function
n_distinct_organisms <- function(data) {

  data |>
    pull(organism_name) |>
    n_distinct()

}

# Define a custom function as a formula
# .x is the notation for the object that is given as an input to this function.
n_distinct_organisms2 <- ~ .x |>
  pull(organism_name) |>
  n_distinct()
```

Apply the function to our nested data:

```
eukaryotes_nested |>
  mutate(n_organisms = map_dbl(data,
                                n_distinct_organisms
                              ),
         n_organisms2 = map_dbl(data,
                                n_distinct_organisms2
                              )
  )
```

```
# A tibble: 5 x 4
# Groups:   group [5]
  group    data                n_organisms n_organisms2
  <chr>   <list>                <dbl>      <dbl>
1 Other  <tibble [51 x 18]>         35         35
2 Protists <tibble [888 x 18]>       490        490
3 Plants  <tibble [1,304 x 18]>     673        673
4 Fungi   <tibble [6,064 x 18]>    2926       2926
5 Animals <tibble [3,201 x 18]>    1987       1987
```

We can define the functions on the fly:

```
eukaryotes_nested |>
  mutate(n_organisms = map_dbl(data,
                                ~ .x |> pull(organism_name) |> n_distinct()),
         n_centers = map_dbl(data,
                               ~ .x |> pull(center) |> n_distinct()),
         n_subgroups = map_dbl(data,
                                ~ .x |> pull(subgroup) |> n_distinct()))
```

```
# A tibble: 5 x 5
# Groups:   group [5]
  group    data                n_organisms n_centers n_subgroups
  <chr>   <list>                <dbl>      <dbl>      <dbl>
1 Other  <tibble [51 x 18]>         35         34         1
2 Protists <tibble [888 x 18]>       490        265         3
3 Plants  <tibble [1,304 x 18]>     673        492         3
4 Fungi   <tibble [6,064 x 18]>    2926        950         3
5 Animals <tibble [3,201 x 18]>    1987        769         9
```



## pmap and walk2 functions

We will explain by the following example for pmap:

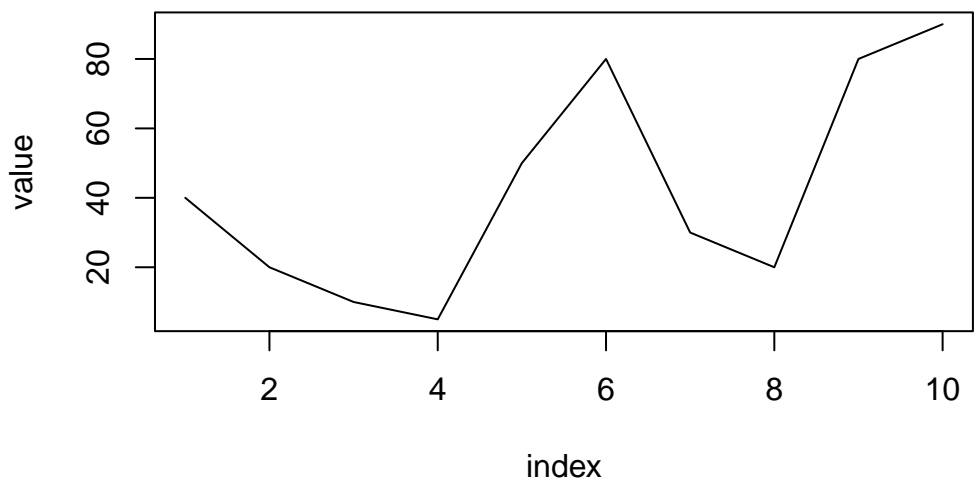
```
df <- data.frame(  
  x = c("ATTTTACTGGGAGGGAA", "TATTTTTTAAAGGGCCC", "GCGCGCCCCAAATTATAGGC", "TGCCACATTTTATCCGC"),  
  pattern = c("A", "T", "G", "C"),  
  replacement = c("a", "t", "g", "c"),  
  stringsAsFactors = FALSE  
)  
  
pmap(df, gsub)
```

```
[[1]]  
[1] "aTTTtTaCTGGGaGGGaa"  
  
[[2]]  
[1] "tAttttttAAAGGGCCC"  
  
[[3]]  
[1] "gCgCgCCCCAAATTATAggC"  
  
[[4]]  
[1] "TGccAcATTTTATccGcGcA"
```

Example for walk2:

```
df1 <- data.frame(  
  index = c(1,2,3,4,5,6,7,8,9,10,1,2,3,4,5,6,7,8,9,10),  
  value = c(40,20,10,5,50,80,30,20,80,90,33,21,56,66,43,89,66,80,30,10),  
  category = c("A","A","A","A","A","A","A","A","A","A","A","B","B","B","B","B","B","B","B","B","B","B"),  
)  
  
df1 %>%  
  split(.$category) %>%  
  .[order(names(.))] %>%  
  walk2(paste('Plot', names(.)),  
    ~plot(value ~ index, data = .x, type = "l", main = .y))
```

**Plot A**



**Plot B**

