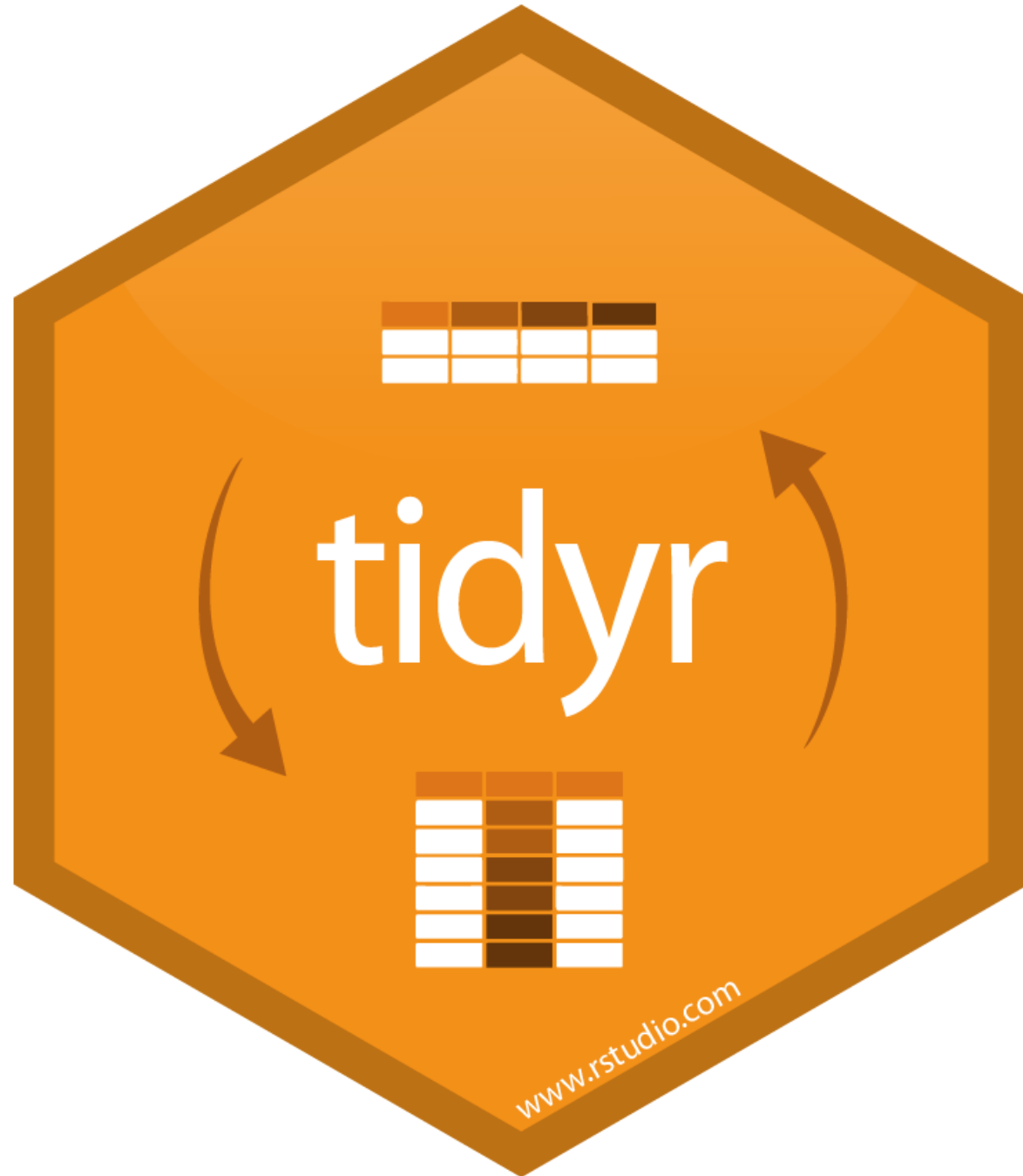





Dr. Colin Rundel



# Reshaping data (Wide vs. Long)

# Wide -> Long

country	1999	2000
A	0.7K	2K
B	37K	80K
C	212K	213K



country	year	cases
A	1999	0.7K
B	1999	37K
C	1999	212K
A	2000	2K
B	2000	80K
C	2000	213K

`pivot_longer` (previously `gather`)

# Syntax

```
1 (d = tibble::tribble(  
2   ~country, ~"1999", ~"2000",  
3     "A", "0.7K", "2K",  
4     "B", "37K", "80K",  
5     "C", "212K", "213K"  
6 ))
```

```
# A tibble: 3 × 3  
  country `1999` `2000`  
  <chr>   <chr>   <chr>  
1 A      0.7K    2K  
2 B      37K    80K  
3 C     212K   213K
```

```
1 pivot_longer(  
2   d,  
3   cols = "1999":"2000",  
4   names_to = "year",  
5   values_to = "cases"  
6 )
```

```
# A tibble: 6 × 3  
  country year  cases  
  <chr>   <chr> <chr>  
1 A      1999  0.7K  
2 A      2000   2K  
3 B      1999  37K  
4 B      2000  80K  
5 C      1999 212K  
6 C      2000 213K
```

# Long -> Wide

country	year	type	count		country	year	cases	pop
A	1999	cases	0.7K	→	A	1999	0.7K	19M
A	1999	pop	19M		A	2000	2K	20M
A	2000	cases	2K		B	1999	37K	172M
A	2000	pop	20M		B	2000	80K	174M
B	1999	cases	37K		C	1999	212K	1T
B	1999	pop	172M		C	2000	213K	1T
B	2000	cases	80K					
B	2000	pop	174M					
C	1999	cases	212K					
C	1999	pop	1T					
C	2000	cases	213K					
C	2000	pop	1T					

`pivot_wider` (previously `spread`)

# Syntax

```

1 ( d = tibble::tribble(
2   ~country, ~year, ~type, ~count,
3   "A", 1999, "cases", "0.7K",
4   "A", 1999, "pop", "19M",
5   "A", 2000, "cases", "2K",
6   "A", 2000, "pop", "20M",
7   "B", 1999, "cases", "37K",
8   "B", 1999, "pop", "172M",
9   "B", 2000, "cases", " 80K",
10  "B", 2000, "pop", "174M",
11  "C", 1999, "cases", "212K",
12  "C", 1999, "pop", "1T",
13  "C", 2000, "cases", "213K",
14  "C", 2000, "pop", "1T"
15 )
16 )

```

```

# A tibble: 12 × 4
  country year type count
  <chr>   <dbl> <chr> <chr>
1 A      1999 cases "0.7K"
2 A      1999 pop  "19M"
3 A      2000 cases "2K"
4 A      2000 pop  "20M"
5 B      1999 cases "37K"
6 B      1999 pop  "172M"
7 B      2000 cases " 80K"
8 B      2000 pop  "174M"
9 C      1999 cases "212K"
10 C     1999 pop  "1T"
11 C     2000 cases "213K"
12 C     2000 pop  "1T"

```

```

1 pivot_wider(
2   d,
3   id_cols = country:year,
4   names_from = type,
5   values_from = count
6 )

```

```

# A tibble: 6 × 4
  country year cases pop
  <chr>   <dbl> <chr> <chr>
1 A      1999 "0.7K" 19M
2 A      2000 "2K" 20M
3 B      1999 "37K" 172M
4 B      2000 " 80K" 174M
5 C      1999 "212K" 1T
6 C      2000 "213K" 1T

```

# Separate

country	year	rate		country	year	cases	pop
A	1999	0.7K/19M		A	1999	0.7K	19M
A	2000	2K/20M		A	2000	2K	20M
B	1999	37K/172M		B	1999	37K	172
B	2000	80K/174M		B	2000	80K	174
C	1999	212K/1T		C	1999	212K	1T
C	2000	213K/1T		C	2000	213K	1T

```
1 separate(d, rate, sep = "/", into = c("cases", "pop"))
```


```
# A tibble: 6 × 4
```

```
  country year cases pop
  <chr>   <dbl> <chr> <chr>
1 A      1999 0.7K  19M
2 A      2000 2K    20M
3 B      1999 37K   172M
4 B      2000 80K   174M
5 C      1999 212K  1T
6 C      2000 213K  1T
```



# Unite

country	century	year
Afghan	19	99
Afghan	20	0
Brazil	19	99
Brazil	20	0
China	19	99
China	20	0



country	year
Afghan	1999
Afghan	2000
Brazil	1999
Brazil	2000
China	1999
China	2000

```
1 unite(d, century, year, col = "year", sep = "")
```

```
# A tibble: 6 × 2
```

```
  country year  
  <chr>   <chr>  
1 Afghan 1999  
2 Afghan 2000  
3 Brazil 1999  
4 Brazil 2000  
5 China  1999  
6 China  2000
```

# Example 1 - tidy grades

Is the following data tidy?

```
1 grades = tibble::tribble(  
2   ~name,    ~hw_1, ~hw_2, ~hw_3, ~hw_4, ~proj_1, ~proj_2,  
3   "Alice",    19,    19,    18,    20,    89,    95,  
4   "Bob",     18,    20,    18,    16,    77,    88,  
5   "Carol",   18,    20,    18,    17,    96,    99,  
6   "Dave",    19,    19,    18,    19,    86,    82  
7 )
```

How would we calculate a final score based on the following formula,

$$\text{score} = 0.5 \frac{\sum_i \text{hw}_i}{80} + 0.5 \frac{\sum_j \text{proj}_j}{200}$$

# Semi-tidy approach

```
1 grades %>%
2   mutate(
3     hw_avg = (hw_1+hw_2+hw_3+hw_4)/4,
4     proj_avg = (proj_1+proj_2)/2
5   ) %>%
6   mutate(
7     overall = 0.5*(proj_avg/100) + 0.5*(hw_avg/20)
8   )
```

# A tibble: 4 × 10

	name	hw_1	hw_2	hw_3	hw_4	proj_1	proj_2	hw_avg	proj_avg	overall
	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1	Alice	19	19	18	20	89	95	19	92	0.935
2	Bob	18	20	18	16	77	88	18	82.5	0.862
3	Carol	18	20	18	17	96	99	18.2	97.5	0.944
4	Dave	19	19	18	19	86	82	18.8	84	0.889

# pivot\_longer (Wide -> Long)

```
1 tidyr::pivot_longer(  
2   grades,  
3   cols = hw_1:proj_2,  
4   names_to = "assignment",  
5   values_to = "score"  
6 )
```

```
# A tibble: 24 × 3  
  name assignment score  
  <chr> <chr>      <dbl>  
1 Alice hw_1        19  
2 Alice hw_2        19  
3 Alice hw_3        18  
4 Alice hw_4        20  
5 Alice proj_1       89  
6 Alice proj_2       95  
7 Bob   hw_1        18  
8 Bob   hw_2        20  
9 Bob   hw_3        18  
10 Bob   hw_4        16  
# ... with 14 more rows
```

# Split type and id

```
1 tidyr::pivot_longer(  
2   grades,  
3   cols = hw_1:proj_2,  
4   names_to = c("type", "id"),  
5   names_sep = "_",  
6   values_to = "score"  
7 )
```

```
# A tibble: 24 × 4  
   name type id    score  
   <chr> <chr> <chr> <dbl>  
1 Alice hw    1      19  
2 Alice hw    2      19  
3 Alice hw    3      18  
4 Alice hw    4      20  
5 Alice proj   1      89  
6 Alice proj   2      95  
7 Bob   hw    1      18  
8 Bob   hw    2      20  
9 Bob   hw    3      18  
10 Bob   hw    4      16  
# ... with 14 more rows
```

# Tidy approach?

```
1 grades %>%
2   tidyr::pivot_longer(
3     cols = hw_1:proj_2,
4     names_to = c("type", "id"),
5     names_sep = "_",
6     values_to = "score"
7   ) %>%
8   group_by(name, type) %>%
9   summarize(
10     total = sum(score),
11     .groups = "drop"
12   )
```

```
# A tibble: 8 × 3
  name type total
<chr> <chr> <dbl>
1 Alice hw      76
2 Alice proj    184
3 Bob hw      72
4 Bob proj    165
5 Carol hw      73
6 Carol proj    195
7 Dave hw      75
8 Dave proj    168
```

# pivot\_wider - (Long -> Wide)

```
1 grades %>%
2   tidyr::pivot_longer(
3     cols = hw_1:proj_2,
4     names_to = c("type", "id"),
5     names_sep = "_",
6     values_to = "score"
7   ) %>%
8   group_by(name, type) %>%
9   summarize(
10     total = sum(score),
11     .groups = "drop"
12   ) %>%
13   tidyr::pivot_wider(
14     names_from = type,
15     values_from = total
16   )
```

```
# A tibble: 4 × 3
  name      hw  proj
  <chr> <dbl> <dbl>
1 Alice    76   184
2 Bob      72   165
3 Carol    73   195
4 Dave     75   168
```

# Wrapping up

```
1 grades %>%
2   tidyr::pivot_longer(
3     cols = hw_1:proj_2,
4     names_to = c("type", "id"),
5     names_sep = "_",
6     values_to = "score"
7   ) %>%
8   group_by(name, type) %>%
9   summarize(
10     total = sum(score),
11     .groups = "drop"
12   ) %>%
13   tidyr::pivot_wider(
14     names_from = type,
15     values_from = total
16   ) %>%
17   mutate(
```

```
# A tibble: 4 × 4
  name      hw  proj score
<chr> <dbl> <dbl> <dbl>
1 Alice     76   184 0.935
2 Bob       72   165 0.862
3 Carol     73   195 0.944
4 Dave      75   168 0.889
```



# Exercise 1

The `palmerpenguins` package contains measurement data on various penguin species on islands near Palmer Station in Antarctica. The code below shows the # of each species measured on each of the three islands (missing island, penguin pairs implies that species does not occur on that island).

```
1 palmerpenguins::penguins %>%  
2   count(island, species)
```

# A tibble: 5 × 3

	island	species	n
	<fct>	<fct>	<int>
1	Biscoe	Adelie	44
2	Biscoe	Gentoo	124
3	Dream	Adelie	56
4	Dream	Chinstrap	68
5	Torgersen	Adelie	52

Starting from these data construct a contingency table of counts for island (rows) by species (columns) using the pivot functions we've just discussed.

# Rectangling

# Star Wars & repurrrsive

`repurrrsive` is a package that contains a number of interesting example data sets that are stored in a hierarchical format. Many come from web-based APIs which provide results as JSON.

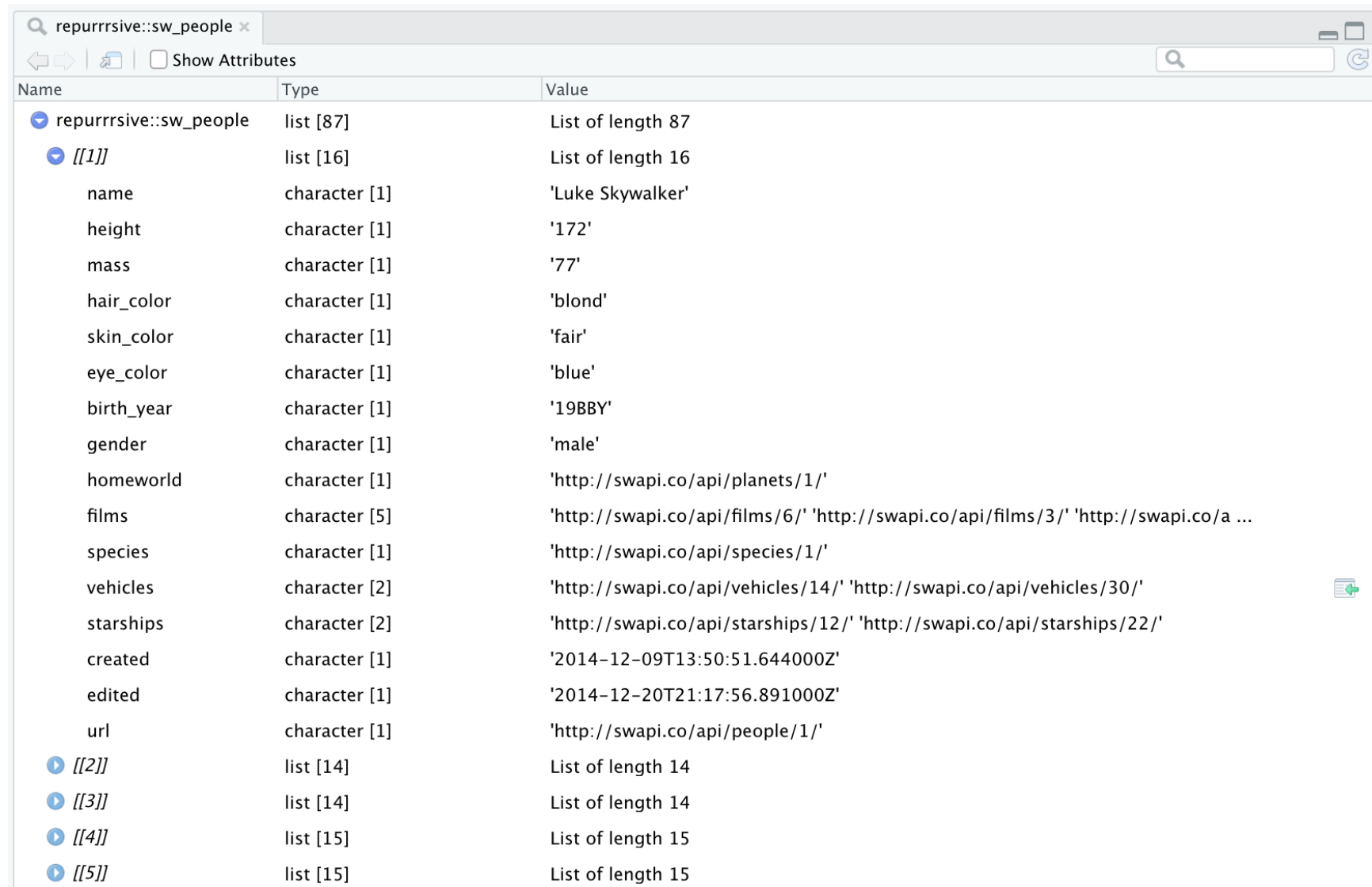
```
1 str(repurrrsive::sw_people)
```

List of 87

```
$ :List of 16
..$ name      : chr "Luke Skywalker"
..$ height    : chr "172"
..$ mass      : chr "77"
..$ hair_color: chr "blond"
..$ skin_color: chr "fair"
..$ eye_color : chr "blue"
..$ birth_year: chr "19BBY"
..$ gender     : chr "male"
..$ homeworld : chr "http://swapi.co/api/planets/1/"
..$ films      : chr [1:5] "http://swapi.co/api/films/6/" "http://swapi.co/api/films/3/"
"http://swapi.co/api/films/2/" "http://swapi.co/api/films/1/" ...
..$ species    : chr "http://swapi.co/api/species/1/"
```

# RStudio data viewer

```
1 View(reprrrrsive::sw_people)
```



Name	Type	Value
reprrrrsive::sw_people	list [87]	List of length 87
[[1]]	list [16]	List of length 16
name	character [1]	'Luke Skywalker'
height	character [1]	'172'
mass	character [1]	'77'
hair_color	character [1]	'blond'
skin_color	character [1]	'fair'
eye_color	character [1]	'blue'
birth_year	character [1]	'19BBY'
gender	character [1]	'male'
homeworld	character [1]	'http://swapi.co/api/planets/1/'
films	character [5]	'http://swapi.co/api/films/6/' 'http://swapi.co/api/films/3/' 'http://swapi.co/a ...
species	character [1]	'http://swapi.co/api/species/1/'
vehicles	character [2]	'http://swapi.co/api/vehicles/14/' 'http://swapi.co/api/vehicles/30/'
starships	character [2]	'http://swapi.co/api/starships/12/' 'http://swapi.co/api/starships/22/'
created	character [1]	'2014-12-09T13:50:51.644000Z'
edited	character [1]	'2014-12-20T21:17:56.891000Z'
url	character [1]	'http://swapi.co/api/people/1/'
[[2]]	list [14]	List of length 14
[[3]]	list [14]	List of length 14
[[4]]	list [15]	List of length 15
[[5]]	list [15]	List of length 15

# Tidy data from nested lists

Recent versions of `tidyr` have added several functions that are designed to aide in the tidying of hierarchical data. Since they are part of `tidyr` all of the following functions work with data frames.

From `hoist()`, `unnest_longer()`, and `unnest_wider()` provide tools for rectangling, collapsing deeply nested lists into regular columns.

# Lists as columns

```
1 (sw_df = tibble::tibble(  
2   people = repurrrsive::sw_people  
3 ))
```

```
# A tibble: 87 × 1  
  people  
  <list>  
1 <named list [16]>  
2 <named list [14]>  
3 <named list [14]>  
4 <named list [15]>  
5 <named list [15]>  
6 <named list [14]>  
7 <named list [14]>  
8 <named list [14]>  
9 <named list [15]>  
10 <named list [16]>  
# ... with 77 more rows
```

```
1 sw_df %>%  
2   as.data.frame() %>%  
3   head()
```

```
people  
1 Luke Skywalker, 172, 77, blond, fair,  
blue, 19BBY, male,  
http://swapi.co/api/planets/1/,  
http://swapi.co/api/films/6/,  
http://swapi.co/api/films/3/,  
http://swapi.co/api/films/2/,  
http://swapi.co/api/films/1/,  
http://swapi.co/api/films/7/,  
http://swapi.co/api/species/1/,  
http://swapi.co/api/vehicles/14/,  
http://swapi.co/api/vehicles/30/,  
http://swapi.co/api/starships/12/,
```

```
1 is.data.frame(sw_df)
```

```
[1] TRUE
```

```
1 nrow(sw_df)
```

[1] 87

# Unnesting

```
1 sw_df %>%  
2   unnest_wider(people)
```

```
# A tibble: 87 × 16
```

	name	height	mass	hair_... <sup>1</sup>	skin_... <sup>2</sup>	eye_c... <sup>3</sup>	birth... <sup>4</sup>	gender	homew... <sup>5</sup>	films
	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>	<lis>
1	Luke Skywa...	172	77	blond	fair	blue	19BBY	male	http:/...	<chr>
2	C-3PO	167	75	n/a	gold	yellow	112BBY	n/a	http:/...	<chr>
3	R2-D2	96	32	n/a	white,...	red	33BBY	n/a	http:/...	<chr>
4	Darth Vader	202	136	none	white	yellow	41.9BBY	male	http:/...	<chr>
5	Leia Organa	150	49	brown	light	brown	19BBY	female	http:/...	<chr>
6	Owen Lars	178	120	brown,...	light	blue	52BBY	male	http:/...	<chr>
7	Beru White...	165	75	brown	light	blue	47BBY	female	http:/...	<chr>
8	R5-D4	97	32	n/a	white,...	red	unknown	n/a	http:/...	<chr>
9	Biggs Dark...	183	84	black	light	brown	24BBY	male	http:/...	<chr>
10	Obi-Wan Ke...	182	77	auburn...	fair	blue-g...	57BBY	male	http:/...	<chr>

```
# ... with 77 more rows, 6 more variables: species <chr>, vehicles <list>,
```



# More list columns

```
1 sw_df %>%  
2   unnest_wider(people) %>%  
3   select(name, starships)
```

# A tibble: 87 × 2

	name	starships
	<chr>	<list>
1	Luke Skywalker	<chr [2]>
2	C-3PO	<NULL>
3	R2-D2	<NULL>
4	Darth Vader	<chr [1]>
5	Leia Organa	<NULL>
6	Owen Lars	<NULL>
7	Beru Whitesun lars	<NULL>
8	R5-D4	<NULL>
9	Biggs Darklighter	<chr [1]>
10	Obi-Wan Kenobi	<chr [5]>

# ... with 77 more rows

```
1 sw_df %>%  
2   unnest_wider(people) %>%  
3   select(name, starships) %>%  
4   pull(starships) %>%  
5   str()
```

List of 87

```
$ : chr [1:2]  
"http://swapi.co/api/starships/12/"  
"http://swapi.co/api/starships/22/"  
$ : NULL  
$ : NULL  
$ : chr  
"http://swapi.co/api/starships/13/"  
$ : NULL  
$ : NULL  
$ : NULL  
$ : NULL  
$ : chr  
"http://swapi.co/api/starships/12/"
```

# Unnest Longer

```
1 unnest_wider(sw_df, people) %>%
2   select(name, starships) %>%
3   unnest_longer(starships)
```

```
# A tibble: 98 × 2
```

	name	starships
	<chr>	<chr>
1	Luke Skywalker	http://swapi.co/api/starships/12/
2	Luke Skywalker	http://swapi.co/api/starships/22/
3	C-3PO	<NA>
4	R2-D2	<NA>
5	Darth Vader	http://swapi.co/api/starships/13/
6	Leia Organa	<NA>
7	Owen Lars	<NA>
8	Beru Whitesun lars	<NA>
9	R5-D4	<NA>
10	Biggs Darklighter	http://swapi.co/api/starships/12/

```
# ... with 88 more rows
```

# Aside - sw\_starships

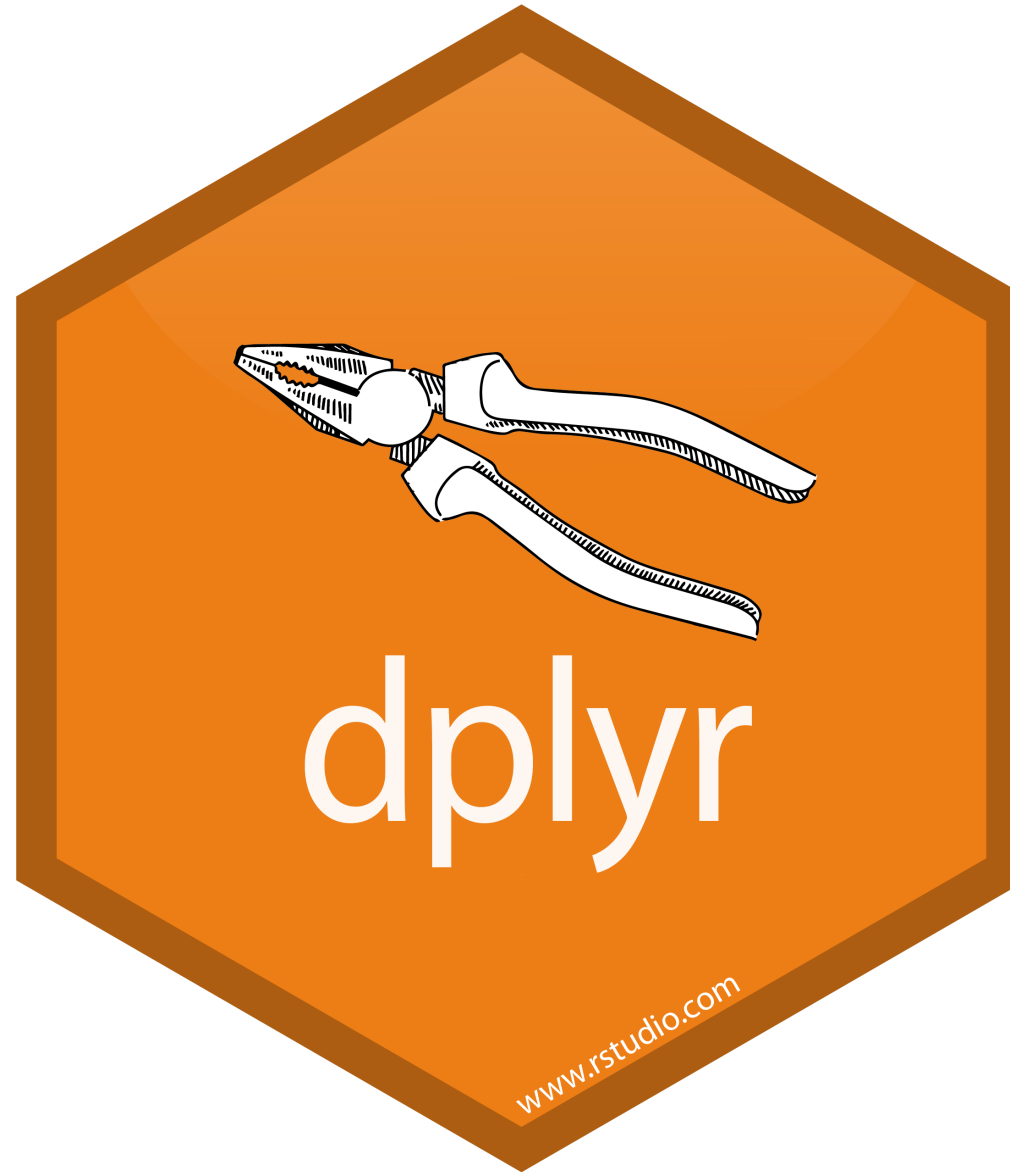
```
1 (ships = tibble(ships = repurrrsive::sw_starships) %>%  
2   unnest_wider(ships) %>%  
3   select(ship = name, url)  
4 )
```

# A tibble: 37 × 2

ship	url
<chr>	<chr>
1 Sentinel-class landing craft	http://swapi.co/api/starships/5/
2 Death Star	http://swapi.co/api/starships/9/
3 Millennium Falcon	http://swapi.co/api/starships/10/
4 Y-wing	http://swapi.co/api/starships/11/
5 X-wing	http://swapi.co/api/starships/12/
6 TIE Advanced x1	http://swapi.co/api/starships/13/
7 Executor	http://swapi.co/api/starships/15/
8 Slave 1	http://swapi.co/api/starships/21/
9 Imperial shuttle	http://swapi.co/api/starships/22/
10 EF76 Nebulon-B escort frigate	http://swapi.co/api/starships/23/

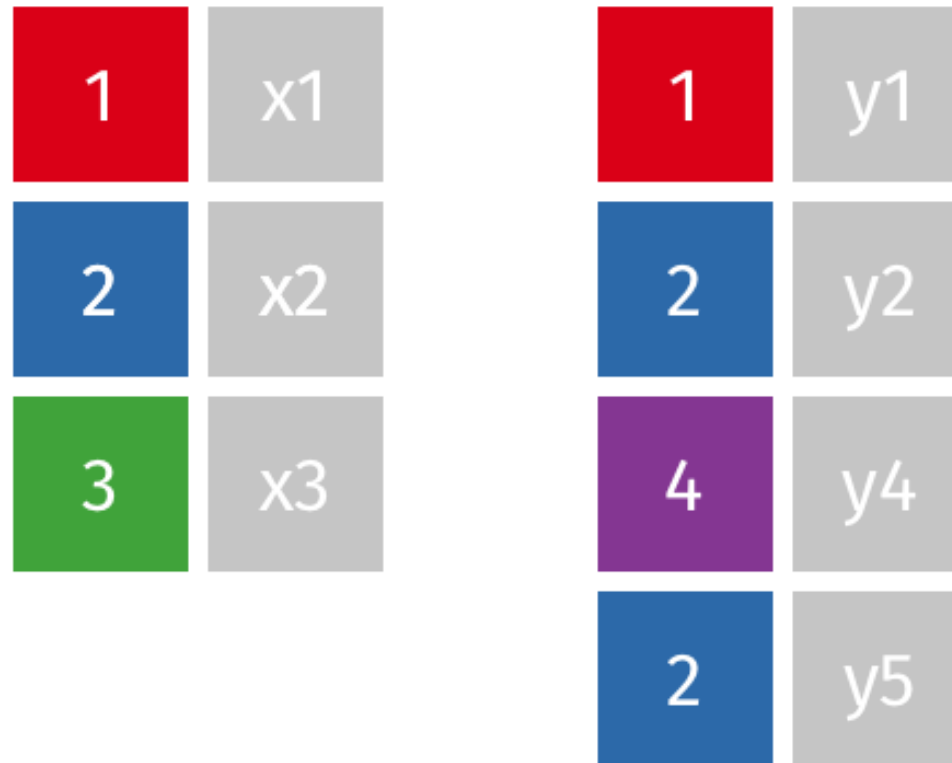
# ... with 27 more rows

# Aside - Joins



# Joins (left)

`left_join(x, y)`



# Joins (right)

`right_join(x, y)`

1	x1	1	y1
2	x2	2	y2
3	x3	4	y4

# Joins (full / outer)

`full_join(x, y)`

1	x1	1	y1
2	x2	2	y2
3	x3	4	y4

# Joins (inner)

`inner_join(x, y)`

1	x1	1	y1
2	x2	2	y2
3	x3	4	y4



# Joining people and starships

```
1 sw_df %>%
2   unnest_wider(people) %>%
3   select(name, starships) %>%
4   unnest_longer(starships) %>%
5   left_join(ships, by = c("starships" = "url"))
```

```
# A tibble: 98 × 3
```

	name <chr>	starships <chr>	ship <chr>
1	Luke Skywalker	http://swapi.co/api/starships/12/	X-wing
2	Luke Skywalker	http://swapi.co/api/starships/22/	Imperial shuttle
3	C-3PO	<NA>	<NA>
4	R2-D2	<NA>	<NA>
5	Darth Vader	http://swapi.co/api/starships/13/	TIE Advanced x1
6	Leia Organa	<NA>	<NA>
7	Owen Lars	<NA>	<NA>
8	Beru Whitesun lars	<NA>	<NA>
9	R5-D4	<NA>	<NA>
10	Riggs Darklighter	http://swapi.co/api/starships/12/	X-wing

# Putting it together

```
1 sw_df %>%
2   unnest_wider(people) %>%
3   select(name, starships) %>%
4   unnest_longer(starships) %>%
5   inner_join(ships, by = c("starships" = "url")) %>%
6   select(-starships) %>%
7   group_by(name) %>%
8   summarize(ships = list(ship), .groups = "drop")
```

# A tibble: 20 × 2

	name	ships
	<chr>	<list>
1	Anakin Skywalker	<chr [3]>
2	Arvel Crynyd	<chr [1]>
3	Biggs Darklighter	<chr [1]>
4	Boba Fett	<chr [1]>
5	Chewbacca	<chr [2]>
6	Darth Maul	<chr [1]>
7	Darth Vader	<chr [1]>
8	Gregar Typho	<chr [1]>

```

1 sw_df %>%
2   unnest_wider(people) %>%
3   select(name, starships) %>%
4   unnest_longer(starships) %>%
5   inner_join(ships, by = c("starships" = "url")) %>%
6   select(-starships) %>%
7   group_by(name) %>%
8   summarize(ships = paste(ship, collapse = ", "), .groups = "drop")

```

# A tibble: 20 × 2

	name	ships
	<chr>	<chr>
1	Anakin Skywalker	Trade Federation cruiser, Jedi Interceptor, Naboo fighter
2	Arvel Crynyd	A-wing
3	Biggs Darklighter	X-wing
4	Boba Fett	Slave 1
5	Chewbacca	Millennium Falcon, Imperial shuttle
6	Darth Maul	Scimitar
7	Darth Vader	TIE Advanced x1
8	Gregar Typho	Naboo fighter
9	Grievous	Belbullab-22 starfighter
10	Han Solo	Millennium Falcon, Imperial shuttle

# Exercise 2

1. Which planet appeared in the most starwars film (according to the data in `sw_planet`)?
2. Which planet was the homeworld of the most characters in the starwars films?