Transform Data with dplyr

gapminder

A subset of Gapminder data: population, GDP per capita and life expectancy, for countries over time.

```
# install.packages("gapminder")
library(gapminder)
```

Your Turn 0

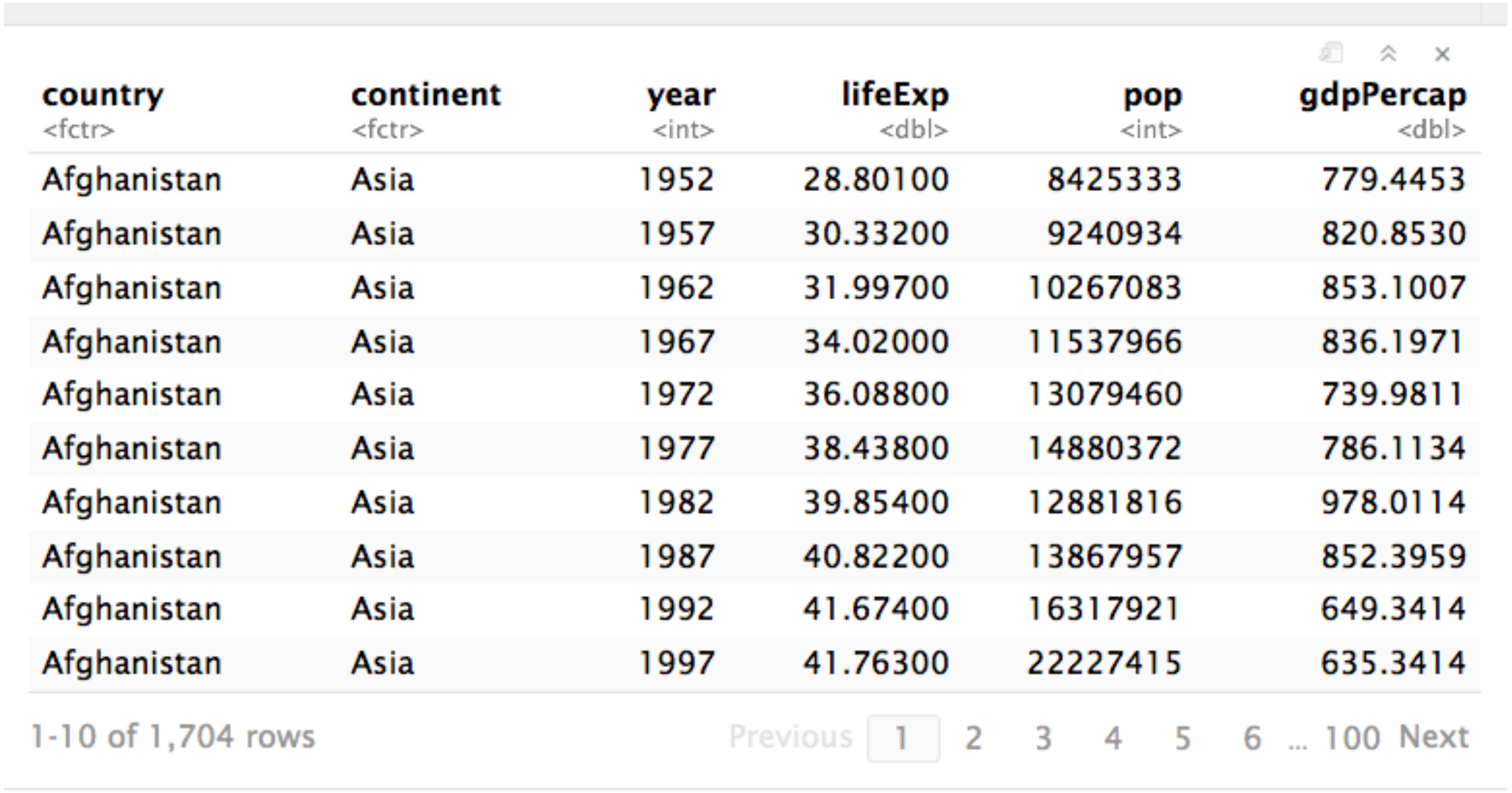
04-Transform-data.Rmd

Run the setup chunk

```
install.packages("gapminder")
library(gapminder)
```

04:00

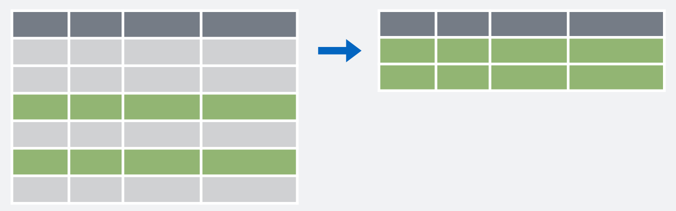
```r
gapminder
```

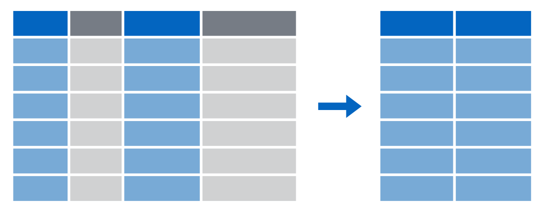


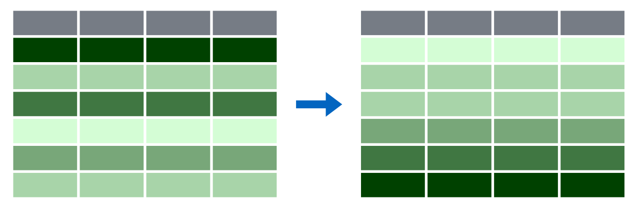
country <fctr>	continent <fctr>	year <int>	lifeExp <dbl>	pop <int>	gdpPercap <dbl>
Afghanistan	Asia	1952	28.80100	8425333	779.4453
Afghanistan	Asia	1957	30.33200	9240934	820.8530
Afghanistan	Asia	1962	31.99700	10267083	853.1007
Afghanistan	Asia	1967	34.02000	11537966	836.1971
Afghanistan	Asia	1972	36.08800	13079460	739.9811
Afghanistan	Asia	1977	38.43800	14880372	786.1134
Afghanistan	Asia	1982	39.85400	12881816	978.0114
Afghanistan	Asia	1987	40.82200	13867957	852.3959
Afghanistan	Asia	1992	41.67400	16317921	649.3414
Afghanistan	Asia	1997	41.76300	22227415	635.3414

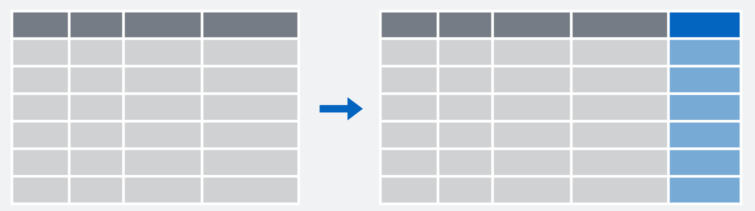
1-10 of 1,704 rows

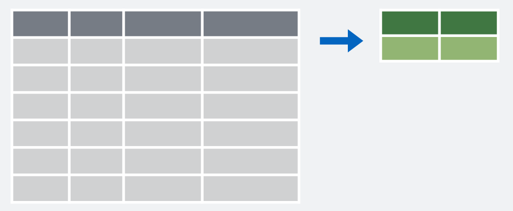
dplyr: Data manipulation verbs


Extract cases with **filter()**


Extract variables with **select()**


Arrange cases, with **arrange()**.


Make new variables, with **mutate()**.


Make tables of summaries with **summarise()**.

along with **group_by()**

filter()

filter()

Extract rows that meet logical criteria.

```
filter(.data, ... )
```

data frame to transform

one or more logical tests
(filter returns each row for which the test is TRUE)

filter()

Extract rows that meet logical criteria.

```r
filter(gapminder, country == "New Zealand")
```

gapminder

country	continent	year	…
Afghanistan	Asia	1952	
Afghanistan	Asia	1957	
…	…	…	
Netherlands	Europe	2007	
New Zealand	Oceania	1952	
New Zealand	Oceania	1957	

country	continent	year	…
New Zealand	Oceania	1952	
New Zealand	Oceania	1957	
New Zealand	Oceania	1962	
New Zealand	Oceania	1967	
…	…	…	…

dplyr

filter()

Extract rows that meet logical criteria.

```
filter(gapminder, country == "New Zealand")
```

gapminder

country	continent	year	…
Afghanistan	Asia	1952	
Afghanistan	Asia	1957	
…	…	…	
Netherlands	Europe	2007	
New Zealand	Oceania	1952	
New Zealand	Oceania	1957	

= sets
(returns nothing)

== tests if equal
(returns TRUE or FALSE)

Logical tests

?Comparison

`x < y`	Less than
`x > y`	Greater than
`x == y`	Equal to
`x <= y`	Less than or equal to
`x >= y`	Greater than or equal to
`x != y`	Not equal to
`x %in% y`	Group membership
`is.na(x)`	Is NA
`!is.na(x)`	Is not NA

Your Turn 1

04-Transform-data.Rmd

See if you can use the logical operators to manipulate our code below to show:

1. The data for Canada
2. All data for countries in Oceania
3. Rows where the life expectancy is greater than 82

04:00

```
filter(gapminder, country == "Canada")
```

```
filter(gapminder, continent == "Oceania")
```

```
filter(gapminder, lifeExp > 82)
```

Two common mistakes

1. Using = instead of ==

```
filter(gapminder, continent = "Oceania")
filter(gapminder, continent == "Oceania")
```

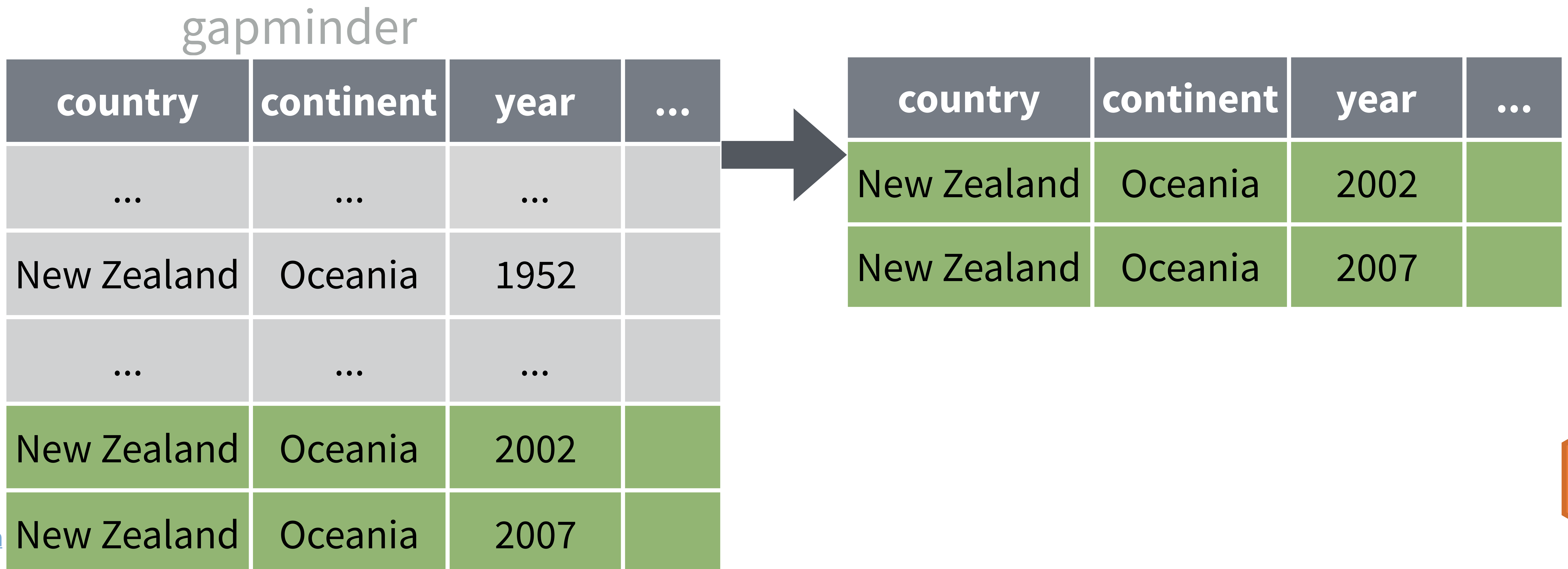
2. Forgetting quotes

```
filter(gapminder, continent == Oceania)
filter(gapminder, continent == "Oceania")
```

filter()

Extract rows that meet *every* logical criteria.

```
filter(gapminder, country == "New Zealand", year > 2000)
```



gapminder

country	continent	year	...
...	...	...	
New Zealand	Oceania	1952	
...	...	...	
New Zealand	Oceania	2002	
New Zealand	Oceania	2007	

country	continent	year	...
New Zealand	Oceania	2002	
New Zealand	Oceania	2007	

Boolean operators

?base::Logic

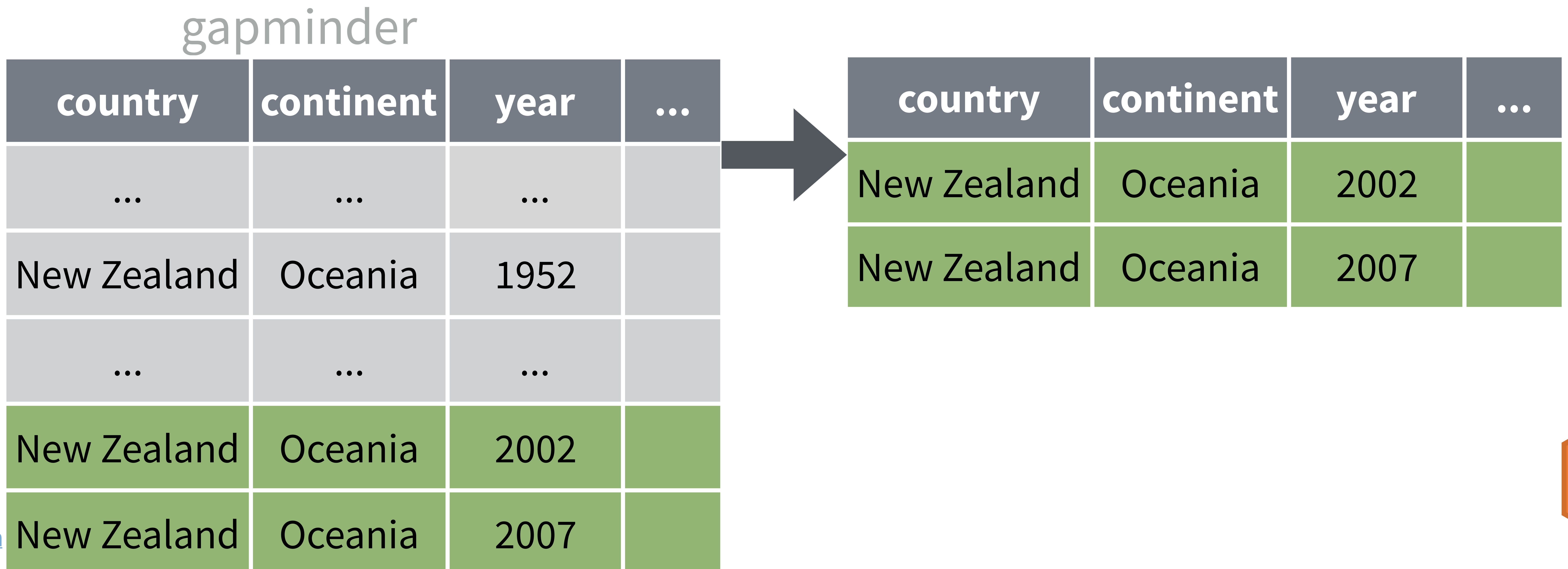
a & b	and
a | b	or
!a	not

Adapted from 'Master the tidyverse' CC by RStudio

filter()

Extract rows that meet *every* logical criteria.

```
filter(gapminder, country == "New Zealand" & year > 2000)
```



gapminder

country	continent	year	…
…	…	…	
New Zealand	Oceania	1952	
…	…	…	
New Zealand	Oceania	2002	
New Zealand	Oceania	2007	

country	continent	year	…
New Zealand	Oceania	2002	
New Zealand	Oceania	2007	

Your Turn 2

Use Boolean operators to alter the code below to return only the rows that contain:

1. Canada before 1970
2. Countries where life expectancy in 2007 is below 50
3. Countries where life expectancy in 2007 is below 50, and are not in Africa.

04:00

```r
filter(gapminder, country == "Canada", year < 1970)
```

```r
filter(gapminder, year == 2007, lifeExp < 50)
```

```r
filter(gapminder, year == 2007, lifeExp < 50, !(continent == "Africa"))
```

Two more common mistakes

3. Collapsing multiple tests into one

```
filter(gapminder, 1960 < year < 1980)
filter(gapminder, 1960 < year, year < 1980)
```

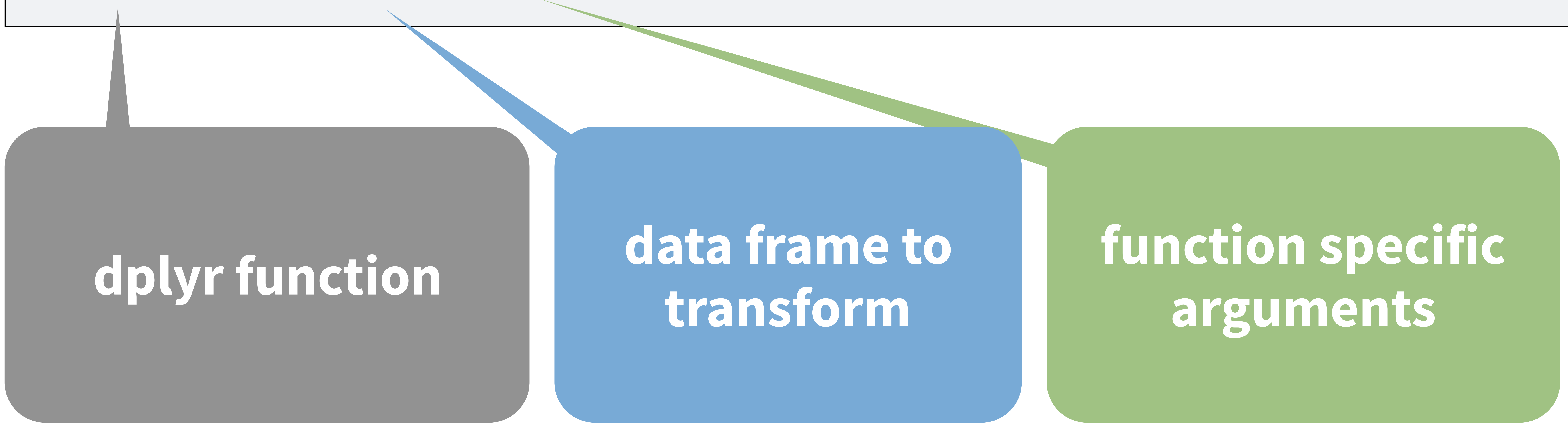
4. Stringing together many tests (when you could use %in%)

```
filter(gapminder, country == "New Zealand" |
  country == "Canada" | country == "United States")
filter(gapminder,
  country %in% c("New Zealand", "Canada", "United States"))
```

common syntax

Each function takes a data frame / tibble as its first argument and returns a data frame / tibble.

```
filter(.data, ...)
```



Adapted from 'Master the tidyverse' CC by RStudio

mutate()

mutate()

Create new columns.

```
mutate(gapminder, gpd = gdpPercap * pop)
```

gapminder

country	continent	year	...
Afghanistan	Asia	1952	
Afghanistan	Asia	1957	
Afghanistan	Asia	1962	
Afghanistan	Asia	1967	
Afghanistan	Asia	1972	
Afghanistan	Asia	1977	

→

country	continent	year	...	gdp
Afghanistan	Asia	1952		6567086330
Afghanistan	Asia	1957		7585448670
Afghanistan	Asia	1962		8758855797
Afghanistan	Asia	1967		9648014150
Afghanistan	Asia	1972		9678553274
Afghanistan	Asia	1977		11697659231

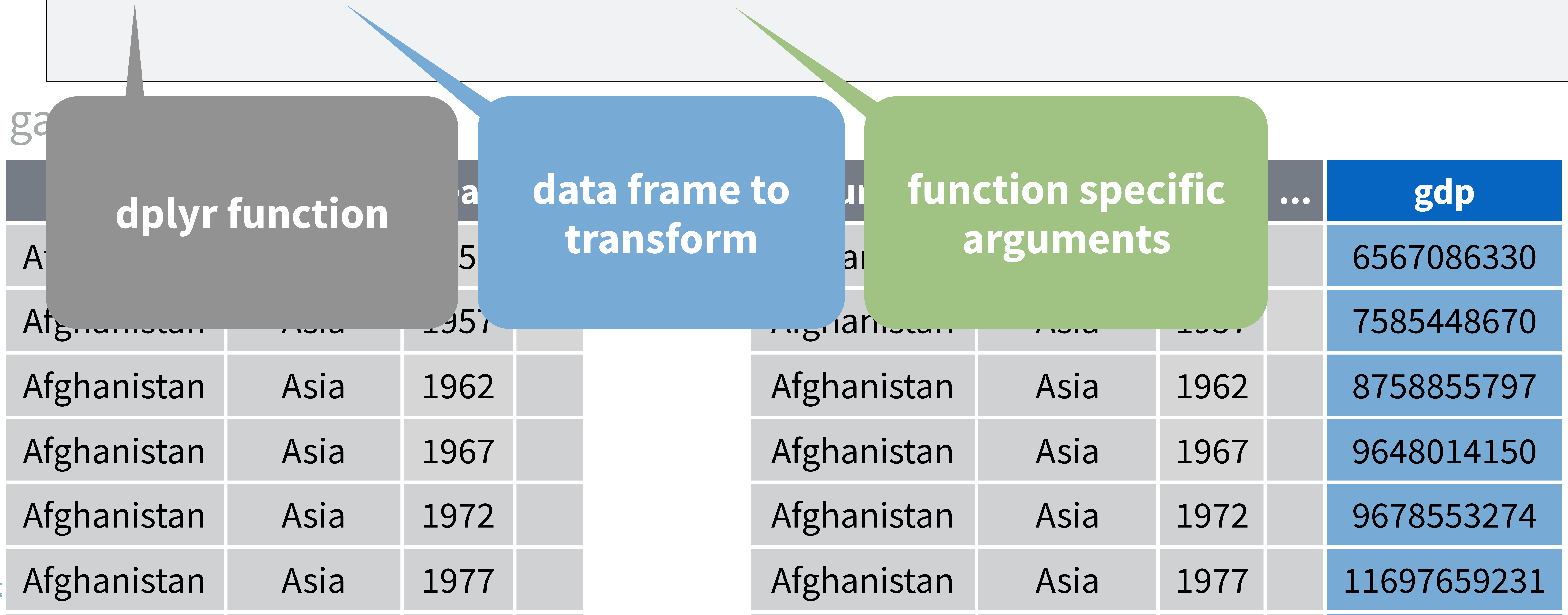
Ac

dplyr

mutate()

Create new columns.

```
mutate(gapminder, gpd = gdpPercap * pop)
```



Af		5	
Afghanistan	Asia	1957	
Afghanistan	Asia	1962	
Afghanistan	Asia	1967	
Afghanistan	Asia	1972	
Afghanistan	Asia	1977	

			...	gdp
				6567086330
Afghanistan	Asia	1957		7585448670
Afghanistan	Asia	1962		8758855797
Afghanistan	Asia	1967		9648014150
Afghanistan	Asia	1972		9678553274
Afghanistan	Asia	1977		11697659231

Ac

mutate()

Create new columns.

```
mutate(gapminder, gpd = gdpPercap * pop,
                  pop_mill = round(pop/1000000))
```

gapminder

country	continent	year	...
Afghanistan	Asia	1952	
Afghanistan	Asia	1957	
Afghanistan	Asia	1962	
Afghanistan	Asia	1967	
Afghanistan	Asia	1972	
Afghanistan	Asia	1977	

country	continent	year	...	gdp	pop_mill
Afghanistan	Asia	1952		6567086330	8
Afghanistan	Asia	1957		7585448670	9
Afghanistan	Asia	1962		8758855797	10
Afghanistan	Asia	1967		9648014150	12
Afghanistan	Asia	1972		9678553274	13
Afghanistan	Asia	1977		11697659231	15

Ac

round()

Round a number to a specified number of decimal digits (0 by default)

```
x <- c(1.2, 1/3, 10.01)
round(x)
[1]  1  0 10
round(x, digits = 2)
[1]  1.20  0.33 10.01
```

When used in `mutate()` the argument will be a column name

```
mutate(gapminder, gpd = gdpPercap * pop,
                  pop_mill = round(pop/1000000))
```

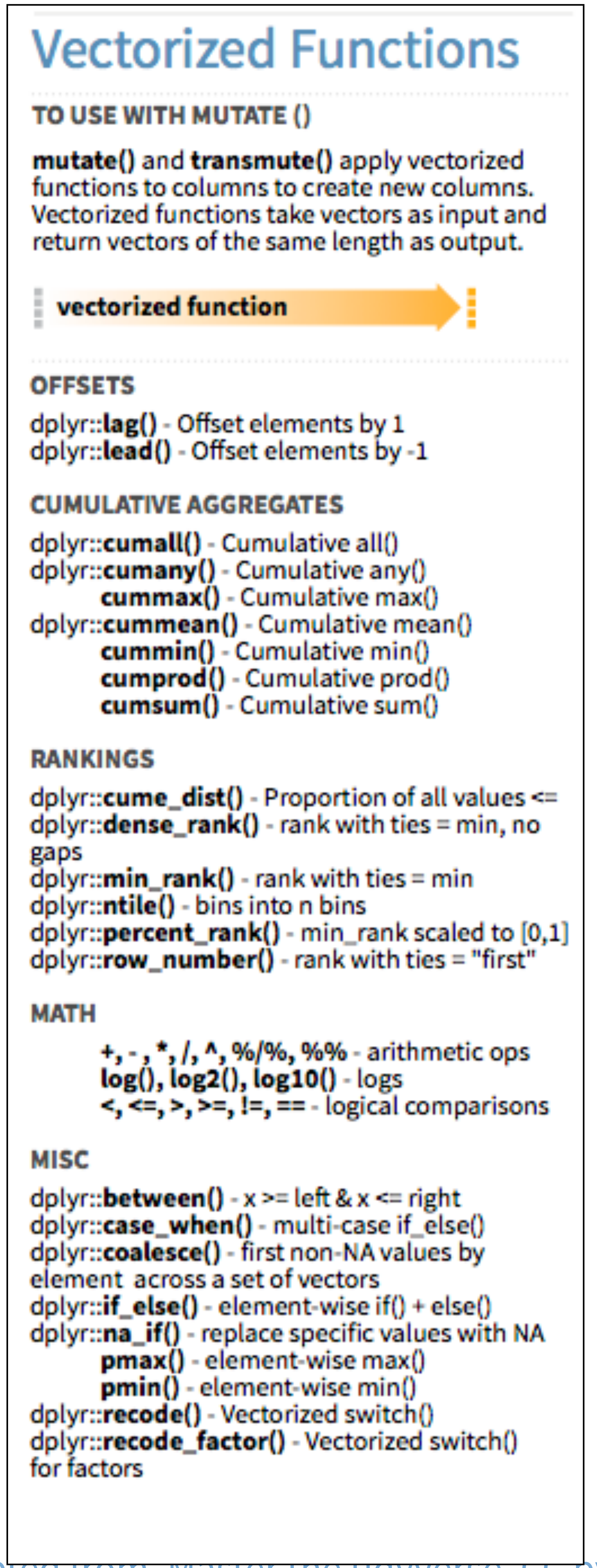
dplyr

[Adapted from 'Master the tidyverse' CC by RStudio]

Vectorized functions

Take a vector as input.

Return a vector of the same length as output.



Vectorized Functions

TO USE WITH MUTATE ()

mutate() and **transmute()** apply vectorized functions to columns to create new columns. Vectorized functions take vectors as input and return vectors of the same length as output.

vectorized function

OFFSETS

dplyr::**lag()** - Offset elements by 1
dplyr::**lead()** - Offset elements by -1

CUMULATIVE AGGREGATES

dplyr::**cumall()** - Cumulative all()
dplyr::**cumany()** - Cumulative any()
cummax() - Cumulative max()
dplyr::**cummean()** - Cumulative mean()
cummin() - Cumulative min()
cumprod() - Cumulative prod()
cumsum() - Cumulative sum()

RANKINGS

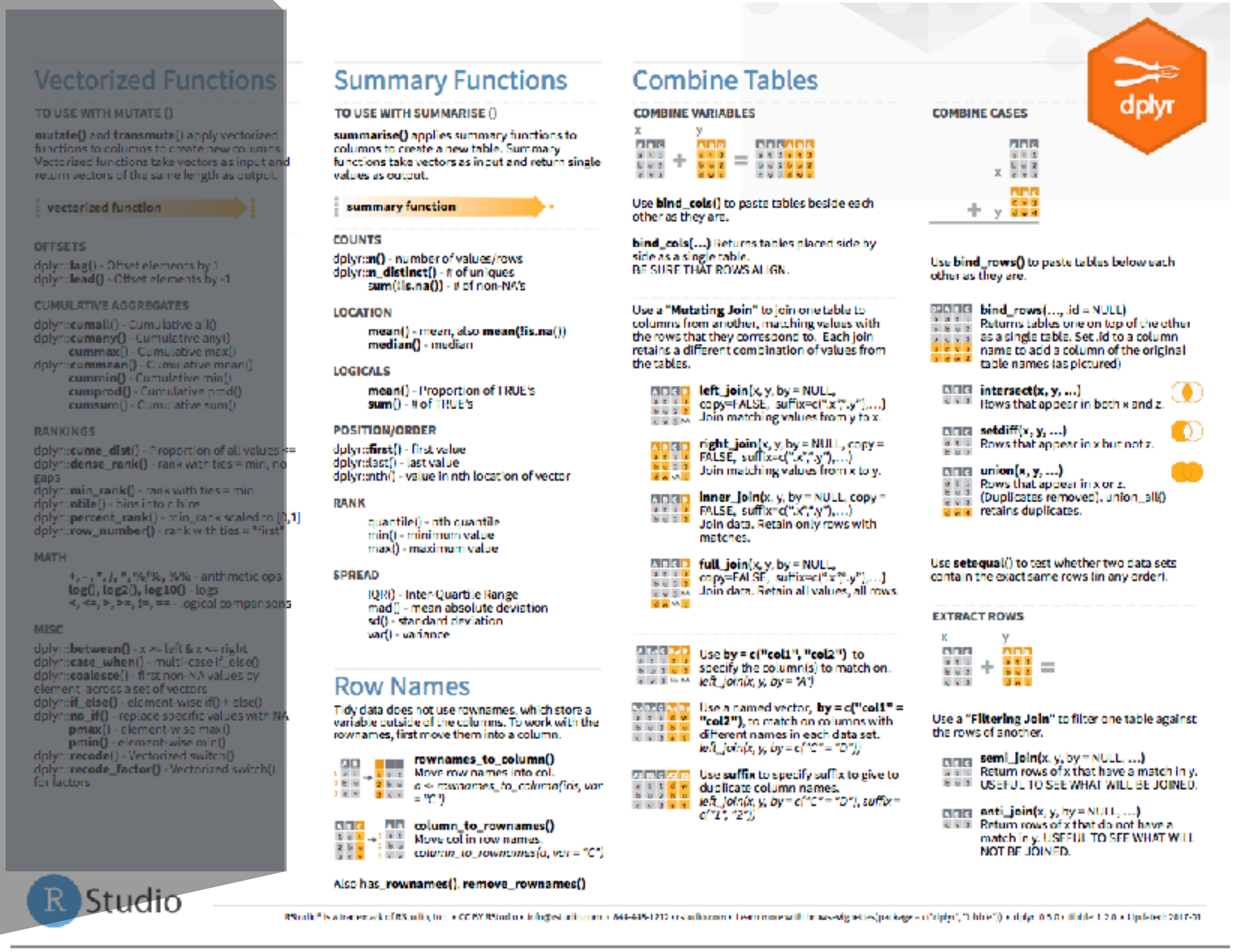
dplyr::**cume_dist()** - Proportion of all values <=
dplyr::**dense_rank()** - rank with ties = min, no gaps
dplyr::**min_rank()** - rank with ties = min
dplyr::**ntile()** - bins into n bins
dplyr::**percent_rank()** - min_rank scaled to [0,1]
dplyr::**row_number()** - rank with ties = "first"

MATH

+, - , *, /, ^, %/%, %% - arithmetic ops
log(), log2(), log10() - logs
<, <=, >, >=, !=, == - logical comparisons

MISC

dplyr::**between()** - x >= left & x <= right
dplyr::**case_when()** - multi-case if_else()
dplyr::**coalesce()** - first non-NA values by element across a set of vectors
dplyr::**if_else()** - element-wise if() + else()
dplyr::**na_if()** - replace specific values with NA
pmax() - element-wise max()
pmin() - element-wise min()
dplyr::**recode()** - Vectorized switch()
dplyr::**recode_factor()** - Vectorized switch() for factors



Most useful:

- Math
- Misc

min_rank()

A goto ranking function (ties share the lowest rank)

```r
min_rank(c(50, 100, 1000))
# [1] 1 2 3
```

```r
min_rank(desc(c(50, 100, 1000)))
# [1] 3 2 1
```

Your Turn 3

Add an `africa` column, which contains TRUE is the country is on the Africa continent.

Add a `rank_pop` column to rank each row in gapminder from largest `pop` to smallest `pop`.

02:00

```
mutate(gapminder,
  africa = continent == "Africa",
  rank_pop = min_rank(desc(pop)))
## # A tibble: 1,704 x 8
##       country continent  year lifeExp      pop gdpPercap africa rank_pop
##        <fctr>    <fctr> <int>   <dbl>    <int>     <dbl>  <lgl>    <int>
## 1 Afghanistan      Asia  1952  28.801  8425333  779.4453  FALSE      762
## 2 Afghanistan      Asia  1957  30.332  9240934  820.8530  FALSE      706
## 3 Afghanistan      Asia  1962  31.997 10267083  853.1007  FALSE      638
## 4 Afghanistan      Asia  1967  34.020 11537966  836.1971  FALSE      576
## 5 Afghanistan      Asia  1972  36.088 13079460  739.9811  FALSE      536
```

%>%

Multistep Operations

Consider the following:

Add a new column for rank, **then**

Extract rows with rank lower than 10

Use intermediate variables:

```
gapminder_ranked <- mutate(gapminder,
                          rank = min_rank(desc(pop)))
filter(gapminder_ranked, rank < 10)
```

Multistep Operations

Consider the following:

Add a new column for rank, **then**

Extract rows with rank lower than 10

Do it all in one line:

```
filter(mutate(gapminder,
              rank = min_rank(desc(pop))),
    rank < 10)
```

Multistep Operations

Consider the following:

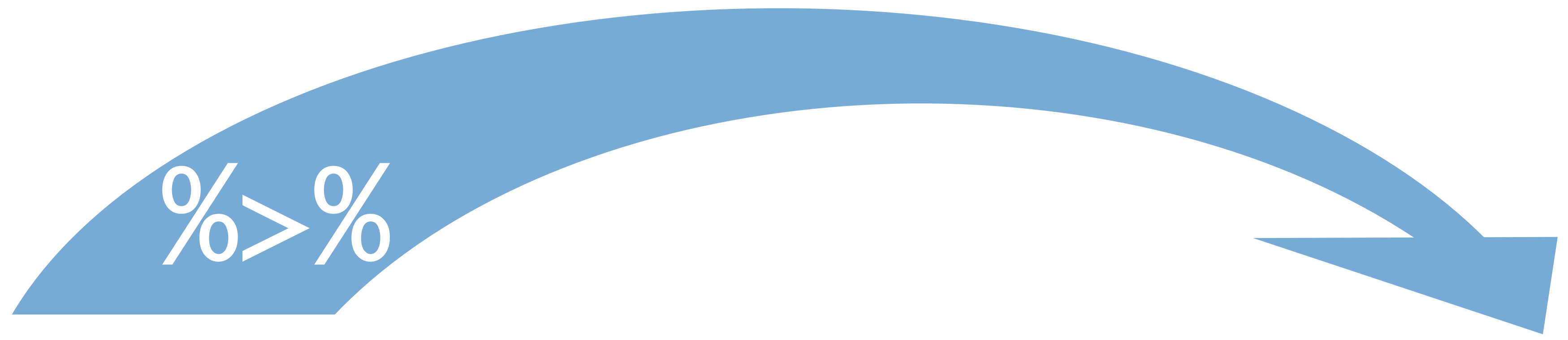
Add a new column for rank, **then**

Extract rows with rank lower than 10

Do it all in one line:

```
filter(mutate(gapminder, rank = min_rank(desc(pop))),
rank < 10)
```

The pipe operator %>%



```
gapminder          filter(______, country == "Canada")
```

Passes result on left into first argument of function on right.
So, for example, these do the same thing. Try it.

```
filter(gapminder, country == "Canada")
gapminder %>% filter(country == "Canada")
```

Pipes

```r
gapminder_ranked <- mutate(gapminder,
                           rank = min_rank(desc(pop)))
filter(gapminder_ranked, rank < 10)
```

```r
gapminder %>%
  mutate(rank = min_rank(desc(prop))) %>%
  filter(rank < 10)
```

Consider the following:

Add a new column for rank, **then**

Extract rows with rank lower than 10

Shortcut to type %>%

Cmd + Shift + M (Mac)

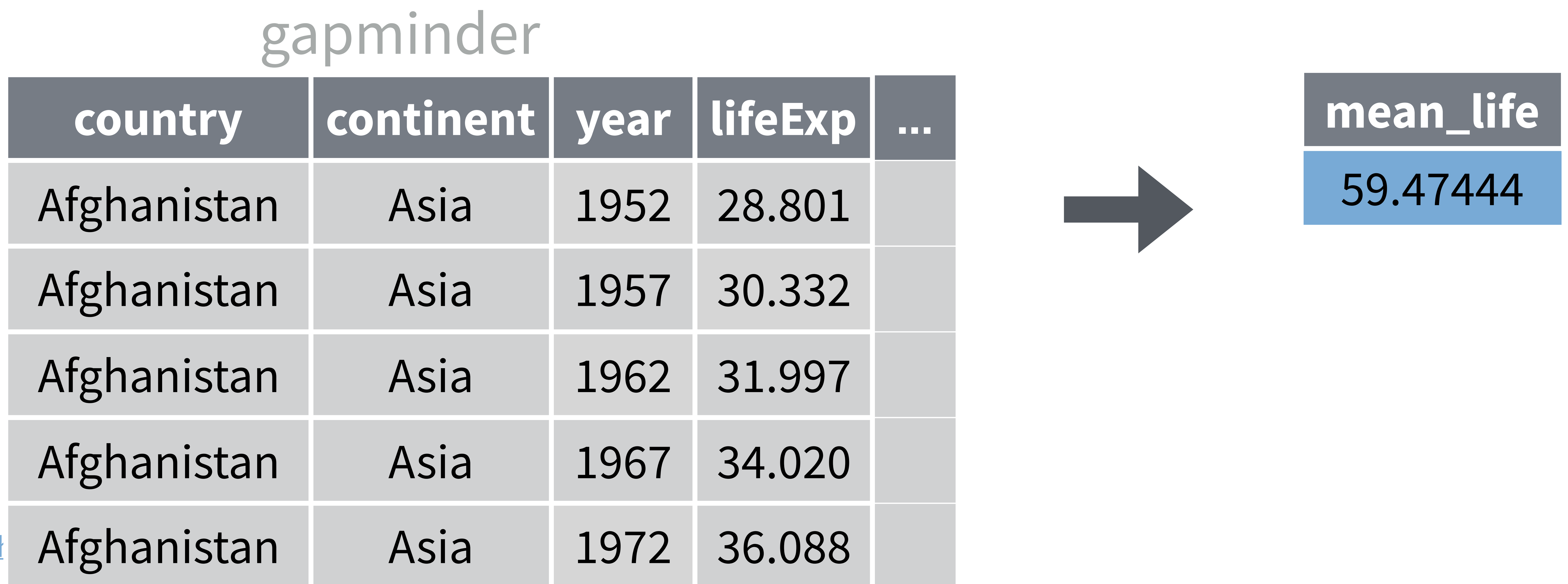
Ctrl + Shift + M (Windows)

summarise()

summarise()

Compute table of summaries.

```
gapminder %>% summarise(mean_life = mean(lifeExp))
summarise(gapminder, mean_life = mean(lifeExp))
```



gapminder

country	continent	year	lifeExp	...
Afghanistan	Asia	1952	28.801	
Afghanistan	Asia	1957	30.332	
Afghanistan	Asia	1962	31.997	
Afghanistan	Asia	1967	34.020	
Afghanistan	Asia	1972	36.088	

mean_life
59.47444

Adapted from 'Master tl

summarise()

Compute table of summaries.

```
gapminder %>% summarise(mean_life = mean(lifeExp),
                        min_life = min(lifeExp))
```

gapminder

country	continent	year	lifeExp	...
Afghanistan	Asia	1952	28.801	
Afghanistan	Asia	1957	30.332	
Afghanistan	Asia	1962	31.997	
Afghanistan	Asia	1967	34.020	
Afghanistan	Asia	1972	36.088	

→

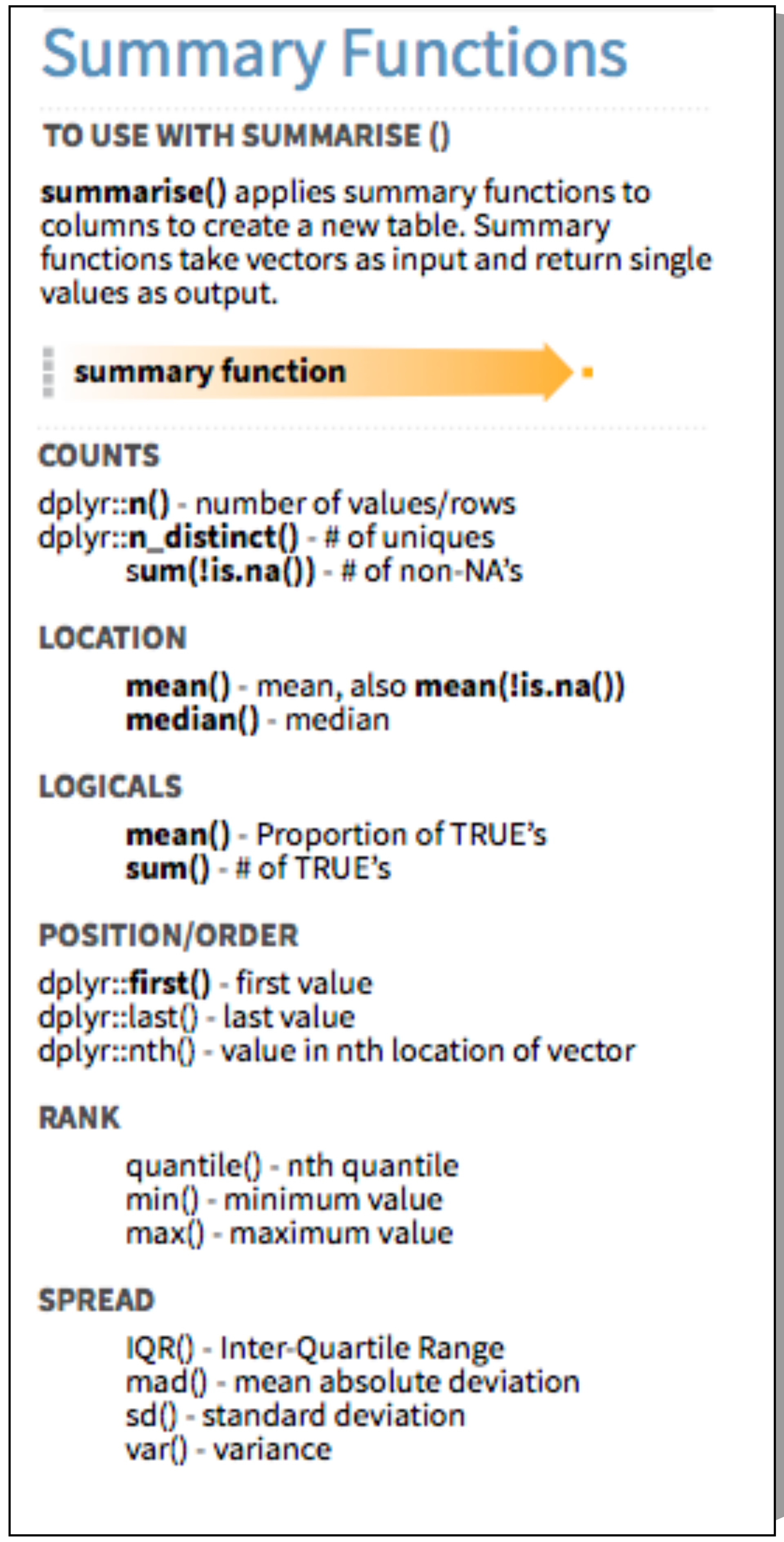
mean_life	min_life
59.47444	23.599

Adapted from 'Master th

dplyr

Summary functions

Take a vector as input.
Return a single value as output.



Summary Functions

TO USE WITH SUMMARISE ()

summarise() applies summary functions to columns to create a new table. Summary functions take vectors as input and return single values as output.

summary function

COUNTS

dplyr::**n()** - number of values/rows
dplyr::**n_distinct()** - # of uniques
sum(!is.na()) - # of non-NA's

LOCATION

mean() - mean, also **mean(!is.na())**
median() - median

LOGICALS

mean() - Proportion of TRUE's
sum() - # of TRUE's

POSITION/ORDER

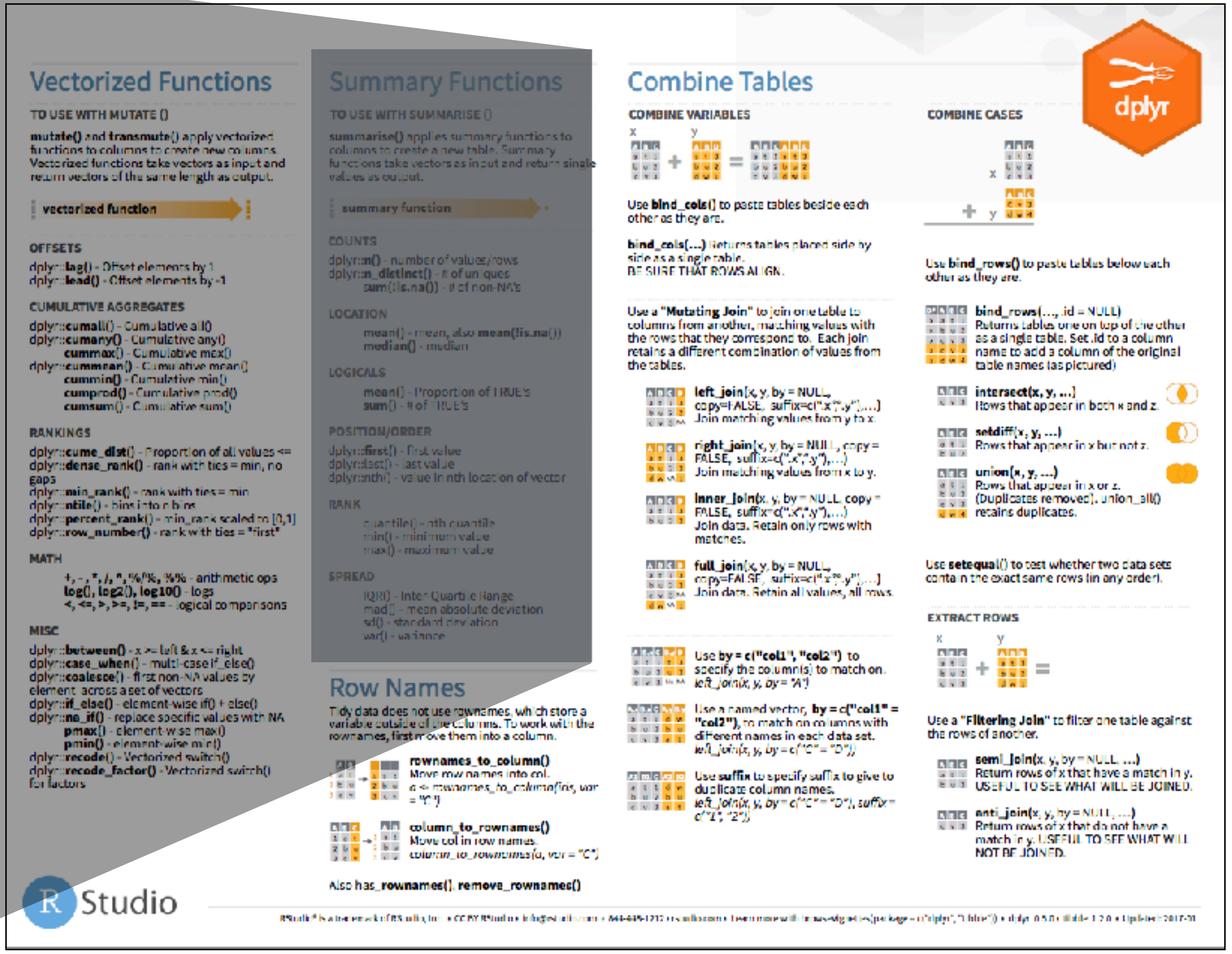
dplyr::**first()** - first value
dplyr::last() - last value
dplyr::nth() - value in nth location of vector

RANK

quantile() - nth quantile
min() - minimum value
max() - maximum value

SPREAD

IQR() - Inter-Quartile Range
mad() - mean absolute deviation
sd() - standard deviation
var() - variance



Vectorized Functions

Summary Functions

Combine Tables

Row Names

RStudio

Adapted from 'Master the tidyverse' CC by RStudio

Your Turn 4

Use summarise() to compute three statistics *about the data*:

1. The first (minimum) year in the dataset
2. The last (maximum) year in the dataset
3. The number of countries represented in the data (Hint: use cheatsheet)

03:00

```
gapminder %>%
  summarise(first = min(year),
            last = max(year),
            n_countries = n_distinct(country))

# A tibble: 1 x 3
#   first  last n_countries
#   <dbl> <dbl>       <int>
# 1  1952  2007         142
```

Your Turn 5

Extract the rows where **continent == "Africa" and year == 2007**.

Then use summarise() and summary functions to find:

1. The number of unique countries
2. The median life expectancy

03:00

```
gapminder %>%
  filter(continent == "Africa", year == 2007) %>%
  summarise(n_countries = n_distinct(country), med_le = median(lifeExp))

## A tibble: 1 x 2
#  n_countries med_life_exp
#        <int>        <dbl>
#1          52      52.9265
```

Grouping cases

group_by()

Groups cases by common values of one or more columns.

```
gapminder %>%
  group_by(continent)
```

In console

```
# A tibble: 1,704 x 6
# Groups:    continent [5]
      country continent  year lifeExp      pop gdpPercap
       <fctr>    <fctr> <int>   <dbl>    <int>     <dbl>
1 Afghanistan      Asia  1952  28.801  8425333  779.4453
2 Afghanistan      Asia  1957  30.332  9240934  820.8530
3 Afghanistan      Asia  1962  31.997 10267083  853.1007
```

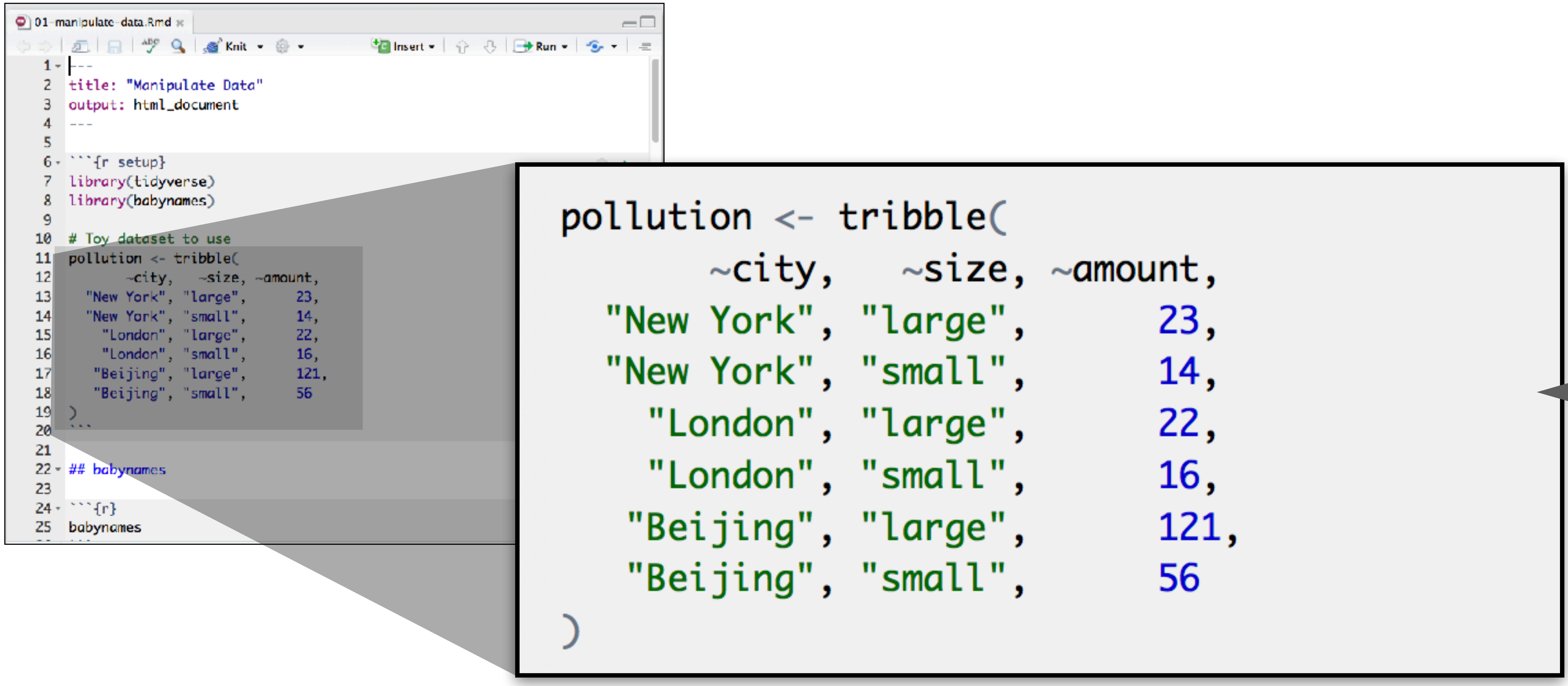
group_by()

Groups cases by common values, then summarise acts by group

```
gapminder %>%
  group_by(continent) %>%
  summarise(n_countries = n_distinct(country))
```

continent	n_countries
Africa	52
Americas	25
Asia	33
Europe	30
Oceania	2

Manipulate Data Notebook



~~~~
---
title: "Manipulate Data"
output: html_document
---

```{r setup}
library(tidyverse)
library(babynames)

# Toy dataset to use
pollution <- tribble(
       ~city,   ~size, ~amount,
  "New York", "large",      23,
  "New York", "small",      14,
    "London", "large",      22,
    "London", "small",      16,
   "Beijing", "large",     121,
   "Beijing", "small",      56
)
```

## babynames

```{r}
babynames
~~~~

```
pollution <- tribble(
       ~city,   ~size, ~amount,
  "New York", "large",      23,
  "New York", "small",      14,
    "London", "large",      22,
    "London", "small",      16,
   "Beijing", "large",     121,
   "Beijing", "small",      56
)
```

Toy data set to practice with

Adapted from 'Master the tidyverse' CC by RStudio

```r
pollution <- tribble(
       ~city,    ~size, ~amount,
  "New York", "large",      23,
  "New York", "small",      14,
    "London", "large",      22,
    "London", "small",      16,
   "Beijing", "large",     121,
   "Beijing", "small",      56
)
```

pollution

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

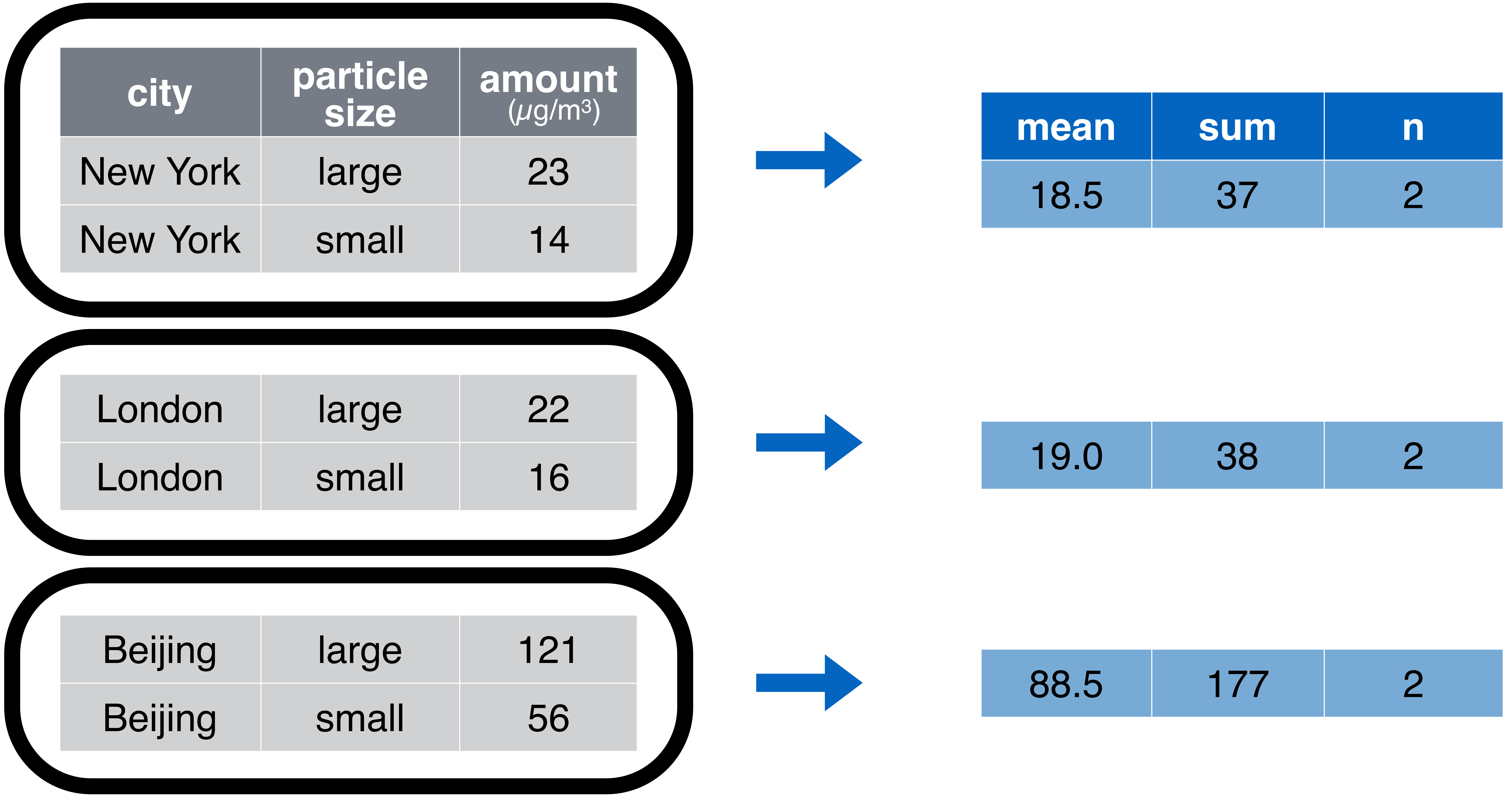
mean	sum	n
42	252	6

```
pollution %>%
 summarise(mean = mean(amount), sum = sum(amount), n = n())
```

Ada

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

mean	sum	n
42	252	6

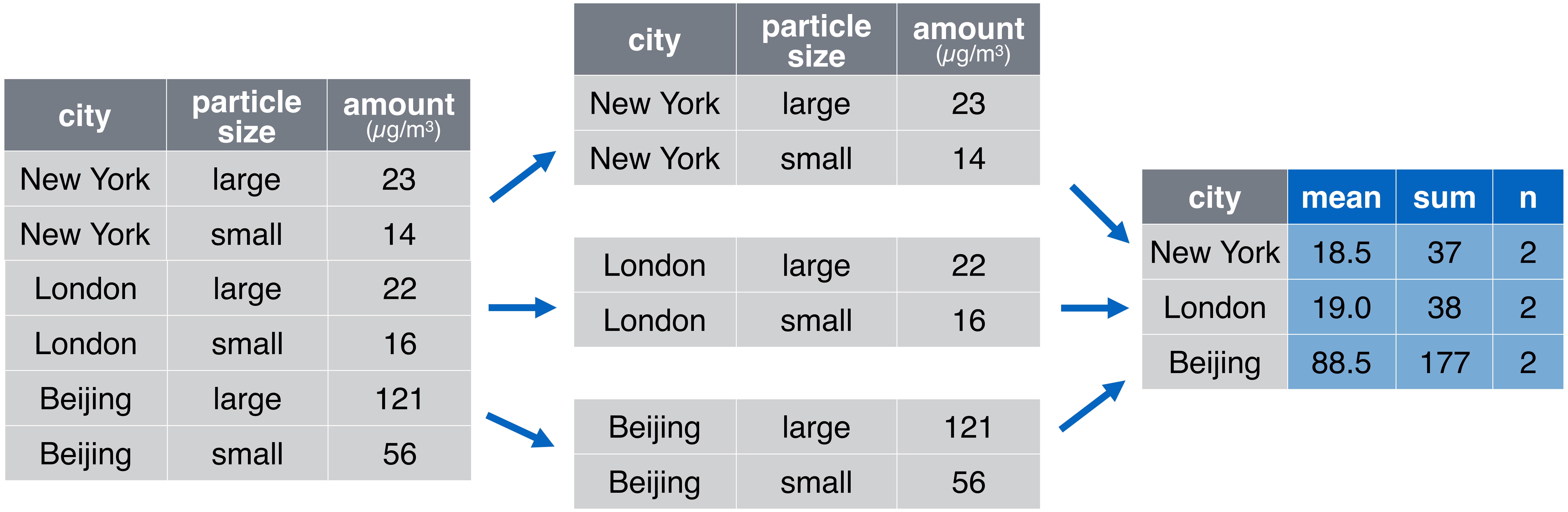


city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

mean	sum	n
18.5	37	2
19.0	38	2
88.5	177	2

group_by() + summarise()

group_by()



city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14

London	large	22
London	small	16

Beijing	large	121
Beijing	small	56

city	mean	sum	n
New York	18.5	37	2
London	19.0	38	2
Beijing	88.5	177	2

```
pollution %>%
  group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

Ada

Your Turn 6

Find the median life expectancy by continent

05:00

```
gapminder %>%
  group_by(continent) %>%
  summarise(med_life_exp = median(lifeExp))
# # A tibble: 5 x 2
#   continent med_life_exp
#      <fctr>        <dbl>
# 1    Africa      47.7920
# 2  Americas      67.0480
# 3      Asia      61.7915
# 4    Europe      72.2410
# 5   Oceania      73.6650
```

Adapted from 'Master the tidyverse' CC by RStudio

Final task

I want to find the country with **biggest jump** in life expectancy (between any two consecutive records) for each continent.

lag()

Gives previous (based on order in data) value

```
lag(c(1, 2, 3))
# [1] NA  1  2
```

Your Turn 7

Brainstorm with your neighbour

What sequence of operations would you need to do?

05:00

Your Turn 8

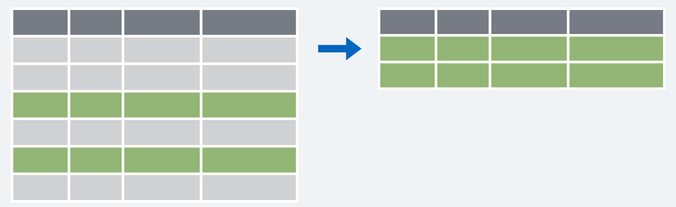
Putting it all together

Find the country with biggest jump in life expectancy (between any two consecutive records) for each continent.

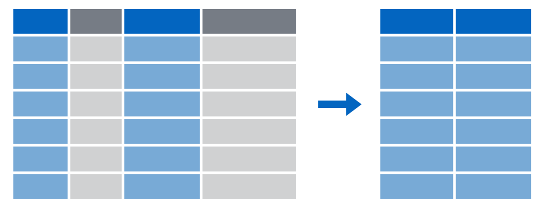
05:00

```r
# One of many solutions
gapminder %>%
  group_by(country) %>%
  mutate(jump = lifeExp - lag(lifeExp)) %>%
  group_by(continent) %>%
  mutate(rank = min_rank(desc(jump))) %>%
  filter(rank == 1)
```

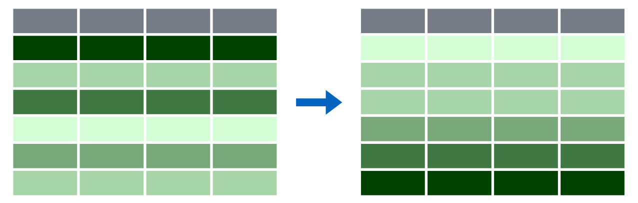
dplyr: Data manipulation verbs



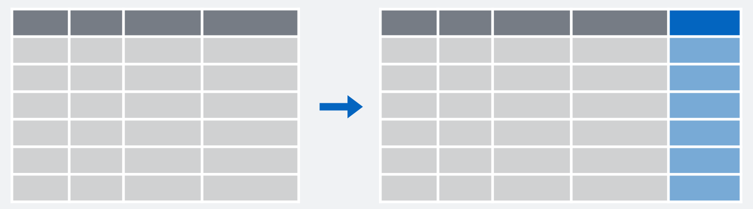
Extract cases with **filter()**



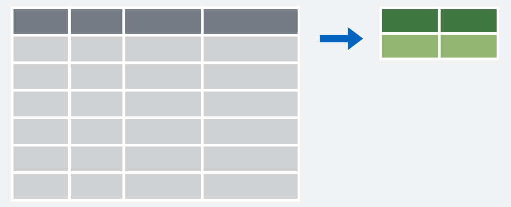
Extract variables with **select()**



Arrange cases, with **arrange()**.



Make new variables, with **mutate()**.



Make tables of summaries with **summarise()**.

along with **group_by()**

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