Chapter 4

Chapter 4 The tidyverse

Up to now we have been manipulating vectors by reordering and subsetting them through indexing. However, once we start more advanced analyses, the preferred unit for data storage is not the vector but the data frame. In this chapter we learn to work directly with data frames, which greatly facilitate the organization of information. We will be using data frames for the majority of this book. We will focus on a specific data format referred to as tidy and on specific collection of packages that are particularly helpful for working with tidy data referred to as the tidyverse.

We can load all the tidyverse packages at once by installing and loading the tidyverse package:

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.2     v dplyr   1.0.7
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   2.0.1     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

We will learn how to implement the tidyverse approach throughout the book, but before delving into the details, in this chapter we introduce some of the most widely used tidyverse functionality, starting with the dplyr package for manipulating data frames and the purrr package for working with functions. Note that the tidyverse also includes a graphing package, ggplot2, which we introduce later in Chapter 7 in the Data Visualization part of the book; the readr package discussed in Chapter 5; and many others. In this chapter, we first introduce the concept of tidy data and then demonstrate how we use the tidyverse to work with data frames in this format.

4.1 Tidy data

We say that a data table is in tidy format if each row represents one observation and columns represent the different variables available for each of these observations. The murders dataset is an example of a tidy data frame.

```
#>        state abb region population total
#> 1    Alabama  AL  South    4779736   135
#> 2     Alaska  AK   West     710231    19
#> 3    Arizona  AZ   West    6392017   232
#> 4   Arkansas  AR  South    2915918    93
#> 5 California  CA   West   37253956  1257
#> 6   Colorado  CO   West    5029196    65
```

Each row represent a state with each of the five columns providing a different variable related to these states: name, abbreviation, region, population, and total murders.

To see how the same information can be provided in different formats, consider the following example:

```
#>       country year fertility
#> 1     Germany 1960      2.41
#> 2 South Korea 1960      6.16
#> 3     Germany 1961      2.44
#> 4 South Korea 1961      5.99
#> 5     Germany 1962      2.47
#> 6 South Korea 1962      5.79
```

This tidy dataset provides fertility rates for two countries across the years. This is a tidy dataset because each row presents one observation with the three variables being country, year, and fertility rate. However, this dataset originally came in another format and was reshaped for the dslabs package. Originally, the data was in the following format:

```
#>       country 1960 1961 1962
#> 1     Germany 2.41 2.44 2.47
#> 2 South Korea 6.16 5.99 5.79
```

The same information is provided, but there are two important differences in the format: 1) each row includes several observations and 2) one of the variables, year, is stored in the header. For the tidyverse packages to be optimally used, data need to be reshaped into tidy format, which you will learn to do in the Data Wrangling part of the book. Until then, we will use example datasets that are already in tidy format.

Although not immediately obvious, as you go through the book you will start to appreciate the advantages of working in a framework in which functions use tidy formats for both inputs and outputs. You will see how this permits the data analyst to focus on more important aspects of the analysis rather than the format of the data.

4.2 Exercises

1. Examine the built-in dataset co2. Which of the following is true:

```
co2
```

```
##          Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1959 315.42 316.31 316.50 317.56 318.13 318.00 316.39 314.65 313.68 313.18
## 1960 316.27 316.81 317.42 318.87 319.87 319.43 318.01 315.74 314.00 313.68
## 1961 316.73 317.54 318.38 319.31 320.42 319.61 318.42 316.63 314.83 315.16
## 1962 317.78 318.40 319.53 320.42 320.85 320.45 319.45 317.25 316.11 315.27
## 1963 318.58 318.92 319.70 321.22 322.08 321.31 319.58 317.61 316.05 315.83
## 1964 319.41 320.07 320.74 321.40 322.06 321.73 320.27 318.54 316.54 316.71
## 1965 319.27 320.28 320.73 321.97 322.00 321.71 321.05 318.71 317.66 317.14
## 1966 320.46 321.43 322.23 323.54 323.91 323.59 322.24 320.20 318.48 317.94
## 1967 322.17 322.34 322.88 324.25 324.83 323.93 322.38 320.76 319.10 319.24
## 1968 322.40 322.99 323.73 324.86 325.40 325.20 323.98 321.95 320.18 320.09
## 1969 323.83 324.26 325.47 326.50 327.21 326.54 325.72 323.50 322.22 321.62
## 1970 324.89 325.82 326.77 327.97 327.91 327.50 326.18 324.53 322.93 322.90
## 1971 326.01 326.51 327.01 327.62 328.76 328.40 327.20 325.27 323.20 323.40
## 1972 326.60 327.47 327.58 329.56 329.90 328.92 327.88 326.16 324.68 325.04
```

```
## 1973 328.37 329.40 330.14 331.33 332.31 331.90 330.70 329.15 327.35 327.02
## 1974 329.18 330.55 331.32 332.48 332.92 332.08 331.01 329.23 327.27 327.21
## 1975 330.23 331.25 331.87 333.14 333.80 333.43 331.73 329.90 328.40 328.17
## 1976 331.58 332.39 333.33 334.41 334.71 334.17 332.89 330.77 329.14 328.78
## 1977 332.75 333.24 334.53 335.90 336.57 336.10 334.76 332.59 331.42 330.98
## 1978 334.80 335.22 336.47 337.59 337.84 337.72 336.37 334.51 332.60 332.38
## 1979 336.05 336.59 337.79 338.71 339.30 339.12 337.56 335.92 333.75 333.70
## 1980 337.84 338.19 339.91 340.60 341.29 341.00 339.39 337.43 335.72 335.84
## 1981 339.06 340.30 341.21 342.33 342.74 342.08 340.32 338.26 336.52 336.68
## 1982 340.57 341.44 342.53 343.39 343.96 343.18 341.88 339.65 337.81 337.69
## 1983 341.20 342.35 342.93 344.77 345.58 345.14 343.81 342.21 339.69 339.82
## 1984 343.52 344.33 345.11 346.88 347.25 346.62 345.22 343.11 340.90 341.18
## 1985 344.79 345.82 347.25 348.17 348.74 348.07 346.38 344.51 342.92 342.62
## 1986 346.11 346.78 347.68 349.37 350.03 349.37 347.76 345.73 344.68 343.99
## 1987 347.84 348.29 349.23 350.80 351.66 351.07 349.33 347.92 346.27 346.18
## 1988 350.25 351.54 352.05 353.41 354.04 353.62 352.22 350.27 348.55 348.72
## 1989 352.60 352.92 353.53 355.26 355.52 354.97 353.75 351.52 349.64 349.83
## 1990 353.50 354.55 355.23 356.04 357.00 356.07 354.67 352.76 350.82 351.04
## 1991 354.59 355.63 357.03 358.48 359.22 358.12 356.06 353.92 352.05 352.11
## 1992 355.88 356.63 357.72 359.07 359.58 359.17 356.94 354.92 352.94 353.23
## 1993 356.63 357.10 358.32 359.41 360.23 359.55 357.53 355.48 353.67 353.95
## 1994 358.34 358.89 359.95 361.25 361.67 360.94 359.55 357.49 355.84 356.00
## 1995 359.98 361.03 361.66 363.48 363.82 363.30 361.94 359.50 358.11 357.80
## 1996 362.09 363.29 364.06 364.76 365.45 365.01 363.70 361.54 359.51 359.65
## 1997 363.23 364.06 364.61 366.40 366.84 365.68 364.52 362.57 360.24 360.83
##         Nov    Dec
## 1959 314.66 315.43
## 1960 314.84 316.03
## 1961 315.94 316.85
## 1962 316.53 317.53
## 1963 316.91 318.20
## 1964 317.53 318.55
## 1965 318.70 319.25
## 1966 319.63 320.87
## 1967 320.56 321.80
## 1968 321.16 322.74
## 1969 322.69 323.95
## 1970 323.85 324.96
## 1971 324.63 325.85
## 1972 326.34 327.39
## 1973 327.99 328.48
## 1974 328.29 329.41
## 1975 329.32 330.59
## 1976 330.14 331.52
## 1977 332.24 333.68
## 1978 333.75 334.78
## 1979 335.12 336.56
## 1980 336.93 338.04
## 1981 338.19 339.44
## 1982 339.09 340.32
## 1983 340.98 342.82
## 1984 342.80 344.04
## 1985 344.06 345.38
## 1986 345.48 346.72
```

```
## 1987 347.64 348.78
## 1988 349.91 351.18
## 1989 351.14 352.37
## 1990 352.69 354.07
## 1991 353.64 354.89
## 1992 354.09 355.33
## 1993 355.30 356.78
## 1994 357.59 359.05
## 1995 359.61 360.74
## 1996 360.80 362.38
## 1997 362.49 364.34
```

Answer: d.co2 is not tidy: to be tidy we would have to wrangle it to have three columns (year, month and value), then each co2 observation would have a row.

2. Examine the built-in dataset ChickWeight. Which of the following is true:

```
ChickWeight
```

```
##     weight Time Chick Diet
## 1       42    0     1    1
## 2       51    2     1    1
## 3       59    4     1    1
## 4       64    6     1    1
## 5       76    8     1    1
## 6       93   10     1    1
## 7      106   12     1    1
## 8      125   14     1    1
## 9      149   16     1    1
## 10     171   18     1    1
## 11     199   20     1    1
## 12     205   21     1    1
## 13      40    0     2    1
## 14      49    2     2    1
## 15      58    4     2    1
## 16      72    6     2    1
## 17      84    8     2    1
## 18     103   10     2    1
## 19     122   12     2    1
## 20     138   14     2    1
## 21     162   16     2    1
## 22     187   18     2    1
## 23     209   20     2    1
## 24     215   21     2    1
## 25      43    0     3    1
## 26      39    2     3    1
## 27      55    4     3    1
## 28      67    6     3    1
## 29      84    8     3    1
## 30      99   10     3    1
## 31     115   12     3    1
## 32     138   14     3    1
## 33     163   16     3    1
```

```
## 34     187   18     3     1
## 35     198   20     3     1
## 36     202   21     3     1
## 37      42    0     4     1
## 38      49    2     4     1
## 39      56    4     4     1
## 40      67    6     4     1
## 41      74    8     4     1
## 42      87   10     4     1
## 43     102   12     4     1
## 44     108   14     4     1
## 45     136   16     4     1
## 46     154   18     4     1
## 47     160   20     4     1
## 48     157   21     4     1
## 49      41    0     5     1
## 50      42    2     5     1
## 51      48    4     5     1
## 52      60    6     5     1
## 53      79    8     5     1
## 54     106   10     5     1
## 55     141   12     5     1
## 56     164   14     5     1
## 57     197   16     5     1
## 58     199   18     5     1
## 59     220   20     5     1
## 60     223   21     5     1
## 61      41    0     6     1
## 62      49    2     6     1
## 63      59    4     6     1
## 64      74    6     6     1
## 65      97    8     6     1
## 66     124   10     6     1
## 67     141   12     6     1
## 68     148   14     6     1
## 69     155   16     6     1
## 70     160   18     6     1
## 71     160   20     6     1
## 72     157   21     6     1
## 73      41    0     7     1
## 74      49    2     7     1
## 75      57    4     7     1
## 76      71    6     7     1
## 77      89    8     7     1
## 78     112   10     7     1
## 79     146   12     7     1
## 80     174   14     7     1
## 81     218   16     7     1
## 82     250   18     7     1
## 83     288   20     7     1
## 84     305   21     7     1
## 85      42    0     8     1
## 86      50    2     8     1
## 87      61    4     8     1
```

```
## 88      71    6     8    1
## 89      84    8     8    1
## 90      93   10     8    1
## 91     110   12     8    1
## 92     116   14     8    1
## 93     126   16     8    1
## 94     134   18     8    1
## 95     125   20     8    1
## 96      42    0     9    1
## 97      51    2     9    1
## 98      59    4     9    1
## 99      68    6     9    1
## 100     85    8     9    1
## 101     96   10     9    1
## 102     90   12     9    1
## 103     92   14     9    1
## 104     93   16     9    1
## 105    100   18     9    1
## 106    100   20     9    1
## 107     98   21     9    1
## 108     41    0    10    1
## 109     44    2    10    1
## 110     52    4    10    1
## 111     63    6    10    1
## 112     74    8    10    1
## 113     81   10    10    1
## 114     89   12    10    1
## 115     96   14    10    1
## 116    101   16    10    1
## 117    112   18    10    1
## 118    120   20    10    1
## 119    124   21    10    1
## 120     43    0    11    1
## 121     51    2    11    1
## 122     63    4    11    1
## 123     84    6    11    1
## 124    112    8    11    1
## 125    139   10    11    1
## 126    168   12    11    1
## 127    177   14    11    1
## 128    182   16    11    1
## 129    184   18    11    1
## 130    181   20    11    1
## 131    175   21    11    1
## 132     41    0    12    1
## 133     49    2    12    1
## 134     56    4    12    1
## 135     62    6    12    1
## 136     72    8    12    1
## 137     88   10    12    1
## 138    119   12    12    1
## 139    135   14    12    1
## 140    162   16    12    1
## 141    185   18    12    1
```

```
## 142    195   20    12    1
## 143    205   21    12    1
## 144     41    0    13    1
## 145     48    2    13    1
## 146     53    4    13    1
## 147     60    6    13    1
## 148     65    8    13    1
## 149     67   10    13    1
## 150     71   12    13    1
## 151     70   14    13    1
## 152     71   16    13    1
## 153     81   18    13    1
## 154     91   20    13    1
## 155     96   21    13    1
## 156     41    0    14    1
## 157     49    2    14    1
## 158     62    4    14    1
## 159     79    6    14    1
## 160    101    8    14    1
## 161    128   10    14    1
## 162    164   12    14    1
## 163    192   14    14    1
## 164    227   16    14    1
## 165    248   18    14    1
## 166    259   20    14    1
## 167    266   21    14    1
## 168     41    0    15    1
## 169     49    2    15    1
## 170     56    4    15    1
## 171     64    6    15    1
## 172     68    8    15    1
## 173     68   10    15    1
## 174     67   12    15    1
## 175     68   14    15    1
## 176     41    0    16    1
## 177     45    2    16    1
## 178     49    4    16    1
## 179     51    6    16    1
## 180     57    8    16    1
## 181     51   10    16    1
## 182     54   12    16    1
## 183     42    0    17    1
## 184     51    2    17    1
## 185     61    4    17    1
## 186     72    6    17    1
## 187     83    8    17    1
## 188     89   10    17    1
## 189     98   12    17    1
## 190    103   14    17    1
## 191    113   16    17    1
## 192    123   18    17    1
## 193    133   20    17    1
## 194    142   21    17    1
## 195     39    0    18    1
```

```
## 196     35    2    18    1
## 197     43    0    19    1
## 198     48    2    19    1
## 199     55    4    19    1
## 200     62    6    19    1
## 201     65    8    19    1
## 202     71   10    19    1
## 203     82   12    19    1
## 204     88   14    19    1
## 205    106   16    19    1
## 206    120   18    19    1
## 207    144   20    19    1
## 208    157   21    19    1
## 209     41    0    20    1
## 210     47    2    20    1
## 211     54    4    20    1
## 212     58    6    20    1
## 213     65    8    20    1
## 214     73   10    20    1
## 215     77   12    20    1
## 216     89   14    20    1
## 217     98   16    20    1
## 218    107   18    20    1
## 219    115   20    20    1
## 220    117   21    20    1
## 221     40    0    21    2
## 222     50    2    21    2
## 223     62    4    21    2
## 224     86    6    21    2
## 225    125    8    21    2
## 226    163   10    21    2
## 227    217   12    21    2
## 228    240   14    21    2
## 229    275   16    21    2
## 230    307   18    21    2
## 231    318   20    21    2
## 232    331   21    21    2
## 233     41    0    22    2
## 234     55    2    22    2
## 235     64    4    22    2
## 236     77    6    22    2
## 237     90    8    22    2
## 238     95   10    22    2
## 239    108   12    22    2
## 240    111   14    22    2
## 241    131   16    22    2
## 242    148   18    22    2
## 243    164   20    22    2
## 244    167   21    22    2
## 245     43    0    23    2
## 246     52    2    23    2
## 247     61    4    23    2
## 248     73    6    23    2
## 249     90    8    23    2
```

```
## 250   103   10   23   2
## 251   127   12   23   2
## 252   135   14   23   2
## 253   145   16   23   2
## 254   163   18   23   2
## 255   170   20   23   2
## 256   175   21   23   2
## 257    42    0   24   2
## 258    52    2   24   2
## 259    58    4   24   2
## 260    74    6   24   2
## 261    66    8   24   2
## 262    68   10   24   2
## 263    70   12   24   2
## 264    71   14   24   2
## 265    72   16   24   2
## 266    72   18   24   2
## 267    76   20   24   2
## 268    74   21   24   2
## 269    40    0   25   2
## 270    49    2   25   2
## 271    62    4   25   2
## 272    78    6   25   2
## 273   102    8   25   2
## 274   124   10   25   2
## 275   146   12   25   2
## 276   164   14   25   2
## 277   197   16   25   2
## 278   231   18   25   2
## 279   259   20   25   2
## 280   265   21   25   2
## 281    42    0   26   2
## 282    48    2   26   2
## 283    57    4   26   2
## 284    74    6   26   2
## 285    93    8   26   2
## 286   114   10   26   2
## 287   136   12   26   2
## 288   147   14   26   2
## 289   169   16   26   2
## 290   205   18   26   2
## 291   236   20   26   2
## 292   251   21   26   2
## 293    39    0   27   2
## 294    46    2   27   2
## 295    58    4   27   2
## 296    73    6   27   2
## 297    87    8   27   2
## 298   100   10   27   2
## 299   115   12   27   2
## 300   123   14   27   2
## 301   144   16   27   2
## 302   163   18   27   2
## 303   185   20   27   2
```

```
## 304    192   21    27    2
## 305     39    0    28    2
## 306     46    2    28    2
## 307     58    4    28    2
## 308     73    6    28    2
## 309     92    8    28    2
## 310    114   10    28    2
## 311    145   12    28    2
## 312    156   14    28    2
## 313    184   16    28    2
## 314    207   18    28    2
## 315    212   20    28    2
## 316    233   21    28    2
## 317     39    0    29    2
## 318     48    2    29    2
## 319     59    4    29    2
## 320     74    6    29    2
## 321     87    8    29    2
## 322    106   10    29    2
## 323    134   12    29    2
## 324    150   14    29    2
## 325    187   16    29    2
## 326    230   18    29    2
## 327    279   20    29    2
## 328    309   21    29    2
## 329     42    0    30    2
## 330     48    2    30    2
## 331     59    4    30    2
## 332     72    6    30    2
## 333     85    8    30    2
## 334     98   10    30    2
## 335    115   12    30    2
## 336    122   14    30    2
## 337    143   16    30    2
## 338    151   18    30    2
## 339    157   20    30    2
## 340    150   21    30    2
## 341     42    0    31    3
## 342     53    2    31    3
## 343     62    4    31    3
## 344     73    6    31    3
## 345     85    8    31    3
## 346    102   10    31    3
## 347    123   12    31    3
## 348    138   14    31    3
## 349    170   16    31    3
## 350    204   18    31    3
## 351    235   20    31    3
## 352    256   21    31    3
## 353     41    0    32    3
## 354     49    2    32    3
## 355     65    4    32    3
## 356     82    6    32    3
## 357    107    8    32    3
```

```
## 358   129   10    32    3
## 359   159   12    32    3
## 360   179   14    32    3
## 361   221   16    32    3
## 362   263   18    32    3
## 363   291   20    32    3
## 364   305   21    32    3
## 365    39    0    33    3
## 366    50    2    33    3
## 367    63    4    33    3
## 368    77    6    33    3
## 369    96    8    33    3
## 370   111   10    33    3
## 371   137   12    33    3
## 372   144   14    33    3
## 373   151   16    33    3
## 374   146   18    33    3
## 375   156   20    33    3
## 376   147   21    33    3
## 377    41    0    34    3
## 378    49    2    34    3
## 379    63    4    34    3
## 380    85    6    34    3
## 381   107    8    34    3
## 382   134   10    34    3
## 383   164   12    34    3
## 384   186   14    34    3
## 385   235   16    34    3
## 386   294   18    34    3
## 387   327   20    34    3
## 388   341   21    34    3
## 389    41    0    35    3
## 390    53    2    35    3
## 391    64    4    35    3
## 392    87    6    35    3
## 393   123    8    35    3
## 394   158   10    35    3
## 395   201   12    35    3
## 396   238   14    35    3
## 397   287   16    35    3
## 398   332   18    35    3
## 399   361   20    35    3
## 400   373   21    35    3
## 401    39    0    36    3
## 402    48    2    36    3
## 403    61    4    36    3
## 404    76    6    36    3
## 405    98    8    36    3
## 406   116   10    36    3
## 407   145   12    36    3
## 408   166   14    36    3
## 409   198   16    36    3
## 410   227   18    36    3
## 411   225   20    36    3
```

```
## 412    220   21    36    3
## 413     41    0    37    3
## 414     48    2    37    3
## 415     56    4    37    3
## 416     68    6    37    3
## 417     80    8    37    3
## 418     83   10    37    3
## 419    103   12    37    3
## 420    112   14    37    3
## 421    135   16    37    3
## 422    157   18    37    3
## 423    169   20    37    3
## 424    178   21    37    3
## 425     41    0    38    3
## 426     49    2    38    3
## 427     61    4    38    3
## 428     74    6    38    3
## 429     98    8    38    3
## 430    109   10    38    3
## 431    128   12    38    3
## 432    154   14    38    3
## 433    192   16    38    3
## 434    232   18    38    3
## 435    280   20    38    3
## 436    290   21    38    3
## 437     42    0    39    3
## 438     50    2    39    3
## 439     61    4    39    3
## 440     78    6    39    3
## 441     89    8    39    3
## 442    109   10    39    3
## 443    130   12    39    3
## 444    146   14    39    3
## 445    170   16    39    3
## 446    214   18    39    3
## 447    250   20    39    3
## 448    272   21    39    3
## 449     41    0    40    3
## 450     55    2    40    3
## 451     66    4    40    3
## 452     79    6    40    3
## 453    101    8    40    3
## 454    120   10    40    3
## 455    154   12    40    3
## 456    182   14    40    3
## 457    215   16    40    3
## 458    262   18    40    3
## 459    295   20    40    3
## 460    321   21    40    3
## 461     42    0    41    4
## 462     51    2    41    4
## 463     66    4    41    4
## 464     85    6    41    4
## 465    103    8    41    4
```

```
## 466    124   10    41    4
## 467    155   12    41    4
## 468    153   14    41    4
## 469    175   16    41    4
## 470    184   18    41    4
## 471    199   20    41    4
## 472    204   21    41    4
## 473     42    0    42    4
## 474     49    2    42    4
## 475     63    4    42    4
## 476     84    6    42    4
## 477    103    8    42    4
## 478    126   10    42    4
## 479    160   12    42    4
## 480    174   14    42    4
## 481    204   16    42    4
## 482    234   18    42    4
## 483    269   20    42    4
## 484    281   21    42    4
## 485     42    0    43    4
## 486     55    2    43    4
## 487     69    4    43    4
## 488     96    6    43    4
## 489    131    8    43    4
## 490    157   10    43    4
## 491    184   12    43    4
## 492    188   14    43    4
## 493    197   16    43    4
## 494    198   18    43    4
## 495    199   20    43    4
## 496    200   21    43    4
## 497     42    0    44    4
## 498     51    2    44    4
## 499     65    4    44    4
## 500     86    6    44    4
## 501    103    8    44    4
## 502    118   10    44    4
## 503    127   12    44    4
## 504    138   14    44    4
## 505    145   16    44    4
## 506    146   18    44    4
## 507     41    0    45    4
## 508     50    2    45    4
## 509     61    4    45    4
## 510     78    6    45    4
## 511     98    8    45    4
## 512    117   10    45    4
## 513    135   12    45    4
## 514    141   14    45    4
## 515    147   16    45    4
## 516    174   18    45    4
## 517    197   20    45    4
## 518    196   21    45    4
## 519     40    0    46    4
```

```
## 520     52    2    46    4
## 521     62    4    46    4
## 522     82    6    46    4
## 523    101    8    46    4
## 524    120   10    46    4
## 525    144   12    46    4
## 526    156   14    46    4
## 527    173   16    46    4
## 528    210   18    46    4
## 529    231   20    46    4
## 530    238   21    46    4
## 531     41    0    47    4
## 532     53    2    47    4
## 533     66    4    47    4
## 534     79    6    47    4
## 535    100    8    47    4
## 536    123   10    47    4
## 537    148   12    47    4
## 538    157   14    47    4
## 539    168   16    47    4
## 540    185   18    47    4
## 541    210   20    47    4
## 542    205   21    47    4
## 543     39    0    48    4
## 544     50    2    48    4
## 545     62    4    48    4
## 546     80    6    48    4
## 547    104    8    48    4
## 548    125   10    48    4
## 549    154   12    48    4
## 550    170   14    48    4
## 551    222   16    48    4
## 552    261   18    48    4
## 553    303   20    48    4
## 554    322   21    48    4
## 555     40    0    49    4
## 556     53    2    49    4
## 557     64    4    49    4
## 558     85    6    49    4
## 559    108    8    49    4
## 560    128   10    49    4
## 561    152   12    49    4
## 562    166   14    49    4
## 563    184   16    49    4
## 564    203   18    49    4
## 565    233   20    49    4
## 566    237   21    49    4
## 567     41    0    50    4
## 568     54    2    50    4
## 569     67    4    50    4
## 570     84    6    50    4
## 571    105    8    50    4
## 572    122   10    50    4
## 573    155   12    50    4
```

```
## 574    175   14    50    4
## 575    205   16    50    4
## 576    234   18    50    4
## 577    264   20    50    4
## 578    264   21    50    4
```

Answer: b. ChickWeight is tidy: each observation (a weight) is represented by one row. The chick from which this measurement came is one of the variables.

3. Examine the built-in dataset BOD. Which of the following is true:

```
BOD
```

```
##   Time demand
## 1    1    8.3
## 2    2   10.3
## 3    3   19.0
## 4    4   16.0
## 5    5   15.6
## 6    7   19.8
```

Answer: c. BOD is tidy: each row is an observation with two values (time and demand)

4. Which of the following built-in datasets is tidy (you can pick more than one):

```
BJsales
```

```
## Time Series:
## Start = 1
## End = 150
## Frequency = 1
##   [1] 200.1 199.5 199.4 198.9 199.0 200.2 198.6 200.0 200.3 201.2 201.6 201.5
##  [13] 201.5 203.5 204.9 207.1 210.5 210.5 209.8 208.8 209.5 213.2 213.7 215.1
##  [25] 218.7 219.8 220.5 223.8 222.8 223.8 221.7 222.3 220.8 219.4 220.1 220.6
##  [37] 218.9 217.8 217.7 215.0 215.3 215.9 216.7 216.7 217.7 218.7 222.9 224.9
##  [49] 222.2 220.7 220.0 218.7 217.0 215.9 215.8 214.1 212.3 213.9 214.6 213.6
##  [61] 212.1 211.4 213.1 212.9 213.3 211.5 212.3 213.0 211.0 210.7 210.1 211.4
##  [73] 210.0 209.7 208.8 208.8 208.8 210.6 211.9 212.8 212.5 214.8 215.3 217.5
##  [85] 218.8 220.7 222.2 226.7 228.4 233.2 235.7 237.1 240.6 243.8 245.3 246.0
##  [97] 246.3 247.7 247.6 247.8 249.4 249.0 249.9 250.5 251.5 249.0 247.6 248.8
## [109] 250.4 250.7 253.0 253.7 255.0 256.2 256.0 257.4 260.4 260.0 261.3 260.4
## [121] 261.6 260.8 259.8 259.0 258.9 257.4 257.7 257.9 257.4 257.3 257.6 258.9
## [133] 257.8 257.7 257.2 257.5 256.8 257.5 257.0 257.6 257.3 257.5 259.6 261.1
## [145] 262.9 263.3 262.8 261.8 262.2 262.7
```

```
EuStockMarkets
```

```
## Time Series:
## Start = c(1991, 130)
## End = c(1998, 169)
## Frequency = 260
```

```
##              DAX    SMI    CAC   FTSE
## 1991.496 1628.75 1678.1 1772.8 2443.6
## 1991.500 1613.63 1688.5 1750.5 2460.2
## 1991.504 1606.51 1678.6 1718.0 2448.2
## 1991.508 1621.04 1684.1 1708.1 2470.4
## 1991.512 1618.16 1686.6 1723.1 2484.7
## 1991.515 1610.61 1671.6 1714.3 2466.8
## 1991.519 1630.75 1682.9 1734.5 2487.9
## 1991.523 1640.17 1703.6 1757.4 2508.4
## 1991.527 1635.47 1697.5 1754.0 2510.5
## 1991.531 1645.89 1716.3 1754.3 2497.4
## 1991.535 1647.84 1723.8 1759.8 2532.5
## 1991.538 1638.35 1730.5 1755.5 2556.8
## 1991.542 1629.93 1727.4 1758.1 2561.0
## 1991.546 1621.49 1733.3 1757.5 2547.3
## 1991.550 1624.74 1734.0 1763.5 2541.5
## 1991.554 1627.63 1728.3 1762.8 2558.5
## 1991.558 1631.99 1737.1 1768.9 2587.9
## 1991.562 1621.18 1723.1 1778.1 2580.5
## 1991.565 1613.42 1723.6 1780.1 2579.6
## 1991.569 1604.95 1719.0 1767.7 2589.3
## 1991.573 1605.75 1721.2 1757.9 2595.0
## 1991.577 1616.67 1725.3 1756.6 2595.6
## 1991.581 1619.29 1727.2 1754.7 2588.8
## 1991.585 1620.49 1727.2 1766.8 2591.7
## 1991.588 1619.67 1731.6 1766.5 2601.7
## 1991.592 1623.07 1724.1 1762.2 2585.4
## 1991.596 1613.98 1716.9 1759.5 2573.3
## 1991.600 1631.87 1723.4 1782.4 2597.4
## 1991.604 1630.37 1723.0 1789.5 2600.6
## 1991.608 1633.47 1728.4 1783.5 2570.6
## 1991.612 1626.55 1722.1 1780.4 2569.4
## 1991.615 1650.43 1724.5 1808.8 2584.9
## 1991.619 1650.06 1733.6 1820.3 2608.8
## 1991.623 1654.11 1739.0 1820.3 2617.2
## 1991.627 1653.60 1726.2 1820.3 2621.0
## 1991.631 1501.82 1587.4 1687.5 2540.5
## 1991.635 1524.28 1630.6 1725.6 2554.5
## 1991.638 1603.65 1685.5 1792.9 2601.9
## 1991.642 1622.49 1701.3 1819.1 2623.0
## 1991.646 1636.68 1718.0 1833.5 2640.7
## 1991.650 1652.10 1726.2 1853.4 2640.7
## 1991.654 1645.81 1716.6 1849.7 2619.8
## 1991.658 1650.36 1725.8 1851.8 2624.2
## 1991.662 1651.55 1737.4 1857.7 2638.2
## 1991.665 1649.88 1736.6 1864.3 2645.7
## 1991.669 1653.52 1732.4 1863.5 2679.6
## 1991.673 1657.51 1731.2 1873.2 2669.0
## 1991.677 1649.55 1726.9 1860.8 2664.6
## 1991.681 1649.09 1727.8 1868.7 2663.3
## 1991.685 1646.41 1720.2 1860.4 2667.4
## 1991.688 1638.65 1715.4 1855.9 2653.2
## 1991.692 1625.80 1708.7 1840.5 2630.8
## 1991.696 1628.64 1713.0 1842.6 2626.6
```

```
## 1991.700 1632.22 1713.5 1861.2 2641.9
## 1991.704 1633.65 1718.0 1876.2 2625.8
## 1991.708 1631.17 1701.7 1878.3 2606.0
## 1991.712 1635.80 1701.7 1878.4 2594.4
## 1991.715 1621.27 1684.9 1869.4 2583.6
## 1991.719 1624.70 1687.2 1880.4 2588.7
## 1991.723 1616.13 1690.6 1885.5 2600.3
## 1991.727 1618.12 1684.3 1888.4 2579.5
## 1991.731 1627.80 1679.9 1885.2 2576.6
## 1991.735 1625.79 1672.9 1877.9 2597.8
## 1991.738 1614.80 1663.1 1876.5 2595.6
## 1991.742 1612.80 1669.3 1883.8 2599.0
## 1991.746 1605.47 1664.7 1880.6 2621.7
## 1991.750 1609.32 1672.3 1887.4 2645.6
## 1991.754 1607.48 1687.7 1878.3 2644.2
## 1991.758 1607.48 1686.8 1867.1 2625.6
## 1991.762 1604.89 1686.6 1851.9 2624.6
## 1991.765 1589.12 1675.8 1843.6 2596.2
## 1991.769 1582.27 1677.4 1848.1 2599.5
## 1991.773 1567.99 1673.2 1843.4 2584.1
## 1991.777 1568.16 1665.0 1843.6 2570.8
## 1991.781 1569.71 1671.3 1833.8 2555.0
## 1991.785 1571.74 1672.4 1833.4 2574.5
## 1991.788 1585.41 1676.2 1856.9 2576.7
## 1991.792 1570.01 1692.6 1863.4 2579.0
## 1991.796 1561.89 1696.5 1855.5 2588.7
## 1991.800 1565.18 1716.1 1864.2 2601.1
## 1991.804 1570.34 1713.3 1846.0 2575.7
## 1991.808 1577.00 1705.1 1836.8 2559.5
## 1991.812 1590.29 1711.3 1830.4 2561.1
## 1991.815 1572.72 1709.8 1831.6 2528.3
## 1991.819 1572.07 1688.6 1834.8 2514.7
## 1991.823 1579.19 1698.9 1852.1 2558.5
## 1991.827 1588.73 1700.0 1849.8 2553.3
## 1991.831 1586.01 1693.0 1861.8 2577.1
## 1991.835 1579.77 1683.9 1856.7 2566.0
## 1991.838 1572.58 1679.2 1856.7 2549.5
## 1991.842 1568.09 1673.9 1841.5 2527.8
## 1991.846 1578.21 1683.9 1846.9 2540.9
## 1991.850 1573.94 1688.4 1836.1 2534.2
## 1991.854 1582.06 1693.9 1838.6 2538.0
## 1991.858 1610.18 1720.9 1857.6 2559.0
## 1991.862 1605.16 1717.9 1857.6 2554.9
## 1991.865 1623.84 1733.6 1858.4 2575.5
## 1991.869 1615.26 1729.7 1846.8 2546.5
## 1991.873 1627.08 1735.6 1868.5 2561.6
## 1991.877 1626.97 1734.1 1863.2 2546.6
## 1991.881 1605.70 1699.3 1808.3 2502.9
## 1991.885 1589.70 1678.6 1765.1 2463.1
## 1991.888 1589.70 1675.5 1763.5 2472.6
## 1991.892 1603.26 1670.1 1766.0 2463.5
## 1991.896 1599.75 1652.2 1741.3 2446.3
## 1991.900 1590.86 1635.0 1743.3 2456.2
## 1991.904 1603.50 1654.9 1769.0 2471.5
```

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## 1991.908 1589.86 1642.0 1757.9 2447.5
## 1991.912 1587.92 1638.7 1754.9 2428.6
## 1991.915 1571.06 1622.6 1739.7 2420.2
## 1991.919 1549.81 1596.1 1708.8 2414.9
## 1991.923 1549.36 1612.4 1722.2 2420.2
## 1991.927 1554.65 1625.0 1713.9 2423.8
## 1991.931 1557.52 1610.5 1703.2 2407.0
## 1991.935 1555.31 1606.6 1685.7 2388.7
## 1991.938 1559.76 1610.7 1663.4 2409.6
## 1991.942 1548.44 1603.1 1636.9 2392.0
## 1991.946 1543.99 1591.5 1645.6 2380.2
## 1991.950 1550.21 1605.2 1671.6 2423.3
## 1991.954 1557.03 1621.4 1688.3 2451.6
## 1991.958 1551.78 1622.5 1696.8 2440.8
## 1991.962 1562.89 1626.6 1711.7 2432.9
## 1991.965 1570.28 1627.4 1706.2 2413.6
## 1991.969 1559.26 1614.9 1684.2 2391.6
## 1991.973 1545.87 1602.3 1648.5 2358.1
## 1991.977 1542.77 1598.3 1633.6 2345.4
## 1991.981 1542.77 1627.0 1699.1 2384.4
## 1991.985 1542.77 1627.0 1699.1 2384.4
## 1991.988 1542.77 1627.0 1722.5 2384.4
## 1991.992 1564.27 1655.7 1720.7 2418.7
## 1991.996 1577.26 1670.1 1741.9 2420.0
## 1992.000 1577.26 1670.1 1765.7 2493.1
## 1992.004 1577.26 1670.1 1765.7 2493.1
## 1992.008 1598.19 1670.1 1749.9 2492.8
## 1992.012 1604.05 1704.0 1770.3 2504.1
## 1992.015 1604.69 1711.8 1787.6 2493.2
## 1992.019 1593.65 1700.5 1778.7 2482.9
## 1992.023 1581.68 1690.3 1785.6 2467.1
## 1992.027 1599.14 1715.4 1833.9 2497.9
## 1992.031 1613.82 1723.5 1837.4 2477.9
## 1992.035 1620.45 1719.4 1824.3 2490.1
## 1992.038 1629.51 1734.4 1843.8 2516.3
## 1992.042 1663.70 1772.8 1873.6 2537.1
## 1992.046 1664.09 1760.3 1860.2 2541.6
## 1992.050 1669.29 1747.2 1860.2 2536.7
## 1992.054 1685.14 1750.2 1865.9 2544.9
## 1992.058 1687.07 1755.3 1867.9 2543.4
## 1992.062 1680.13 1754.6 1841.3 2522.0
## 1992.065 1671.84 1751.2 1838.7 2525.3
## 1992.069 1669.52 1752.5 1849.9 2510.4
## 1992.073 1686.71 1769.4 1869.3 2539.9
## 1992.077 1685.51 1767.6 1890.6 2552.0
## 1992.081 1671.01 1750.0 1879.6 2546.5
## 1992.085 1683.06 1747.1 1873.9 2550.8
## 1992.088 1685.70 1753.5 1875.3 2571.2
## 1992.092 1685.66 1752.8 1857.0 2560.2
## 1992.096 1678.77 1752.9 1856.5 2556.8
## 1992.100 1685.85 1764.7 1865.8 2547.1
## 1992.104 1683.71 1776.8 1860.6 2534.3
## 1992.108 1686.59 1779.3 1861.6 2517.2
## 1992.112 1683.73 1785.1 1865.6 2538.4
```

```
## 1992.115 1679.14 1798.2 1864.1 2537.1
## 1992.119 1685.03 1794.1 1861.6 2523.7
## 1992.123 1680.81 1795.2 1876.5 2522.6
## 1992.127 1676.17 1780.4 1865.1 2513.9
## 1992.131 1688.46 1789.5 1882.1 2541.0
## 1992.135 1696.55 1794.2 1912.2 2555.9
## 1992.138 1690.24 1784.4 1915.4 2536.7
## 1992.142 1711.35 1800.1 1951.2 2543.4
## 1992.146 1711.29 1804.0 1962.4 2542.3
## 1992.150 1729.86 1816.2 1976.5 2559.7
## 1992.154 1716.63 1810.5 1953.5 2546.8
## 1992.158 1743.36 1821.9 1981.3 2565.0
## 1992.162 1745.17 1828.2 1985.1 2562.0
## 1992.165 1746.76 1840.6 1983.4 2562.1
## 1992.169 1749.29 1841.1 1979.7 2554.3
## 1992.173 1763.86 1846.3 1983.8 2565.4
## 1992.177 1762.27 1850.0 1988.1 2558.4
## 1992.181 1762.29 1839.0 1973.0 2538.3
## 1992.185 1746.77 1820.2 1966.9 2533.1
## 1992.188 1753.50 1815.2 1976.3 2550.7
## 1992.192 1753.21 1820.6 1993.9 2574.8
## 1992.196 1739.88 1807.1 1968.0 2522.4
## 1992.200 1723.92 1791.4 1941.8 2493.3
## 1992.204 1734.42 1806.2 1947.1 2476.0
## 1992.208 1723.13 1798.7 1929.2 2470.7
## 1992.212 1732.92 1818.2 1943.6 2491.2
## 1992.215 1729.89 1820.5 1928.2 2464.7
## 1992.219 1725.74 1833.3 1922.0 2467.6
## 1992.223 1730.90 1837.1 1919.1 2456.6
## 1992.227 1714.17 1818.2 1884.6 2441.0
## 1992.231 1716.20 1824.1 1896.3 2458.7
## 1992.235 1719.06 1830.1 1928.3 2464.9
## 1992.238 1718.21 1835.6 1934.8 2472.2
## 1992.242 1698.84 1828.7 1923.5 2447.9
## 1992.246 1714.76 1839.2 1943.8 2452.9
## 1992.250 1718.35 1837.2 1942.4 2440.1
## 1992.254 1706.69 1826.7 1928.1 2408.6
## 1992.258 1723.37 1838.0 1942.0 2405.4
## 1992.262 1716.18 1829.1 1942.7 2382.7
## 1992.265 1738.78 1843.1 1974.8 2400.9
## 1992.269 1737.41 1850.5 1975.4 2404.2
## 1992.273 1714.77 1827.1 1907.5 2393.2
## 1992.277 1724.24 1829.1 1943.6 2436.4
## 1992.281 1733.77 1848.0 1974.1 2572.6
## 1992.285 1729.96 1840.5 1963.3 2591.0
## 1992.288 1734.46 1853.8 1972.3 2600.5
## 1992.292 1744.35 1874.1 1990.7 2640.2
## 1992.296 1746.88 1871.3 1978.2 2638.6
## 1992.300 1746.88 1871.3 1978.2 2638.6
## 1992.304 1746.88 1871.3 1978.2 2638.6
## 1992.308 1747.47 1860.5 1980.4 2625.8
## 1992.312 1753.10 1874.7 1983.7 2607.8
## 1992.315 1745.17 1880.1 1978.1 2609.8
## 1992.319 1745.72 1874.7 1984.9 2643.0
```

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## 1992.323 1742.92 1875.6 1995.7 2658.2
## 1992.327 1731.68 1859.5 2006.6 2651.0
## 1992.331 1731.18 1874.2 2036.7 2664.9
## 1992.335 1728.09 1880.1 2031.1 2654.1
## 1992.338 1728.09 1880.1 2031.1 2659.8
## 1992.342 1731.29 1907.7 2041.6 2659.8
## 1992.346 1733.82 1920.5 2046.9 2662.2
## 1992.350 1745.78 1937.3 2047.2 2698.7
## 1992.354 1752.57 1936.8 2063.4 2701.9
## 1992.358 1748.13 1949.1 2063.4 2725.7
## 1992.362 1750.70 1963.7 2077.5 2737.8
## 1992.365 1747.91 1950.8 2063.6 2722.4
## 1992.369 1745.79 1953.5 2053.2 2720.5
## 1992.373 1735.34 1945.0 2017.0 2694.7
## 1992.377 1719.92 1921.1 2024.0 2682.6
## 1992.381 1763.59 1939.1 2051.6 2703.6
## 1992.385 1766.76 1928.0 2023.1 2700.6
## 1992.388 1785.40 1933.4 2030.8 2711.9
## 1992.392 1783.56 1925.7 2016.8 2702.0
## 1992.396 1804.42 1931.7 2045.1 2715.0
## 1992.400 1812.33 1928.7 2046.3 2715.0
## 1992.404 1799.51 1924.5 2029.6 2704.6
## 1992.408 1792.80 1914.2 2014.1 2698.6
## 1992.412 1792.80 1914.2 2014.1 2694.2
## 1992.415 1806.36 1920.6 2033.3 2707.6
## 1992.419 1798.23 1923.3 2017.4 2697.6
## 1992.423 1800.62 1930.4 2024.9 2705.9
## 1992.427 1786.19 1915.2 1992.6 2680.9
## 1992.431 1791.35 1916.9 1994.9 2681.9
## 1992.435 1789.05 1913.8 1981.6 2668.5
## 1992.438 1789.05 1913.8 1981.6 2645.8
## 1992.442 1784.71 1899.7 1962.2 2635.4
## 1992.446 1789.45 1888.0 1953.7 2636.1
## 1992.450 1779.74 1868.8 1928.8 2614.1
## 1992.454 1786.97 1879.9 1928.3 2603.7
## 1992.458 1773.25 1865.7 1918.1 2593.6
## 1992.462 1781.62 1881.3 1931.4 2616.3
## 1992.465 1773.75 1873.1 1908.8 2598.4
## 1992.469 1773.75 1862.5 1891.8 2562.7
## 1992.473 1776.34 1869.3 1913.9 2584.8
## 1992.477 1770.72 1846.9 1885.8 2550.3
## 1992.481 1772.39 1847.1 1895.8 2560.6
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## 1998.212 4852.22 7246.5 3521.5 5828.5
## 1998.215 4862.41 7276.7 3539.4 5829.8
## 1998.219 4838.67 7267.9 3526.6 5794.8
## 1998.223 4872.24 7328.0 3540.2 5782.3
## 1998.227 4905.59 7261.2 3598.3 5785.1
## 1998.231 4945.91 7236.5 3661.3 5834.9
## 1998.235 4908.55 7132.4 3652.5 5903.6
## 1998.238 4949.91 7143.8 3688.7 5997.9
## 1998.242 5045.16 7300.5 3688.9 5956.3
## 1998.246 5014.13 7341.0 3680.1 5947.0
## 1998.250 5064.35 7407.4 3738.5 5983.7
## 1998.254 5114.13 7472.1 3818.7 5967.8
## 1998.258 5029.00 7415.9 3783.8 5905.6
## 1998.262 5066.90 7530.3 3810.2 5939.3
## 1998.265 5069.89 7536.3 3800.2 5911.9
## 1998.269 5097.25 7585.5 3875.3 5932.2
## 1998.273 5135.35 7615.5 3883.3 6017.6
## 1998.277 5179.04 7638.8 3935.9 6052.8
## 1998.281 5254.32 7725.9 3932.0 6064.2
## 1998.285 5345.89 7827.7 3986.8 6105.8
## 1998.288 5309.67 7744.3 3903.3 6094.0
## 1998.292 5267.35 7588.1 3873.9 6055.2
## 1998.296 5312.25 7624.1 3894.5 6105.5
## 1998.300 5312.25 7624.1 3894.5 6105.5
## 1998.304 5312.25 7624.1 3894.5 6105.5
## 1998.308 5367.98 7662.9 3867.7 6104.1
## 1998.312 5359.24 7616.3 3884.6 6074.1
## 1998.315 5292.97 7500.1 3845.9 6002.0
## 1998.319 5326.63 7453.7 3861.6 5922.2
## 1998.323 5407.93 7500.1 3885.7 5954.1
## 1998.327 5373.80 7369.1 3860.4 5955.0
## 1998.331 5312.28 7308.9 3835.1 5931.1
## 1998.335 5262.57 7265.5 3822.1 5898.1
## 1998.338 5144.42 7232.3 3788.7 5863.9
## 1998.342 5002.71 7053.5 3689.4 5722.4
```

```
## 1998.346 5110.88 7180.1 3777.2 5806.6
## 1998.350 5083.80 7241.8 3726.2 5833.1
## 1998.354 5241.23 7401.4 3867.9 5928.3
## 1998.358 5241.23 7401.4 3867.9 6011.3
## 1998.362 5337.75 7640.8 3979.3 6011.3
## 1998.365 5226.20 7596.2 3945.5 5986.5
## 1998.369 5264.62 7610.8 3947.5 5992.4
## 1998.373 5164.89 7536.0 3912.8 5938.0
## 1998.377 5270.61 7587.1 3912.8 5969.8
## 1998.381 5348.75 7677.5 4007.3 6028.3
## 1998.385 5307.82 7627.3 3986.1 5956.7
## 1998.388 5371.99 7582.8 4018.5 5972.9
## 1998.392 5374.11 7550.6 4012.0 5948.5
## 1998.396 5414.31 7519.4 3990.2 5917.8
## 1998.400 5343.66 7371.4 3945.3 5826.2
## 1998.404 5441.00 7483.2 3980.8 5877.8
## 1998.408 5514.51 7495.8 4047.9 5907.4
## 1998.412 5514.51 7495.8 4047.9 5935.6
## 1998.415 5530.19 7542.7 4049.8 5955.6
## 1998.419 5592.46 7657.1 4108.7 5955.6
## 1998.423 5639.89 7731.9 4115.9 5970.7
## 1998.427 5466.88 7633.5 4017.4 5870.2
## 1998.431 5507.36 7605.0 4014.9 5862.3
## 1998.435 5556.99 7656.1 4041.2 5870.7
## 1998.438 5556.99 7656.1 4041.2 5837.9
## 1998.442 5583.83 7657.5 4087.0 5842.3
## 1998.446 5640.42 7676.3 4149.4 5898.4
## 1998.450 5605.38 7592.9 4119.0 5860.8
## 1998.454 5724.75 7699.5 4185.1 5947.3
## 1998.458 5787.05 7743.4 4204.6 6037.8
## 1998.462 5773.77 7716.8 4201.9 6019.8
## 1998.465 5799.22 7652.6 4208.6 5987.4
## 1998.469 5799.22 7498.4 4141.6 5852.5
## 1998.473 5631.34 7417.4 4050.8 5769.8
## 1998.477 5581.24 7342.7 4005.3 5715.7
## 1998.481 5621.71 7388.7 4013.3 5729.7
## 1998.485 5742.83 7562.7 4092.9 5832.7
## 1998.488 5689.89 7488.0 4052.3 5812.1
## 1998.492 5644.22 7518.6 4027.3 5748.1
## 1998.496 5648.11 7511.8 4018.6 5712.4
## 1998.500 5748.34 7624.8 4065.0 5772.0
## 1998.504 5784.40 7667.9 4126.3 5804.9
## 1998.508 5886.72 7794.7 4203.8 5858.9
## 1998.512 5870.49 7816.9 4215.7 5877.4
## 1998.515 5933.73 7881.9 4248.2 5884.5
## 1998.519 5841.83 7882.0 4203.5 5832.5
## 1998.523 5910.51 8038.2 4260.7 5919.9
## 1998.527 5905.15 8047.3 4252.1 5960.2
## 1998.531 5961.45 8099.0 4304.4 5988.4
## 1998.535 5942.06 8166.0 4311.1 5990.3
## 1998.538 5975.88 8160.0 4333.1 6003.4
## 1998.542 6018.89 8227.2 4339.9 6009.6
## 1998.546 6000.84 8205.0 4319.2 5969.7
## 1998.550 6001.24 8192.4 4256.4 5927.9
```

```
## 1998.554 6023.31 8141.9 4256.4 5958.2
## 1998.558 6101.90 8180.5 4256.4 6100.2
## 1998.562 6106.10 8158.1 4344.3 6151.5
## 1998.565 6108.00 8126.5 4358.1 6116.8
## 1998.569 6162.86 8288.2 4388.5 6174.0
## 1998.573 6186.09 8400.8 4368.9 6179.0
## 1998.577 6184.10 8412.0 4322.1 6132.7
## 1998.581 6081.11 8340.7 4220.1 5989.6
## 1998.585 6043.82 8229.2 4235.9 5976.2
## 1998.588 6040.58 8205.7 4205.4 5892.3
## 1998.592 5854.35 7998.7 4139.5 5836.1
## 1998.596 5867.52 8093.0 4122.4 5835.8
## 1998.600 5828.74 8102.7 4139.2 5844.1
## 1998.604 5906.33 8205.5 4197.6 5910.7
## 1998.608 5861.19 8239.5 4177.3 5837.0
## 1998.612 5774.38 8139.2 4095.0 5809.7
## 1998.615 5718.70 8170.2 4047.9 5736.1
## 1998.619 5614.77 7943.2 3976.4 5632.5
## 1998.623 5528.12 7846.2 3968.6 5594.1
## 1998.627 5598.32 7952.9 4041.9 5680.4
## 1998.631 5460.43 7721.3 3939.5 5587.6
## 1998.635 5285.78 7447.9 3846.0 5432.8
## 1998.638 5386.94 7607.5 3945.7 5462.2
## 1998.642 5355.03 7552.6 3951.7 5399.5
## 1998.646 5473.72 7676.3 3995.0 5455.0
```

```
DNase
```

```
##     Run        conc density
## 1     1  0.04882812   0.017
## 2     1  0.04882812   0.018
## 3     1  0.19531250   0.121
## 4     1  0.19531250   0.124
## 5     1  0.39062500   0.206
## 6     1  0.39062500   0.215
## 7     1  0.78125000   0.377
## 8     1  0.78125000   0.374
## 9     1  1.56250000   0.614
## 10    1  1.56250000   0.609
## 11    1  3.12500000   1.019
## 12    1  3.12500000   1.001
## 13    1  6.25000000   1.334
## 14    1  6.25000000   1.364
## 15    1 12.50000000   1.730
## 16    1 12.50000000   1.710
## 17    2  0.04882812   0.045
## 18    2  0.04882812   0.050
## 19    2  0.19531250   0.137
## 20    2  0.19531250   0.123
## 21    2  0.39062500   0.225
## 22    2  0.39062500   0.207
## 23    2  0.78125000   0.401
## 24    2  0.78125000   0.383
## 25    2  1.56250000   0.672
```

```
## 26    2  1.56250000   0.681
## 27    2  3.12500000   1.116
## 28    2  3.12500000   1.078
## 29    2  6.25000000   1.554
## 30    2  6.25000000   1.526
## 31    2 12.50000000   1.932
## 32    2 12.50000000   1.914
## 33    3  0.04882812   0.070
## 34    3  0.04882812   0.068
## 35    3  0.19531250   0.173
## 36    3  0.19531250   0.165
## 37    3  0.39062500   0.277
## 38    3  0.39062500   0.248
## 39    3  0.78125000   0.434
## 40    3  0.78125000   0.426
## 41    3  1.56250000   0.703
## 42    3  1.56250000   0.689
## 43    3  3.12500000   1.067
## 44    3  3.12500000   1.077
## 45    3  6.25000000   1.629
## 46    3  6.25000000   1.479
## 47    3 12.50000000   2.003
## 48    3 12.50000000   1.884
## 49    4  0.04882812   0.011
## 50    4  0.04882812   0.016
## 51    4  0.19531250   0.118
## 52    4  0.19531250   0.108
## 53    4  0.39062500   0.200
## 54    4  0.39062500   0.206
## 55    4  0.78125000   0.364
## 56    4  0.78125000   0.360
## 57    4  1.56250000   0.620
## 58    4  1.56250000   0.640
## 59    4  3.12500000   0.979
## 60    4  3.12500000   0.973
## 61    4  6.25000000   1.424
## 62    4  6.25000000   1.399
## 63    4 12.50000000   1.740
## 64    4 12.50000000   1.732
## 65    5  0.04882812   0.035
## 66    5  0.04882812   0.035
## 67    5  0.19531250   0.132
## 68    5  0.19531250   0.135
## 69    5  0.39062500   0.224
## 70    5  0.39062500   0.220
## 71    5  0.78125000   0.385
## 72    5  0.78125000   0.390
## 73    5  1.56250000   0.658
## 74    5  1.56250000   0.647
## 75    5  3.12500000   1.060
## 76    5  3.12500000   1.031
## 77    5  6.25000000   1.425
## 78    5  6.25000000   1.409
## 79    5 12.50000000   1.750
```

```
## 80    5 12.50000000   1.738
## 81    6  0.04882812   0.086
## 82    6  0.04882812   0.103
## 83    6  0.19531250   0.191
## 84    6  0.19531250   0.189
## 85    6  0.39062500   0.272
## 86    6  0.39062500   0.277
## 87    6  0.78125000   0.440
## 88    6  0.78125000   0.426
## 89    6  1.56250000   0.686
## 90    6  1.56250000   0.676
## 91    6  3.12500000   1.062
## 92    6  3.12500000   1.072
## 93    6  6.25000000   1.424
## 94    6  6.25000000   1.459
## 95    6 12.50000000   1.768
## 96    6 12.50000000   1.806
## 97    7  0.04882812   0.094
## 98    7  0.04882812   0.092
## 99    7  0.19531250   0.182
## 100   7  0.19531250   0.182
## 101   7  0.39062500   0.282
## 102   7  0.39062500   0.273
## 103   7  0.78125000   0.444
## 104   7  0.78125000   0.439
## 105   7  1.56250000   0.686
## 106   7  1.56250000   0.668
## 107   7  3.12500000   1.052
## 108   7  3.12500000   1.035
## 109   7  6.25000000   1.409
## 110   7  6.25000000   1.392
## 111   7 12.50000000   1.759
## 112   7 12.50000000   1.739
## 113   8  0.04882812   0.054
## 114   8  0.04882812   0.054
## 115   8  0.19531250   0.152
## 116   8  0.19531250   0.148
## 117   8  0.39062500   0.226
## 118   8  0.39062500   0.222
## 119   8  0.78125000   0.392
## 120   8  0.78125000   0.383
## 121   8  1.56250000   0.658
## 122   8  1.56250000   0.644
## 123   8  3.12500000   1.043
## 124   8  3.12500000   1.002
## 125   8  6.25000000   1.466
## 126   8  6.25000000   1.381
## 127   8 12.50000000   1.743
## 128   8 12.50000000   1.724
## 129   9  0.04882812   0.032
## 130   9  0.04882812   0.043
## 131   9  0.19531250   0.142
## 132   9  0.19531250   0.155
## 133   9  0.39062500   0.239
```

```
## 134   9  0.39062500   0.242
## 135   9  0.78125000   0.420
## 136   9  0.78125000   0.395
## 137   9  1.56250000   0.624
## 138   9  1.56250000   0.705
## 139   9  3.12500000   1.046
## 140   9  3.12500000   1.026
## 141   9  6.25000000   1.398
## 142   9  6.25000000   1.405
## 143   9 12.50000000   1.693
## 144   9 12.50000000   1.729
## 145  10  0.04882812   0.052
## 146  10  0.04882812   0.094
## 147  10  0.19531250   0.164
## 148  10  0.19531250   0.166
## 149  10  0.39062500   0.259
## 150  10  0.39062500   0.256
## 151  10  0.78125000   0.439
## 152  10  0.78125000   0.439
## 153  10  1.56250000   0.690
## 154  10  1.56250000   0.701
## 155  10  3.12500000   1.042
## 156  10  3.12500000   1.075
## 157  10  6.25000000   1.340
## 158  10  6.25000000   1.406
## 159  10 12.50000000   1.699
## 160  10 12.50000000   1.708
## 161  11  0.04882812   0.047
## 162  11  0.04882812   0.057
## 163  11  0.19531250   0.159
## 164  11  0.19531250   0.155
## 165  11  0.39062500   0.246
## 166  11  0.39062500   0.252
## 167  11  0.78125000   0.427
## 168  11  0.78125000   0.411
## 169  11  1.56250000   0.704
## 170  11  1.56250000   0.684
## 171  11  3.12500000   0.994
## 172  11  3.12500000   0.980
## 173  11  6.25000000   1.421
## 174  11  6.25000000   1.385
## 175  11 12.50000000   1.715
## 176  11 12.50000000   1.721
```

```
Formaldehyde
```

```
##   carb optden
## 1  0.1  0.086
## 2  0.3  0.269
## 3  0.5  0.446
## 4  0.6  0.538
## 5  0.7  0.626
## 6  0.9  0.782
```

```
Orange
```

```
##    Tree  age circumference
## 1     1  118            30
## 2     1  484            58
## 3     1  664            87
## 4     1 1004           115
## 5     1 1231           120
## 6     1 1372           142
## 7     1 1582           145
## 8     2  118            33
## 9     2  484            69
## 10    2  664           111
## 11    2 1004           156
## 12    2 1231           172
## 13    2 1372           203
## 14    2 1582           203
## 15    3  118            30
## 16    3  484            51
## 17    3  664            75
## 18    3 1004           108
## 19    3 1231           115
## 20    3 1372           139
## 21    3 1582           140
## 22    4  118            32
## 23    4  484            62
## 24    4  664           112
## 25    4 1004           167
## 26    4 1231           179
## 27    4 1372           209
## 28    4 1582           214
## 29    5  118            30
## 30    5  484            49
## 31    5  664            81
## 32    5 1004           125
## 33    5 1231           142
## 34    5 1372           174
## 35    5 1582           177
```

```
UCBAdmissions
```

```
## , , Dept = A
##
##           Gender
## Admit      Male Female
##   Admitted  512     89
##   Rejected  313     19
##
## , , Dept = B
##
##           Gender
## Admit      Male Female
##   Admitted  353     17
```

```
##   Rejected  207      8
##
## , , Dept = C
##
##           Gender
## Admit      Male Female
##   Admitted  120    202
##   Rejected  205    391
##
## , , Dept = D
##
##           Gender
## Admit      Male Female
##   Admitted  138    131
##   Rejected  279    244
##
## , , Dept = E
##
##           Gender
## Admit      Male Female
##   Admitted   53     94
##   Rejected  138    299
##
## , , Dept = F
##
##           Gender
## Admit      Male Female
##   Admitted   22     24
##   Rejected  351    317
```

Answer: b,c,d,e

4.3 Manipulating data frames

The dplyr package from the tidyverse introduces functions that perform some of the most common operations when working with data frames and uses names for these functions that are relatively easy to remember. For instance, to change the data table by adding a new column, we use mutate. To filter the data table to a subset of rows, we use filter. Finally, to subset the data by selecting specific columns, we use select.

4.3.1 Adding a column with mutate

We want all the necessary information for our analysis to be included in the data table. So the first task is to add the murder rates to our murders data frame. The function mutate takes the data frame as a first argument and the name and values of the variable as a second argument using the convention name = values. So, to add murder rates, we use:

```
library(dslabs)
data("murders")
murders<-mutate(murders, rate=total/population*100000)
```

Notice that here we used total and population inside the function, which are objects that are not defined in our workspace. But why don't we get an error?

This is one of dplyr's main features. Functions in this package, such as mutate, know to look for variables in the data frame provided in the first argument. In the call to mutate above, total will have the values in murders$total. This approach makes the code much more readable.

We can see that the new column is added:

```
head(murders)
```

```
##        state abb region population total     rate
## 1    Alabama  AL  South    4779736   135 2.824424
## 2     Alaska  AK   West     710231    19 2.675186
## 3    Arizona  AZ   West    6392017   232 3.629527
## 4   Arkansas  AR  South    2915918    93 3.189390
## 5 California  CA   West   37253956  1257 3.374138
## 6   Colorado  CO   West    5029196    65 1.292453
```

Although we have overwritten the original murders object, this does not change the object that loaded with data(murders). If we load the murders data again, the original will overwrite our mutated version.

4.3.2 Subsetting with filter

Now suppose that we want to filter the data table to only show the entries for which the murder rate is lower than 0.71. To do this we use the filter function, which takes the data table as the first argument and then the conditional statement as the second. Like mutate, we can use the unquoted variable names from murders inside the function and it will know we mean the columns and not objects in the workspace.

```
filter(murders,rate<=0.71)
```

```
##           state abb        region population total      rate
## 1        Hawaii  HI          West    1360301     7 0.5145920
## 2          Iowa  IA North Central    3046355    21 0.6893484
## 3 New Hampshire  NH     Northeast    1316470     5 0.3798036
## 4  North Dakota  ND North Central     672591     4 0.5947151
## 5       Vermont  VT     Northeast     625741     2 0.3196211
```

4.3.3 Selecting column with select

Although our data table only has six columns, some data tables include hundreds. If we want to view just a few, we can use the dplyr select function. In the code below we select three columns, assign this to a new object and then filter the new object:

```
new_table<-select(murders,state,region,rate)
filter(new_table,rate<=0.71)
```

```
##           state        region      rate
## 1        Hawaii          West 0.5145920
## 2          Iowa North Central 0.6893484
## 3 New Hampshire     Northeast 0.3798036
## 4  North Dakota North Central 0.5947151
## 5       Vermont     Northeast 0.3196211
```

In the call to select, the first argument murders is an object, but state, region, and rate are variable names.

4.4 Exercises

1. Load the dplyr package and the murders dataset.

```
library(dplyr)
library(dslabs)
data(murders)
```

You can add columns using the dplyr function mutate. This function is aware of the column names and inside the function you can call them unquoted:

```
murders<-mutate(murders,population_in_millions=population/10^6)
```

We can write population rather than murders$population. The function mutate knows we are grabbing columns from murders.

Use the function mutate to add a murders column named rate with the per 100,000 murder rate as in the example code above. Make sure you redefine murders as done in the example code above (murders <- [your code]) so we can keep using this variable.

```
murders<-mutate(murders,rate=total/population*100000)
```

2. If rank(x) gives you the ranks of x from lowest to highest, rank(-x) gives you the ranks from highest to lowest. Use the function mutate to add a column rank containing the rank, from highest to lowest murder rate. Make sure you redefine murders so we can keep using this variable.

```
murders<-mutate(murders,rank=rank(-rate))
```

3. With dplyr, we can use select to show only certain columns. For example, with this code we would only show the states and population sizes:

```
select(murders,state,population)%>%head()
```

```
##        state population
## 1    Alabama    4779736
## 2     Alaska     710231
## 3    Arizona    6392017
## 4   Arkansas    2915918
## 5 California   37253956
## 6   Colorado    5029196
```

Use select to show the state names and abbreviations in murders. Do not redefine murders, just show the results.

```
select(murders,state,abb)%>%head()
```

```
##        state abb
## 1    Alabama  AL
## 2     Alaska  AK
## 3    Arizona  AZ
## 4   Arkansas  AR
## 5 California  CA
## 6   Colorado  CO
```

4. The dplyr function filter is used to choose specific rows of the data frame to keep. Unlike select which is for columns, filter is for rows. For example, you can show just the New York row like this:

```
filter(murders,state=="New York")
```

```
##      state abb    region population total population_in_millions    rate rank
## 1 New York  NY Northeast   19378102   517                19.3781 2.66796   29
```

You can use other logical vectors to filter rows.

Use filter to show the top 5 states with the highest murder rates. After we add murder rate and rank, do not change the murders dataset, just show the result. Remember that you can filter based on the rank column.

```
filter(murders,rank<=5)
```

```
##                   state abb        region population total
## 1 District of Columbia  DC         South     601723    99
## 2            Louisiana  LA         South    4533372   351
## 3             Maryland  MD         South    5773552   293
## 4             Missouri  MO North Central    5988927   321
## 5       South Carolina  SC         South    4625364   207
##   population_in_millions      rate rank
## 1               0.601723 16.452753    1
## 2               4.533372  7.742581    2
## 3               5.773552  5.074866    4
## 4               5.988927  5.359892    3
## 5               4.625364  4.475323    5
```

5. We can remove rows using the != operator. For example, to remove Florida, we would do this:

```
no_florida<-filter(murders,state!="Florida")
```

Create a new data frame called no_south that removes states from the South region. How many states are in this category? You can use the function nrow for this.

```
no_south<-filter(murders,region!="South")
nrow(no_south)
```

```
## [1] 34
```

6. We can also use %in% to filter with dplyr. You can therefore see the data from New York and Texas like this:

```
filter(murders, state%in%c("New York","Texas"))
```

```
##      state abb    region population total population_in_millions    rate rank
## 1 New York  NY Northeast   19378102   517                19.37810 2.66796   29
## 2    Texas  TX     South   25145561   805                25.14556 3.20136   16
```

Create a new data frame called murders_nw with only the states from the Northeast and the West. How many states are in this category?

```
murders_nw<-filter(murders,region%in%c("Northeast","West"))
nrow(murders_nw)
```

```
## [1] 22
```

7. Suppose you want to live in the Northeast or West and want the murder rate to be less than 1. We want to see the data for the states satisfying these options. Note that you can use logical operators with filter. Here is an example in which we filter to keep only small states in the Northeast region.

```
filter(murders,population<5000000&region=="Northeast")
```

```
##           state abb    region population total population_in_millions      rate
## 1   Connecticut  CT Northeast    3574097    97               3.574097 2.7139722
## 2         Maine  ME Northeast    1328361    11               1.328361 0.8280881
## 3 New Hampshire  NH Northeast    1316470     5               1.316470 0.3798036
## 4  Rhode Island  RI Northeast    1052567    16               1.052567 1.5200933
## 5       Vermont  VT Northeast     625741     2               0.625741 0.3196211
##   rank
## 1   25
## 2   44
## 3   50
## 4   35
## 5   51
```

Make sure murders has been defined with rate and rank and still has all states. Create a table called my_states that contains rows for states satisfying both the conditions: it is in the Northeast or West and the murder rate is less than 1. Use select to show only the state name, the rate, and the rank.

```
my_states<-filter(murders,region%in%c("Northeast","West") & rate<1)
select(my_states,state,rate,rank)
```

```
##           state      rate rank
## 1        Hawaii 0.5145920   49
## 2         Idaho 0.7655102   46
## 3         Maine 0.8280881   44
## 4 New Hampshire 0.3798036   50
## 5        Oregon 0.9396843   42
## 6          Utah 0.7959810   45
## 7       Vermont 0.3196211   51
## 8       Wyoming 0.8871131   43
```

4.5 The pipe: %>%

With dplyr we can perform a series of operations, for example select and then filter, by sending the results of one function to another using what is called the pipe operator: %>%. Some details are included below.

We wrote code above to show three variables (state, region, rate) for states that have murder rates below 0.71. To do this, we defined the intermediate object new_table. In dplyr we can write code that looks more like a description of what we want to do without intermediate objects:

original data->select->filter

For such an operation, we can use the pipe %>%. The code looks like this:

```
murders%>% select(state,region,rate)%>% filter(rate<=0.71)
```

```
##           state        region      rate
## 1        Hawaii          West 0.5145920
## 2          Iowa North Central 0.6893484
## 3 New Hampshire     Northeast 0.3798036
## 4  North Dakota North Central 0.5947151
## 5       Vermont     Northeast 0.3196211
```

This line of code is equivalent to the two lines of code above. What is going on here?

In general, the pipe sends the result of the left side of the pipe to be the first argument of the function on the right side of the pipe. Here is a very simple example:

```
16%>%sqrt()
```

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

We can continue to pipe values along:

```
16%>% sqrt()%>% log2()
```

```
## [1] 2
```

The above statement is equivalent to log2(sqrt(16)).

Remember that the pipe sends values to the first argument, so we can define other arguments as if the first argument is already defined:

```
16%>% sqrt()%>% log(base = 2)
```

```
## [1] 2
```

Therefore, when using the pipe with data frames and dplyr, we no longer need to specify the required first argument since the dplyr functions we have described all take the data as the first argument. In the code we wrote:

```
murders%>%select(state,region,rate)%>%filter(rate<=0.71)
```

```
##           state        region      rate
## 1        Hawaii          West 0.5145920
## 2          Iowa North Central 0.6893484
## 3 New Hampshire     Northeast 0.3798036
## 4  North Dakota North Central 0.5947151
## 5       Vermont     Northeast 0.3196211
```

murders is the first argument of the select function, and the new data frame (formerly new_table) is the first argument of the filter function.

Note that the pipe works well with functions where the first argument is the input data. Functions in tidyverse packages like dplyr have this format and can be used easily with the pipe.

4.6 Exercises

1. The pipe %>% can be used to perform operations sequentially without having to define intermediate objects. Start by redefining murder to include rate and rank.

```
murders<-mutate(murders,rate=total/population*100000,
                rank=rank(-rate))
```

In the solution to the previous exercise, we did the following:

```
my_states<-filter(murders,region%in%c("Northeast","West")&rate<1)
select(my_states,state,rate,rank)
```

```
##           state      rate rank
## 1        Hawaii 0.5145920   49
## 2         Idaho 0.7655102   46
## 3         Maine 0.8280881   44
## 4 New Hampshire 0.3798036   50
## 5        Oregon 0.9396843   42
## 6          Utah 0.7959810   45
## 7       Vermont 0.3196211   51
## 8       Wyoming 0.8871131   43
```

The pipe %>% permits us to perform both operations sequentially without having to define an intermediate variable my_states. We therefore could have mutated and selected in the same line like this:

```
mutate(murders,rate=total/population*100000,
       rank=rank(-rate))%>%
  select(state,rate,rank)
```

```
##                   state       rate rank
## 1               Alabama  2.8244238   23
## 2                Alaska  2.6751860   27
## 3               Arizona  3.6295273   10
## 4              Arkansas  3.1893901   17
## 5            California  3.3741383   14
## 6              Colorado  1.2924531   38
## 7           Connecticut  2.7139722   25
## 8              Delaware  4.2319369    6
## 9  District of Columbia 16.4527532    1
## 10              Florida  3.3980688   13
## 11              Georgia  3.7903226    9
## 12               Hawaii  0.5145920   49
## 13                Idaho  0.7655102   46
## 14             Illinois  2.8369608   22
## 15              Indiana  2.1900730   31
## 16                 Iowa  0.6893484   47
## 17               Kansas  2.2081106   30
## 18             Kentucky  2.6732010   28
## 19            Louisiana  7.7425810    2
## 20                Maine  0.8280881   44
## 21             Maryland  5.0748655    4
```

```
## 22        Massachusetts  1.8021791   32
## 23             Michigan  4.1786225    7
## 24            Minnesota  0.9992600   40
## 25          Mississippi  4.0440846    8
## 26             Missouri  5.3598917    3
## 27              Montana  1.2128379   39
## 28             Nebraska  1.7521372   33
## 29               Nevada  3.1104763   19
## 30        New Hampshire  0.3798036   50
## 31           New Jersey  2.7980319   24
## 32           New Mexico  3.2537239   15
## 33             New York  2.6679599   29
## 34       North Carolina  2.9993237   20
## 35         North Dakota  0.5947151   48
## 36                 Ohio  2.6871225   26
## 37             Oklahoma  2.9589340   21
## 38               Oregon  0.9396843   42
## 39         Pennsylvania  3.5977513   11
## 40         Rhode Island  1.5200933   35
## 41       South Carolina  4.4753235    5
## 42         South Dakota  0.9825837   41
## 43            Tennessee  3.4509357   12
## 44                Texas  3.2013603   16
## 45                 Utah  0.7959810   45
## 46              Vermont  0.3196211   51
## 47             Virginia  3.1246001   18
## 48           Washington  1.3829942   37
## 49        West Virginia  1.4571013   36
## 50            Wisconsin  1.7056487   34
## 51              Wyoming  0.8871131   43
```

Notice that select no longer has a data frame as the first argument. The first argument is assumed to be the result of the operation conducted right before the %>%.

Repeat the previous exercise, but now instead of creating a new object, show the result and only include the state, rate, and rank columns. Use a pipe %>% to do this in just one line.

```
murders%>%filter(region%in%c("Northeast","West")&rate<1)%>%
  select(state,rate,rank)
```

```
##           state      rate rank
## 1        Hawaii 0.5145920   49
## 2         Idaho 0.7655102   46
## 3         Maine 0.8280881   44
## 4 New Hampshire 0.3798036   50
## 5        Oregon 0.9396843   42
## 6          Utah 0.7959810   45
## 7       Vermont 0.3196211   51
## 8       Wyoming 0.8871131   43
```

2. Reset murders to the original table by using data(murders). Use a pipe to create a new data frame called my_states that considers only states in the Northeast or West which have a murder rate lower than 1, and contains only the state, rate and rank columns. The pipe should also have four components separated by three %>%. The code should look something like this:

```
data(murders)
my_states<-murders%>%
  mutate(rate=total/population*100000,rank=rank(-rate))%>%
  filter(region%in%c("Northeast","West")&rate<1)%>%
  select(state,rate,rank)
```