Cleaning Data

Cleaning Data In R

GitHub Repository with this demonstration: https://github.com/unmrds/R-data-cleaning

Zipfile Download: https://github.com/unmrds/R-data-cleaning/archive/master.zip

Check out the **Preflight Check** to see if you have the needed R libraries installed run the `package.check.R` script in the top directory of this R project. This script will check to see if the packages are installed, and if they are not will do so. The script finishes with a listing of the currently installed packages so you can verify that the packages we need are installed. Check out the README.md file in the workshop repository for full setup instructions.

When planning a data analysis the first step, and often most time consuming, is the acquisition and processing of the data into a form that can be used in the analytic procedures you intend to use. Today we are going to focus on a sequence of steps that generally follow the workflow that you will find yourself going through when bringing data into R to perform an analysis.

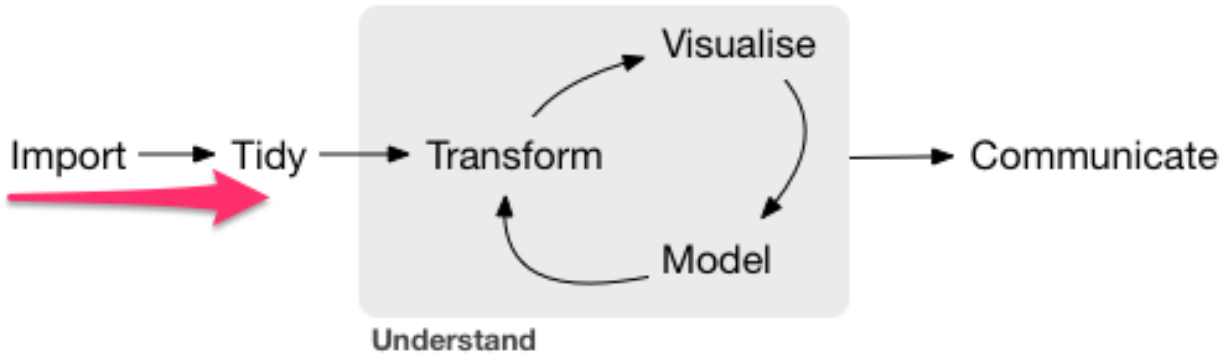


Figure 1: Portion of *R for Data Science*[1] workflow

Deal with issues that may come up when importing data files

1. Identify and correct structural issues in the source data that prevent clean import into R data structures
2. Check and handle data type errors
3. Check and handle missing data values

Tuning up the structure of the data to facilitate analysis

4. Split up fields that contain mutiple values in a single field
5. Check for anomalous values and otherwise explore the data to become familiar with its content and structure.

Beyond what we will cover today - continued structural changes and the rest of the exploration, analysis, and communication process.

[1] Hadley Wickham & Garrett Grolemund. 2017. *R for Data Science*. O'Reilly. https://r4ds.had.co.nz

Data for today's demonstration

The data for this demonstration are based upon the idigbio_rodents.csv dataset. The data are described as follows in the repository where they are shared:

> The idigbio_rodents.csv dataset is just over 10k records and contains data from natural history collections specimen records representing 5 genera from 4 major US collections, limited to US records. All records are from the Order Rodentia. All the data are mapped to the biodiversity data standard Darwin Core (http://rs.tdwg.org/dwc/terms/).

The original data have been modified for use in this demonstration by:

1. Generating new data columns (`latDMS` and `lonDMS`) for latitude and longitude that have sample coordinates presented in Degrees-Minutes-Seconds instead of the originally provided decimal degrees.
2. Generating a column of mixed numeric and text values - `textLatDD`.

This is the `../data/learning.csv` file. These newly created columns in addition to some of the originally provided ones will be used to demonstrate a variety of data cleaning steps in R.

An additional file was developed that only includes the first 10 rows of the file (including headers) but introduces a strucutral error. This file is the `../data/learning_struct.csv` file.

R libraries used in the demonstration

For this demonstration a combination of R packages that are part of the *Tidyverse* and additional specialized data evaluation packages will be used. The tidyverse collection of packages provide (as described on the project's homepage):

> an opinionated collection of R packages designed for data science. All packages share an underlying design philosophy, grammar, and data structures.

In addition to `tidyverse`, this workshop also uses the `mice`, `VIM`, and `assertr` packages.

There are currently over 14,000 R packages in the Comprehensive R Archive Network (CRAN). While the tidyverse packages provide a useful degree of consistency and internal interoperablity it is strongly encouraged to examine the broad collection of R packages when working on a particular analysis problem.

If you need to install any of the needed packages in your enviornment you can execute the `install.packages("<package name>")` command in the R console.

1. Identify and correct structural issues in the source data that prevent clean import into R data structures

R can import a wide variety of *rectangular* data structures: comma-delimited, tab-delimited, excel spreadsheets, fixed-width among the many options. If there are errors in the structure of these files, R import commands may not be able to parse the lines in the data file preventing import. In these cases the returned error messages *may* provide some clues to where the errors may be found.

One strategy for identifying potential strucutral issues in the source file is to try to import the dataset and review any errors that are returned

Let's try it first with a small file . . .

```
########## Working with a CSV file with structural problems ###################

library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.1.0     v dplyr   1.0.5
```

```
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1
```

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

```
# Import the source CSV file that contains a structural flaw
rawDataStruct <- read_csv("../data/learning_struct.csv",
                    progress = FALSE)
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

```
##
## -- Column specification --------------------------------------------------------
## cols(
##   .default = col_character(),
##   X1 = col_double(),
##   catalogNumber = col_double(),
##   year = col_double(),
##   day = col_double()
## )
## i Use `spec()` for the full column specifications.
```

```
## Warning: 1 parsing failure.
## row col   expected     actual                          file
##   7  -- 24 columns 26 columns '../data/learning_struct.csv'
```

```
# Display the column definitions for the imported dataset
spec(rawDataStruct)
```

```
## cols(
##   X1 = col_double(),
##   uuid = col_character(),
##   institutionCode = col_character(),
##   collectionCode = col_character(),
##   catalogNumber = col_double(),
##   recordedBy = col_character(),
##   countryCode = col_character(),
##   stateProvince = col_character(),
##   county = col_character(),
##   decimalLatitude = col_character(),
##   decimalLongitude = col_character(),
##   eventDate = col_character(),
##   year = col_double(),
##   month = col_character(),
##   day = col_double(),
##   genus = col_character(),
##   specificEpithet = col_character(),
##   scientificName = col_character(),
##   weight = col_character(),
##   length = col_character(),
##   sex = col_character(),
##   latDMS = col_character(),
##   lonDMS = col_character(),
##   textLatDD = col_character()
## )
```

```
# Report the problems that were encountered when the data were imported.
problems(rawDataStruct)
```

```
## # A tibble: 1 x 5
##     row col   expected   actual     file
##   <int> <chr> <chr>      <chr>      <chr>
## 1     7 <NA>  24 columns 26 columns '../data/learning_struct.csv'
```

```
# Display the imported table
rawDataStruct
```

```
## # A tibble: 9 x 24
##      X1 uuid       institutionCode collectionCode catalogNumber recordedBy
##   <dbl> <chr>      <chr>           <chr>                 <dbl> <chr>
## 1     1 060380ea-~ mvz             mammal specim~       219088 collector(s): a~
## 2     2 0fb17a79-~ mvz             mammal specim~       233524 collector(s): w~
## 3     3 1a69c8ad-~ mvz             mammal specim~       234346 collector(s): w~
## 4     4 1a9932b4-~ mvz             mammal specim~       233951 collector(s): w~
## 5     5 1f3b8aea-~ mvz             mammal specim~       235290 collector(s): w~
## 6     6 203f0531-~ uam             mammal specim~        85106 collector(s): t~
## 7     7 21ceb6f0-~ omnh            mammals               50048 caldwell
## 8     8 23d3f0d9-~ mvz             mammal specim~       216309 collector(s): j~
## 9     9 244bbe9f-~ msb             mammal specim~       294933 collector(s): t~
## # ... with 18 more variables: countryCode <chr>, stateProvince <chr>,
## #   county <chr>, decimalLatitude <chr>, decimalLongitude <chr>,
## #   eventDate <chr>, year <dbl>, month <chr>, day <dbl>, genus <chr>,
## #   specificEpithet <chr>, scientificName <chr>, weight <chr>, length <chr>,
## #   sex <chr>, latDMS <chr>, lonDMS <chr>, textLatDD <chr>
```

The output of the `read_csv` command and of the `problems` function indicate that there was a problem of some sort around row 7 during the import of the CSV:

1 parsing failure. row col expected actual file 7 – 24 columns 26 columns '../data/learning_struct.csv'

Let's take a look at the source data file and see if we can find the problem...

After the structural problem has been resolved load the full dataset for use in the rest of the workshop

```
########## Load the full CSV file without the structural error ################

library(tidyverse)

# Import the source CSV file that does not contain the structural problem highlighted above
rawData <- read_csv("../data/learning.csv",
                    progress = FALSE)
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

```
##
## -- Column specification --------------------------------------------------------
## cols(
##   .default = col_character(),
##   X1 = col_double(),
##   catalogNumber = col_double(),
##   decimalLatitude = col_double(),
##   decimalLongitude = col_double(),
```

```
##   eventDate = col_datetime(format = ""),
##   year = col_double(),
##   month = col_double(),
##   day = col_double(),
##   weight = col_double(),
##   length = col_double()
## )
## i Use `spec()` for the full column specifications.
```

```
# Display the column definitions for the imported dataset
spec(rawData)
```

```
## cols(
##   X1 = col_double(),
##   uuid = col_character(),
##   institutionCode = col_character(),
##   collectionCode = col_character(),
##   catalogNumber = col_double(),
##   recordedBy = col_character(),
##   countryCode = col_character(),
##   stateProvince = col_character(),
##   county = col_character(),
##   decimalLatitude = col_double(),
##   decimalLongitude = col_double(),
##   eventDate = col_datetime(format = ""),
##   year = col_double(),
##   month = col_double(),
##   day = col_double(),
##   genus = col_character(),
##   specificEpithet = col_character(),
##   scientificName = col_character(),
##   weight = col_double(),
##   length = col_double(),
##   sex = col_character(),
##   latDMS = col_character(),
##   lonDMS = col_character(),
##   textLatDD = col_character()
## )
```

```
# Report the problems that were encountered when the data were imported.
problems(rawData)
```

```
## [1] row      col      expected actual
## <0 rows> (or 0-length row.names)
```

```
# Display the imported table
rawData
```

```
## # A tibble: 10,767 x 24
##       X1 uuid      institutionCode collectionCode  catalogNumber recordedBy
##    <dbl> <chr>     <chr>           <chr>                   <dbl> <chr>
##  1     1 060380ea~ mvz             mammal specime~        219088 collector(s): ~
##  2     2 0fb17a79~ mvz             mammal specime~        233524 collector(s): ~
##  3     3 1a69c8ad~ mvz             mammal specime~        234346 collector(s): ~
##  4     4 1a9932b4~ mvz             mammal specime~        233951 collector(s): ~
##  5     5 1f3b8aea~ mvz             mammal specime~        235290 collector(s): ~
##  6     6 203f0531~ uam             mammal specime~         85106 collector(s): ~
```

```
##  7     7 21ceb6f0~ omnh            mammals                 50048 caldwell, j. p~
##  8     8 23d3f0d9~ mvz             mammal specime~        216309 collector(s): ~
##  9     9 244bbe9f~ msb             mammal specime~        294933 collector(s): ~
## 10    10 2682aa08~ uam             mammal specime~         50255 collector(s): ~
## # ... with 10,757 more rows, and 18 more variables: countryCode <chr>,
## #   stateProvince <chr>, county <chr>, decimalLatitude <dbl>,
## #   decimalLongitude <dbl>, eventDate <dttm>, year <dbl>, month <dbl>,
## #   day <dbl>, genus <chr>, specificEpithet <chr>, scientificName <chr>,
## #   weight <dbl>, length <dbl>, sex <chr>, latDMS <chr>, lonDMS <chr>,
## #   textLatDD <chr>
```

Some questions:

1. How do the data types for the columns from this import process differ from those in the previous subset (at least before we fixed it)? Why do you think this is the case?
2. Where there any errors identified during the import? If no, does this mean that there are no potential problems or issues with the imported data? **Let's take a look**
3. How would you explain the values in the `eventDate` column when compared to the `year`, `month`, and `day` columns?
4. What were the different ways in which missing data values were handled?

2. Checking and handling data type errors

Depending on the types of data that are encountered in each column of the imported dataset different R import functions will automatically "type" the column (or in R terminology set the "mode" of the column) based on some sample of rows from the source file. In the case of `readr`, the data reading package used by tidyverse, the first 1000 lines of data will be read to determine the data type that should be used for each column. The core R data types are:

- character
- numeric (real or decimal)
- integer
- logical
- complex

These core data types can then be used as the foundation for more complex data types such as *dates*, *times* and *datetimes*.

The core data structures that can be used to organize collections of these data types include:

- vector - a sequence of data values of the same type
- list - a sequence of data values of the same or different types, and structures
- matrix - a vector for which one or more *dimensions* are defined
- data frame (and the "tibble" in the tidyverse) - a structured collection of vectors of the same length
- factors - a factor vector is a set of integer values that are associated with a collection of categorical character values

Let's focus on the `catalogNumber` and `textLatDD` columns in our sample datasets.

```
########## Handling data type errors on import ################################

## Take a look at the types and content of a couple of columns
spec(rawData)
```

```
## cols(
##   X1 = col_double(),
##   uuid = col_character(),
##   institutionCode = col_character(),
```

```
##   collectionCode = col_character(),
##   catalogNumber = col_double(),
##   recordedBy = col_character(),
##   countryCode = col_character(),
##   stateProvince = col_character(),
##   county = col_character(),
##   decimalLatitude = col_double(),
##   decimalLongitude = col_double(),
##   eventDate = col_datetime(format = ""),
##   year = col_double(),
##   month = col_double(),
##   day = col_double(),
##   genus = col_character(),
##   specificEpithet = col_character(),
##   scientificName = col_character(),
##   weight = col_double(),
##   length = col_double(),
##   sex = col_character(),
##   latDMS = col_character(),
##   lonDMS = col_character(),
##   textLatDD = col_character()
## )
```

```
rawData %>%
  select(catalogNumber,textLatDD)
```

```
## # A tibble: 10,767 x 2
##    catalogNumber textLatDD
##            <dbl> <chr>
##  1        219088 37.7609527778
##  2        233524 37.8999569
##  3        234346 37.8999569
##  4        233951 37.8999569
##  5        235290 37.8999569
##  6         85106 43.2751187
##  7         50048 34.53903
##  8        216309 36.97099
##  9        294933 36.584948
## 10         50255 44.2611111111
## # ... with 10,757 more rows
```

```
## Test the creation of a numLatDD column as a numeric column and
## see what rows were converted to NA
rawData %>%
  mutate(numLatDD = as.numeric(rawData$textLatDD)) %>%
  filter(is.na(numLatDD)) %>%
  select(textLatDD, numLatDD) %>%
  print() %>%
  group_by(textLatDD) %>%
  summarize(count = n())
```

```
## Warning in mask$eval_all_mutate(quo): NAs introduced by coercion
```

```
## # A tibble: 1,222 x 2
##    textLatDD numLatDD
##    <chr>        <dbl>
```

```
##  1 missing         NA
##  2 missing         NA
##  3 missing         NA
##  4 missing         NA
##  5 missing         NA
##  6 missing         NA
##  7 missing         NA
##  8 missing         NA
##  9 missing         NA
## 10 missing         NA
## # ... with 1,212 more rows
```

```
## # A tibble: 1 x 2
##   textLatDD count
##   <chr>     <int>
## 1 missing    1222
```

```
## create a numeric column based on the previously tested conversion of
## the textLatDD column
rawData$numLatDD <- as.numeric(rawData$textLatDD)
```

```
## Warning: NAs introduced by coercion
```

```
rawData
```

```
## # A tibble: 10,767 x 25
##       X1 uuid      institutionCode collectionCode  catalogNumber recordedBy
##    <dbl> <chr>     <chr>           <chr>                   <dbl> <chr>
##  1     1 060380ea~ mvz             mammal specime~        219088 collector(s): ~
##  2     2 0fb17a79~ mvz             mammal specime~        233524 collector(s): ~
##  3     3 1a69c8ad~ mvz             mammal specime~        234346 collector(s): ~
##  4     4 1a9932b4~ mvz             mammal specime~        233951 collector(s): ~
##  5     5 1f3b8aea~ mvz             mammal specime~        235290 collector(s): ~
##  6     6 203f0531~ uam             mammal specime~         85106 collector(s): ~
##  7     7 21ceb6f0~ omnh            mammals                 50048 caldwell, j. p~
##  8     8 23d3f0d9~ mvz             mammal specime~        216309 collector(s): ~
##  9     9 244bbe9f~ msb             mammal specime~        294933 collector(s): ~
## 10    10 2682aa08~ uam             mammal specime~         50255 collector(s): ~
## # ... with 10,757 more rows, and 19 more variables: countryCode <chr>,
## #   stateProvince <chr>, county <chr>, decimalLatitude <dbl>,
## #   decimalLongitude <dbl>, eventDate <dttm>, year <dbl>, month <dbl>,
## #   day <dbl>, genus <chr>, specificEpithet <chr>, scientificName <chr>,
## #   weight <dbl>, length <dbl>, sex <chr>, latDMS <chr>, lonDMS <chr>,
## #   textLatDD <chr>, numLatDD <dbl>
```

We can also accomplish a similar outcome by specifying the column type that should be created as part of the import process.

```
## Specify the column data type when importing
rawData2 <- read_csv("../data/learning.csv",
                     col_types = cols(
                        textLatDD = col_double()
                        ),
                     progress = FALSE)
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

```
## Warning: 1222 parsing failures.
```

```
## row       col expected  actual                   file
##  11 textLatDD a double missing '../data/learning.csv'
##  21 textLatDD a double missing '../data/learning.csv'
##  25 textLatDD a double missing '../data/learning.csv'
##  32 textLatDD a double missing '../data/learning.csv'
##  39 textLatDD a double missing '../data/learning.csv'
## ... ......... ........ ....... ......................
## See problems(...) for more details.
```

```
# Display the column definitions for the imported dataset
spec(rawData2)
```

```
## cols(
##   X1 = col_double(),
##   uuid = col_character(),
##   institutionCode = col_character(),
##   collectionCode = col_character(),
##   catalogNumber = col_double(),
##   recordedBy = col_character(),
##   countryCode = col_character(),
##   stateProvince = col_character(),
##   county = col_character(),
##   decimalLatitude = col_double(),
##   decimalLongitude = col_double(),
##   eventDate = col_datetime(format = ""),
##   year = col_double(),
##   month = col_double(),
##   day = col_double(),
##   genus = col_character(),
##   specificEpithet = col_character(),
##   scientificName = col_character(),
##   weight = col_double(),
##   length = col_double(),
##   sex = col_character(),
##   latDMS = col_character(),
##   lonDMS = col_character(),
##   textLatDD = col_double()
## )
```

```
# Report the problems that were encountered when the data were imported.
problems(rawData2)
```

```
## # A tibble: 1,222 x 5
##      row col       expected actual  file
##    <int> <chr>     <chr>    <chr>   <chr>
##  1    11 textLatDD a double missing '../data/learning.csv'
##  2    21 textLatDD a double missing '../data/learning.csv'
##  3    25 textLatDD a double missing '../data/learning.csv'
##  4    32 textLatDD a double missing '../data/learning.csv'
##  5    39 textLatDD a double missing '../data/learning.csv'
##  6    44 textLatDD a double missing '../data/learning.csv'
##  7    54 textLatDD a double missing '../data/learning.csv'
##  8    55 textLatDD a double missing '../data/learning.csv'
##  9    59 textLatDD a double missing '../data/learning.csv'
## 10    63 textLatDD a double missing '../data/learning.csv'
## # ... with 1,212 more rows
```

```
# Display the imported table
rawData2
```

```
## # A tibble: 10,767 x 24
##       X1 uuid      institutionCode collectionCode  catalogNumber recordedBy
##    <dbl> <chr>     <chr>           <chr>                   <dbl> <chr>
##  1     1 060380ea~ mvz             mammal specime~        219088 collector(s): ~
##  2     2 0fb17a79~ mvz             mammal specime~        233524 collector(s): ~
##  3     3 1a69c8ad~ mvz             mammal specime~        234346 collector(s): ~
##  4     4 1a9932b4~ mvz             mammal specime~        233951 collector(s): ~
##  5     5 1f3b8aea~ mvz             mammal specime~        235290 collector(s): ~
##  6     6 203f0531~ uam             mammal specime~         85106 collector(s): ~
##  7     7 21ceb6f0~ omnh            mammals                 50048 caldwell, j. p~
##  8     8 23d3f0d9~ mvz             mammal specime~        216309 collector(s): ~
##  9     9 244bbe9f~ msb             mammal specime~        294933 collector(s): ~
## 10    10 2682aa08~ uam             mammal specime~         50255 collector(s): ~
## # ... with 10,757 more rows, and 18 more variables: countryCode <chr>,
## #   stateProvince <chr>, county <chr>, decimalLatitude <dbl>,
## #   decimalLongitude <dbl>, eventDate <dttm>, year <dbl>, month <dbl>,
## #   day <dbl>, genus <chr>, specificEpithet <chr>, scientificName <chr>,
## #   weight <dbl>, length <dbl>, sex <chr>, latDMS <chr>, lonDMS <chr>,
## #   textLatDD <dbl>
```

```
## Convert the catalogNumberTxt column to a character column and see what
## the result is
rawData %>%
  mutate(catalogNumberTxt = as.character(catalogNumber)) %>%
  filter(is.na(catalogNumberTxt))
```

```
## # A tibble: 0 x 26
## # ... with 26 variables: X1 <dbl>, uuid <chr>, institutionCode <chr>,
## #   collectionCode <chr>, catalogNumber <dbl>, recordedBy <chr>,
## #   countryCode <chr>, stateProvince <chr>, county <chr>,
## #   decimalLatitude <dbl>, decimalLongitude <dbl>, eventDate <dttm>,
## #   year <dbl>, month <dbl>, day <dbl>, genus <chr>, specificEpithet <chr>,
## #   scientificName <chr>, weight <dbl>, length <dbl>, sex <chr>, latDMS <chr>,
## #   lonDMS <chr>, textLatDD <chr>, numLatDD <dbl>, catalogNumberTxt <chr>
```

3. Check and handle missing values

It is important to understand the potential impact that missing data will have on your analysis. As we've already seen the import process may automatically produce missing data values in your analysis dataframe (or *tibble* in the context of tidyverse based processes). Some functions enable you to efficiently visualize the patterns of missing values in your dataset - allowing for the analysis of large datasets that otherwise would not be feasible to review manually.

```
########## Check and handle missing values #####################################

## Manually by printing out sum (FALSE = 0, TRUE = 1) of is.na test results
paste("decimalLatitude: number of NA values",
      sum(is.na(rawData$decimalLatitude)),
      sep = " ")
```

```
## [1] "decimalLatitude: number of NA values 1222"
```

```
paste("decimalLongitude: number of NA values",
      sum(is.na(rawData$decimalLongitude)),
      sep = " ")
```

```
## [1] "decimalLongitude: number of NA values 1222"
```

```
paste("weight: number of NA values",
      sum(is.na(rawData$weight)),
      sep = " ")
```

```
## [1] "weight: number of NA values 0"
```

```
paste("length: number of NA values",
      sum(is.na(rawData$length)),
      sep = " ")
```

```
## [1] "length: number of NA values 0"
```

```
paste("sex: number of NA values",
      sum(is.na(rawData$sex)),
      sep = " ")
```

```
## [1] "sex: number of NA values 1446"
```

```
paste("latDMS: number of NA values",
      sum(is.na(rawData$latDMS)),
      sep = " ")
```

```
## [1] "latDMS: number of NA values 0"
```

```
paste("lonDMS: number of NA values",
      sum(is.na(rawData$lonDMS)),
      sep = " ")
```

```
## [1] "lonDMS: number of NA values 0"
```

```
paste("textLatDD: number of NA values",
      sum(is.na(rawData$textLatDD)),
      sep = " ")
```

```
## [1] "textLatDD: number of NA values 0"
```

```
paste("numLatDD: number of NA values",
      sum(is.na(rawData$numLatDD)),
      sep = " ")
```

```
## [1] "numLatDD: number of NA values 1222"
```

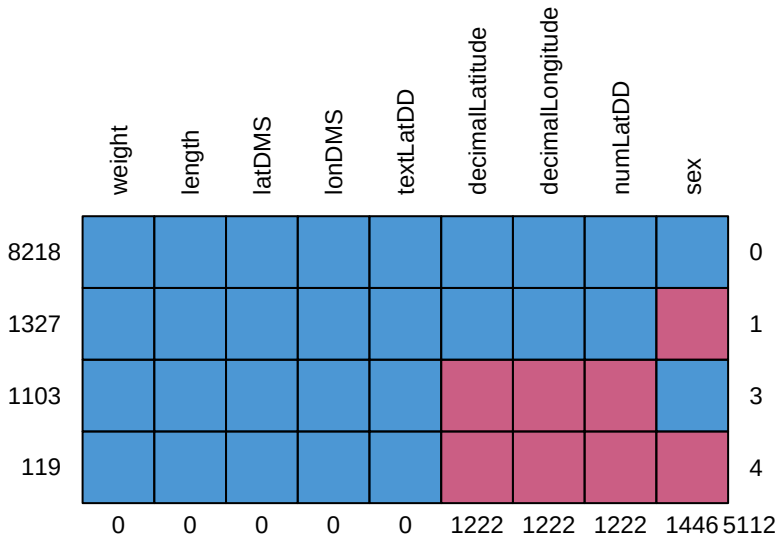
In this analysis we will be using the `md.pattern` function that is part of the `mice` package, and the `aggr` function which is part of the `VIM` package. If you haven't already installed the `mice` and `VIM` packages you can do so by executing the `install.packages("mice")` and `install.packages("VIM")` commands.

```
##
## Attaching package: 'mice'
```

```
## The following object is masked from 'package:stats':
##
##     filter
```

```
## The following objects are masked from 'package:base':
##
```

```
##     cbind, rbind
```




```
##      weight length latDMS lonDMS textLatDD decimalLatitude decimalLongitude numLatDD  sex
## 8218      1      1      1      1         1               1                1        1    1    0
## 1327      1      1      1      1         1               1                1        1    0    1
## 1103      1      1      1      1         1               0                0        0    1    3
## 119       1      1      1      1         1               0                0        0    0    4
##           0      0      0      0         0            1222             1222     1222 1446 5112
```

Another method of viewing similar information

```
## View the combinations of NA values across multiple columns with the
## aggr function from the VIM package
library(VIM)
```

```
## Loading required package: colorspace
```

```
## Loading required package: grid
```

```
## VIM is ready to use.
```

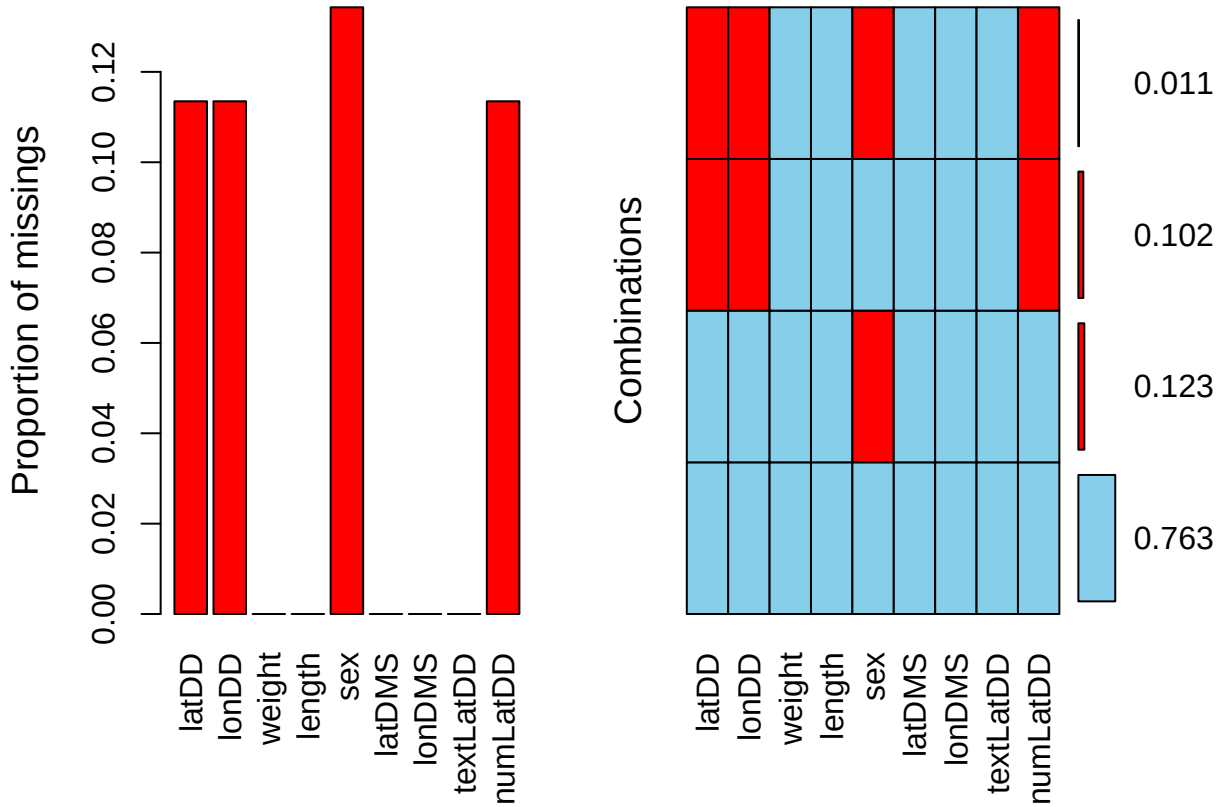
```
## Suggestions and bug-reports can be submitted at: https://github.com/statistikat/VIM/issues
```

```
##
## Attaching package: 'VIM'
```

```
## The following object is masked from 'package:datasets':
##
##     sleep
```

```
rawData %>%
  select(decimalLatitude,
         decimalLongitude,
         weight,
         length,
         sex,
         latDMS,
         lonDMS,
         textLatDD,
         numLatDD) %>%
  rename(latDD = decimalLatitude, lonDD = decimalLongitude) %>%
```

```
aggr(numbers=TRUE)
```



4. Multi-value columns

A core principle of having well structured data that is read for analysis is that:

In the context of "Tidy" data that underlie the tools developed as part of the tidyverse packageˆ[Hadley Wickham & Garrett Grolemund. 2017. *R for Data Science*. O'Reilly. - section on Tidy Data https://r4ds.had.co.nz/tidy-data.html

> There are three interrelated rules which make a dataset tidy:
>
> 1. Each variable must have its own column.
> 2. Each observation must have its own row.
> 3. **Each value must have its own cell.**

This issue also relates to the idea of *atomicity* in Codd's definition of *First Normal Form* when *normalizing* a relational database[2]. While we're not going to get into relational data modeling in R here, well structured data allow for the use of relational data models in your analysis independent of a separate database server.

In this example we are going to focus on three columns: `recordedBy`, `latDMS`, and `lonDMS`.

```
########## Handling multi-value columns ########################################

## Take a look at the recordedBy, latDMS, and lonDMS columns
rawData %>%
  select(recordedBy, latDMS, lonDMS)
```

```
## # A tibble: 10,767 x 3
```

[2]https://en.wikipedia.org/wiki/First_normal_form

```
##    recordedBy                                        latDMS         lonDMS
##    <chr>                                             <chr>          <chr>
##  1 collector(s): ana lilia trujano álvarez, eric~ "37°45'39.430~ "-122° 6'48.37~
##  2 collector(s): william z. lidicker jr.          "37°53'59.845~ "-123°38'18.03~
##  3 collector(s): william z. lidicker jr.          "37°53'59.845~ "-123°38'18.03~
##  4 collector(s): william z. lidicker jr.          "37°53'59.845~ "-123°38'18.03~
##  5 collector(s): william z. lidicker jr.          "37°53'59.845~ "-123°38'18.03~
##  6 collector(s): tom manning; preparator(s): amb~ "43°16'30.427~ "-123°12'32.02~
##  7 caldwell, j. p. and vitt, l. j.                "34°32'20.508~ "-95° 6'42.444~
##  8 collector(s): james l. patton                  "36°58'15.564~ "-119°54'16.74~
##  9 collector(s): troy l. best; preparator(s): tr~ "36°35' 5.813~ "-108° 0'55.75~
## 10 collector(s): karl j. martin; preparator(s): ~ "44°15'40.000~ "-124°25' 1.00~
## # ... with 10,757 more rows
```

Breaking apart the `recordedBy` column using the `str_match` function from the `stringr` package. This uses *regular expressions* for defining the text patterns that should be found and processed in the process of breaking the column apart into new columns. Regular expressions are an art to themselves and there are many resources for learning their effective use - ranging from one-page cheat-sheets to full length books. Some great resources include:

- Jeffrey E.F. Friedl (2006) *Mastering Regular Expressions*. 3rd Ed. O'Reilly. http://shop.oreilly.com/product/9780596528126.do and for UNM affiliates through our Safari Online Learning subscription: https://learning.oreilly.com/library/view/mastering-regular-expressions/0596528124/ - this is a comprehensive, in-depth treatment of regular expressions from the most simple to most complex - including disucssions of implementations of regular expression support in different programming languages.
- Steven Levithan, Jan Goyvaerts (2012). *Regular Expressions Cookbook*. 2nd Ed. O'Reilly. http://shop.oreilly.com/product/0636920023630.do and for UNM affiliates https://learning.oreilly.com/library/view/regular-expressions-cookbook/9781449327453/ - a good set of regular expression common problems, and their solutions in multiple language implementations.
- Ian Kopacka (2016). *Basic Regular Expressions in R - Cheat Sheet*. Online resource: https://rstudio.com/wp-content/uploads/2016/09/RegExCheatsheet.pdf

The following figure describes the structure of the regular expressions used in the sample code:

```
## Define and use some R regular expressions for extracting text from the
## recordedBy column
collectorExtract <- "^collector\\(s\\):\\s(.*;|.*$)"
preparatorExtract <- "preparator\\(s\\):\\s(.*;|.*$)"

collector_string <- str_match(rawData$recordedBy, collectorExtract)
preparator_string <- str_match(rawData$recordedBy, preparatorExtract)

print(head(collector_string))
```

```
##      [,1]
## [1,] "collector(s): ana lilia trujano álvarez, eric ghilarducci"
## [2,] "collector(s): william z. lidicker jr."
## [3,] "collector(s): william z. lidicker jr."
## [4,] "collector(s): william z. lidicker jr."
## [5,] "collector(s): william z. lidicker jr."
## [6,] "collector(s): tom manning;"
##      [,2]
## [1,] "ana lilia trujano álvarez, eric ghilarducci"
## [2,] "william z. lidicker jr."
## [3,] "william z. lidicker jr."
```

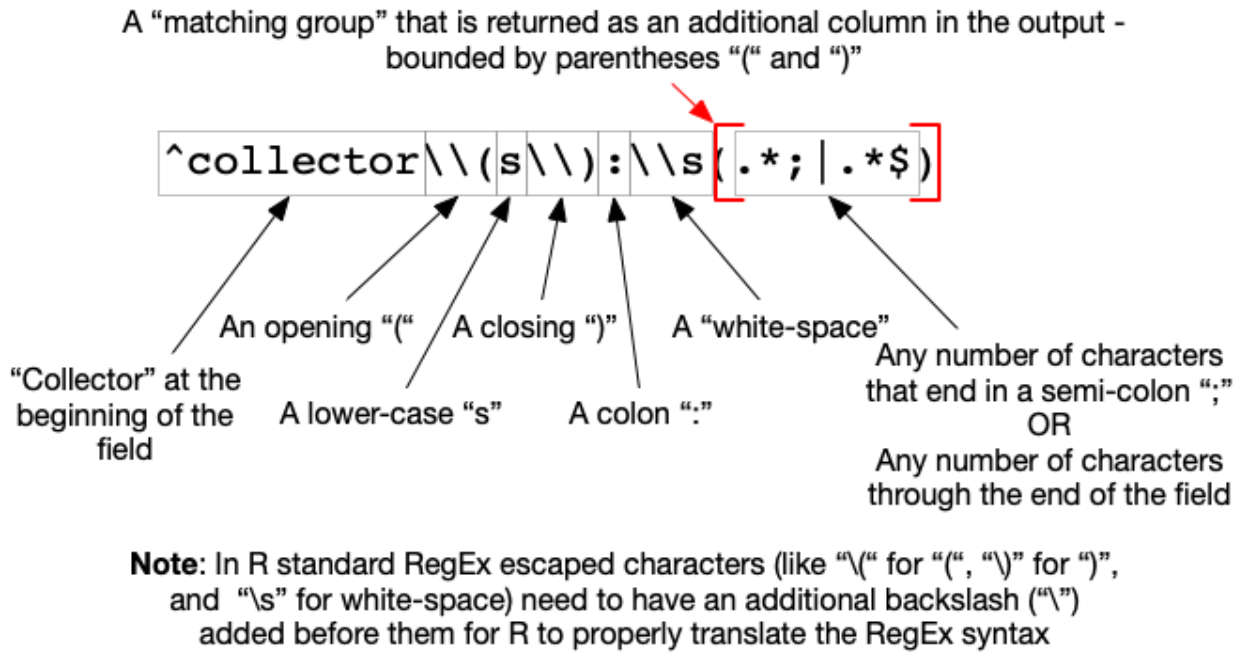


Figure 2: Description of the regular expression used to extract targeted substrings from the combined “recordedBy” field

```
## [4,] "william z. lidicker jr."
## [5,] "william z. lidicker jr."
## [6,] "tom manning;"
```

```
print(head(preparator_string))
```

```
##      [,1]                          [,2]
## [1,] NA                            NA
## [2,] NA                            NA
## [3,] NA                            NA
## [4,] NA                            NA
## [5,] NA                            NA
## [6,] "preparator(s): amber baxter" "amber baxter"
```

```
rawData$collectors <- collector_string[,2]
rawData$preparators <- preparator_string[,2]

# check the first ten rows to see what the output looks like
head(rawData, n=10) %>%
  select(recordedBy, collectors, preparators)
```

```
## # A tibble: 10 x 3
##    recordedBy                          collectors                  preparators
##    <chr>                               <chr>                       <chr>
##  1 collector(s): ana lilia trujano álv~ ana lilia trujano álvarez, ~ <NA>
##  2 collector(s): william z. lidicker j~ william z. lidicker jr.      <NA>
##  3 collector(s): william z. lidicker j~ william z. lidicker jr.      <NA>
##  4 collector(s): william z. lidicker j~ william z. lidicker jr.      <NA>
##  5 collector(s): william z. lidicker j~ william z. lidicker jr.      <NA>
##  6 collector(s): tom manning; preparat~ tom manning;                amber baxt~
```

```
##  7 caldwell, j. p. and vitt, l. j.      <NA>                        <NA>
##  8 collector(s): james l. patton        james l. patton             <NA>
##  9 collector(s): troy l. best; prepara~ troy l. best;               troy l. be~
## 10 collector(s): karl j. martin; prepa~ karl j. martin;            paul ollig
```

What would the next logical step in the process be for cleaning up the ***recordedBy*** *or newly generated columns?*

Breaking apart the `latDMS` and `lonDMS` columns into their constituent parts

```
## Define a regular expression and use it to extract pieces from a DMS string
dmsExtract <- "\\s*(-*[:digit:]+)°\\s*([:digit:]+)\\'\\s*([:digit:]+\\.*[:digit:]*)"

latSubstrings <- str_match(rawData$latDMS, dmsExtract)
print(head(latSubstrings))
```

```
##      [,1]           [,2] [,3] [,4]
## [1,] "37°45'39.430" "37" "45" "39.430"
## [2,] "37°53'59.845" "37" "53" "59.845"
## [3,] "37°53'59.845" "37" "53" "59.845"
## [4,] "37°53'59.845" "37" "53" "59.845"
## [5,] "37°53'59.845" "37" "53" "59.845"
## [6,] "43°16'30.427" "43" "16" "30.427"
```

```
rawData$latD <- as.numeric(latSubstrings[,2])
rawData$latM <- as.numeric(latSubstrings[,3])
rawData$latS <- as.numeric(latSubstrings[,4])

lonSubstrings <- str_match(rawData$lonDMS, dmsExtract)
print(head(lonSubstrings))
```

```
##      [,1]             [,2]   [,3] [,4]
## [1,] "-122° 6'48.370" "-122" "6"  "48.370"
## [2,] "-123°38'18.039" "-123" "38" "18.039"
## [3,] "-123°38'18.039" "-123" "38" "18.039"
## [4,] "-123°38'18.039" "-123" "38" "18.039"
## [5,] "-123°38'18.039" "-123" "38" "18.039"
## [6,] "-123°12'32.023" "-123" "12" "32.023"
```

```
rawData$lonD <- as.numeric(lonSubstrings[,2])
rawData$lonM <- as.numeric(lonSubstrings[,3])
rawData$lonS <- as.numeric(lonSubstrings[,4])


head(rawData, n=10) %>%
  select(latDMS, latD, latM, latS,
         lonDMS, lonD, lonM, lonS)
```

```
## # A tibble: 10 x 8
##    latDMS             latD  latM  latS lonDMS               lonD  lonM  lonS
##    <chr>             <dbl> <dbl> <dbl> <chr>               <dbl> <dbl> <dbl>
##  1 "37°45'39.430\"N"    37    45 39.4  "-122° 6'48.370\"E"  -122     6  48.4
##  2 "37°53'59.845\"N"    37    53 59.8  "-123°38'18.039\"E"  -123    38  18.0
##  3 "37°53'59.845\"N"    37    53 59.8  "-123°38'18.039\"E"  -123    38  18.0
##  4 "37°53'59.845\"N"    37    53 59.8  "-123°38'18.039\"E"  -123    38  18.0
##  5 "37°53'59.845\"N"    37    53 59.8  "-123°38'18.039\"E"  -123    38  18.0
##  6 "43°16'30.427\"N"    43    16 30.4  "-123°12'32.023\"E"  -123    12  32.0
##  7 "34°32'20.508\"N"    34    32 20.5  "-95° 6'42.444\"E"    -95     6  42.4
```

```
##  8 "36°58'15.564\"N"    36    58 15.6  "-119°54'16.740\"E"  -119    54  16.7
##  9 "36°35' 5.813\"N"    36    35  5.81 "-108° 0'55.757\"E"  -108     0  55.8
## 10 "44°15'40.000\"N"    44    15 40    "-124°25' 1.000\"E"  -124    25   1
```

5. Check value ranges and explore data

As part of the examiniation of these columns we will use the `assertr`. If you need to install the `assertr` package in your enviornment you can execute the `install.packages("assertr")` command.

Checking the `weight` and `length` columns.

```
########## Check value ranges and explore data ################################

## assert GitHub repository with instructions and examples:
##      https://github.com/ropensci/assertr
library(assertr)

## you can just run this if you want execution of your workflow to stop if
## any of your tests fail

# rawData %>%
#   chain_start %>%
#   assert(within_bounds(1,Inf), weight) %>% # assert checks individual values
#   assert(within_bounds(1,Inf), length) %>%
#   insist(within_n_sds(3), weight) %>% # insist checks against calculated vals
#   insist(within_n_sds(3), length) %>%
#   chain_end

## you can run this if you want to prevent the errors that are generated
## by your tests from halting execution of your workflow
tryCatch({rawData %>%
  chain_start %>%
  assert(within_bounds(1,Inf), weight) %>% # assert checks individual values
  assert(within_bounds(1,Inf), length) %>%
  insist(within_n_sds(3), weight) %>% # insist checks against calculated vals
  insist(within_n_sds(3), length) %>%
  chain_end
}, warning = function(w) {
    paste("A warning was generated: ", w, sep = "")
}, error = function(e) {
    print(e)
}, finally = {
    print("this is the end of the validation check ...")
  }
)
```

```
## There are 312 errors across 4 verbs:
## -
##       verb redux_fn             predicate column index  value
## 1   assert       NA within_bounds(1, Inf) weight  2772   0.00
## 2   assert       NA within_bounds(1, Inf) weight  2801   0.00
## 3   assert       NA within_bounds(1, Inf) weight  3118   0.00
## 4   assert       NA within_bounds(1, Inf) weight  3159   0.00
## 5   assert       NA within_bounds(1, Inf) weight  5417   0.00
## 6   assert       NA within_bounds(1, Inf) weight  6788   0.00
## 7   assert       NA within_bounds(1, Inf) weight  7334   0.00
```

```
## 8   assert       NA within_bounds(1, Inf) weight  8309   0.00
## 9   assert       NA within_bounds(1, Inf) weight  9539   0.00
## 10  assert       NA within_bounds(1, Inf) weight 10040   0.00
## 11  assert       NA within_bounds(1, Inf) weight 10628   0.00
## 12  assert       NA within_bounds(1, Inf) weight 10708   0.00
## 13  assert       NA within_bounds(1, Inf) length  2801   0.00
## 14  assert       NA within_bounds(1, Inf) length  8896   0.00
## 15  assert       NA within_bounds(1, Inf) length 10628   0.00
## 16  insist       NA       within_n_sds(3) weight    52 269.00
## 17  insist       NA       within_n_sds(3) weight   117 142.00
## 18  insist       NA       within_n_sds(3) weight   162 164.70
## 19  insist       NA       within_n_sds(3) weight   256 135.00
## 20  insist       NA       within_n_sds(3) weight   258 215.00
## 21  insist       NA       within_n_sds(3) weight   316 155.20
## 22  insist       NA       within_n_sds(3) weight   757 317.19
## 23  insist       NA       within_n_sds(3) weight   764 198.00
## 24  insist       NA       within_n_sds(3) weight   777 138.00
## 25  insist       NA       within_n_sds(3) weight   839 135.00
## 26  insist       NA       within_n_sds(3) weight   855 160.00
## 27  insist       NA       within_n_sds(3) weight   886 152.00
## 28  insist       NA       within_n_sds(3) weight   891 157.00
## 29  insist       NA       within_n_sds(3) weight   971 146.00
## 30  insist       NA       within_n_sds(3) weight   994 235.00
## 31  insist       NA       within_n_sds(3) weight  1035 157.00
## 32  insist       NA       within_n_sds(3) weight  1125 165.00
## 33  insist       NA       within_n_sds(3) weight  1168 153.00
## 34  insist       NA       within_n_sds(3) weight  1217 145.80
## 35  insist       NA       within_n_sds(3) weight  1244 142.00
## 36  insist       NA       within_n_sds(3) weight  1283 140.00
## 37  insist       NA       within_n_sds(3) weight  1418 159.00
## 38  insist       NA       within_n_sds(3) weight  1575 142.00
## 39  insist       NA       within_n_sds(3) weight  1581 146.00
## 40  insist       NA       within_n_sds(3) weight  1625 161.00
## 41  insist       NA       within_n_sds(3) weight  1628 141.00
## 42  insist       NA       within_n_sds(3) weight  1688 168.00
## 43  insist       NA       within_n_sds(3) weight  1754 150.00
## 44  insist       NA       within_n_sds(3) weight  1780 240.20
## 45  insist       NA       within_n_sds(3) weight  1945 150.00
## 46  insist       NA       within_n_sds(3) weight  2000 226.00
## 47  insist       NA       within_n_sds(3) weight  2076 170.00
## 48  insist       NA       within_n_sds(3) weight  2109 152.00
## 49  insist       NA       within_n_sds(3) weight  2165 172.00
## 50  insist       NA       within_n_sds(3) weight  2183 141.00
## 51  insist       NA       within_n_sds(3) weight  2186 139.00
## 52  insist       NA       within_n_sds(3) weight  2207 237.00
## 53  insist       NA       within_n_sds(3) weight  2242 155.00
## 54  insist       NA       within_n_sds(3) weight  2266 140.00
## 55  insist       NA       within_n_sds(3) weight  2279 167.00
## 56  insist       NA       within_n_sds(3) weight  2370 211.00
## 57  insist       NA       within_n_sds(3) weight  2469 140.00
## 58  insist       NA       within_n_sds(3) weight  2483 144.80
## 59  insist       NA       within_n_sds(3) weight  2510 230.00
## 60  insist       NA       within_n_sds(3) weight  2529 156.00
## 61  insist       NA       within_n_sds(3) weight  2535 150.00
```

```
## 62  insist       NA       within_n_sds(3) weight  2708 240.00
## 63  insist       NA       within_n_sds(3) weight  2727 253.00
## 64  insist       NA       within_n_sds(3) weight  2794 162.00
## 65  insist       NA       within_n_sds(3) weight  2836 236.00
## 66  insist       NA       within_n_sds(3) weight  2948 162.00
## 67  insist       NA       within_n_sds(3) weight  2962 181.00
## 68  insist       NA       within_n_sds(3) weight  3004 178.10
## 69  insist       NA       within_n_sds(3) weight  3017 156.00
## 70  insist       NA       within_n_sds(3) weight  3026 160.00
## 71  insist       NA       within_n_sds(3) weight  3030 140.00
## 72  insist       NA       within_n_sds(3) weight  3074 252.00
## 73  insist       NA       within_n_sds(3) weight  3108 139.00
## 74  insist       NA       within_n_sds(3) weight  3125 140.00
## 75  insist       NA       within_n_sds(3) weight  3143 138.10
## 76  insist       NA       within_n_sds(3) weight  3216 140.00
## 77  insist       NA       within_n_sds(3) weight  3222 166.00
## 78  insist       NA       within_n_sds(3) weight  3244 135.00
## 79  insist       NA       within_n_sds(3) weight  3309 153.00
## 80  insist       NA       within_n_sds(3) weight  3332 160.00
## 81  insist       NA       within_n_sds(3) weight  3399 169.00
## 82  insist       NA       within_n_sds(3) weight  3447 140.00
## 83  insist       NA       within_n_sds(3) weight  3486 135.00
## 84  insist       NA       within_n_sds(3) weight  3496 160.00
## 85  insist       NA       within_n_sds(3) weight  3526 370.00
## 86  insist       NA       within_n_sds(3) weight  3538 151.00
## 87  insist       NA       within_n_sds(3) weight  3557 216.00
## 88  insist       NA       within_n_sds(3) weight  3583 230.60
## 89  insist       NA       within_n_sds(3) weight  3630 135.00
## 90  insist       NA       within_n_sds(3) weight  3647 152.00
## 91  insist       NA       within_n_sds(3) weight  3724 157.00
## 92  insist       NA       within_n_sds(3) weight  3924 290.00
## 93  insist       NA       within_n_sds(3) weight  3968 165.00
## 94  insist       NA       within_n_sds(3) weight  4026 237.00
## 95  insist       NA       within_n_sds(3) weight  4051 146.00
## 96  insist       NA       within_n_sds(3) weight  4284 245.00
## 97  insist       NA       within_n_sds(3) weight  4325 135.00
## 98  insist       NA       within_n_sds(3) weight  4377 165.00
## 99  insist       NA       within_n_sds(3) weight  4491 151.60
## 100 insist       NA       within_n_sds(3) weight  4502 173.00
## 101 insist       NA       within_n_sds(3) weight  4690 205.00
## 102 insist       NA       within_n_sds(3) weight  4728 166.30
## 103 insist       NA       within_n_sds(3) weight  4733 158.20
## 104 insist       NA       within_n_sds(3) weight  4768 248.00
## 105 insist       NA       within_n_sds(3) weight  4962 146.00
## 106 insist       NA       within_n_sds(3) weight  5055 177.00
## 107 insist       NA       within_n_sds(3) weight  5106 190.00
## 108 insist       NA       within_n_sds(3) weight  5120 136.10
## 109 insist       NA       within_n_sds(3) weight  5219 151.00
## 110 insist       NA       within_n_sds(3) weight  5275 140.00
## 111 insist       NA       within_n_sds(3) weight  5283 264.90
## 112 insist       NA       within_n_sds(3) weight  5342 146.00
## 113 insist       NA       within_n_sds(3) weight  5355 146.00
## 114 insist       NA       within_n_sds(3) weight  5398 158.50
## 115 insist       NA       within_n_sds(3) weight  5510 148.00
```

```
## 116 insist       NA       within_n_sds(3) weight  5618 146.50
## 117 insist       NA       within_n_sds(3) weight  5775 145.00
## 118 insist       NA       within_n_sds(3) weight  5789 155.00
## 119 insist       NA       within_n_sds(3) weight  5799 157.00
## 120 insist       NA       within_n_sds(3) weight  5817 134.00
## 121 insist       NA       within_n_sds(3) weight  5837 250.00
## 122 insist       NA       within_n_sds(3) weight  5841 165.00
## 123 insist       NA       within_n_sds(3) weight  5900 170.00
## 124 insist       NA       within_n_sds(3) weight  5914 167.10
## 125 insist       NA       within_n_sds(3) weight  5924 265.00
## 126 insist       NA       within_n_sds(3) weight  6037 174.00
## 127 insist       NA       within_n_sds(3) weight  6147 195.00
## 128 insist       NA       within_n_sds(3) weight  6174 154.00
## 129 insist       NA       within_n_sds(3) weight  6181 213.00
## 130 insist       NA       within_n_sds(3) weight  6203 177.00
## 131 insist       NA       within_n_sds(3) weight  6270 219.00
## 132 insist       NA       within_n_sds(3) weight  6291 138.00
## 133 insist       NA       within_n_sds(3) weight  6305 160.00
## 134 insist       NA       within_n_sds(3) weight  6342 145.00
## 135 insist       NA       within_n_sds(3) weight  6382 148.00
## 136 insist       NA       within_n_sds(3) weight  6426 135.00
## 137 insist       NA       within_n_sds(3) weight  6441 135.00
## 138 insist       NA       within_n_sds(3) weight  6608 200.00
## 139 insist       NA       within_n_sds(3) weight  6621 145.00
## 140 insist       NA       within_n_sds(3) weight  6626 220.00
## 141 insist       NA       within_n_sds(3) weight  6748 190.00
## 142 insist       NA       within_n_sds(3) weight  6760 155.00
## 143 insist       NA       within_n_sds(3) weight  6778 135.00
## 144 insist       NA       within_n_sds(3) weight  6779 144.00
## 145 insist       NA       within_n_sds(3) weight  6869 194.90
## 146 insist       NA       within_n_sds(3) weight  7062 135.00
## 147 insist       NA       within_n_sds(3) weight  7110 250.00
## 148 insist       NA       within_n_sds(3) weight  7118 205.00
## 149 insist       NA       within_n_sds(3) weight  7169 143.00
## 150 insist       NA       within_n_sds(3) weight  7172 149.10
## 151 insist       NA       within_n_sds(3) weight  7193 168.50
## 152 insist       NA       within_n_sds(3) weight  7223 215.00
## 153 insist       NA       within_n_sds(3) weight  7232 183.00
## 154 insist       NA       within_n_sds(3) weight  7411 240.00
## 155 insist       NA       within_n_sds(3) weight  7443 136.00
## 156 insist       NA       within_n_sds(3) weight  7551 148.00
## 157 insist       NA       within_n_sds(3) weight  7556 156.20
## 158 insist       NA       within_n_sds(3) weight  7626 251.00
## 159 insist       NA       within_n_sds(3) weight  7798 143.00
## 160 insist       NA       within_n_sds(3) weight  7844 171.00
## 161 insist       NA       within_n_sds(3) weight  7915 158.00
## 162 insist       NA       within_n_sds(3) weight  7929 149.00
## 163 insist       NA       within_n_sds(3) weight  7932 170.00
## 164 insist       NA       within_n_sds(3) weight  7944 135.00
## 165 insist       NA       within_n_sds(3) weight  7957 160.00
## 166 insist       NA       within_n_sds(3) weight  7958 250.00
## 167 insist       NA       within_n_sds(3) weight  7983 134.30
## 168 insist       NA       within_n_sds(3) weight  7987 190.00
## 169 insist       NA       within_n_sds(3) weight  8110 150.00
```

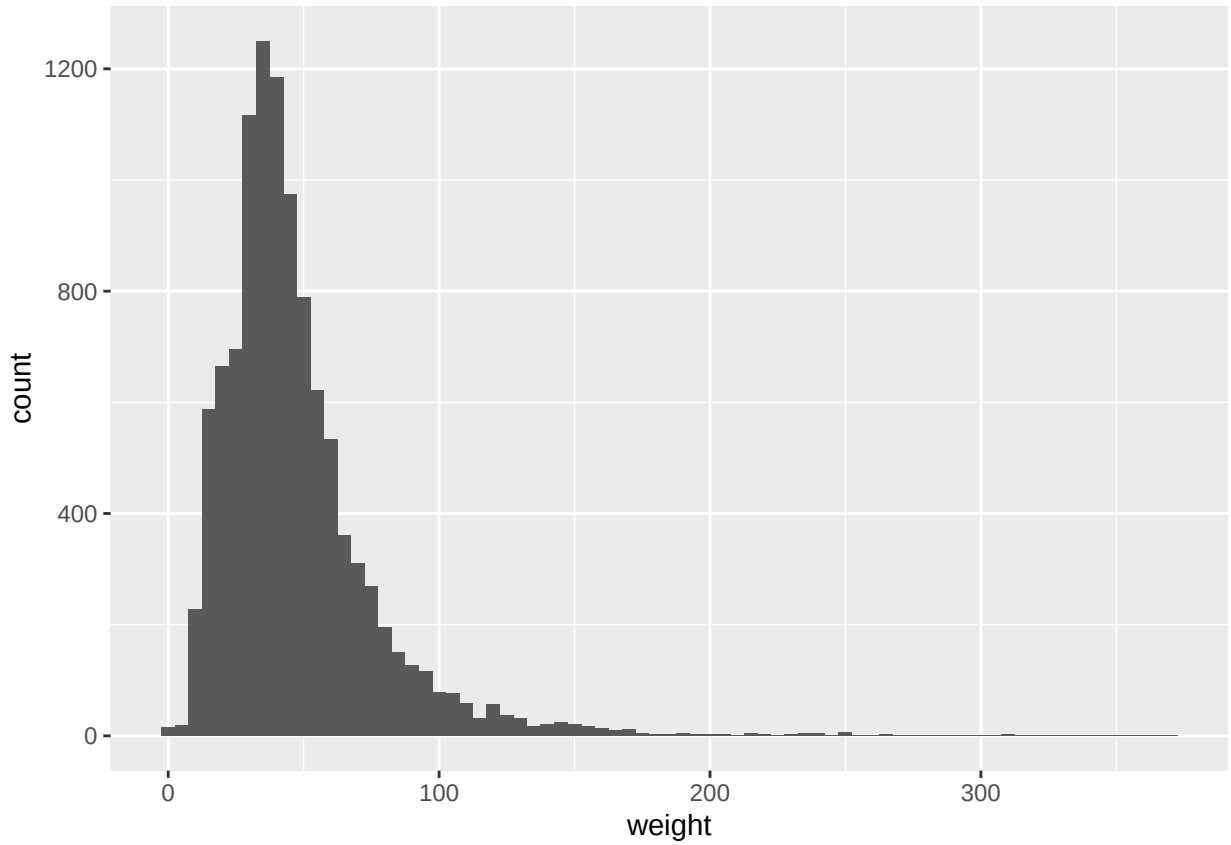
```
## 170 insist       NA       within_n_sds(3) weight  8193 145.00
## 171 insist       NA       within_n_sds(3) weight  8212 192.00
## 172 insist       NA       within_n_sds(3) weight  8258 148.00
## 173 insist       NA       within_n_sds(3) weight  8280 145.00
## 174 insist       NA       within_n_sds(3) weight  8335 154.50
## 175 insist       NA       within_n_sds(3) weight  8355 145.00
## 176 insist       NA       within_n_sds(3) weight  8517 145.00
## 177 insist       NA       within_n_sds(3) weight  8547 230.00
## 178 insist       NA       within_n_sds(3) weight  8635 153.00
## 179 insist       NA       within_n_sds(3) weight  8692 310.20
## 180 insist       NA       within_n_sds(3) weight  8704 168.00
## 181 insist       NA       within_n_sds(3) weight  8781 172.00
## 182 insist       NA       within_n_sds(3) weight  8848 148.00
## 183 insist       NA       within_n_sds(3) weight  8962 165.00
## 184 insist       NA       within_n_sds(3) weight  9004 136.00
## 185 insist       NA       within_n_sds(3) weight  9021 146.00
## 186 insist       NA       within_n_sds(3) weight  9053 148.10
## 187 insist       NA       within_n_sds(3) weight  9110 235.00
## 188 insist       NA       within_n_sds(3) weight  9194 145.00
## 189 insist       NA       within_n_sds(3) weight  9226 155.00
## 190 insist       NA       within_n_sds(3) weight  9248 168.00
## 191 insist       NA       within_n_sds(3) weight  9288 150.00
## 192 insist       NA       within_n_sds(3) weight  9520 145.50
## 193 insist       NA       within_n_sds(3) weight  9548 238.00
## 194 insist       NA       within_n_sds(3) weight  9610 145.00
## 195 insist       NA       within_n_sds(3) weight  9684 141.00
## 196 insist       NA       within_n_sds(3) weight  9712 144.00
## 197 insist       NA       within_n_sds(3) weight 10000 186.00
## 198 insist       NA       within_n_sds(3) weight 10262 148.00
## 199 insist       NA       within_n_sds(3) weight 10276 141.90
## 200 insist       NA       within_n_sds(3) weight 10310 161.00
## 201 insist       NA       within_n_sds(3) weight 10316 133.70
## 202 insist       NA       within_n_sds(3) weight 10400 144.60
## 203 insist       NA       within_n_sds(3) weight 10583 310.00
## 204 insist       NA       within_n_sds(3) weight 10676 148.00
## 205 insist       NA       within_n_sds(3) weight 10765 142.00
## 206 insist       NA       within_n_sds(3) length    29 350.00
## 207 insist       NA       within_n_sds(3) length   150  19.40
## 208 insist       NA       within_n_sds(3) length   259 356.00
## 209 insist       NA       within_n_sds(3) length   345 386.00
## 210 insist       NA       within_n_sds(3) length   697 342.00
## 211 insist       NA       within_n_sds(3) length   704 341.00
## 212 insist       NA       within_n_sds(3) length   839 351.00
## 213 insist       NA       within_n_sds(3) length   886 344.00
## 214 insist       NA       within_n_sds(3) length  1002 363.00
## 215 insist       NA       within_n_sds(3) length  1232 342.00
## 216 insist       NA       within_n_sds(3) length  1490 344.00
## 217 insist       NA       within_n_sds(3) length  1567 373.00
## 218 insist       NA       within_n_sds(3) length  1575 349.00
## 219 insist       NA       within_n_sds(3) length  1628 373.00
## 220 insist       NA       within_n_sds(3) length  1671 345.00
## 221 insist       NA       within_n_sds(3) length  2121 343.00
## 222 insist       NA       within_n_sds(3) length  2146 357.00
## 223 insist       NA       within_n_sds(3) length  2183 358.00
```

```
## 224 insist       NA       within_n_sds(3) length  2242 350.00
## 225 insist       NA       within_n_sds(3) length  2243 368.00
## 226 insist       NA       within_n_sds(3) length  2292  10.70
## 227 insist       NA       within_n_sds(3) length  2397 341.00
## 228 insist       NA       within_n_sds(3) length  2449 337.00
## 229 insist       NA       within_n_sds(3) length  2529 358.00
## 230 insist       NA       within_n_sds(3) length  2801   0.00
## 231 insist       NA       within_n_sds(3) length  3026 381.00
## 232 insist       NA       within_n_sds(3) length  3030 353.00
## 233 insist       NA       within_n_sds(3) length  3059 337.00
## 234 insist       NA       within_n_sds(3) length  3216 363.00
## 235 insist       NA       within_n_sds(3) length  3274 336.00
## 236 insist       NA       within_n_sds(3) length  3323 361.00
## 237 insist       NA       within_n_sds(3) length  3402 355.00
## 238 insist       NA       within_n_sds(3) length  3500  19.50
## 239 insist       NA       within_n_sds(3) length  3526 370.00
## 240 insist       NA       within_n_sds(3) length  3579   8.90
## 241 insist       NA       within_n_sds(3) length  3581 359.00
## 242 insist       NA       within_n_sds(3) length  3630 377.00
## 243 insist       NA       within_n_sds(3) length  3668 350.00
## 244 insist       NA       within_n_sds(3) length  4002 338.00
## 245 insist       NA       within_n_sds(3) length  4225 348.00
## 246 insist       NA       within_n_sds(3) length  4325 350.00
## 247 insist       NA       within_n_sds(3) length  4377 344.00
## 248 insist       NA       within_n_sds(3) length  4391 343.00
## 249 insist       NA       within_n_sds(3) length  4406 335.00
## 250 insist       NA       within_n_sds(3) length  4634 352.00
## 251 insist       NA       within_n_sds(3) length  4709 352.00
## 252 insist       NA       within_n_sds(3) length  4757 357.00
## 253 insist       NA       within_n_sds(3) length  4885 362.00
## 254 insist       NA       within_n_sds(3) length  4912  19.20
## 255 insist       NA       within_n_sds(3) length  4948 355.00
## 256 insist       NA       within_n_sds(3) length  5067  22.00
## 257 insist       NA       within_n_sds(3) length  5275 357.00
## 258 insist       NA       within_n_sds(3) length  5299  28.00
## 259 insist       NA       within_n_sds(3) length  5329 364.00
## 260 insist       NA       within_n_sds(3) length  5398 384.00
## 261 insist       NA       within_n_sds(3) length  5491 341.00
## 262 insist       NA       within_n_sds(3) length  5625 337.00
## 263 insist       NA       within_n_sds(3) length  5715  32.00
## 264 insist       NA       within_n_sds(3) length  5760 335.00
## 265 insist       NA       within_n_sds(3) length  5843  12.50
## 266 insist       NA       within_n_sds(3) length  5912  18.40
## 267 insist       NA       within_n_sds(3) length  5914 371.00
## 268 insist       NA       within_n_sds(3) length  6113 335.00
## 269 insist       NA       within_n_sds(3) length  6215 337.00
## 270 insist       NA       within_n_sds(3) length  6291 343.00
## 271 insist       NA       within_n_sds(3) length  6342 353.00
## 272 insist       NA       within_n_sds(3) length  6522 341.00
## 273 insist       NA       within_n_sds(3) length  6621 364.00
## 274 insist       NA       within_n_sds(3) length  6622 346.00
## 275 insist       NA       within_n_sds(3) length  6764  16.00
## 276 insist       NA       within_n_sds(3) length  6953  19.50
## 277 insist       NA       within_n_sds(3) length  6999  20.50
```

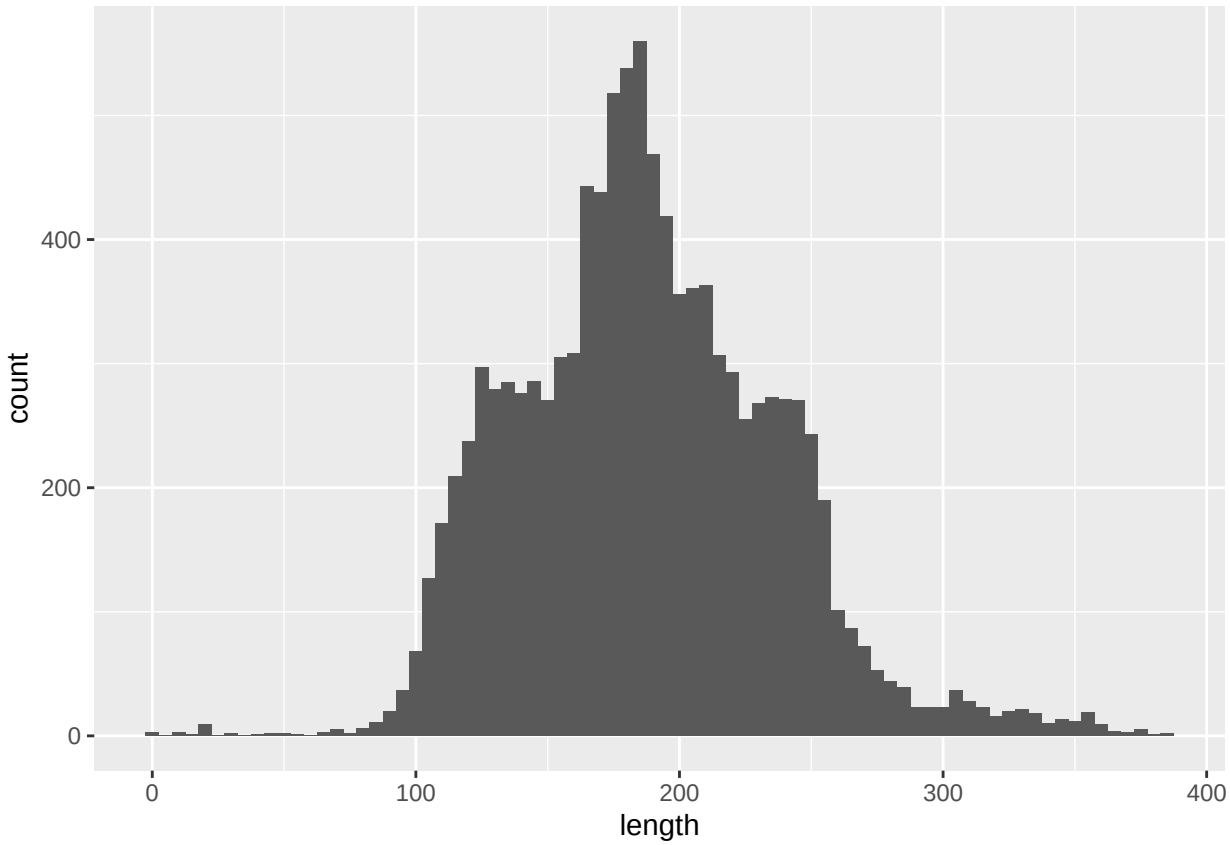
```
## 278 insist       NA       within_n_sds(3) length  7020 357.00
## 279 insist       NA       within_n_sds(3) length  7369 335.00
## 280 insist       NA       within_n_sds(3) length  7425 340.00
## 281 insist       NA       within_n_sds(3) length  7453 351.00
## 282 insist       NA       within_n_sds(3) length  7506 356.00
## 283 insist       NA       within_n_sds(3) length  7535 345.00
## 284 insist       NA       within_n_sds(3) length  7640 353.00
## 285 insist       NA       within_n_sds(3) length  7844 362.00
## 286 insist       NA       within_n_sds(3) length  8003 338.00
## 287 insist       NA       within_n_sds(3) length  8193 351.00
## 288 insist       NA       within_n_sds(3) length  8405 344.00
## 289 insist       NA       within_n_sds(3) length  8527 353.00
## 290 insist       NA       within_n_sds(3) length  8557 358.00
## 291 insist       NA       within_n_sds(3) length  8713 352.00
## 292 insist       NA       within_n_sds(3) length  8794  19.00
## 293 insist       NA       within_n_sds(3) length  8896   0.00
## 294 insist       NA       within_n_sds(3) length  9021 354.00
## 295 insist       NA       within_n_sds(3) length  9053 335.00
## 296 insist       NA       within_n_sds(3) length  9288 353.00
## 297 insist       NA       within_n_sds(3) length  9461 358.00
## 298 insist       NA       within_n_sds(3) length  9520 374.00
## 299 insist       NA       within_n_sds(3) length  9542 353.00
## 300 insist       NA       within_n_sds(3) length  9604 340.00
## 301 insist       NA       within_n_sds(3) length  9621 355.00
## 302 insist       NA       within_n_sds(3) length  9689 357.00
## 303 insist       NA       within_n_sds(3) length  9712 355.00
## 304 insist       NA       within_n_sds(3) length  9981 345.00
## 305 insist       NA       within_n_sds(3) length 10108  18.80
## 306 insist       NA       within_n_sds(3) length 10243 337.00
## 307 insist       NA       within_n_sds(3) length 10262 353.00
## 308 insist       NA       within_n_sds(3) length 10473 347.00
## 309 insist       NA       within_n_sds(3) length 10533 345.00
## 310 insist       NA       within_n_sds(3) length 10615 362.00
## 311 insist       NA       within_n_sds(3) length 10628   0.00
## 312 insist       NA       within_n_sds(3) length 10721 373.00
##
## <simpleError: assertr stopped execution>
## [1] "this is the end of the validation check ..."
```

```
## Visual assessment of your data
library(ggplot2)

ggplot(rawData, aes(x=weight)) +
  geom_histogram(binwidth = 5)
```




```
ggplot(rawData, aes(x=length)) +
  geom_histogram(binwidth = 5)
```



6. Bringing it all together to produce our analysis dataset

```
##############################################################################
########## Bringing it all together into a single series of commands ##########

# import the data with explicit column definitions for the textLatDD and catalogNumber columns
analysisData <- read_csv("../data/learning.csv",
                     col_types = cols(
                        textLatDD = col_double(),
                        catalogNumber = col_character()
                        ),
                     progress = FALSE)
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

```
## Warning: 1222 parsing failures.
## row       col expected  actual                   file
##  11 textLatDD a double missing '../data/learning.csv'
##  21 textLatDD a double missing '../data/learning.csv'
##  25 textLatDD a double missing '../data/learning.csv'
##  32 textLatDD a double missing '../data/learning.csv'
##  39 textLatDD a double missing '../data/learning.csv'
## ... ......... ........ ....... ......................
## See problems(...) for more details.
```

```
# split up the recordedBy column
collectorExtract <- "^collector\\(s\\):\\s(.*;|.*$)"
```

```
preparatorExtract <- "preparator\\(s\\):\\s(.*;|.*$)"

collector_string <- str_match(rawData$recordedBy, collectorExtract)
preparator_string <- str_match(rawData$recordedBy, preparatorExtract)

rawData$collectors <- collector_string[,2]
rawData$preparators <- preparator_string[,2]

# split up the latDMS and lonDMS columns
dmsExtract <- "\\s*(-*[:digit:]+)°\\s*([:digit:]+)\\'\\s*([:digit:]+\\.*[:digit:]*)"

latSubstrings <- str_match(rawData$latDMS, dmsExtract)

rawData$latD <- as.numeric(latSubstrings[,2])
rawData$latM <- as.numeric(latSubstrings[,3])
rawData$latS <- as.numeric(latSubstrings[,4])

lonSubstrings <- str_match(rawData$lonDMS, dmsExtract)

rawData$lonD <- as.numeric(lonSubstrings[,2])
rawData$lonM <- as.numeric(lonSubstrings[,3])
rawData$lonS <- as.numeric(lonSubstrings[,4])

glimpse(analysisData)
```

```
## Rows: 10,767
## Columns: 24
## $ X1               <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16~
## $ uuid             <chr> "060380ea-7b06-474e-8d2e-b6e4a8c21e1a", "0fb17a79-a8c~
## $ institutionCode  <chr> "mvz", "mvz", "mvz", "mvz", "mvz", "uam", "omnh", "mv~
## $ collectionCode   <chr> "mammal specimens", "mammal specimens", "mammal speci~
## $ catalogNumber    <chr> "219088", "233524", "234346", "233951", "235290", "85~
## $ recordedBy       <chr> "collector(s): ana lilia trujano álvarez, eric ghilar~
## $ countryCode      <chr> "usa", "usa", "usa", "usa", "usa", "usa", "usa", "usa~
## $ stateProvince    <chr> "california", "california", "california", "california~
## $ county           <chr> "contra costa county", "contra costa county", "contra~
## $ decimalLatitude  <dbl> 37.76095, 37.89996, 37.89996, 37.89996, 37.89996, 43.~
## $ decimalLongitude <dbl> -121.88656, -122.36166, -122.36166, -122.36166, -122.~
## $ eventDate        <dttm> 2005-11-23, 1959-06-21, 1962-11-22, 1960-07-31, 1964~
## $ year             <dbl> 2005, 1959, 1962, 1960, 1964, 1996, 2011, 2005, 1989,~
## $ month            <dbl> 11, 6, 11, 7, 7, 10, 1, 8, 6, 5, 8, 8, 11, 6, 7, 6, 4~
## $ day              <dbl> 22, 20, 21, 30, 3, 22, 17, 6, 4, 19, 10, 12, 30, 17, ~
## $ genus            <chr> "microtus", "microtus", "microtus", "microtus", "micr~
## $ specificEpithet  <chr> "californicus", "californicus", "californicus", "cali~
## $ scientificName   <chr> "microtus californicus californicus", "microtus calif~
## $ weight           <dbl> 30.5, 22.0, 49.0, 33.0, 29.0, 23.5, 24.0, 27.0, 125.0~
## $ length           <dbl> 165, 143, 187, 169, 159, 141, 121, 176, 294, 110, 210~
## $ sex              <chr> "male", "female", "male", "female", "female", "female~
## $ latDMS           <chr> "37°45'39.430\"N", "37°53'59.845\"N", "37°53'59.845\"~
## $ lonDMS           <chr> "-122° 6'48.370\"E", "-123°38'18.039\"E", "-123°38'18~
## $ textLatDD        <dbl> 37.76095, 37.89996, 37.89996, 37.89996, 37.89996, 43.~
```

Export the code from the workshop both as a documented and undocumented R script

```
#library(knitr)
#purl("code/cleaning_data.Rmd", "code/cleaning_data_nodocs.R", documentation = 0)
```