Data Wrangling with `dplyr`

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Setup

The package suite `tidyverse()` which includes the package `dplyr` needs to be included. Also, the package `gapminder` needs to be installed prior to running the commands below. For installing `dplyr`, type `install.packages("dplyr")` or equivalently for `tidyverse`, type `install.packages("tidyverse")`. To install `gapminder`, type `install.packages("gapminder")` in the RStudio console.

```
(data_gapminder <- gapminder::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
```

```
#what is the format: wide or long?
#what is a tibble?
```

Notes

1. **Data Types**: R has many in-built data types. Examples:
   i. `fct`: "factor": categorical data which can assume finite levels, say A, B, C etc.
   ii. `dbl`: "double": real numbers, say 3.671, 4.00, 10.122482929 etc.
   iii. `int`: "integer": integers, say 3, 10, -9, 0 etc.
   iv. `chr`: "character": say, "FMC", "Term 4" etc.
   v. `lgl`: "logical": $\{0, 1\} \equiv \{\text{T, F}\}$
   vi. `date`, and many more
2. **Tibbles**: Tibbles are essentially data frames, but slightly altered to work better in tidyverse. (Compare `head(data_frame_name)` versus `tibble_name`.)

`dplyr()`: The Main Verbs

1. `filter()`: Extract rows
2. `select()`: Extract columns
3. `arrange()`: Order rows
4. `mutate()`: Create new columns (= variables)
5. `summarise()`: Compute summary statistics

The syntax for all five verbs is similar. The first argument is the data frame, followed by the action to be performed using the variable name.

Filter

Let us observe the state of the world in 1952 and the contrast and compare with that in 2007.

```
(data_1952 <- data_gapminder %>%
  dplyr::filter(year == 1952) #extract the rows for year 1952
 ) #note == as opposed to =
```

```
## # A tibble: 142 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Albania     Europe     1952    55.2  1282697     1601.
##  3 Algeria     Africa     1952    43.1  9279525     2449.
##  4 Angola      Africa     1952    30.0  4232095     3521.
##  5 Argentina   Americas   1952    62.5 17876956     5911.
##  6 Australia   Oceania    1952    69.1  8691212    10040.
##  7 Austria     Europe     1952    66.8  6927772     6137.
##  8 Bahrain     Asia       1952    50.9   120447     9867.
##  9 Bangladesh  Asia       1952    37.5 46886859      684.
## 10 Belgium     Europe     1952    68    8730405     8343.
## # ... with 132 more rows
```

```
(data_2007 <- data_gapminder %>%
  dplyr::filter(year == 2007) #extract the rows for year 2007
 )
```

```
## # A tibble: 142 x 6
##    country     continent  year lifeExp       pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>     <int>     <dbl>
##  1 Afghanistan Asia       2007    43.8  31889923      975.
##  2 Albania     Europe     2007    76.4   3600523     5937.
##  3 Algeria     Africa     2007    72.3  33333216     6223.
##  4 Angola      Africa     2007    42.7  12420476     4797.
##  5 Argentina   Americas   2007    75.3  40301927    12779.
##  6 Australia   Oceania    2007    81.2  20434176    34435.
##  7 Austria     Europe     2007    79.8   8199783    36126.
##  8 Bahrain     Asia       2007    75.6    708573    29796.
##  9 Bangladesh  Asia       2007    64.1 150448339     1391.
## 10 Belgium     Europe     2007    79.4  10392226    33693.
## # ... with 132 more rows
```

Select

Let us also focus on two variables—GDP/capita and life expectancy. We extract both for years 1952 and 2007.

```
(data_1952_gdppc <- data_1952 %>%
  dplyr::select(country, year, gdpPercap)
 )
```

```
## # A tibble: 142 x 3
##    country      year gdpPercap
##    <fct>       <int>     <dbl>
##  1 Afghanistan  1952      779.
##  2 Albania      1952     1601.
##  3 Algeria      1952     2449.
##  4 Angola       1952     3521.
##  5 Argentina    1952     5911.
##  6 Australia    1952    10040.
##  7 Austria      1952     6137.
##  8 Bahrain      1952     9867.
##  9 Bangladesh   1952      684.
## 10 Belgium      1952     8343.
## # ... with 132 more rows
```

```
(data_2007_gdppc <- data_2007 %>%
  dplyr::select(country, year, gdpPercap)
 )
```

```
## # A tibble: 142 x 3
##    country      year gdpPercap
##    <fct>       <int>     <dbl>
##  1 Afghanistan  2007      975.
##  2 Albania      2007     5937.
##  3 Algeria      2007     6223.
##  4 Angola       2007     4797.
##  5 Argentina    2007    12779.
##  6 Australia    2007    34435.
##  7 Austria      2007    36126.
##  8 Bahrain      2007    29796.
##  9 Bangladesh   2007     1391.
## 10 Belgium      2007    33693.
## # ... with 132 more rows
```

```
(data_1952_life_exp <- data_1952 %>%
  dplyr::select(country, year, lifeExp)
 )
```

```
## # A tibble: 142 x 3
##    country      year lifeExp
##    <fct>       <int>   <dbl>
##  1 Afghanistan  1952    28.8
##  2 Albania      1952    55.2
##  3 Algeria      1952    43.1
##  4 Angola       1952    30.0
##  5 Argentina    1952    62.5
##  6 Australia    1952    69.1
##  7 Austria      1952    66.8
##  8 Bahrain      1952    50.9
##  9 Bangladesh   1952    37.5
## 10 Belgium      1952    68
## # ... with 132 more rows
```

```
(data_2007_life_exp <- data_2007 %>%
  dplyr::select(country, year, lifeExp)
 )
```

```
## # A tibble: 142 x 3
##    country      year lifeExp
##    <fct>       <int>   <dbl>
##  1 Afghanistan  2007    43.8
##  2 Albania      2007    76.4
##  3 Algeria      2007    72.3
##  4 Angola       2007    42.7
##  5 Argentina    2007    75.3
##  6 Australia    2007    81.2
##  7 Austria      2007    79.8
##  8 Bahrain      2007    75.6
##  9 Bangladesh   2007    64.1
## 10 Belgium      2007    79.4
## # ... with 132 more rows
```

```
# = dplyr::select(-c(continent, pop, gdpPercap))
```

`dplyr::rename()` is a wrapper function for `select()` which renames the variable in consideration and keeps all other variables intact.

Arrange

Usage of `arrange()` orders (from first to last) entries on the basis of a variable.

Question: Is the set of richest countries the same in 1952 and 2007?

```
(data_1952_rich <- data_1952_gdppc %>%
  dplyr::arrange(desc(gdpPercap)) #note the use of desc()
 )
```

```
## # A tibble: 142 x 3
##    country          year gdpPercap
##    <fct>           <int>     <dbl>
##  1 Kuwait           1952   108382.
##  2 Switzerland      1952    14734.
##  3 United States    1952    13990.
##  4 Canada           1952    11367.
##  5 New Zealand      1952    10557.
##  6 Norway           1952    10095.
##  7 Australia        1952    10040.
##  8 United Kingdom   1952     9980.
##  9 Bahrain         1952     9867.
## 10 Denmark         1952     9692.
## # ... with 132 more rows
```

```
(data_2007_rich <- data_2007_gdppc %>%
  dplyr::arrange(desc(gdpPercap)) #note the use of desc()
 )
```

```
## # A tibble: 142 x 3
##    country           year gdpPercap
##    <fct>            <int>     <dbl>
##  1 Norway            2007    49357.
##  2 Kuwait            2007    47307.
##  3 Singapore         2007    47143.
##  4 United States     2007    42952.
##  5 Ireland           2007    40676.
##  6 Hong Kong, China  2007    39725.
##  7 Switzerland       2007    37506.
##  8 Netherlands       2007    36798.
##  9 Canada            2007    36319.
## 10 Iceland           2007    36181.
## # ... with 132 more rows
```

Which countries display the highest life expectancy pre-2000?

```
(data_life_pre00 <- data_gapminder %>%
  dplyr::select(country, year, lifeExp) %>%
  dplyr::filter(year <= 2000) %>%
  dplyr::arrange(desc(lifeExp))
 )
```

```
## # A tibble: 1,420 x 3
##    country           year lifeExp
##    <fct>            <int>   <dbl>
##  1 Japan             1997    80.7
##  2 Hong Kong, China  1997    80
##  3 Sweden            1997    79.4
##  4 Switzerland       1997    79.4
##  5 Japan             1992    79.4
##  6 Iceland           1997    79.0
##  7 Australia         1997    78.8
##  8 Italy             1997    78.8
##  9 Iceland           1992    78.8
## 10 Spain             1997    78.8
## # ... with 1,410 more rows
```

Post-2000?

```
(data_life_post00 <- data_gapminder %>%
  dplyr::select(country, year, lifeExp) %>%
  dplyr::filter(year > 2000) %>%
  dplyr::arrange(desc(lifeExp))
 )
```

```
## # A tibble: 284 x 3
##    country           year lifeExp
##    <fct>            <int>   <dbl>
##  1 Japan             2007    82.6
##  2 Hong Kong, China  2007    82.2
##  3 Japan             2002    82
##  4 Iceland           2007    81.8
##  5 Switzerland       2007    81.7
##  6 Hong Kong, China  2002    81.5
##  7 Australia         2007    81.2
##  8 Spain             2007    80.9
##  9 Sweden            2007    80.9
## 10 Israel            2007    80.7
## # ... with 274 more rows
```

Mutate

Let's define a new variable called "total GDP" which is the product of the GDP/capita and the total population. To compute it and include it in the list of variables we can use the verb `dplyr::mutate()`.

```r
(data_GDP_tot <- data_gapminder %>%
   dplyr::mutate(GDP_total = pop*gdpPercap/10^9) #in USD billions
 )
```

```
## # A tibble: 1,704 x 7
##    country     continent  year lifeExp      pop gdpPercap GDP_total
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.      6.57
##  2 Afghanistan Asia       1957    30.3  9240934      821.      7.59
##  3 Afghanistan Asia       1962    32.0 10267083      853.      8.76
##  4 Afghanistan Asia       1967    34.0 11537966      836.      9.65
##  5 Afghanistan Asia       1972    36.1 13079460      740.      9.68
##  6 Afghanistan Asia       1977    38.4 14880372      786.     11.7
##  7 Afghanistan Asia       1982    39.9 12881816      978.     12.6
##  8 Afghanistan Asia       1987    40.8 13867957      852.     11.8
##  9 Afghanistan Asia       1992    41.7 16317921      649.     10.6
## 10 Afghanistan Asia       1997    41.8 22227415      635.     14.1
## # ... with 1,694 more rows
```

In general, for `mutate()` to work well, the function must take a vector of values as input and return a vector with the same number of values as output. A short list of functions that can be used with `mutate()` are:

1. Arithmetic operators: `+`, `-`, `*`, `/`, `^`
2. Logs: `log()`, `log2()`, `log10()`
3. Cumulative aggregates: `cumsum()`, `cumprod()`, `cummin()`, `cummax()`, `cummean()` etc.

and many more.

Question: Which countries have the highest total GDP in 1952 and 2007?

```
(data_GDP_tot %>%
   dplyr::filter(year == 1952) %>%
   dplyr::arrange(desc(GDP_total))
 )
```

```
## # A tibble: 142 x 7
##    country        continent  year lifeExp       pop gdpPercap GDP_total
##    <fct>          <fct>     <int>   <dbl>     <int>     <dbl>     <dbl>
##  1 United States  Americas   1952    68.4 157553000    13990.     2204.
##  2 United Kingdom Europe     1952    69.2  50430000     9980.      503.
##  3 Germany        Europe     1952    67.5  69145952     7144.      494.
##  4 France         Europe     1952    67.4  42459667     7030.      298.
##  5 Japan          Asia       1952    63.0  86459025     3217.      278.
##  6 Italy          Europe     1952    65.9  47666000     4931.      235.
##  7 China          Asia       1952    44   556263527      400.      223.
##  8 India          Asia       1952    37.4 372000000      547.      203.
##  9 Canada         Americas   1952    68.8  14785584    11367.      168.
## 10 Brazil         Americas   1952    50.9  56602560     2109.      119.
## # ... with 132 more rows
```

```
(data_GDP_tot %>%
   dplyr::filter(year == 2007) %>%
   dplyr::arrange(desc(GDP_total))
 )
```

```
## # A tibble: 142 x 7
##    country        continent  year lifeExp        pop gdpPercap GDP_total
##    <fct>          <fct>     <int>   <dbl>      <int>     <dbl>     <dbl>
##  1 United States  Americas   2007    78.2  301139947    42952.    12934.
##  2 China          Asia       2007    73.0 1318683096     4959.     6540.
##  3 Japan          Asia       2007    82.6  127467972    31656.     4035.
##  4 India          Asia       2007    64.7 1110396331     2452.     2723.
##  5 Germany        Europe     2007    79.4   82400996    32170.     2651.
##  6 United Kingdom Europe     2007    79.4   60776238    33203.     2018.
##  7 France         Europe     2007    80.7   61083916    30470.     1861.
##  8 Brazil         Americas   2007    72.4  190010647     9066.     1723.
##  9 Italy          Europe     2007    80.5   58147733    28570.     1661.
## 10 Mexico         Americas   2007    76.2  108700891    11978.     1302.
## # ... with 132 more rows
```

Question: Which are the five smallest economies in 2007 (by total GDP)?

```r
(data_GDP_tot %>%
   dplyr::filter(year == 2007) %>%
   dplyr::arrange(GDP_total) %>%
   dplyr::filter(rank(GDP_total) <= 5)
 )
```

```
## # A tibble: 5 x 7
##   country                continent  year lifeExp    pop gdpPercap GDP_total
##   <fct>                  <fct>     <int>   <dbl>  <int>     <dbl>     <dbl>
## 1 Sao Tome and Principe Africa     2007    65.5 2.00e5     1598.     0.319
## 2 Comoros               Africa     2007    65.2 7.11e5      986.     0.701
## 3 Guinea-Bissau         Africa     2007    46.4 1.47e6      579.     0.853
## 4 Djibouti              Africa     2007    54.8 4.96e5     2082.     1.03
## 5 Gambia                Africa     2007    59.4 1.69e6      753.     1.27
```

Summarise

The function `summarise()` (or equivalently `summarize()`) can be used to compute summary statistics. Here is an example, where we summarize the variable life expectancy for the continent Europe.

```r
(life_exp_summ_eur <- data_gapminder %>%
  dplyr::filter(continent == "Europe") %>%
  dplyr::summarise(average = mean(lifeExp),
                   med = median(lifeExp),
                   std = sd(lifeExp),
                   variance = var(lifeExp),
                   iqr = IQR(lifeExp)
                   )
 )
```

```
## # A tibble: 1 x 5
##   average   med   std variance   iqr
##     <dbl> <dbl> <dbl>    <dbl> <dbl>
## 1    71.9  72.2  5.43     29.5  5.88
```

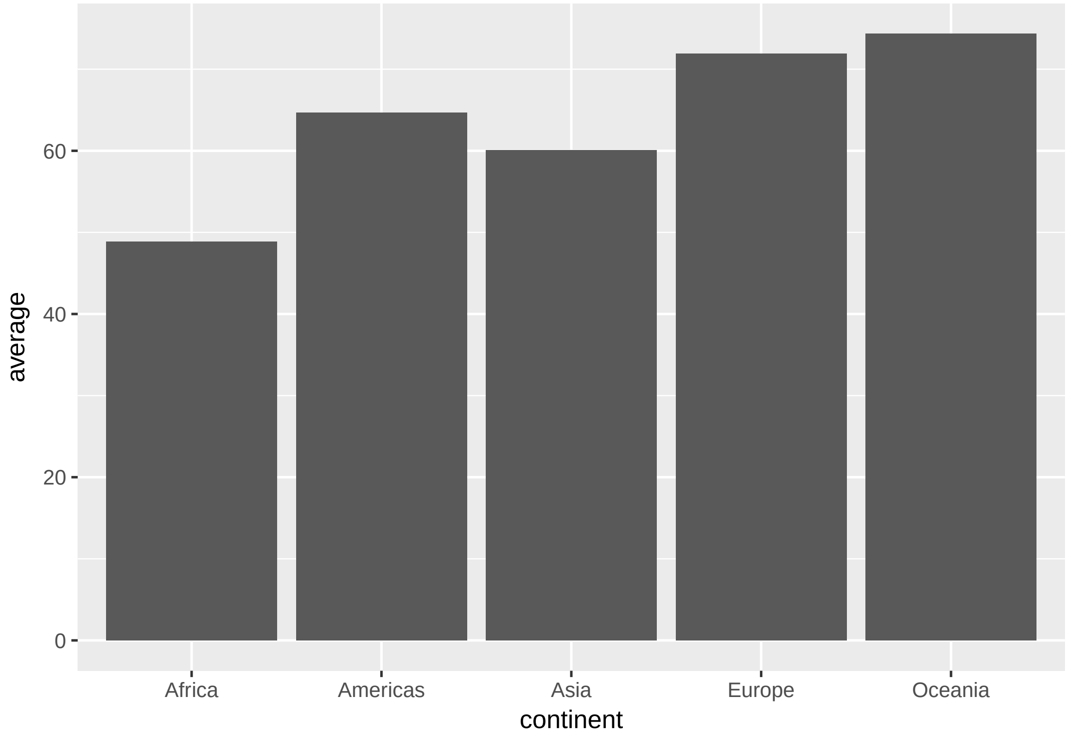
Grouped Summaries

Question: What are continent-wise summary statistics?

```
(summ_life_exp <- data_gapminder %>%
  dplyr::group_by(continent) %>%
  dplyr::summarise(average = mean(lifeExp),
                   med = median(lifeExp),
                   std = sd(lifeExp),
                   variance = var(lifeExp),
                   iqr = IQR(lifeExp)
                   )
 )
```

```
## # A tibble: 5 x 6
##   continent average   med   std variance   iqr
##   <fct>       <dbl> <dbl> <dbl>    <dbl> <dbl>
## 1 Africa       48.9  47.8  9.15     83.7 12.0
## 2 Americas     64.7  67.0  9.35     87.3 13.3
## 3 Asia         60.1  61.8 11.9     141.  18.1
## 4 Europe       71.9  72.2  5.43     29.5  5.88
## 5 Oceania      74.3  73.7  3.80     14.4  6.35
```

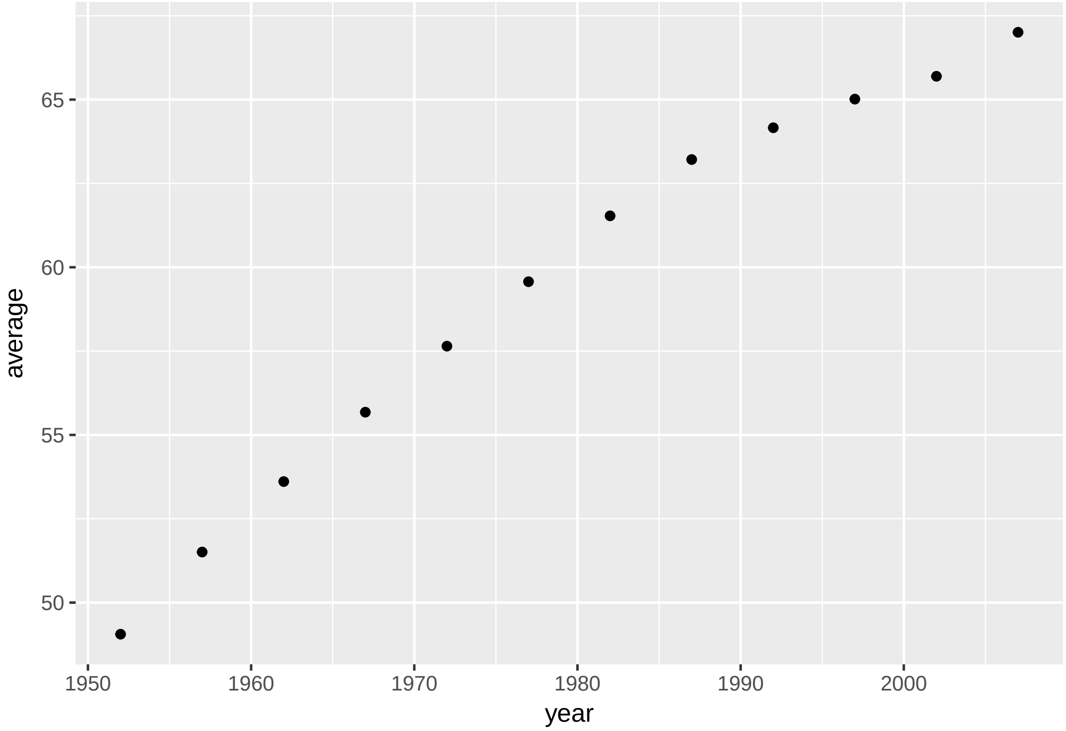
```
ggplot(data = summ_life_exp,
       aes(x = continent, y = average)) +
  geom_bar(stat = "identity")
```



```
(summ_year_life_exp <- data_gapminder %>%
  dplyr::group_by(year) %>%
  dplyr::summarise(average = mean(lifeExp),
                   med = median(lifeExp),
                   std = sd(lifeExp),
                   variance = var(lifeExp),
                   iqr = IQR(lifeExp)
                   )
 )
```

```
## # A tibble: 12 x 6
##     year average   med   std variance   iqr
##    <int>   <dbl> <dbl> <dbl>    <dbl> <dbl>
##  1  1952    49.1  45.1  12.2     149.  20.7
##  2  1957    51.5  48.4  12.2     150.  21.8
##  3  1962    53.6  50.9  12.1     146.  21.8
##  4  1967    55.7  53.8  11.7     137.  21.4
##  5  1972    57.6  56.5  11.4     130.  20.7
##  6  1977    59.6  59.7  11.2     126.  19.9
##  7  1982    61.5  62.4  10.8     116.  18.0
##  8  1987    63.2  65.8  10.6     111.  16.9
##  9  1992    64.2  67.7  11.2     126.  16.5
## 10  1997    65.0  69.4  11.6     134.  18.5
## 11  2002    65.7  70.8  12.3     151.  19.9
## 12  2007    67.0  71.9  12.1     146.  19.3
```

```
ggplot(data = summ_year_life_exp,
       aes(x = year, y = average)) +
  geom_point()
```



One can also perform grouped mutates and grouped filters.