Functional programming in R

2021-10-12

purrr: A functional programming toolkit for R

Complete and consistent set of tools for working with functions and vectors

Problems we want to solve:

1. **Making code clear**
2. **Making code safe**
3. **Working with lists and data frames**

Lists, vectors, and data.frames (or tibbles)

```
c(char = "hello", num = 1)
```

```
##    char     num
## "hello"     "1"
```

lists can contain any object

```
list(char = "hello", num = 1, fun = mean)
```

```
## $char
## [1] "hello"
##
## $num
## [1] 1
##
## $fun
## function (x, ...)
## UseMethod("mean")
## <bytecode: 0x1358a64b8>
## <environment: namespace:base>
```

Your Turn 1

```
measurements <- list(
  blood_glucose = rnorm(10, mean = 140, sd = 10),
  age = rnorm(5, mean = 40, sd = 5),
  heartrate = rnorm(20, mean = 80, sd = 15)
)
```

There are two ways to subset lists: dollar signs and brackets. Try to subset blood_glucose **from** measurements **using these approaches. Are they different? What about** measurements[["blood_glucose"]]**?**

Your Turn 1

```
measurements["blood_glucose"]
```

```
## $blood_glucose
##  [1] 127.9293 142.7743 150.8444 116.5430 144.2912
##  [6] 145.0606 134.2526 134.5337 134.3555 131.0996
```

```
measurements$blood_glucose
```

```
##  [1] 127.9293 142.7743 150.8444 116.5430 144.2912
##  [6] 145.0606 134.2526 134.5337 134.3555 131.0996
```

```
measurements[["blood_glucose"]]
```

```
##  [1] 127.9293 142.7743 150.8444 116.5430 144.2912
##  [6] 145.0606 134.2526 134.5337 134.3555 131.0996
```

data frames are lists

```
x <- list(char = "hello", num = 1)
as.data.frame(x)
```

```
##    char num
## 1 hello   1
```

data frames are lists

```
library(gapminder)
head(gapminder$pop)
```

```
## [1]  8425333  9240934 10267083 11537966 13079460
## [6] 14880372
```

data frames are lists

```
gapminder[1:6, "pop"]
```

data frames are lists

```
gapminder[1:6, "pop"]
```

```
## # A tibble: 6 × 1
##        pop
##      <int>
## 1  8425333
## 2  9240934
## 3 10267083
## 4 11537966
## 5 13079460
## 6 14880372
```

data frames are lists

```
head(gapminder[["pop"]])
```

```
## [1]  8425333  9240934 10267083 11537966 13079460
## [6] 14880372
```

programming with functions

View source code of a function

```
mean
```

```
## function (x, ...)
## UseMethod("mean")
## <bytecode: 0x1358a64b8>
## <environment: namespace:base>
```

```
sd
```

```
## function (x, na.rm = FALSE)
## sqrt(var(if (is.vector(x) || is.factor(x)) x else as.double(x),
##     na.rm = na.rm))
## <bytecode: 0x131868f98>
## <environment: namespace:stats>
```

programming with functions

functions are objects and can be assigned to variables

```
f <- mean
```

```
f
```

```
## function (x, ...)
## UseMethod("mean")
## <bytecode: 0x1358a64b8>
## <environment: namespace:base>
```

```
identical(x = mean, y = f)
```

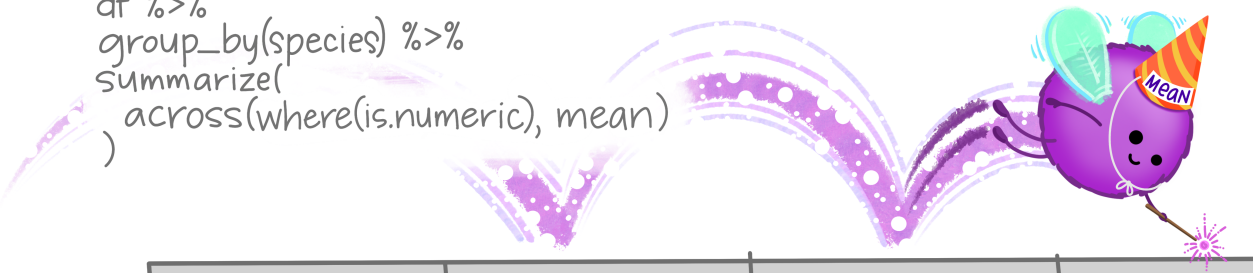
```
## [1] TRUE
```

dplyr::across()

use within **mutate()** or **summarize()** to apply function(s) to a **selection of columns!**

EXAMPLE:

```
df %>%
group_by(species) %>%
summarize(
  across(where(is.numeric), mean)
)
```



species	mass_g	age_yr	range_sqmi
pika	163	2.4	0.46
marmot	1509	3.0	0.87
marmot	2417	5.6	0.62

@allison_horst

Art by Allison Horst

mutate(across())

```
mutate(
  <DATA>,
  across(c(<VARIABLES>), list(<NAMES> = <FUNCTIONS>))
)
```

mutate(across())

```
mutate(
  diamonds,
  across(c("carat", "depth"), list(sd = sd, mean = mean))
)
```

mutate(across())

```
mutate(
  diamonds,
  across(c("carat", "depth"), list(sd = sd, mean = mean))
)
```

```
## # A tibble: 53,940 × 14
##    carat cut       color clarity depth table price
##    <dbl> <ord>     <ord> <ord>   <dbl> <dbl> <int>
##  1  0.23 Ideal     E     SI2      61.5    55   326
##  2  0.21 Premium   E     SI1      59.8    61   326
##  3  0.23 Good      E     VS1      56.9    65   327
##  4  0.29 Premium   I     VS2      62.4    58   334
##  5  0.31 Good      J     SI2      63.3    58   335
##  6  0.24 Very Go… J     VVS2     62.8    57   336
##  7  0.24 Very Go… I     VVS1     62.3    57   336
##  8  0.26 Very Go… H     SI1      61.9    55   337
##  9  0.22 Fair      E     VS2      65.1    61   337
## 10  0.23 Very Go… H     VS1      59.4    61   338
##        x     y     z carat_sd carat_mean depth_sd
##    <dbl> <dbl> <dbl>    <dbl>      <dbl>    <dbl>
##  1  3.95  3.98  2.43    0.474      0.798     1.43
##  2  3.89  3.84  2.31    0.474      0.798     1.43
##  3  4.05  4.07  2.31    0.474      0.798     1.43
##  4  4.2   4.23  2.63    0.474      0.798     1.43
##  5  4.34  4.35  2.75    0.474      0.798     1.43
##  6  3.94  3.96  2.48    0.474      0.798     1.43
```

mutate(across(where()))

```
mutate(
  gapminder,
  across(where(is.numeric), list(mean = mean, median = median))
)
```

mutate(across(where()))

```
mutate(
  gapminder,
  across(where(is.numeric), list(mean = mean, median = median))
)
```

```
## # A tibble: 1,704 × 14
##    country     continent  year lifeExp      pop
##    <fct>       <fct>     <int>   <dbl>    <int>
##  1 Afghanistan Asia       1952    28.8  8425333
##  2 Afghanistan Asia       1957    30.3  9240934
##  3 Afghanistan Asia       1962    32.0 10267083
##  4 Afghanistan Asia       1967    34.0 11537966
##  5 Afghanistan Asia       1972    36.1 13079460
##  6 Afghanistan Asia       1977    38.4 14880372
##  7 Afghanistan Asia       1982    39.9 12881816
##  8 Afghanistan Asia       1987    40.8 13867957
##  9 Afghanistan Asia       1992    41.7 16317921
## 10 Afghanistan Asia       1997    41.8 22227415
##    gdpPercap year_mean year_median lifeExp_mean
##        <dbl>     <dbl>       <dbl>        <dbl>
##  1      779.     1980.       1980.         59.5
##  2      821.     1980.       1980.         59.5
##  3      853.     1980.       1980.         59.5
##  4      836.     1980.       1980.         59.5
##  5      740.     1980.       1980.         59.5
##  6      786.     1980.       1980.         59.5
```

Review: tidyselect

'Behind the scenes' workhorse for dplyr::select(), dplyr::pull(), **and** tidyr::pivot_ **functions**

starts_with(), ends_with(), contains(), matches(), **etc.**

```
# column names contain a word
select(diabetes, ends_with("ht"))
```

```
## # A tibble: 403 × 2
##    height weight
##     <dbl>  <dbl>
##  1     62    121
##  2     64    218
##  3     61    256
##  4     67    119
##  5     68    183
##  6     71    190
##  7     69    191
##  8     59    170
##  9     69    166
## 10     63    202
## # … with 393 more rows
```

```
# regular expression
select(diabetes, matches("\\d"))
```

```
## # A tibble: 403 × 4
##    bp.1s bp.1d bp.2s bp.2d
##    <dbl> <dbl> <dbl> <dbl>
##  1   118    59    NA    NA
##  2   112    68    NA    NA
##  3   190    92   185    92
##  4   110    50    NA    NA
##  5   138    80    NA    NA
##  6   132    86    NA    NA
##  7   161   112   161   112
##  8    NA    NA    NA    NA
##  9   160    80   128    86
## 10   108    72    NA    NA
## # … with 393 more rows
```

```
gapminder %>%
  group_by(continent) %>%
  summarise(across(c("lifeExp", "gdpPercap"), list(med = median,
      iqr = IQR)))
```

```
gapminder %>%
  group_by(continent) %>%
  summarise(across(c("lifeExp", "gdpPercap"), list(med = median,
      iqr = IQR)))
```

```
## # A tibble: 5 × 5
##   continent lifeExp_med lifeExp_iqr gdpPercap_med
##   <fct>           <dbl>       <dbl>         <dbl>
## 1 Africa           47.8       12.0          1192.
## 2 Americas         67.0       13.3          5466.
## 3 Asia             61.8       18.1          2647.
## 4 Europe           72.2        5.88        12082.
## 5 Oceania          73.7        6.35        17983.
##   gdpPercap_iqr
##           <dbl>
## 1         1616.
## 2         4402.
## 3         7492.
## 4        13248.
## 5         8072.
```

mutate(across()) & summarise()

Control output names with .names argument

```
gapminder %>%
  group_by(continent) %>%
  summarise(across(c("lifeExp", "gdpPercap"), list(med = median,
      iqr = IQR) .names = "{.fn}_{.col}"))
```

```
## # A tibble: 5 × 5
##   continent med_lifeExp iqr_lifeExp med_gdpPercap
##   <fct>           <dbl>       <dbl>         <dbl>
## 1 Africa           47.8       12.0          1192.
## 2 Americas         67.0       13.3          5466.
## 3 Asia             61.8       18.1          2647.
## 4 Europe           72.2        5.88        12082.
## 5 Oceania          73.7        6.35        17983.
##   iqr_gdpPercap
##           <dbl>
## 1         1616.
## 2         4402.
```

Your Turn 2

Use starts_with() **from** tidyselect() **to calculate the average** bp **columns in** diabetes**, grouped by** gender**. Name the new columns** bp_ **+** mean

hint: {.fn} **will give you the function name, and** {.col} **will give you the column name**

Your Turn 2

```
diabetes %>%
  group_by(gender) %>%
  summarise(across(starts_with("bp"), list(mean = mean),
      na.rm = TRUE, .names = "{.col}_{.fn}"))
```

```
## # A tibble: 2 × 5
##   gender bp.1s_mean bp.1d_mean bp.2s_mean
##   <chr>       <dbl>      <dbl>      <dbl>
## 1 female       136.       82.5       153.
## 2 male         138.       84.5       151.
##   bp.2d_mean
##        <dbl>
## 1       91.8
## 2       93.5
```

vectorized functions don't work on lists

```
sum(rnorm(10))
```

vectorized functions don't work on lists

```
sum(rnorm(10))
```

```
## [1] -3.831574
```

vectorized functions don't work on lists

```
sum(rnorm(10))
```

```
## [1] -3.831574
```

```
sum(list(x = rnorm(10), y = rnorm(10), z = rnorm(10)))
```

vectorized functions don't work on lists

```
sum(rnorm(10))
```

```
## [1] -3.831574
```

```
sum(list(x = rnorm(10), y = rnorm(10), z = rnorm(10)))
```

```
## Error in sum(list(x = rnorm(10), y = rnorm(10), z = rnorm(10))): inval
```

map(.x, .f)

.x: a vector, list, or data frame

.f: a function

Returns a list

Using map()

```
library(purrr)
x_list <- list(x = rnorm(10), y = rnorm(10), z = rnorm(10))

map(x_list, mean)
```

Using map()

```
library(purrr)
x_list <- list(x = rnorm(10), y = rnorm(10), z = rnorm(10))

map(x_list, mean)
```

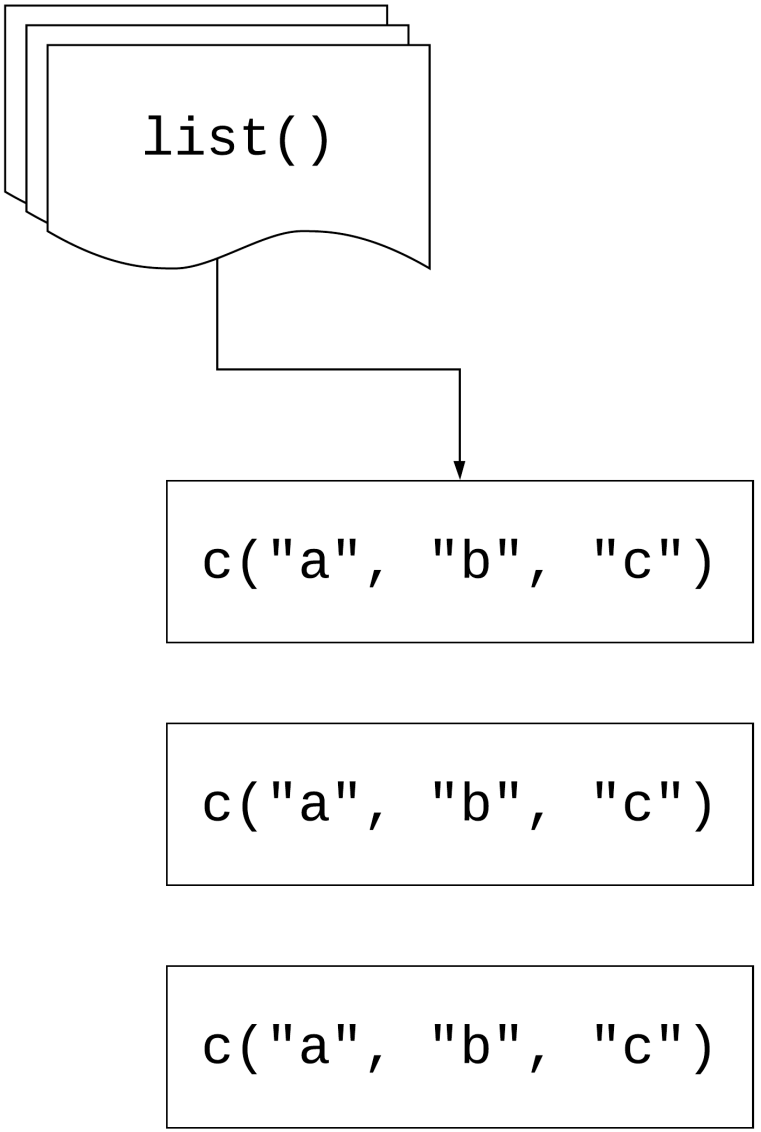
Using map()

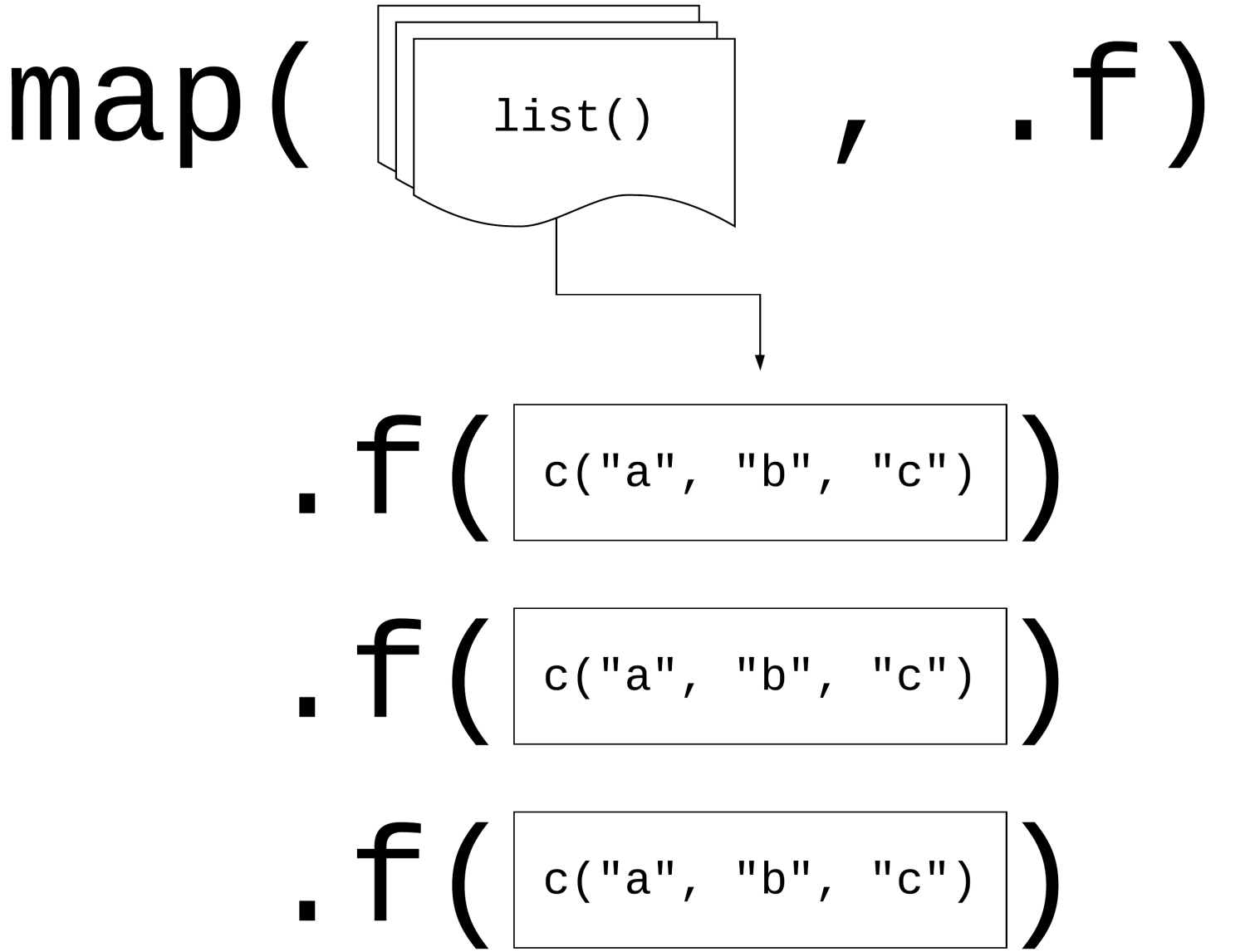
```
library(purrr)
x_list <- list(x = rnorm(10), y = rnorm(10), z = rnorm(10))

map(x_list, mean)
```

Using map()

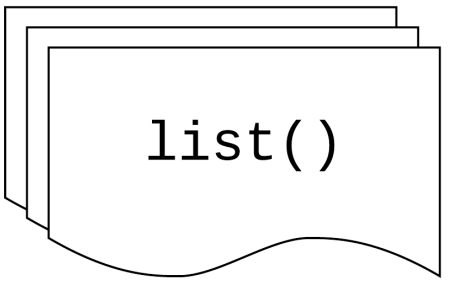
```
library(purrr)
x_list <- list(x = rnorm(10), y = rnorm(10), z = rnorm(10))

map(x_list, mean)
```

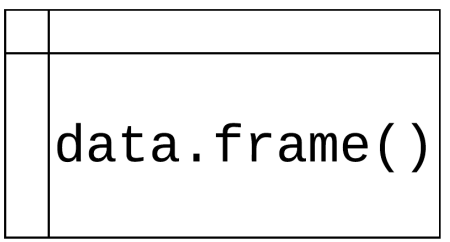
```
## $x
## [1] -0.6097971
##
## $y
## [1] -0.2788647
##
## $z
## [1] 0.6165922
```


list()
c("a", "b", "c")
c("a", "b", "c")
c("a", "b", "c")


map(list() , .f)
.f(c("a", "b", "c"))
.f(c("a", "b", "c"))
.f(c("a", "b", "c"))

map(c("a", "b", "c") , .f)

map( , .f)

map( , .f)

Your Turn 3

Read the code in the first chunk and predict what will happen

Run the code in the first chunk. What does it return?

```
list(
  blood_glucose = sum(measurements$blood_glucose),
  age = sum(measurements$age),
  heartrate = sum(measurements$heartrate)
)
```

Now, use map() to create the same output.

Your Turn 3

```
map(measurements, sum)
```

```
## $blood_glucose
## [1] 1361.684
##
## $age
## [1] 193.8606
##
## $heartrate
## [1] 1509.304
```

using map() with data frames

```
library(dplyr)
gapminder %>%
  select(where(is.numeric)) %>%
  map(sd)
```

using map() with data frames

```
library(dplyr)
gapminder %>%
  select(where(is.numeric)) %>%
  map(sd)
```

using map() with data frames

```
library(dplyr)
gapminder %>%
  select(where(is.numeric)) %>%
  map(sd)
```

using map() with data frames

```
library(dplyr)
gapminder %>%
  select(where(is.numeric)) %>%
  map(sd)
```

```
## $year
## [1] 17.26533
##
## $lifeExp
## [1] 12.91711
##
## $pop
## [1] 106157897
##
## $gdpPercap
## [1] 9857.455
```

Your Turn 4

Pass diabetes to map() **and map using** class()**. What are these results telling you?**

Your Turn 4

```
head(
  map(diabetes, class),
  3
)
```

```
## $id
## [1] "numeric"
##
## $chol
## [1] "numeric"
##
## $stab.glu
## [1] "numeric"
```

Review: writing functions

```
x <- x^2
x <- scale(x)
x <- max(x)
```

Review: writing functions

```
x <- x^2
x <- scale(x)
x <- max(x)

y <- x^2
y <- scale(y)
y <- max(y)

z <- z^2
z <- scale(x)
z <- max(z)
```

Review: writing functions

```
x <- x^2
x <- scale(x)
x <- max(x)

y <- x^2
y <- scale(y)
y <- max(y)

z <- z^2
z <- scale(x)
z <- max(z)
```

Review: writing functions

```
x <- x^3
x <- scale(x)
x <- max(x)

y <- x^2
y <- scale(y)
y <- max(y)

z <- z^2
z <- scale(x)
z <- max(z)
```

Review: writing functions

```
.f <- function(x) {
  x <- x^3
  x <- scale(x)

  max(x)
}

.f(x)
.f(y)
.f(z)
```

If you copy and paste your code three times, it's time to write a function

Your Turn 5

Write a function that returns the mean and standard deviation of a numeric vector.

Give the function a name

Find the mean and SD of x

Map your function to measurements

Your Turn 5

```
mean_sd <- function(x) {
  x_mean <- mean(x)
  x_sd <- sd(x)
  tibble(mean = x_mean, sd = x_sd)
}

map(measurements, mean_sd)
```

Your Turn 5

```
## $blood_glucose
## # A tibble: 1 × 2
##    mean    sd
##   <dbl> <dbl>
## 1  136.  9.96
##
## $age
## # A tibble: 1 × 2
##    mean    sd
##   <dbl> <dbl>
## 1  38.8  3.91
##
## $heartrate
## # A tibble: 1 × 2
##    mean    sd
##   <dbl> <dbl>
## 1  75.5  13.8
```

Three ways to pass functions to map()

1. **pass directly to** map()
2. **use an anonymous function**
3. **use ~**

```
map(
    .x,
    mean,
    na.rm = TRUE
)
```

```
map(
    .x,
    function(.x) {
      mean(.x,
      na.rm = TRUE)
    }
)
```

```
map(
    .x,
    ~mean(.x,
  na.rm = TRUE)
)
```

```
map(gapminder, ~length(unique(.x)))
```

```
map(gapminder, ~length(unique(.x)))
```

```
## $country
## [1] 142
##
## $continent
## [1] 5
##
## $year
## [1] 12
##
## $lifeExp
## [1] 1626
##
## $pop
## [1] 1704
##
## $gdpPercap
## [1] 1704
```

Returning types

map	returns
map()	list
map_chr()	character vector
map_dbl()	double vector (numeric)
map_int()	integer vector
map_lgl()	logical vector
map_dfc()	data frame (by column)
map_dfr()	data frame (by row)

Returning types

```
map_int(gapminder, ~length(unique(.x)))
```

Returning types

```
map_int(gapminder, ~length(unique(.x)))
```

```
##   country continent      year   lifeExp
##       142         5        12      1626
##       pop gdpPercap
##      1704      1704
```

Your Turn 6

Do the same as #4 above but return a vector instead of a list.

Your Turn 6

```
map_chr(diabetes, class)
```

```
##          id        chol    stab.glu         hdl
##   "numeric"   "numeric"   "numeric"   "numeric"
##       ratio       glyhb    location         age
##   "numeric"   "numeric" "character"   "numeric"
##      gender      height      weight       frame
## "character"   "numeric"   "numeric" "character"
##       bp.1s       bp.1d       bp.2s       bp.2d
##   "numeric"   "numeric"   "numeric"   "numeric"
##       waist         hip    time.ppn
##   "numeric"   "numeric"   "numeric"
```

Your Turn 7

Check diabetes **for any missing data.**

Using the ~.f(.x) shorthand, check each column for any missing values using is.na() **and** any()

Return a logical vector. Are any columns missing data? What happens if you don't include any()**? Why?**

Try counting the number of missing, returning an integer vector

Your Turn 7

```
map_lgl(diabetes, ~any(is.na(.x)))
```

```
##       id     chol stab.glu      hdl    ratio
##    FALSE     TRUE    FALSE     TRUE     TRUE
##    glyhb location      age   gender   height
##     TRUE    FALSE    FALSE    FALSE     TRUE
##   weight    frame    bp.1s    bp.1d    bp.2s
##     TRUE     TRUE     TRUE     TRUE     TRUE
##    bp.2d    waist      hip time.ppn
##     TRUE     TRUE     TRUE     TRUE
```

Your Turn 7

```
map_int(diabetes, ~sum(is.na(.x)))
```

```
##       id     chol stab.glu      hdl    ratio
##        0        1        0        1        1
##    glyhb location      age   gender   height
##       13        0        0        0        5
##   weight    frame    bp.1s    bp.1d    bp.2s
##        1       12        5        5      262
##    bp.2d    waist      hip time.ppn
##      262        2        2        3
```

group_map()

Apply a function across a grouping variable and return a list of grouped tibbles

```
diabetes %>%
  group_by(gender) %>%
  group_map(~ broom::tidy(lm(weight ~ height, data = .x)))
```

group_map()

```
diabetes %>%
  group_by(gender) %>%
  group_map(~ broom::tidy(lm(weight ~ height, data = .x)))
```

```
## [[1]]
## # A tibble: 2 × 5
##   term        estimate std.error statistic
##   <chr>          <dbl>     <dbl>     <dbl>
## 1 (Intercept)   -73.8     59.2       -1.25
## 2 height          3.90     0.928      4.20
##     p.value
##       <dbl>
## 1 0.214
## 2 0.0000383
##
## [[2]]
## # A tibble: 2 × 5
##   term        estimate std.error statistic
##   <chr>          <dbl>     <dbl>     <dbl>
## 1 (Intercept)   -49.7     68.9      -0.722
```

group_modify()

Apply a function across grouped tibbles and return grouped tibbles

```
diabetes %>%
  group_by(gender) %>%
  group_modify(~ broom::tidy(lm(weight ~ height, data = .x)))
```

```
## # A tibble: 4 × 6
## # Groups:   gender [2]
##   gender term        estimate std.error statistic
##   <chr>  <chr>          <dbl>     <dbl>     <dbl>
## 1 female (Intercept)   -73.8     59.2      -1.25
## 2 female height          3.90     0.928     4.20
## 3 male   (Intercept)   -49.7     68.9      -0.722
## 4 male   height          3.35     0.995     3.37
##     p.value
##       <dbl>
## 1 0.214
```

Your Turn 8

Fill in the model_lm function to model chol (the outcome) with ratio and pass the .data argument to lm()

Group diabetes **by** location

Use group_modify() **with** model_lm

Your Turn 8

```
model_lm <- function(.data, ...) {
  mdl <- lm(chol ~ ratio, data = .data)
  # get model statistics
  broom::glance(mdl)
}

diabetes %>%
  group_by(location) %>%
  group_modify(model_lm)
```

Your Turn 8

```
## # A tibble: 2 × 13
## # Groups:   location [2]
##   location   r.squared adj.r.squared sigma
##   <chr>          <dbl>         <dbl> <dbl>
## 1 Buckingham     0.252         0.248  38.8
## 2 Louisa         0.204         0.201  39.4
##   statistic  p.value    df logLik   AIC   BIC
##       <dbl>    <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1      66.4 4.11e-14     1 -1009. 2025. 2034.
## 2      51.7 1.26e-11     1 -1033. 2072. 2082.
## # … with 3 more variables: deviance <dbl>,
## #   df.residual <int>, nobs <int>
```

map2(.x, .y, .f)

.x, .y: a vector, list, or data frame

.f: a function

Returns a list

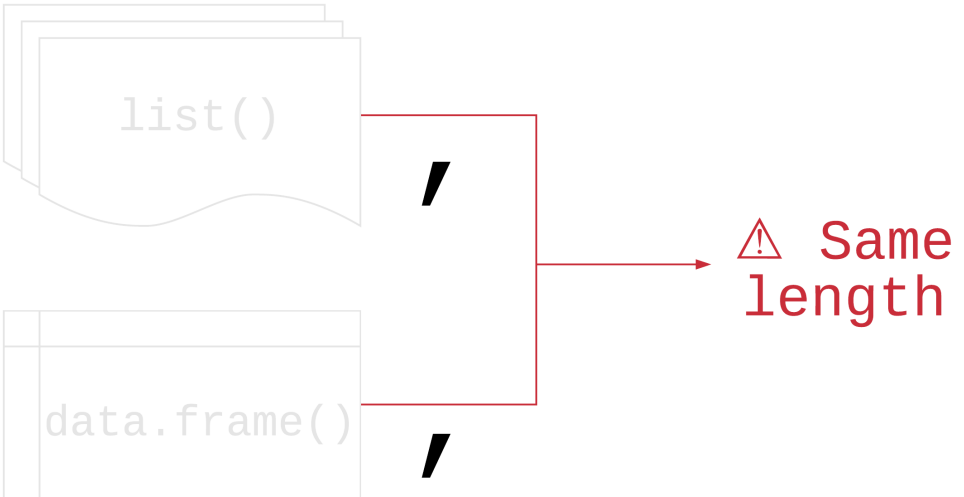
```
map2(
```

,

,

```
  .f
)
```

```
map2(
```




```
    .f
)
```

```
map2(
```

,

,

```
  ~.f(.x, .y)
)
```

map2()

```
means <- c(-3, 4, 2, 2.3)
sds <- c(.3, 4, 2, 1)

map2_dbl(means, sds, rnorm, n = 1)
```

map2()

```
means <- c(-3, 4, 2, 2.3)
sds <- c(.3, 4, 2, 1)

map2_dbl(means, sds, rnorm, n = 1)
```

map2()

```
means <- c(-3, 4, 2, 2.3)
sds <- c(.3, 4, 2, 1)

map2_dbl(means, sds, rnorm, n = 1)
```

```
## [1] -2.997932  2.178125  1.266952  2.948287
```

Your Turn 9

Split the gapminder dataset into a list by country using the split() **function**

Create a list of models using map(). For the first argument, pass gapminder_countries. For the second, use the ~.f() notation to write a model with lm(). Use lifeExp on the left hand side of the formula and year on the second. Pass .x to the data argument.

Use map2() to take the models list and the data set list and map them to predict(). Since we're not adding new arguments, you don't need to use ~.f().

Your Turn 9

```
gapminder_countries <- split(gapminder, gapminder$country)
models <- map(gapminder_countries, ~ lm(lifeExp ~ year, data = .x))
preds <- map2(models, gapminder_countries, predict)
head(preds, 3)
```

Your Turn 9

```
gapminder_countries <- split(gapminder, gapminder$country)
models <- map(gapminder_countries, ~ lm(lifeExp ~ year, data = .x))
preds <- map2(models, gapminder_countries, predict)
head(preds, 3)
```

Your Turn 9

```
gapminder_countries <- split(gapminder, gapminder$country)
models <- map(gapminder_countries, ~ lm(lifeExp ~ year, data = .x))
preds <- map2(models, gapminder_countries, predict)
head(preds, 3)
```

Your Turn 9

```
## $Afghanistan
##        1        2        3        4        5
## 29.90729 31.28394 32.66058 34.03722 35.41387
##        6
## 36.79051
##
## $Albania
##        1        2        3        4        5
## 59.22913 60.90254 62.57596 64.24938 65.92279
##        6
## 67.59621
##
## $Algeria
##        1        2        3        4        5
## 43.37497 46.22137 49.06777 51.91417 54.76057
##        6
## 57.60697
```

input 1	input 2	returns
map()	map2()	list
map_chr()	map2_chr()	character vector
map_dbl()	map2_dbl()	double vector (numeric)
map_int()	map2_int()	integer vector
map_lgl()	map2_lgl()	logical vector
map_dfc()	map2_dfc()	data frame (by column)
map_dfr()	map2_dfr()	data frame (by row)

Other mapping functions

pmap() and friends: take n lists or data frame with argument names

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pmap() and friends: take n lists or data frame with argument names

walk() and friends: for side effects like plotting; returns input invisibly

imap() and friends: includes counter i

map_if(), map_at(): Apply only to certain elements

input 1	input 2	input n	returns
map()	map2()	pmap()	list
map_chr()	map2_chr()	pmap_chr()	character vector
map_dbl()	map2_dbl()	pmap_dbl()	double vector (numeric)
map_int()	map2_int()	pmap_int()	integer vector
map_lgl()	map2_lgl()	pmap_lgl()	logical vector
map_dfc()	map2_dfc()	pmap_dfc()	data frame (by column)
map_dfr()	map2_dfr()	pmap_dfr()	data frame (by row)
walk()	walk2()	pwalk()	input (side effects!)

group_walk()

Use group_walk() **for side effects across groups**

```
temp <- "temporary_folder"
fs::dir_create(temp)
gapminder %>%
  group_by(continent) %>%
  group_walk(
    ~ write_csv(
      .x,
      file = file.path(temp,  paste0(.y$continent, ".csv"))
    )
  )
```

group_walk()

Use group_walk() **for side effects across groups**

```
## temporary_folder
## ├── Africa.csv
## ├── Americas.csv
## ├── Asia.csv
## ├── Europe.csv
## └── Oceania.csv
```

Your turn 10

Create a new directory using the fs package. Call it "figures".

Write a function to plot a line plot of a given variable in gapminder over time, faceted by continent. Then, save the plot (how do you save a ggplot?). For the file name, paste together the folder, name of the variable, and extension so it follows the pattern "folder/variable_name.png"

Create a character vector that has the three variables we'll plot: "lifeExp", "pop", and "gdpPercap".

Use walk() **to save a plot for each of the variables**

Your turn 10

```
fs::dir_create("figures")

ggsave_gapminder <- function(variable) {
  #  we're using `aes_string()` so we don't need the
  #  curly-curly syntax
  p <- ggplot(
    gapminder,
    aes_string(x = "year", y = variable, color = "country")
  ) +
    geom_line() +
    scale_color_manual(values = country_colors) +
    facet_wrap(vars(continent)) +
    theme(legend.position = "none")

  ggsave(
    filename = paste0("figures/", variable, ".png"),
    plot = p,
    dpi = 320
  )
}
```

Your turn 10

```
vars <- c("lifeExp", "pop", "gdpPercap")
walk(vars, ggsave_gapminder)
```

Base R

base R	purrr
lapply()	map()
vapply()	map_*()
sapply()	?
x[] <- lapply()	map_dfc()
mapply()	map2(), pmap()

Benefits of purrr

1. Consistent
2. Type-safe
3. ~f(.x)

Loops vs functional programming

```
x <- rnorm(10)
y <- map(x, mean)
```

```
x <- rnorm(10)
y <- vector("list", length(x))
for (i in seq_along(x)) {
  y[[i]] <- mean(x[[i]])
}
```

Loops vs functional programming

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y <- map(x, mean)
```

```
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Loops vs functional programming

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```
x <- rnorm(10)
y <- vector("list", length(x))
for (i in seq_along(x)) {
  y[[i]] <- mean(x[[i]])
}
```

Of course someone has to write loops. It doesn't have to be you.

—Jenny Bryan

Working with lists and nested data

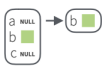
Work with Lists

FILTER LISTS

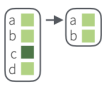
pluck(.x, ..., .default=NULL) Select an element by name or index, *pluck(x,"b")* ,or its attribute with **attr_getter**. *pluck(x,"b",attr_getter("n"))*

keep(.x, .p, …) Select elements that pass a logical test. *keep(x, is.na)*

discard(.x, .p, …) Select elements that do not pass a logical test. *discard(x, is.na)*



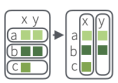
compact(.x, .p = identity) Drop empty elements. *compact(x)*



head_while(.x, .p, …) Return head elements until one does not pass. Also **tail_while**. *head_while(x, is.character)*

RESHAPE LISTS

flatten(.x) Remove a level of indexes from a list. Also **flatten_chr**, **flatten_dbl**, **flatten_dfc**, **flatten_dfr**, **flatten_int**, **flatten_lgl**. *flatten(x)*



transpose(.l, .names = NULL) Transposes the index order in a multi-level list. *transpose(x)*

SUMMARISE LISTS

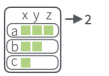
every(.x, .p, …) Do all elements pass a test? *every(x, is.character)*

some(.x, .p, …) Do some elements pass a test? *some(x, is.character)*

has_element(.x, .y) Does a list contain an element? *has_element(x, "foo")*

detect(.x, .f, ..., .right=FALSE, .p) Find first element to pass. *detect(x, is.character)*

detect_index(.x, .f, ..., .right = FALSE, .p) Find index of first element to pass. *detect_index(x, is.character)*



vec_depth(x) Return depth (number of levels of indexes). *vec_depth(x)*

JOIN (TO) LISTS

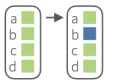
append(x, values, after = length(x)) Add to end of list. *append(x, list(d = 1))*

prepend(x, values, before = 1) Add to start of list. *prepend(x, list(d = 1))*

splice(…) Combine objects into a list, storing S3 objects as sub-lists. *splice(x, y, "foo")*

TRANSFORM LISTS

modify(.x, .f, ...) Apply function to each element. Also **map**, **map_chr**, **map_dbl**, **map_dfc**, **map_dfr**, **map_int**, **map_lgl**. *modify(x, ~.+2)*



modify_at(.x, .at, .f, ...) Apply function to elements by name or index. Also **map_at**. *modify_at(x, "b", ~.+2)*

modify_if(.x, .p, .f, ...) Apply function to elements that pass a test. Also **map_if**. *modify_if(x, is.numeric,~.+2)*

modify_depth(.x,.depth,.f,...) Apply function to each element at a given level of a list. *modify_depth(x, 1, ~.+2)*

WORK WITH LISTS

array_tree(array, margin = NULL) Turn array into list. Also **array_branch**. *array_tree(x, margin = 3)*

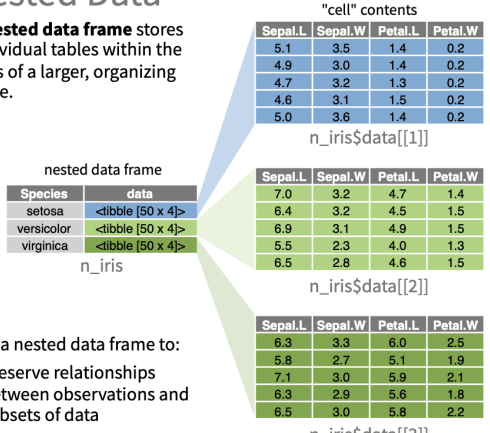
cross2(.x, .y, .filter = NULL) All combinations of .x and .y. Also **cross**, **cross3**, **cross_df**. *cross2(1:3, 4:6)*

set_names(x, nm = x) Set the names of a vector/list directly or with a function. *set_names(x, c("p", "q", "r"))* *set_names(x, tolower)*

Working with lists and nested data

Nested Data

A **nested data frame** stores individual tables within the cells of a larger, organizing table.



Use a nested data frame to:

- preserve relationships between observations and subsets of data
- manipulate many sub-tables at once with the **purrr** functions **map()**, **map2()**, or **pmap()**.

List Column Workflow

Nested data frames use a **list column**, a list that is stored as a column vector of a data frame. A typical **workflow** for list columns:

1. MAKE A LIST COLUMN - You can create list columns with functions in the **tibble** and **dplyr** packages, as well as **tidyr**'s nest()

tibble::**tribble(**…**)** tibble::**tibble(**…**)** dplyr::**mutate(**.data, …**)** Also **transmute()**

Adverbs: Modify function behavior

Modify function behavior

compose() Compose multiple functions.

lift() Change the type of input a function takes. Also **lift_dl**, **lift_dv**, **lift_ld**, **lift_lv**, **lift_vd**, **lift_vl**.

rerun() Rerun expression n times.

negate() Negate a predicate function (a pipe friendly !)

partial() Create a version of a function that has some args preset to values.

safely() Modify func to return list of results and errors.

quietly() Modify function to return list of results, output, messages, warnings.

possibly() Modify function to return default value whenever an error occurs (instead of error).

Learn more!

Jenny Bryan's purrr tutorial: A detailed introduction to purrr. Free online.

R for Data Science: A comprehensive but friendly introduction to the tidyverse. Free online.

RStudio Primers: Free interactive courses in the Tidyverse