

How to repeat yourself with purrr

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RStudio

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R installed? Pretty recent?

- Current version: 3.5.1

RStudio installed?

- Current Preview: 1.2.907

Have these packages?

- tidyverse (includes purrr)
- repurrrsive

Get some help NOW
if you need/want to
do some setup
during the intro!

rstd.io/purrrr-latinr

bit.ly/jenny-live-code

Resources

My purrr materials:

<https://jennybc.github.io/purrr-tutorial/>

Charlotte Wickham's purrr materials:

<https://github.com/cwickham/purrr-tutorial>

My "row-oriented workflows" materials:

rstudio.io/row-work

"Functionals" chapter of 2nd of Advanced R by Wickham

<https://adv-r.hadley.nz/functionals.html>

1. What is the harm with copy/paste and repetitive code?

2. What should I do instead?

- write functions (R-Ladies Thursday)
- use formal tools to iterate the R way

3. Hands-on practice with the purrr package for iteration

```
library(gapminder)
library(tidyverse)
```

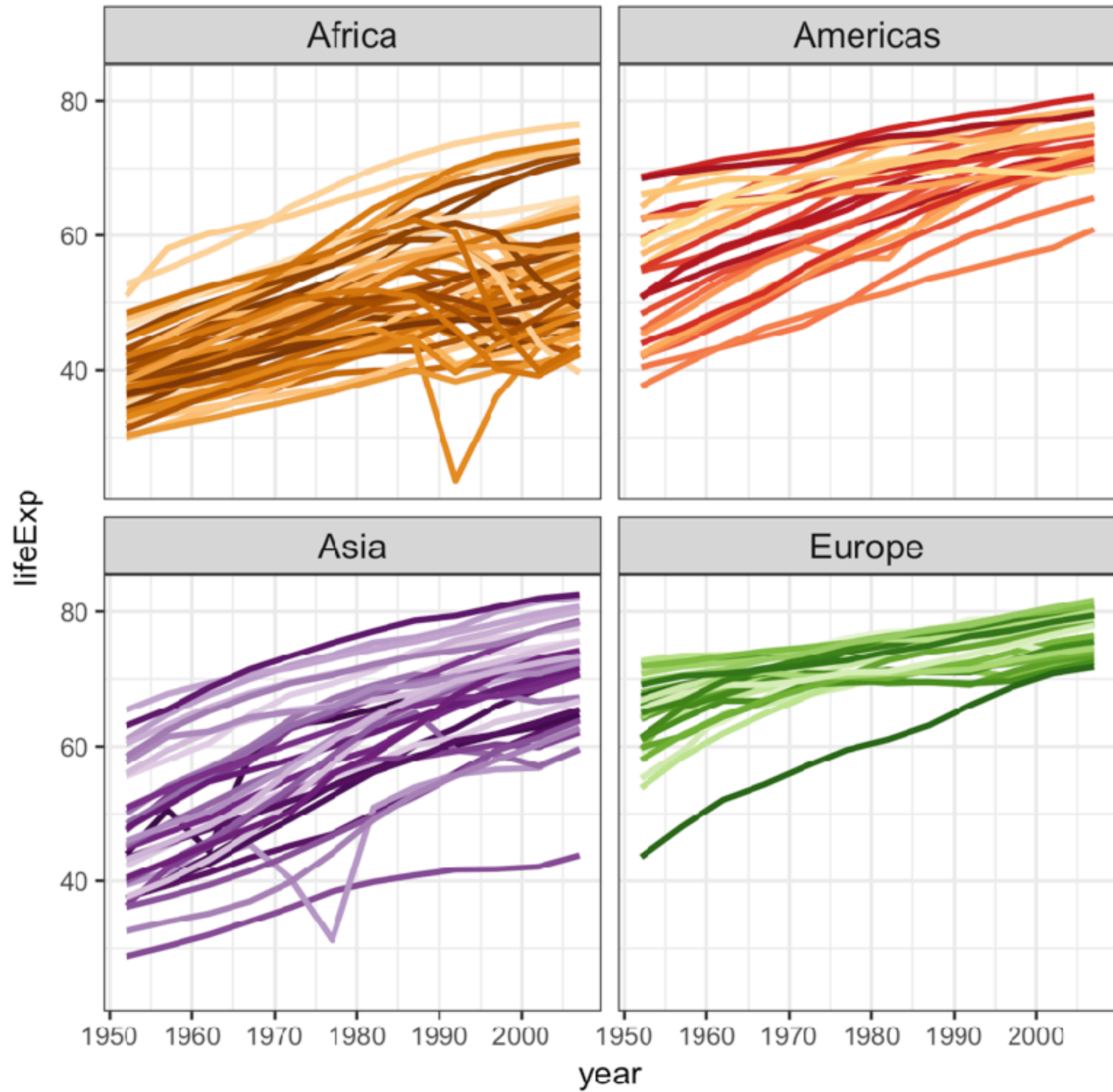
```
gapminder
```

```
#> # A tibble: 1,704 x 6
```

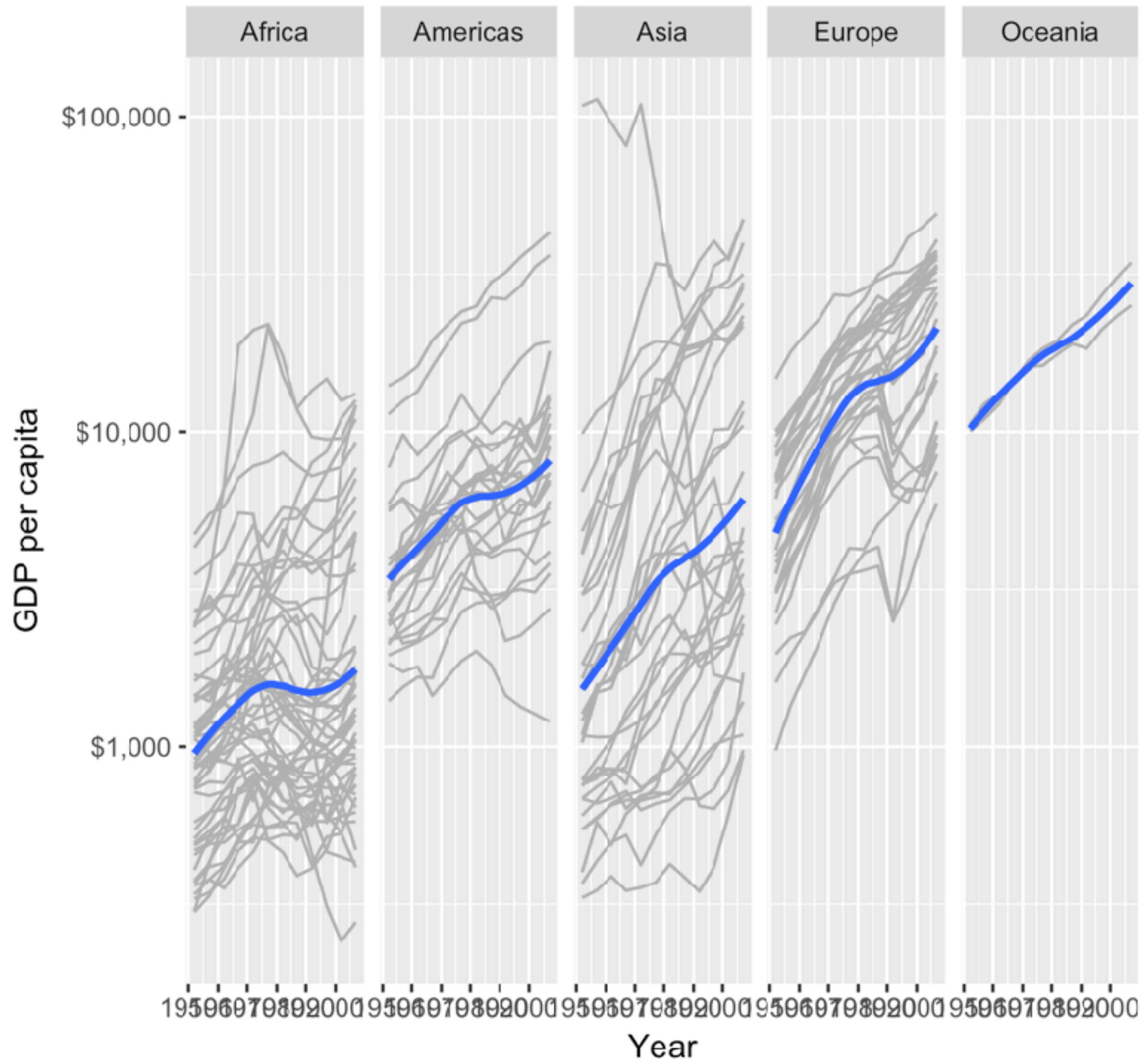
```
#>   country      continent  year  lifeExp      pop  gdpPercap
#>   <fct>       <fct>      <int>    <dbl>    <int>    <dbl>
#> 1 Afghanistan Asia      1952    28.8   8425333    779.
#> 2 Afghanistan Asia      1957    30.3   9240934    821.
#> 3 Afghanistan Asia      1962    32.0  10267083    853.
#> 4 Afghanistan Asia      1967    34.0  11537966    836.
#> 5 Afghanistan Asia      1972    36.1  13079460    740.
#> 6 Afghanistan Asia      1977    38.4  14880372    786.
#> 7 Afghanistan Asia      1982    39.9  12881816    978.
#> 8 Afghanistan Asia      1987    40.8  13867957    852.
#> 9 Afghanistan Asia      1992    41.7  16317921    649.
#> 10 Afghanistan Asia      1997    41.8  22227415    635.
#> # ... with 1,694 more rows
```



```
gapminder %>%  
  count(continent)  
#> # A tibble: 5 x 2  
#>   continent      n  
#>   <fct>      <int>  
#> 1 Africa      624  
#> 2 Americas    300  
#> 3 Asia        396  
#> 4 Europe      360  
#> 5 Oceania     24
```



GDP per capita on Five Continents



```
africa <- gapminder[gapminder$continent == "Africa", ]
africa_mm <- max(africa$lifeExp) - min(africa$lifeExp)

americas <- gapminder[gapminder$continent == "Americas", ]
americas_mm <- max(americas$lifeExp) - min(americas$lifeExp)

asia <- gapminder[gapminder$continent == "Asia", ]
asia_mm <- max(asia$lifeExp) - min(africa$lifeExp)

europe <- gapminder[gapminder$continent == "Europe", ]
europe_mm <- max(europe$lifeExp) - min(europe$lifeExp)

oceania <- gapminder[gapminder$continent == "Oceania", ]
oceania_mm <- max(europe$lifeExp) - min(oceania$lifeExp)

cbind(
  continent = c("Africa", "Asias", "Europe", "Oceania"),
  max_minus_min = c(africa_mm, americas_mm, asia_mm,
                    europe_mm, oceania_mm)
)
```

What am I trying to do?

Have I even done it?*

* Can you find my mistakes?

How would *you* compute this?

for each country

max life exp - min life exp

put result in a data frame

Here's how I would do it.

```
gapminder %>%  
  group_by(continent) %>%  
  summarize(max_minus_min = max(lifeExp) - min(lifeExp))  
#> # A tibble: 5 x 2  
#>   continent max_minus_min  
#>   <fct>         <dbl>  
#> 1 Africa         52.8  
#> 2 Americas        43.1  
#> 3 Asia           53.8  
#> 4 Europe         38.2  
#> 5 Oceania        12.1
```

Conclusion: there are many ways to write a for loop in R!

sidebar on %>%

New example: making strings

```
child <- c("Reed", "Wesley", "Eli", "Toby")
age    <- c(    14,      12,     12,      1)

s <- rep_len("", length(child))
for (i in seq_along(s)) {
  s[i] <- paste(child[i], "is", age[i], "years old")
}
s
#> [1] "Reed is 14 years old"      "Wesley is 12 years old"
#> [3] "Eli is 12 years old"       "Toby is 1 years old"
```

Here's how I would do it.

```
child <- c("Reed", "Wesley", "Eli", "Toby")
age    <- c(    14,      12,      12,      1)

paste(child, "is", age, "years old")
#> [1] "Reed is 14 years old"      "Wesley is 12 years old"
#> [3] "Eli is 12 years old"       "Toby is 1 years old"
glue::glue("{child} is {age} years old")
#> Reed is 14 years old
#> Wesley is 12 years old
#> Eli is 12 years old
#> Toby is 1 years old
```

Conclusion: maybe someone already wrote that for loop for you!

But what if you really do
need to iterate?



<https://purrr.tidyverse.org>



Part of the tidyverse

A "core" package in the tidyverse meta-package

```
install.packages("tidyverse") # <-- install purrr + much more  
install.packages("purrr")    # <-- installs only purrr
```

```
library(tidyverse) # <-- loads purrr + much more  
library(purrr)     # <-- loads only purrr
```

purrr is an alternative to "apply" functions

`purrr::map()` \approx `base::lapply()`

[purrr tutorial](#) [Lessons and examples](#) [More resources](#) [Talks](#) [About](#)

Why not base?

- Why purrr?
- Why not plyr?
- `lapply()` vs. `purrr::map()`
- `sapply()` vs. `_(ツ)_/`
- `vapply()` vs. `map_*()`
- `_(ツ)_/` vs. `map_df()`
- `mapply()` vs. `map2()`, `pmap()`
- `aggregate()` vs. `dplyr::summarize()`
- `by()` vs. `tidyr::nest()`

Relationship to base and plyr functions

Why not base?

You need a way to iterate in R in a data-structure-informed way. What does that mean?

- Iterate over elements of a list
- Iterate over rows or columns of a 2-dimensional object
- Iterate over sub data frames induced by one or more factors
- Iterate over tuples formed from the *i*-th element of several vectors of equal length

All of this is absolutely possible with base R, using `for()` loops or

```
library(purrr)  
library(repurrrsive)  
help(package = "repurrrsive")
```



Get comfortable with **lists**!

atomic vectors are familiar:

logical, integer, double, character, etc

a list = a generalized vector

a list can hold almost anything



"working with lists"

How many elements are in `got_chars`?

Who is the 9th person listed in `got_chars`?

What information is given for this person?

What is the difference between `got_chars[9]`
and `got_chars[[9]]`?

Or ... do same for `sw_people` or the `n`-th person

List exploration

```
str(x, list.len = ?, max.level = ?)
```

```
x[i]
```

```
x[[i]]
```

```
str(x[[i]], ...)
```

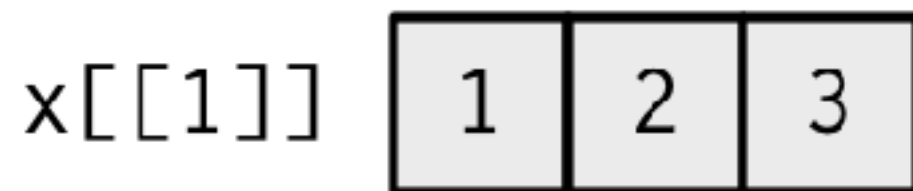
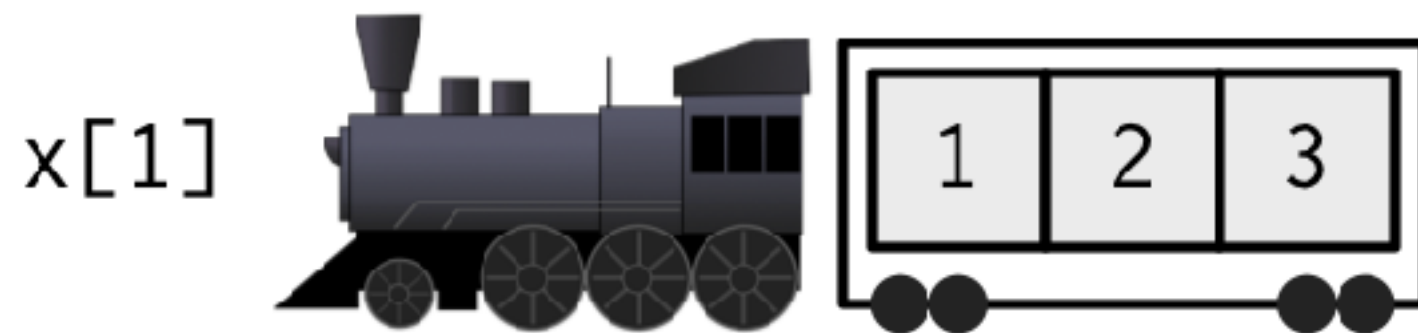
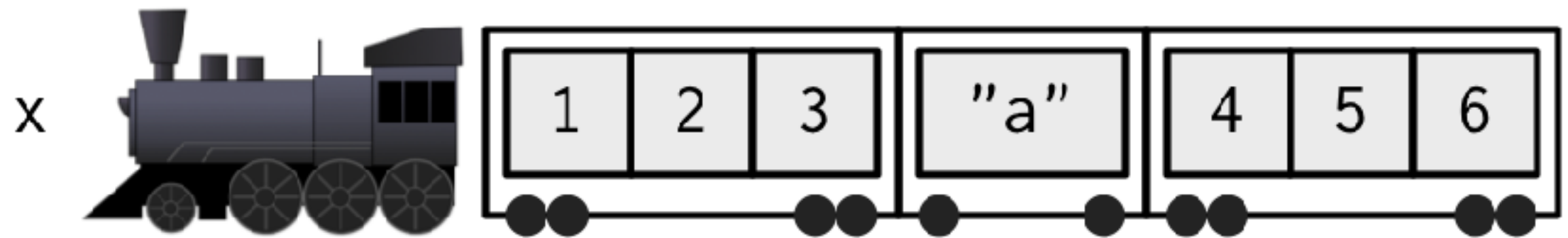
```
View(x), in RStudio
```

If list `x` is a train carrying objects:

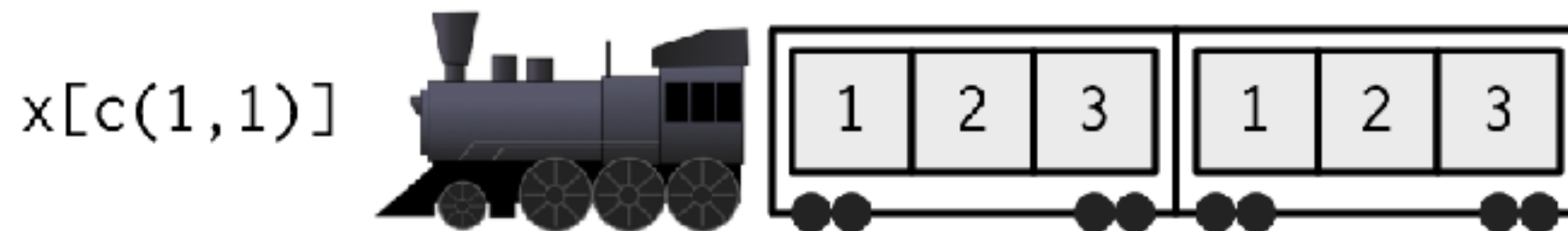
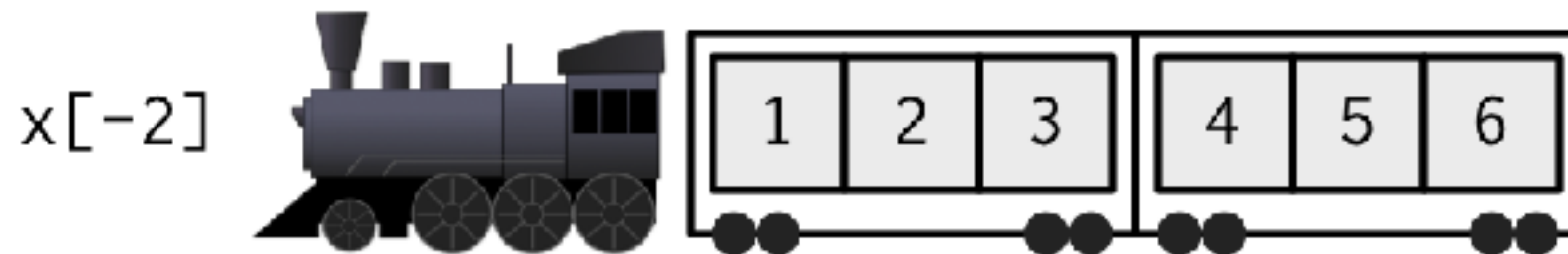
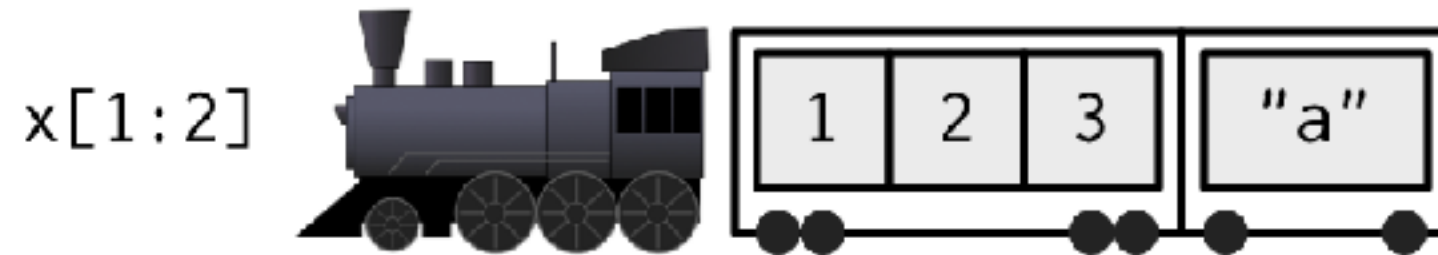
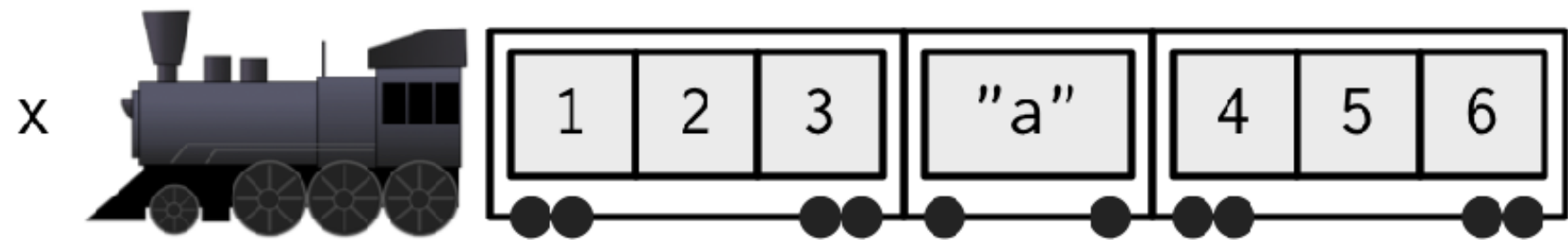
`x[[5]]` is the object in car 5

`x[4:6]` is a train of cars 4-6.

-- Tweet by @RLangTip



from Subsetting chapter of 2nd ed Advanced R



from Subsetting chapter of 2nd ed Advanced R



\times $\times [i]$



$\times [[i]]$



from
<http://r4ds.had.co.nz/vectors.html#lists-of-condiments>

```
purrr::  
map(.x, .f, ...)
```

```
purrr::  
map(.x, .f, ...)
```

for every element of **.x**

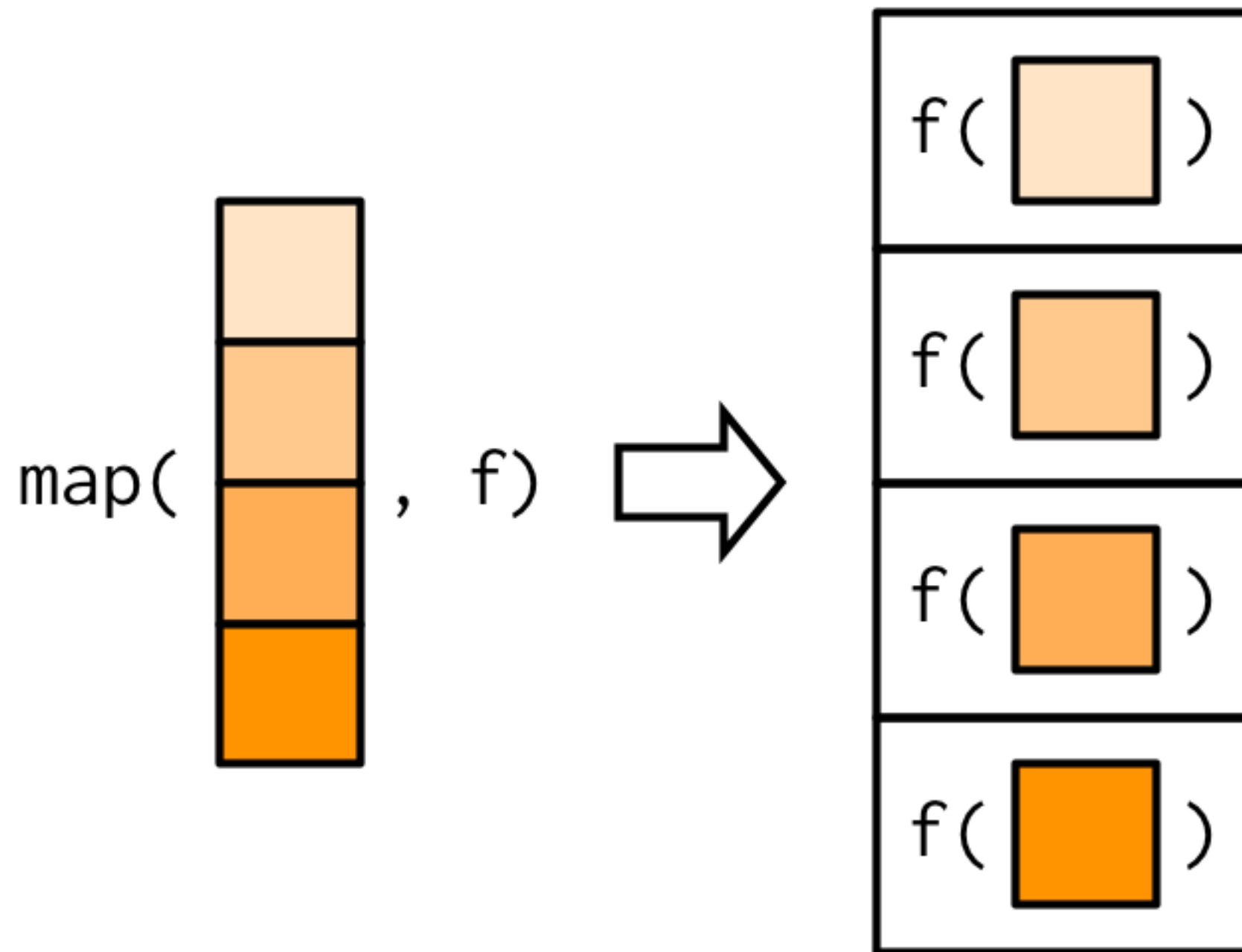
do **.f**

• $x = \min i s$



map(minis, antennate)





from Functionals chapter of 2nd ed Advanced R

purrr::
map(.x, .f)

```
.x <- SOME VECTOR OR LIST  
out <- vector(mode = "list", length = length(.x))  
for (i in seq_along(out)) {  
  out[[i]] <- .f(.x[[i]])  
}  
out
```

purrr:: map(.x, .f)

```
.x <- SOME VECTOR OR LIST  
out <- vector(mode = "list", length = length(.x))  
for (i in seq_along(out)) {  
  out[[i]] <- .f(.x[[i]])  
}  
out
```

purrr::map() is a nice way to
write a for loop.

How many aliases does each GoT character have?

map(got_chars, .f = 🙄)

or

map(sw_people, .f = 🙄)

Workflow:

1. Do it for one element.
2. Find the general recipe.
3. Drop into `map()` to do for all.

Step 1: Do it for one element

```
daenerys <- got_chars[[9]]  
## View(daenerys)
```

```
daenerys[["aliases"]]  
#> [1] "Dany" "Daenerys Stormborn"  
#> [3] "The Unburnt" "Mother of Dragons"  
#> [5] "Mother" "Mhysa"  
#> [7] "The Silver Queen" "Silver Lady"  
#> [9] "Dragonmother" "The Dragon Queen"  
#> [11] "The Mad King's daughter"
```

```
length(daenerys[["aliases"]])  
#> [1] 11
```

Step 1: Do it for one element

```
asha <- got_chars[[13]]  
## View(asha)
```

```
asha[["aliases"]]  
#> [1] "Esgred" "The Kraken's Daughter"
```

```
length(asha[["aliases"]])  
#> [1] 2
```

Step 2: Find the general recipe

```
.x <- got_chars[[?]]
```

```
length(.x[["aliases"]])
```

Step 2: Find the general recipe

```
.x <- got_chars[[?]]
```

```
length(.x[["aliases"]])
```

.x is a pronoun, like "it"

means "the current element"

Step 3: Drop into map() to do for all

```
map(got_chars, ~ length(.x[["aliases"]]))  
#> [[1]]  
#> [1] 4  
#>  
#> [[2]]  
#> [1] 11  
#>  
#> [[3]]  
#> [1] 1  
#>  
#> [[4]]  
#> [1] 1  
#> ...
```

Step 3: Drop into map() to do for all

```
map(got_chars, ~ length(.x[["aliases"]]))
```

```
#> [[1]]
```

```
#> [1] 4
```

```
#>
```

```
#> [[2]]
```

```
#> [1] 11
```

```
#>
```

```
#> [[3]]
```

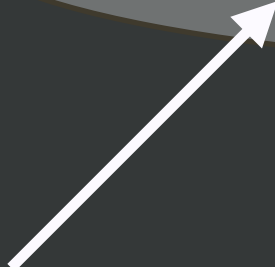
```
#> [1] 1
```

```
#>
```

```
#> [[4]]
```

```
#> [1] 1
```

```
#> ...
```



formula method of specifying . f
. x means "the current element"
concise syntax for anonymous functions
a.k.a. lambda functions

Challenge (pick one or more!)

How many x does each (GoT or SW) character have? (x = titles, allegiances, vehicles, starships)

```
map(got_chars, ~ length(.x[["aliases"]]))
```

Oh, would you prefer an integer vector?

```
map_int(got_chars, ~ length(.x[["aliases"]]))  
#>   [1]   4 11  1  1  1  1  1  1 11  5 16  
#>  [12]   1  2  5  3  3  3  5  0  3  4  1  
#>  [25]   8  2  1  5  1  4  7  3
```

map()

map_lgl()

map_int()

map_dbl()

map_chr()

type-specific
variants of map()

Challenge:

Replace map() with type-specific map()

```
# What's each character's name?
```

```
map(got_chars, ~.x[["name"]])
```

```
map(sw_people, ~.x[["name"]])
```

```
# What color is each SW character's hair?
```

```
map(sw_people, ~ .x[["hair_color"]])
```

```
# Is the GoT character alive?
```

```
map(got_chars, ~ .x[["alive"]])
```

```
# Is the SW character female?
```

```
map(sw_people, ~ .x[["gender"]] == "female")
```

```
# How heavy is each SW character?
```

```
map(sw_people, ~ .x[["mass"]])
```

Review

Lists can be awkward

Lists are necessary

Get to know your list

```
purrr::  
map(.x, .f, ...)
```

for every element of **.x**

do **.f**

```
purrr::  
map(.x, .f)
```

```
map(got_chars, ~ length(.x[["aliases"]]))
```

quick anonymous functions
via formula



```
map_lgl(sw_people, ~ .x[["gender"]] == "female")
```

```
map_int(got_chars, ~ length(.x[["aliases"]]))
```

```
map_chr(got_chars, ~ .x[["name"]])
```

Onwards!

Notice:

We extract by name a lot

```
# What's each character's name?
```

```
map(got_chars, ~.x[["name"]])
```

```
# What color is each SW character's hair?
```

```
map(sw_people, ~.x[["hair_color"]])
```

```
# Is the GoT character alive?
```

```
map(got_chars, ~.x[["alive"]])
```

```
# How heavy is each SW character?
```

```
map(sw_people, ~.x[["mass"]])
```



```
map_chr(got_chars, ~ .x[["name"]])
```



```
map_chr(got_chars, "name")
```

Shortcut!

.f accepts a name or position

• $x = \min i s$



map(minis, "pants")



Challenge:

Explore a GoT or SW list and find a new element to look at

Extract it across the whole list with **name and position shortcuts** for .f

Use **map_TYPE()** to get an atomic vector as output

```
map_??(got_??, ??)
```

```
map_??( sw_??, ??)
```

Common problem

I'm using `map_TYPE()` but some individual elements aren't of length 1.

They are absent or have length > 1 .

Solutions

Missing elements?

Specify a `.default` value.

Elements of length > 1 ?

You can't make an atomic vector.

Get happy with a list or list-column.

Or pick one element, e.g., the first.

```
map(sw_vehicles, "pilots", .default = NA)
```

```
#> [[1]]
```

```
#> [1] NA
```

```
#>
```

```
#> ...
```

```
#>
```

```
#> [[19]]
```

```
#> [1] "http://swapi.co/api/people/10/" "http://swapi.co/api/people/32/"
```

```
#>
```

```
#> [[20]]
```

```
#> [1] "http://swapi.co/api/people/44/"
```

```
#>
```

```
#> ...
```

```
#>
```

```
#> [[37]]
```

```
#> [1] "http://swapi.co/api/people/67/"
```

```
#>
```

```
#> [[38]]
```

```
#> [1] NA
```

```
#>
```

```
#> [[39]]
```

```
#> [1] NA
```



```
map_chr(sw_vehicles, list("pilots", 1), .default = NA)
#> [1] NA NA
#> [3] NA NA
#> [5] "http://swapi.co/api/people/1/" NA
#> [7] NA "http://swapi.co/api/people/13/"
#> [9] NA NA
#> [11] NA NA
#> [13] "http://swapi.co/api/people/1/" NA
#> [15] NA NA
#> [17] NA NA
#> [19] "http://swapi.co/api/people/10/" "http://swapi.co/api/people/44/"
#> [21] "http://swapi.co/api/people/11/" "http://swapi.co/api/people/70/"
#> [23] "http://swapi.co/api/people/11/" NA
#> [25] NA "http://swapi.co/api/people/79/"
#> [27] NA NA
#> [29] NA NA
#> [31] NA NA
#> [33] NA NA
#> [35] NA NA
#> [37] "http://swapi.co/api/people/67/" NA
#> [39] NA
```

```
map(got_chars, c(14, 1))
```

```
map(sw_vehicles, list("pilots", 1))
```

Shortcut!

.f accepts a ~~name or position~~ vector of names or positions or a list of names and positions

Names make life nicer!

```
map_chr(got_chars, "name")  
#> [1] "Theon Greyjoy"      "Tyrion Lannister"    "Victarion Greyjoy"  
#> ...
```

```
got_chars_named <- set_names(got_chars, map_chr(got_chars, "name"))
```

```
got_chars_named %>%  
  map_lgl("alive")  
#>      Theon Greyjoy      Tyrion Lannister      Victarion Greyjoy  
#>              TRUE              TRUE              TRUE  
#>      ...
```

Names propagate in purrr pipelines.
Set them early and enjoy!

`tibble::enframe()` does this:

named list → df w/ names & list-column

```
allegiances <- map(got_chars_named, "allegiances")
tibble::enframe(allegiances, value = "allegiances")
#> # A tibble: 30 x 2
#>   name      allegiances
#>   <chr>      <list>
#> 1 Theon Greyjoy <chr [1]>
#> 2 Tyrion Lannister <chr [1]>
#> 3 Victarion Greyjoy <chr [1]>
#> 4 Will        <NULL>
#> 5 Areo Hotah   <chr [1]>
#> 6 Chett        <NULL>
#> 7 Cressen      <NULL>
#> 8 Arianne Martell <chr [1]>
#> 9 Daenerys Targaryen <chr [1]>
#> 10 Davos Seaworth <chr [2]>
#> # ... with 20 more rows
```

Review #2

Set list names for a happier life.

```
got_chars_named <- set_names(got_chars, map_chr(got_chars, "name"))
```

There are many ways to specify .f.

```
map(got_chars, ~ length(.x[["aliases"]]))  
map_chr(got_chars, "name")  
map(sw_vehicles, list("pilots", 1))
```

.default is useful for missing things.

```
map(sw_vehicles, "pilots", .default = NA)  
map_chr(sw_vehicles, list("pilots", 1), .default = NA)
```

Challenge:

Create a **named** copy of a GoT or SW list with `set_names()`.

Find an element with **tricky** presence/absence or length.

Extract it many ways:

- by name
- by position
- by `list("name", pos)` or `c(pos, pos)`
- use `.default` for missing data
- use `map_TYPE()` to coerce output to atomic vector

Challenge (pick one or more):

Which SW film has the most characters?

Which SW species has the most possible eye colors?

Which GoT character has the most allegiances? Aliases?
Titles?

Which GoT character has been played by multiple actors?

Inspiration for your
future purrrr work

map(.x, .f, ...)

```
books <- map(got_chars_named, "books")
```

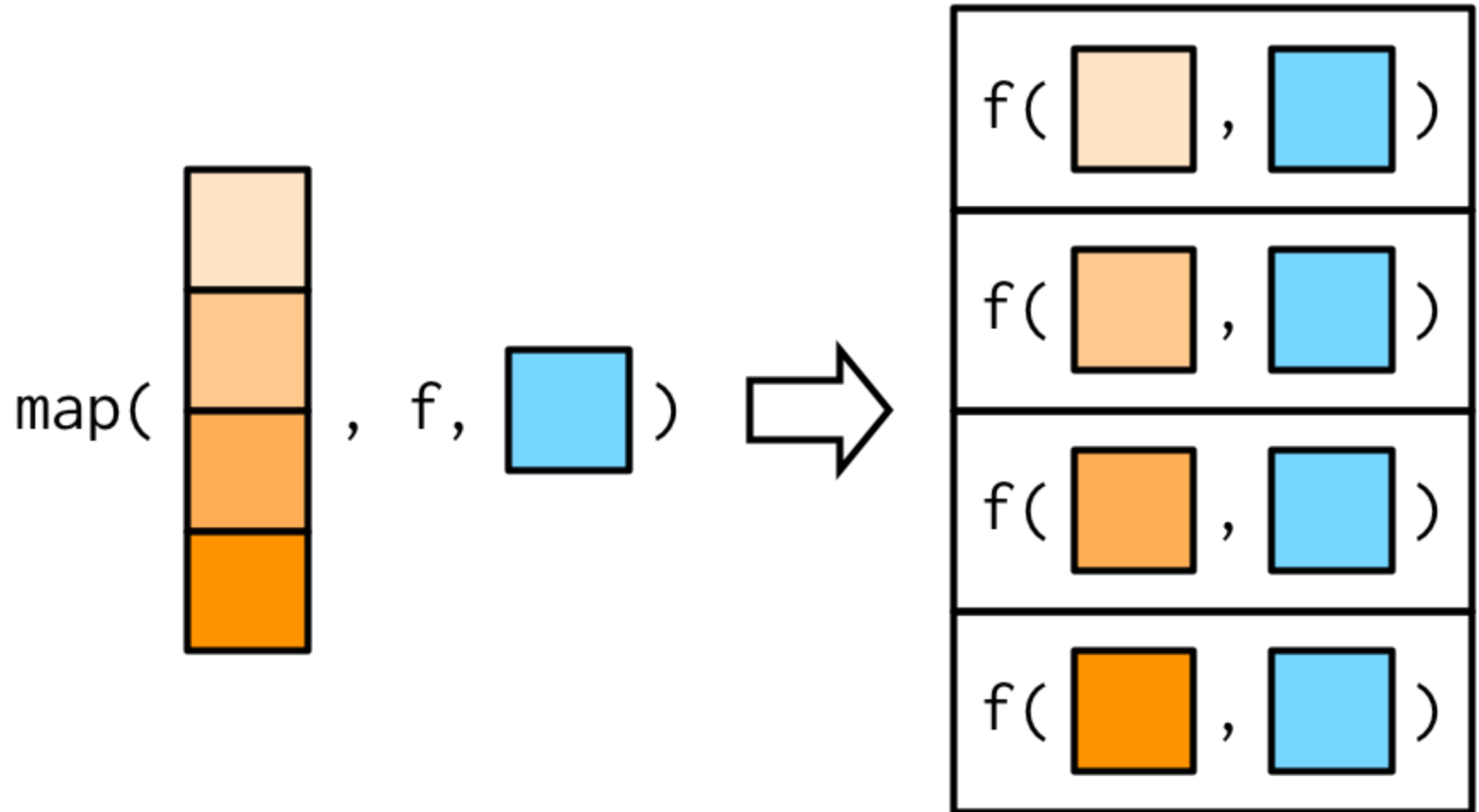
```
map_chr(books[1:2], paste, collapse = ", ")
```

```
#> Theon Greyjoy  
#> "A Game of Thrones, A Storm of Swords, A Feast for Crows"  
#> Tyrion Lannister  
#> "A Feast for Crows, The World of Ice and Fire"
```

```
map_chr(books[1:2], ~ paste(.x, collapse = ", "))
```

```
#> Theon Greyjoy  
#> "A Game of Thrones, A Storm of Swords, A Feast for Crows"  
#> Tyrion Lannister  
#> "A Feast for Crows, The World of Ice and Fire"
```

`map(.x, .f, ...)`



from Functionals chapter of 2nd ed Advanced R

map(.x, .f, ...)

```
books <- map(got_chars_named, "books")
```

```
map_chr(books[1:2], paste, collapse = ", ")
```

```
#> Theon Greyjoy  
#> "A Game of Thrones, A Storm of Swords, A Feast for Crows"  
#> Tyrion Lannister  
#> "A Feast for Crows, The World of Ice and Fire"
```

```
map_chr(books[1:2], ~ paste(.x, collapse = ", "))
```

```
#> Theon Greyjoy  
#> "A Game of Thrones, A Storm of Swords, A Feast for Crows"  
#> Tyrion Lannister  
#> "A Feast for Crows, The World of Ice and Fire"
```

So, yes,
there are **many** ways to specify .f.

```
map(got_chars, ~ length(.x[["aliases"]]))  
map_chr(got_chars, "name")  
map_chr(books[1:2], paste, collapse = ", ")  
map(sw_vehicles, list("pilots", 1))
```

The screenshot shows the 'purrr tutorial' website. The navigation bar includes 'purrr tutorial', 'Lessons and examples', 'More resources', 'Talks', and 'About'. A sidebar on the left lists the following items: 'Load packages' (highlighted), 'map() overview', 'map() function specification', 'List to data frame', 'Recap', and 'Parallel map'. The main content area is titled 'Specifying the function in map() + parallel mapping' and 'Load packages'. The text below the title reads: 'Load purrr and repurrrsive, which contains recursive list examples. If you're just jumping here, the example datasets are introduced elsewhere, including via interactive listviewer widgets.' Below this text is a code block containing the following R code:

```
library(purrr)  
library(repurrrsive)
```

```
library(tidyverse)
library(gapminder)

countries <- c("Argentina", "Brazil", "Canada")
gap_small <- gapminder %>%
  filter(country %in% countries, year > 1996)
gap_small
#> # A tibble: 9 x 6
#>   country    continent  year lifeExp      pop gdpPercap
#>   <fct>      <fct>    <int>   <dbl>    <int>    <dbl>
#> 1 Argentina Americas   1997    73.3  36203463  10967.
#> 2 Argentina Americas   2002    74.3  38331121   8798.
#> 3 Argentina Americas   2007    75.3  40301927  12779.
#> 4 Brazil    Americas   1997    69.4 168546719   7958.
#> 5 Brazil    Americas   2002    71.0 179914212   8131.
#> 6 Brazil    Americas   2007    72.4 190010647   9066.
#> 7 Canada    Americas   1997    78.6  30305843  28955.
#> 8 Canada    Americas   2002    79.8  31902268  33329.
#> 9 Canada    Americas   2007    80.7  33390141  36319.
```

```
write_one <- function(x) {
  filename <- paste0(x, ".csv")
  dataset <- filter(gap_small, country == x)
  write_csv(dataset, filename)
}
```

```
walk(countries, write_one)
list.files(pattern = "*.csv")
#> [1] "Argentina.csv" "Brazil.csv"    "Canada.csv"
```

walk() is map() but
returns no output

map_dfr() rowbinds a list of data frames

```
library(tidyverse)
```

```
csv_files <- list.files(pattern = "*.csv")
```

```
csv_files
```

```
#> [1] "Argentina.csv" "Brazil.csv"      "Canada.csv"
```

```
map_dfr(csv_files, ~ read_csv(.x))
```

```
#> # A tibble: 9 x 6
```

	country	continent	year	lifeExp	pop	gdpPercap
	<fct>	<fct>	<int>	<dbl>	<int>	<dbl>
#> 1	Argentina	Americas	1997	73.3	36203463	10967.
#> 2	Argentina	Americas	2002	74.3	38331121	8798.
#> 3	Argentina	Americas	2007	75.3	40301927	12779.
#> 4	Brazil	Americas	1997	69.4	168546719	7958.
#> 5	Brazil	Americas	2002	71.0	179914212	8131.
#> 6	Brazil	Americas	2007	72.4	190010647	9066.
#> 7	Canada	Americas	1997	78.6	30305843	28955.
#> 8	Canada	Americas	2002	79.8	31902268	33329.
#> 9	Canada	Americas	2007	80.7	33390141	36319.

mapping over 2 or
more things in parallel



• $y = \text{hair}$

• $x = \text{minis}$



map2(minis, hair, enhair)





• $y = \text{weapons}$
• $x = \text{minis}$



map2(minis, weapons, arm)

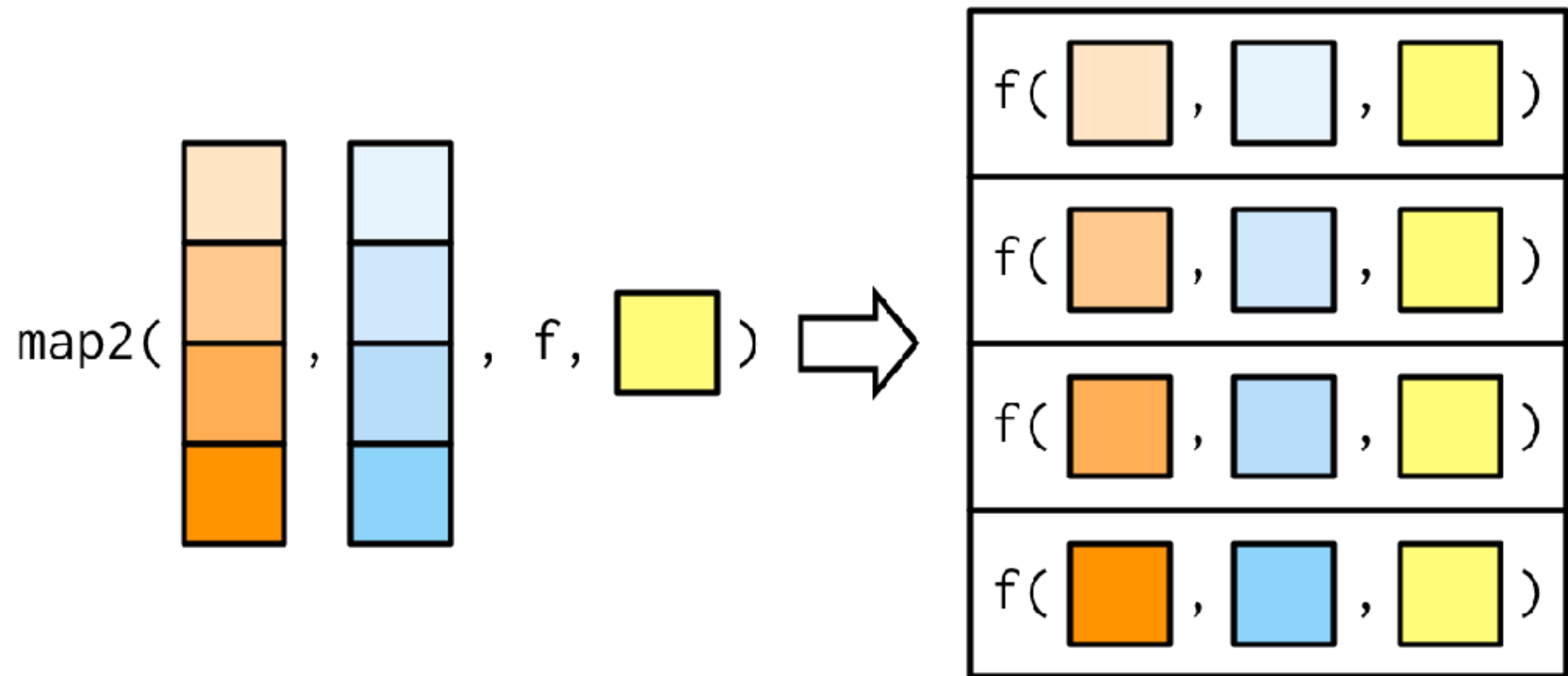


minis %>%

map2(hair, enhair) %>%

map2(weapons, arm)





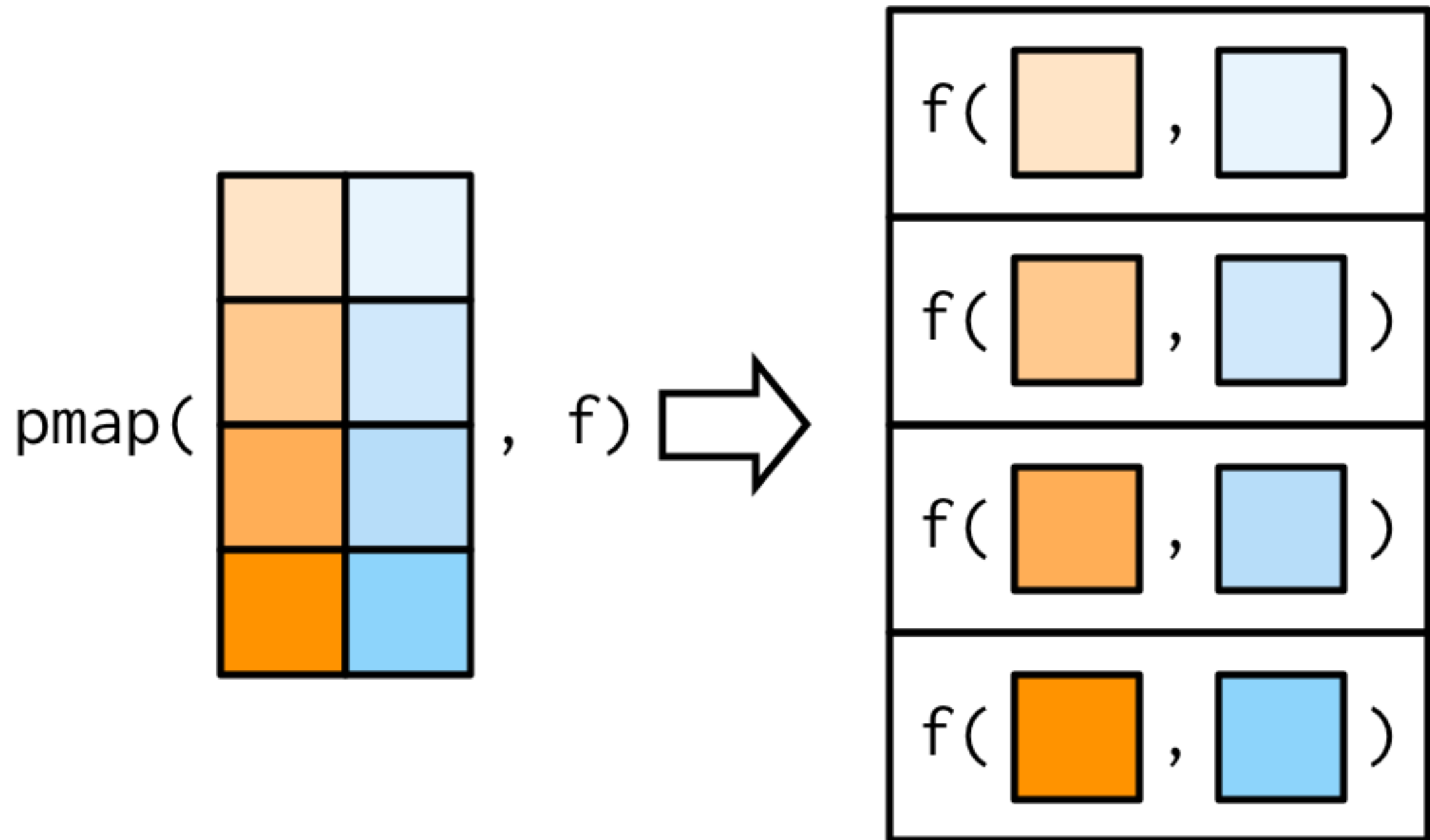
from Functionals chapter of 2nd ed Advanced R


```
df <- tibble(pants, torso, head)  
embody <- function(pants, torso, head)  
  insert(insert(pants, torso), head)
```



pmap(df, embody)





from Functionals chapter of 2nd ed Advanced R

```
map_dfr(minis, `[`,  
        c("pants", "torso", "head"))
```



For much more on this:
rstudio.io/row-work

Row-oriented workflows in R with the tidyverse

Materials for [RStudio webinar](#) recording available at this link!:

Thinking inside the box: you can do that inside a data frame?!

Jenny Bryan

Wednesday, April 11 at 1:00pm ET / 10:00am PT

rstudio.io/row-work <-- shortlink to this repo

Slides available on [SpeakerDeck](#)

You have the basis for exploring the world of purrr now!

	List	Atomic	Same type	Nothing
One argument	<code>map()</code>	<code>map_lgl()</code> , ...	<code>modify()</code>	<code>walk()</code>
Two arguments	<code>map2()</code>	<code>map2_lgl()</code> , ...	<code>modify2()</code>	<code>walk2()</code>
One argument + index	<code>imap()</code>	<code>imap_lgl()</code> , ...	<code>imodify()</code>	<code>iwalk()</code>
N arguments	<code>pmap()</code>	<code>pmap_lgl()</code> , ...	—	<code>pwalk()</code>

from Functionals chapter of 2nd ed Advanced R