

# stat547-hw06-thibodeau-mylinh

I installed these new packages of the ontologyX suite here (<https://cran.r-project.org/web/packages/ontologyIndex/vignettes/intro-to-ontologyX.html>), which offer tools to explore ontology data.

We can use the `getNamespaceExports()` to see what are the functions of these packages !

```
getNamespaceExports("ontologyIndex")
```

```
## [1] "get_term_info_content"      "get_OBO"
## [3] "minimal_set"               "get_descendants"
## [5] "get_term_property"         "exclude_descendants"
## [7] "get_term_descendancy_matrix" "check"
## [9] "get_ancestors"             "get_ontology"
## [11] "intersection_with_descendants" "prune_descendants"
## [13] "propagate_relations"       "ontology_index"
## [15] "get_term_frequencies"      "get_relation_names"
```

```
getNamespaceExports("ontologySimilarity")
```

```
## [1] "get_similarity_rank_matrix"  "lin"
## [3] "get_term_sim_mat"           "get_term_set_to_term_sims"
## [5] "get_profile_sims"           "get_sim_grid"
## [7] "create_sim_index"           "get_sim"
## [9] "sample_group_sim_from_ontology" "sample_group_sim"
## [11] "get_sim_p"                  "descendants_IC"
## [13] "resnik"                     "get_asym_sim_grid"
## [15] "get_sim_p_from_ontology"
```

First step, get the Human Disease Ontology as explained here

(<https://github.com/DiseaseOntology/HumanDiseaseOntology/blob/master/src/ontology/README-editors.md>), I had to clone the repository (which I called `HumanDiseaseOntology_git`, as suggested by the github README document).

```
get_relation_names("HumanDiseaseOntology_git/src/ontology/HumanDO.obo")
```

```
## [[1]]
## [1] "is_a"
```

```
HumanDO <- get_ontology("HumanDiseaseOntology_git/src/ontology/HumanDO.obo", propagate_relationships=c("is_a", "part_of"))
#View(HumanDO)
```

I have downloaded a basic version of the Gene Ontology (GO) at here (<http://www.geneontology.org/page/download-ontology>) and I will now look into what are the relationships between the GO terms.

```
get_relation_names("GO/go-basic.obo")
```

```
## [1] "is_a"           "regulates"      "part_of"
## [4] "negatively_regulates" "positively_regulates"
```

```
GO <- get_ontology("GO/go-basic.obo")
#View(GO)
str(GO, max.level = 1) %>% head()
```

```
## List of 6
## $ id : Named chr [1:47068] "GO:0000001" "GO:0000002" "GO:0000003" "GO:0000005" ...
## $ name : Named chr [1:47068] "mitochondrion inheritance" "mitochondrial genome maintenance" "reproductio
n" "obsolete ribosomal chaperone activity" ...
## $ parents :List of 47068
## $ children :List of 47068
## $ ancestors:List of 47068
## $ obsolete : Named logi [1:47068] FALSE FALSE FALSE TRUE FALSE FALSE ...
## $ attr(*, "names")= chr [1:47068] "GO:0000001" "GO:0000002" "GO:0000003" "GO:0000005" ...
## - attr(*, "class")= chr "ontology_index"
## - attr(*, "version")= chr [1:30] "format-version: 1.2" "data-version: releases/2017-11-03" "subsetdef: goanti
slim_grouping \"Grouping classes that can be excluded\" \"subsetdef: gocheck_do_not_annotate \"Term not to be use
d for direct annotation\" ...
```

```
## NULL
```

Interestingly, the ontologyIndex package does come with an R version of HPO (Human Phenotype Ontology) and GO (Gene Ontology), which you can load as follow.

```
data(hpo)
#View(hpo)
data(go)
#View(go)
```

*Note.* I will try not use the R lists of the ontologyIndex, because I am trying to learn how to read and manipulate the OBO format files directly.

## Homework instructions

**Pick (at least) two of the six (numbered) topics below and do one of the exercise prompts listed, or something comparable using your dataset of choice.**

The two tasks I picked are the following:

1. Character data
2. Work with a list

## 1. Character data

### Let's take a peak at the data

For the first task, we will be exploring some character data, and we will use ontology terms for this. This examples is modelled on Daniel Greene's work here (<https://cran.r-project.org/web/packages/ontologySimilarity/vignettes/ontologySimilarity-introduction.html>).

However, I think it would be useful to try and understand the data of HumanDO a bit better first. Here are some key concepts about HumanDO:

- As opposed to the GO dataset above, HumanDO only has one type of relationship and it is "is\_a"
- It is a large list of 6 elements
- These 6 elements are:
  1. id: specific DOID (Disease Ontology ID) identifier
  2. name: specific term attached to the identifier (e.g. angiosarcoma)
  3. parents: an ontology goes from general terms (parents) to more specific terms (children)
  4. children: on parent can have zero children (if it is a unique term), or many children (if it is a general term which can be further divided into more specific terms)
  5. ancestors: this list keep an aggregate list of all the more general terms that preceded a term (all the parents, grand-parents, great grand-parents "terms", etc.)
  6. obsolete: this is a boolean list, which includes all the terms/DOID identifiers that were once in the HumanOD ontology: most of these are currently valid ("TRUE"), but some are not in use anymore ("FALSE")

Let us look at an example. Let's look at the diseases that contain the word "encephalitis":

```
head(HumanDO$name[ grep(x=HumanDO$name, pattern = "encephalitis")])
```

```
##          DOID:0050015          DOID:0050066
## "Rocio virus encephalitis" "Listeria meningoencephalitis"
##          DOID:0050118          DOID:0050123
## "La Crosse encephalitis" "tuberculous encephalitis"
##          DOID:0050126          DOID:0050170
## "Tahyna virus encephalitis" "Jamestown Canyon encephalitis"
```

Note. Use of grep in ontology data also from Daniel Greene's work here (<https://cran.r-project.org/web/packages/ontologyIndex/vignettes/intro-to-ontologyX.html>)

Put in a dataframe?

Let's look at the diseases that contain the word "Japanese":

```
HumanDO$name[grepl(x=HumanDO$name, pattern = "Japanese")]
```

```
##          DOID:0050050          DOID:10844
## "Japanese spotted fever" "Japanese encephalitis"
```

We note that DOID:0050050 is associated with the disease "Japanese spotted fever". Let's look at the ancestor of this term.

```
get_term_property(ontology=HumanDO, property = "ancestors", term = "DOID:0050050", as_names=TRUE)
```

```
##          DOID:4
## "disease"
##          DOID:0050117
## "disease by infectious agent"
##          DOID:104
## "bacterial infectious disease"
##          DOID:0050338
## "primary bacterial infectious disease"
##          DOID:11104
## "spotted fever"
##          DOID:0050050
## "Japanese spotted fever"
```

Note. So this is pretty intuitive when we think about it: some terms like "disease" are very general, and when the ontology tree gains more granularity, then the addition of characteristics such as "bacterial", "infectious" and "spotted fever" lead to the creation of a specific ontology disease identifier: diagnosis (DOID:0050050 = Japanese spotted fever).

We will use the HumanDO data and set a seed.

```
set.seed(1)
```

Then, we will use the `descendants_IC()` function to calculate information content of terms based on frequency with which it is an ancestor of other terms.

```
information_content <- descendants_IC(HumanDO)
```

Then, we generate 5 random sets of 8 terms.

```
term_sets <- replicate(simplify=FALSE, n=5, expr=minimal_set(HumanDO, sample(HumanDO$id, size=8)))
term_sets
```

```
## [[1]]
## [1] "DOID:0110818" "DOID:11574" "DOID:262" "DOID:8224"
## [5] "DOID:0110104" "DOID:8020" "DOID:891" "DOID:4006"
##
## [[2]]
## [1] "DOID:3486" "DOID:0050738" "DOID:0110151" "DOID:0080169"
## [5] "DOID:4397" "DOID:11824" "DOID:5601" "DOID:14433"
##
## [[3]]
## [1] "DOID:4872" "DOID:9869" "DOID:11747" "DOID:5709"
## [5] "DOID:8692" "DOID:0110218" "DOID:3847" "DOID:0060443"
##
## [[4]]
## [1] "DOID:0110837" "DOID:11861" "DOID:0050194" "DOID:118"
## [5] "DOID:7455" "DOID:10933" "DOID:14049" "DOID:3029"
##
## [[5]]
## [1] "DOID:1432" "DOID:0090077" "DOID:6641" "DOID:4112"
## [5] "DOID:5983" "DOID:0060252" "DOID:4942" "DOID:12380"
```

Note that the `term_sets` variable is a small nested list of characters items: there are 5 lists, each of which contains one list of 8 items, as exemplified here:

```
str(term_sets)
```

```
## List of 5
## $ : chr [1:8] "DOID:0110818" "DOID:11574" "DOID:262" "DOID:8224" ...
## $ : chr [1:8] "DOID:3486" "DOID:0050738" "DOID:0110151" "DOID:0080169" ...
## $ : chr [1:8] "DOID:4872" "DOID:9869" "DOID:11747" "DOID:5709" ...
## $ : chr [1:8] "DOID:0110837" "DOID:11861" "DOID:0050194" "DOID:118" ...
## $ : chr [1:8] "DOID:1432" "DOID:0090077" "DOID:6641" "DOID:4112" ...
```

In genomics, it can be helpful to compare sets of terms and determine how much similarity is shared between datasets (here, we have 5 lists, or 5 “mini datasets”). We can use the `get_sim_grid()` function to produce a similarity matrix and verify if any dataset is highly similar to another one.

```
similarity_matrix <- get_sim_grid(ontology= HumanDO, term_sets = term_sets)
# similarity_matrix %>% kable(format = "markdown", align="c")
similarity_matrix
```

```
##           [,1]      [,2]      [,3]      [,4]      [,5]
## [1,] 1.0000000 0.1692971 0.2282228 0.1094473 0.3079935
## [2,] 0.1692971 1.0000000 0.1102068 0.1301982 0.0806324
## [3,] 0.2282228 0.1102068 1.0000000 0.1452106 0.2733638
## [4,] 0.1094473 0.1301982 0.1452106 1.0000000 0.1525723
## [5,] 0.3079935 0.0806324 0.2733638 0.1525723 1.0000000
```

Note. From the top-left corner to the bottom-right corner, the similarity score is always 1 because we are comparing respectively list 1 with list 1, list 2 with list 2, etc.

## Let’s manipulate some strings now

I will be completed the tasks of this R for Data Science tutorial here (<http://r4ds.had.co.nz/strings.html>), as suggested in the homework 6 instructions.

### String basics

```
string1 <- "anemia"
string2 <- 'I am looking for the word "anemia" in a list' # Using double quotes inside simple quotes
```

Using one double quote or single quote

```
double_quote <- "\""  
double_quote2 <- '"'  
single_quote <- '\'  
single_quote2 <- '\"'
```

```
double_quote
```

```
## [1] "\""
```

```
double_quote2
```

```
## [1] "\""
```

```
single_quote
```

```
## [1] "'"
```

```
single_quote2
```

```
## [1] "'"
```

Note. In the tutorial, it seems as if the backslash bar is not printed, but in the example above, it does get printed. It seems that only the use of single quotes provides us with the expected result, so I will keep this format in the future.

Let's try to print a backslash. These all produced an error message:

- ""
- ""
- ""

```
"\ '"
```

```
## [1] " '"
```

Note. This simply does not print a backslash.

As shown in block028 of the character data stat545 website here ([http://stat545.com/block028\\_character-data.html](http://stat545.com/block028_character-data.html)), using the function `cat` instead of `print` allow us to print a backslash (or “escape”)

```
cat("Here is a backslash: \\ ")
```

```
## Here is a backslash: \
```

There can be some printed representation of a string that is not the same than the string itself, and using the `writeLines()` function allows us to see the raw content:

```
x <- c("one \"", "two \\")  
x
```

```
## [1] "one \" "two \\"
```

```
writeLines(x)
```

```
## one "  
## two \
```

Other handy special characters are `"\n"` (newline) and `"\t"`

```
cat("We can use \n to print a new line \n\n")
```

```
## We can use
## to print a new line
```

```
cat("While \t inserts a tab")
```

```
## While      inserts a tab
```

Some strings actually represent non-English characters in all coding platforms, for example:

```
x <- "\u00b5"
x
```

```
## [1] "μ"
```

Strings can be put into a character vector

```
c("anemia", "low iron", "pallor")
```

```
## [1] "anemia" "low iron" "pallor"
```

## String length

How many character in this string? Use `str_length`

```
str_length(c("anemia", "low iron", "pallor"))
```

```
## [1] 6 8 6
```

Note. White spaces count as characters.

## Combining strings

Use `str_c()`

```
str_c("anemia", "low iron", "pallor")
```

```
## [1] "anemialow ironpallor"
```

Note. As mentioned, white spaces count as characters, so the white space in “low iron” is preserved here.

You can also specify the separator:

```
str_c("anemia", "low iron", "pallor", sep=" = ")
```

```
## [1] "anemia = low iron = pallor"
```

You can specify what the missing values “NA” can be replaced with:

```
x <- c("anemia", NA)
str_c("--> ", x, " <--")
```

```
## [1] "--> anemia <--" NA
```

```
str_c("--> ", str_replace_na(x), " <--")
```

```
## [1] "--> anemia <--" "--> NA <--"
```

In the example, `str_c()` is vectorized, and it makes the shorter vectors the same length as the longest vector:

```
str_c("prefix-", c("a", "b", "c"), "", "-suffix")
```

```
## [1] "prefix-a-suffix" "prefix-b-suffix" "prefix-c-suffix"
```

Note. Objects of length zero (e.g. "" above) are dropped.

This can be used with an if statement.

```
cancer_type <- "breast cancer"
time_since_diagnosis <- "2 years"
day_of_diagnosis <- FALSE

str_c(
  "It has been ", time_since_diagnosis, " since your diagnosis of ", cancer_type,
  if (day_of_diagnosis) "and I am sorry to give you this bad news today"
)
```

```
## [1] "It has been 2 years since your diagnosis of breast cancer"
```

We can also collapse a vector of strings as followed:

```
str_c(c("anemia", "low iron", "pallor"), collapse=" = ")
```

```
## [1] "anemia = low iron = pallor"
```

## Subsetting strings

We can extract part of a string with `str_sub()`, and specify the inclusive positions (start and end) of the substring to extract.

```
list_of_strings <- c("dominant", "recessive", "X-linked", "mitochondrial")
str_sub(list_of_strings, 1, 4)
```

```
## [1] "domi" "rece" "X-li" "mito"
```

```
str_sub(list_of_strings, -4, -1)
```

```
## [1] "nant" "sive" "nked" "rial"
```

Even if you put “too big of a range”, it will still works !

```
str_sub(list_of_strings, 1, 15)
```

```
## [1] "dominant"      "recessive"      "X-linked"      "mitochondrial"
```

```
str_sub(list_of_strings, -1, -1) <- str_to_upper(str_sub(list_of_strings, -1, -1))
list_of_strings
```

```
## [1] "dominantT"      "recessiveE"      "X-linkedD"      "mitochondriaL"
```

## Locales

Here are some functions to change the letter format:

```
str_to_upper("recessive") # Change to upper case
```

```
## [1] "RECESSIVE"
```

```
str_to_lower("PIK3CA") # Change to lower case
```

```
## [1] "pik3ca"
```

```
str_to_title("MTOR pathway") # Capitalizes the first letter of each word
```

```
## [1] "Mtor Pathway"
```

Locales are used to specify special characters according to the specific language. Different languages have different rules for changing case, hence the need to specify. ISO is a 639 language code, you can peak here ([http://www.loc.gov/standards/iso639-2/php/English\\_list.php](http://www.loc.gov/standards/iso639-2/php/English_list.php)).

```
str_to_upper("i") # English
```

```
## [1] "I"
```

```
str_to_upper("i", "tr") # Turkish
```

```
## [1] "İ"
```

Base R has some functions, like `order()` and `sort()` functions, which can sort strings using the current locale. But `stringr` functions is more consistent and flexible as it can take a locale argument.

```
list_of_strings <- c("recessive", "X-linked", "dominant", "mitochondrial", "anticipation")
str_sort(list_of_strings, locale = "en")
```

```
## [1] "anticipation" "dominant" "mitochondrial" "recessive"
## [5] "X-linked"
```

```
str_sort(list_of_strings, locale = "haw")
```

```
## [1] "anticipation" "dominant" "mitochondrial" "recessive"
## [5] "X-linked"
```

```
str_order(list_of_strings, locale = "en")
```

```
## [1] 5 3 4 1 2
```

```
str_order(list_of_strings, locale = "haw")
```

```
## [1] 5 3 4 1 2
```

Note. Apparently, the order can change according to the locale (language) selected, as showed here (<http://r4ds.had.co.nz/strings.html>), but I must have tried a dozen languages and it never changed the order of my list. Oh well, I'll still keep it in mind just in case.

---

Exploring some functions.

*paste()* and *paste0()*

```
paste("PIK3CA", "BRCA1", "TP53", "PTEN", "MLH1")
```

```
## [1] "PIK3CA BRCA1 TP53 PTEN MLH1"
```

```
paste0("PIK3CA", "BRCA1", "TP53", "PTEN", "MLH1")
```

```
## [1] "PIK3CABRCA1TP53PTENMLH1"
```

I found with this blog here (<https://www.r-bloggers.com/difference-between-paste-and-paste0/>) that the difference between `paste` and `paste0` is that their separator is " " and "" respectively.

Get the character in the middle using `str_length()` and `str_sub()`



```
gene1 <- "BRCA1"
str_sub(gene1, ceiling(str_length(gene1)/2), ceiling(str_length(gene1)/2))
```

```
## [1] "C"
```

*Difference between sep and collapse?*

```
str_c("BRCA1", "PTEN", sep = " and ") # Takes the list of strings as argument
```

```
## [1] "BRCA1 and PTEN"
```

```
str_c(c("BRCA1", "PTEN"), collapse = " + ") # Takes a vector as argument
```

```
## [1] "BRCA1 + PTEN"
```

The function `str_wrap()` can be used to reformat strings, but I see very little application for this function in my type of research work, so I will not illustrate it here.

`str_trim()` trim whitespace from start and end of string.

```
cancer_diagnoses <- str_trim(c(" breast cancer", "paraganglioma ", "medullary thyroid cancer", " glioblastoma", "pheochromocytoma"))
#str(cancer_diagnoses)
```

## Matching patterns with regular expressions

Find a substring to highlight with `str_view()`

```
str_view(cancer_diagnoses, "oma")
```

breast cancer

paraganglioma

medullary thyroid cancer

glioblastoma

pheochromocytoma

A dot (“.”) can be used to replace any unknown character.

```
str_view(cancer_diagnoses, "..oma")
```

breast cancer

paraganglioma

medullary thyroid cancer

glioblastoma

pheochromocytoma

Note. The two dots highlight the 2 characters preceding “oma”.

You have to use the escape `\\` in order to be able to search for the actual “.” character in strings.

```
dot <- "\\."
writeLines(dot)
```

```
## \.
```

```
str_view(c("abc", "a.c", "bef"), "a\\.c")
```

abc

a.c

bef

In order to look for a backslash, you need no less than 4 of them:

```
x <- "a\\b"
writeLines(x)
```

```
## a\b
```

```
#> a\b

str_view(x, "\\")
```

a\b

Why each of these strings don't match a \: "\", "\", "\\\" ?

- "\" : this doesn't work because the backslash is leading to an "escape" for the " and the expression is still open.
- "\\" : this doesn't work because it literally prints "\\".
- "\\\" : the expression is interpreted as is still open.

## Anchor

Here are some useful options as well:

- ^ to match the start of the string.
- \$ to match the end of the string.

```
str_view(cancer_diagnoses, "oma$")
```

```
breast cancer
paraganglioma
medullary thyroid cancer
glioblastoma
pheochromocytoma
```

```
str_view(cancer_diagnoses, "^p")
```

```
breast cancer
paraganglioma
medullary thyroid cancer
glioblastoma
pheochromocytoma
```

```
lung_cancer <- c("Non-Small Cell Lung Carcinoma", "Small Cell Lung Cancer", "Lung Carcinoid Tumor")
str_view(lung_cancer, "^Lung$") # Exact match is not found (starts with and finishes with), so it's not highlighted by this function
```

```
Non-Small Cell Lung Carcinoma
Small Cell Lung Cancer
Lung Carcinoid Tumor
```

```
str_view(lung_cancer, "Lung") # Highlights all the words mathing "Lung" regardless of position of the word
```

```
Non-Small Cell Lung Carcinoma
Small Cell Lung Cancer
Lung Carcinoid Tumor
```

## Replacing matched

Replace matches with new string (here, replace vowels by "\*\*")

```
str_replace(lung_cancer, "[aeiou]", "**")
```

```
## [1] "N*n-Small Cell Lung Carcinoma" "Sm*ll Cell Lung Cancer"
## [3] "L*ng Carcinoid Tumor"
```

```
str_replace_all(lung_cancer, "[aeiou]", "*")
```

```
## [1] "N*n-Sm*ll C*ll L*ng C*rc*n*m*" "Sm*ll C*ll L*ng C*nc*r"
## [3] "L*ng C*rc*n**d T*m*r"
```

Can be used for multiple replacements:

```
copy_number <- c("2 copies of PTEN", "4 copies of GSK3B", "1 copy of TP53")
str_replace_all(copy_number, c("1" = "one", "2" = "two", "4" = "four"))
```

```
## [1] "two copies of PTEN" "four copies of GSK3B" "one copy of TP53"
```

```
sentences <- c("Lung cancer is largely due to tobacco smoking (active and passive).", "Sun exposure increases the
risk for melanoma.", "Acute lymphoblastic leukemia is largely a diagnosis of the pediatric age group.")
sentences %>%
  str_replace("([ ^ ]+) ([ ^ ]+) ([ ^ ]+)", "\\1 \\3 \\2")
```

```
## [1] "Lung is cancer largely due to tobacco smoking (active and passive)."
```

```
## [2] "Sun increases exposure the risk for melanoma."
```

```
## [3] "Acute leukemia lymphoblastic is largely a diagnosis of the pediatric age group."
```

Note. This flips the order of the 2nd and 3rd word.

## Splitting

Let's explore `str_split()` function, which returns a list separated by a white space (as specified below)

```
sentences %>%
  str_split(" ")
```

```
## [[1]]
## [1] "Lung"      "cancer"    "is"        "largely"   "due"
## [6] "to"        "tobacco"   "smoking"    "(active"   "and"
## [11] "passive)."
```

```
## [[2]]
## [1] "Sun"      "exposure"  "increases" "the"       "risk"      "for"
## [7] "melanoma."
```

```
## [[3]]
## [1] "Acute"      "lymphoblastic" "leukemia"   "is"
## [5] "largely"    "a"            "diagnosis"  "of"
## [9] "the"        "pediatric"    "age"        "group."
```

```
"breast|brain|lung|pancreas" %>%
  str_split("\\|") %>%
  .[[1]]
```

```
## [1] "breast" "brain" "lung" "pancreas"
```

Note. Since the vector length is one, it's easier to extract the 1st element of the list.

In a matrix, `simplify = TRUE` can be used:

```
sentences %>%
  str_split(" ", simplify = TRUE)
```

```
##      [,1]      [,2]          [,3]      [,4]      [,5]      [,6]
## [1,] "Lung"   "cancer"      "is"      "largely" "due"    "to"
## [2,] "Sun"    "exposure"    "increases" "the"    "risk"   "for"
## [3,] "Acute"  "lymphoblastic" "leukemia" "is"     "largely" "a"
##      [,7]      [,8]      [,9]      [,10]     [,11]     [,12]
## [1,] "tobacco"  "smoking" "(active" "and"     "passive)." ""
## [2,] "melanoma." ""        ""        ""        ""        ""
## [3,] "diagnosis" "of"      "the"     "pediatric" "age"     "group."
```

Note. This puts the sentences in a “3 by 12” matrix, each cell containing 1 word (or nothing if the sentence is shorter than the longest sentence).

For example, we can isolate the word Japanese.

```
Japanese_disorders <- HumanDO$name[grep(x=HumanDO$name, pattern = "Japanese")]
Japanese_disorders %>% str_split(" ", n = 2, simplify = TRUE)
```

```
##      [,1]      [,2]
## [1,] "Japanese" "spotted fever"
## [2,] "Japanese" "encephalitis"
```

Highlights all the words or sentences using the boundary argument.

```
str_view_all(Japanese_disorders, boundary("word"))
```

Japanese spotted fever

Japanese encephalitis

```
str_view_all(Japanese_disorders, boundary("sentence"))
```

Japanese spotted fever

Japanese encephalitis

This only takes the first element of the list.

```
str_split(Japanese_disorders, boundary("word"))[[1]]
```

```
## [1] "Japanese" "spotted" "fever"
```

## Find matches

With regex() !

```
encephalitis_disorders <- HumanDO$name[grep(x=HumanDO$name, pattern = "encephalitis")]
str_view(encephalitis_disorders, regex("vir"))
```

Rocio virus encephalitis

Listeria meningoenkephalitis

La Crosse encephalitis

tuberculous encephalitis

Tahyna virus encephalitis

Jamestown Canyon encephalitis

snowshoe hare encephalitis

trivittatus encephalitis

inkoo encephalitis

Kunjin encephalitis

tick-borne encephalitis

Powassan encephalitis

Colorado tick fever encephalitis

Herpes simplex virus encephalitis

Varicella-zoster virus encephalitis

Epstein-Barr virus encephalitis  
Measles virus encephalitis  
Cytomegalovirus encephalitis  
Rubella virus encephalitis  
coxsackievirus encephalitis  
polioencephalitis  
adenovirus encephalitis  
influenza virus encephalitis  
Nipah virus encephalitis  
Lymphocytic choriomeningitis virus encephalitis  
primary amebic meningoencephalitis  
granulomatous amebic encephalitis  
tertiary syphilitic encephalitis  
Banna virus encephalitis  
Lymphocytic choriomeningitis virus meningoencephalitis  
syphilitic encephalitis  
Mumps virus encephalitis  
meningoencephalitis  
congenital syphilitic encephalitis  
Eastern equine encephalitis  
Murray Valley encephalitis  
Western equine encephalitis  
Japanese encephalitis  
St. Louis encephalitis  
acute hemorrhagic leukoencephalitis  
postinfectious encephalitis  
post-vaccinal encephalitis  
meningococcal encephalitis  
West Nile encephalitis  
acute necrotizing encephalitis  
acute hemorrhagic encephalitis  
viral encephalitis  
subacute sclerosing panencephalitis  
Herpes simplex virus meningoencephalitis  
Venezuelan equine encephalitis  
equine encephalitis  
encephalitis

Note. This allows use to highlight words containing “vir”, so here “viral” and “virus”.

ignore\_case = TRUE can be useful!

```
fever_disorders <- HumanDO$name[grepl(x=HumanDO$name, pattern = "fever")]  
str_view(fever_disorders, "rocky")
```

African tick-bite fever  
Astrakhan spotted fever  
Far Eastern spotted fever  
Flinders Island spotted fever  
Japanese spotted fever  
Rickettsia parkeri spotted fever

Rocky Mountain spotted fever  
Rickettsia honei spotted fever  
Pontiac fever  
Colorado tick fever encephalitis  
Argentine hemorrhagic fever  
Bolivian hemorrhagic fever  
Venezuelan hemorrhagic fever  
Brazilian hemorrhagic fever  
Chapare hemorrhagic fever  
Whitewater Arroyo hemorrhagic fever  
Korean hemorrhagic fever  
lujo hemorrhagic fever  
yellow fever hepatitis  
Alkhurma hemorrhagic fever  
Rickettsia aeschlimannii spotted fever  
aneruptive fever  
sennetsu fever  
O'nyong'nyong fever  
Ross River fever  
Oropouche fever  
Balkan hemorrhagic fever  
Zika fever  
autosomal dominant familial periodic fever  
Q fever  
trench fever  
spotted fever  
hemorrhagic fever with renal syndrome  
Phlebotomus fever  
tickborne fever  
rat-bite fever  
dengue hemorrhagic fever  
Crimean-Congo hemorrhagic fever  
relapsing fever  
louse-borne relapsing fever  
tick-borne relapsing fever  
Haverhill fever  
typhoid fever  
Rift Valley fever  
uveoparotid fever  
pharyngoconjunctival fever  
blackwater fever  
boutonneuse fever  
rheumatic fever  
West Nile fever  
Yellow fever virus infectious disease  
familial Mediterranean fever  
paratyphoid fever  
Ebola hemorrhagic fever

Marburg hemorrhagic fever  
Colorado tick fever  
ephemeral fever  
African swine fever  
classical swine fever  
scarlet fever  
Arenavirus hemorrhagic fever  
Lassa fever  
yellow fever  
Omsk hemorrhagic fever

```
str_view(fever_disorders, regex("rocky", ignore_case = TRUE))
```

African tick-bite fever  
Astrakhan spotted fever  
Far Eastern spotted fever  
Flinders Island spotted fever  
Japanese spotted fever  
Rickettsia parkeri spotted fever  
Rocky Mountain spotted fever  
Rickettsia honei spotted fever  
Pontiac fever  
Colorado tick fever encephalitis  
Argentine hemorrhagic fever  
Bolivian hemorrhagic fever  
Venezuelan hemorrhagic fever  
Brazilian hemorrhagic fever  
Chapare hemorrhagic fever  
Whitewater Arroyo hemorrhagic fever  
Korean hemorrhagic fever  
lujo hemorrhagic fever  
yellow fever hepatitis  
Alkhurma hemorrhagic fever  
Rickettsia aeschlimannii spotted fever  
aneruptive fever  
sennetsu fever  
O'nyong'nyong fever  
Ross River fever  
Oropouche fever  
Balkan hemorrhagic fever  
Zika fever  
autosomal dominant familial periodic fever  
Q fever  
trench fever  
spotted fever  
hemorrhagic fever with renal syndrome  
Phlebotomus fever  
tickborne fever  
rat-bite fever

dengue hemorrhagic fever  
Crimean-Congo hemorrhagic fever  
relapsing fever  
louse-borne relapsing fever  
tick-borne relapsing fever  
Haverhill fever  
typhoid fever  
Rift Valley fever  
uveoparotid fever  
pharyngoconjunctival fever  
blackwater fever  
boutonneuse fever  
rheumatic fever  
West Nile fever  
Yellow fever virus infectious disease  
familial Mediterranean fever  
paratyphoid fever  
Ebola hemorrhagic fever  
Marburg hemorrhagic fever  
Colorado tick fever  
ephemeral fever  
African swine fever  
classical swine fever  
scarlet fever  
Arenavirus hemorrhagic fever  
Lassa fever  
yellow fever  
Omsk hemorrhagic fever

Note. In the first example, the word “Rocky” is not found because the first letter is capitalized, but using regex with `ignore_case = TRUE` resolves this issues.

Another useful one: `multiline = TRUE` allows `^` and `$` to match the start and end of each line

```
x <- "BRCA1 1\nPTEN 2\nTP53 3\nBRCA2 4"
str_extract_all(x, "^BRCA")[[1]]
```

```
## [1] "BRCA"
```

```
str_extract_all(x, regex("^BRCA", multiline = TRUE))[[1]]
```

```
## [1] "BRCA" "BRCA"
```

As mentioned in the tutorial (<http://r4ds.had.co.nz/strings.html>), `comments = TRUE` allows you to use comments and white space to make complex regular expressions more understandable. Spaces are ignored, as is everything after `#`. To match a literal space, you'll need to escape it: `"\"`

If we use genomic coordinates for example, with regex, you can put optional format so that the function can accept either a specific chromosomal location or a chromosomal region range.



```
genomic_position <- regex("
  (^chr)  # specify the chromosome number will be indicated
  (\\d{1}) # chromosome number
  (:)      # nomenclature
  (\\d{7}) # five numbers
  [-]?     # optional dash (for genomic range)
  (\\d{7})?
  ", comments = TRUE)
str_match("chr1:1234567", genomic_position)
```

```
##      [,1]      [,2] [,3] [,4] [,5]      [,6]
## [1,] "chr1:1234567" "chr" "1" ":" "1234567" NA
```

```
str_match("chr1:1234567-3217654", genomic_position)
```

```
##      [,1]      [,2] [,3] [,4] [,5]      [,6]
## [1,] "chr1:1234567-3217654" "chr" "1" ":" "1234567" "3217654"
```

Note. `dotall = TRUE` allows `.` to match everything, including `.`

```
genomic_position2 <- regex("
  (^chr)  # specify the chromosome number will be indicated
  (\\d{1}) # chromosome number
  (.)      # nomenclature
  (\\d{7}) # five numbers
  [-]?     # optional dash (for genomic range)
  (\\d{7})?
  ", comments = TRUE,
  dotall = TRUE)
str_match("chr1:1234567", genomic_position2)
```

```
##      [,1]      [,2] [,3] [,4] [,5]      [,6]
## [1,] "chr1:1234567" "chr" "1" ":" "1234567" NA
```

```
str_match("chr1:1234567-3217654", genomic_position2)
```

```
##      [,1]      [,2] [,3] [,4] [,5]      [,6]
## [1,] "chr1:1234567-3217654" "chr" "1" ":" "1234567" "3217654"
```

```
str_match("chr1*1234567-3217654", genomic_position2)
```

```
##      [,1]      [,2] [,3] [,4] [,5]      [,6]
## [1,] "chr1*1234567-3217654" "chr" "1" "*" "1234567" "3217654"
```

Note. In the example above, I replace the `":"` by `","` and then regardless of the character at that position, the function will take it.

Three other options for "regex-like" tasks.

Option 1 - `fixed()`, the fast one, ignores all special regular expressions.

The `microbenchmark` package is able to evaluate how much time expressions are taking to run.

```
#install.packages("microbenchmark")
library(microbenchmark)
microbenchmark::microbenchmark(
  fixed = str_detect(sentences, fixed("the")),
  regex = str_detect(sentences, "the"),
  times = 20
)
```

```
## Unit: microseconds
##   expr    min      lq      mean  median      uq     max neval cld
## fixed 28.362 29.9185 43.69695 32.4175 33.7345 247.370   20   b
## regex 15.925 17.3400 20.81130 18.3410 19.4245  69.062   20   a
```

Note.1. As you can see, the `fixed()` function takes about twice as much time to run than `regex`. Note.2. It can not be used with non-English data. As there are often multiple ways of representing the same character, this can cause problem. For example, there are two ways to define “á”: either as a single character or as an “a” plus an accent:

```
a1 <- "\u00e1"
a2 <- "a\u0301"
c(a1, a2)
```

```
## [1] "á" "á"
```

```
a1 == a2
```

```
## [1] FALSE
```

Option 2 - `coll()`

```
str_detect(a1, fixed(a2)) # Regex does not identify that the two terms are identical, because it looks at the literal form and they are encoded differently
```

```
## [1] FALSE
```

```
str_detect(a1, coll(a2)) # coll is able to identify it's the same letter
```

```
## [1] TRUE
```

Note.1. So I guess I won't be using French with `regex` then ;) Note.2. `coll()` though compares strings using standard collation rules, which is useful for doing case insensitive matching, and it takes a locale parameter.

```
i <- c("I", "İ", "i", "ı")
i
```

```
## [1] "I" "İ" "i" "ı"
```

```
str_subset(i, coll("i", ignore_case = TRUE)) # reads the Turkish "İ" as "I"
```

```
## [1] "I" "i"
```

```
str_subset(i, coll("i", ignore_case = TRUE, locale = "tr")) # presents the Turkish "İ"
```

```
## [1] "İ" "i"
```

This allows you to identify your default locale (English Canada here).

```
stringi::stri_locale_info()
```

```
## $Language
## [1] "en"
##
## $Country
## [1] "CA"
##
## $Variant
## [1] ""
##
## $Name
## [1] "en_CA"
```

The boundary argument used in `str_split` can also be used in the other stringr package functions. ### Other uses of regular expressions

This function `apropos()` searches all objects available from the global environment, which is particularly helpful when you can't quite remember the object/function name but you know it contains a word like “replace”.

```
apropos("replace")
```

```
## [1] "%+replace%"      "replace"      "replace_na"  
## [4] "setReplaceMethod" "str_replace"  "str_replace_all"  
## [7] "str_replace_na"   "theme_replace"
```

Note. I find it funny to see that the English language borrowed the term “apropos” from French. However, in the French language, this expression is actually written “à propos” and it can have two different meanings, as seen in the Collins dictionary here (<https://www.collinsdictionary.com/dictionary/french-english/%C3%A0-propos>): “to show presence of mind, to do the right thing” or “suitably, aptly”.

List all the files in the directory with `dir()`

```
dir()
```

```
## [1] "GO"  
## [2] "HumanDiseaseOntology_git"  
## [3] "README.md"  
## [4] "scratch-space"  
## [5] "stat547-hw06-thibodeau-mylinh.html"  
## [6] "stat547-hw06-thibodeau-mylinh.pdf"  
## [7] "stat547-hw06-thibodeau-mylinh.Rmd"
```

## stringi

Talking of ontology, it appears that the `stringi` package is actually an ancestor of `stringr`, which was built on top of `stringi`.

We can use the `getNamespaceExports()` to see what functions `stringi` has.

```
library(stringi)  
getNamespaceExports("stringi") %>% head()
```

```
## [1] "stri_width"          "stri_replace_last_charclass"  
## [3] "stri_replace_all_charclass" "stri_sub<-"  
## [5] "stri_numbytes"       "stri_extract_first_fixed"
```

```
stri_join("BRCA1", "BRCA2")
```

```
## [1] "BRCA1BRCA2"
```

```
stri_compare("BRCA1", "BRCA2") # the only difference between these 2 words is a position -1
```

```
## [1] -1
```

```
stri_info() # Get the default settings used by the ICU library.
```

```

## $Unicode.version
## [1] "7.0"
##
## $ICU.version
## [1] "55.1"
##
## $Locale
## $Locale$Language
## [1] "en"
##
## $Locale$Country
## [1] "CA"
##
## $Locale$Variant
## [1] ""
##
## $Locale$Name
## [1] "en_CA"
##
##
## $Charset.internal
## [1] "UTF-8" "UTF-16"
##
## $Charset.native
## $Charset.native$Name.friendly
## [1] "UTF-8"
##
## $Charset.native$Name.ICU
## [1] "UTF-8"
##
## $Charset.native$Name.UTR22
## [1] NA
##
## $Charset.native$Name.IBM
## [1] "ibm-1208"
##
## $Charset.native$Name.WINDOWS
## [1] "windows-65001"
##
## $Charset.native$Name.JAVA
## [1] "UTF-8"
##
## $Charset.native$Name.IANA
## [1] "UTF-8"
##
## $Charset.native$Name.MIME
## [1] "UTF-8"
##
## $Charset.native$ASCII.subset
## [1] TRUE
##
## $Charset.native$Unicode.1to1
## [1] NA
##
## $Charset.native$CharSize.8bit
## [1] FALSE
##
## $Charset.native$CharSize.min
## [1] 1
##
## $Charset.native$CharSize.max
## [1] 3
##
##
## $ICU.system
## [1] FALSE

```

Note. Here, ICU stands for the International Components for Unicode, which Wikipedia here ([https://en.wikipedia.org/wiki/International\\_Components\\_for\\_Unicode](https://en.wikipedia.org/wiki/International_Components_for_Unicode)) tells me are a set of open source C/C++ and Java libraries. However, my brain always thinks about Intensive Care Unit (ICU) when I read it because of my clinical training ;)

Wow, this took a lot of time !! Of course, not all the lines have code and I tried something different, but still, reaching 600 lines for the first part of the homework, that is a bit intense.

## 5. Work with a list

This exercise is using the GitHub GenomicDataCommons tutorial here (<https://github.com/seandavi/GenomicDataCommons#filtering>) which shows a step by step process to obtain some cancer genomic data.

The tasks completed are based on the STAT545/547 purrr tutorial (Simplifying data from a list of GitHub users) here ([https://jennybc.github.io/purrr-tutorial/ls02\\_map-extraction-advanced.html](https://jennybc.github.io/purrr-tutorial/ls02_map-extraction-advanced.html)), the general purrr tutorial here (<https://jennybc.github.io/purrr-tutorial/index.html>), the Trump tweets tutorial here ([https://jennybc.github.io/purrr-tutorial/ls08\\_trump-tweets.html](https://jennybc.github.io/purrr-tutorial/ls08_trump-tweets.html)) and the class notes from the STAT545 (<http://stat545.com/syllabus.html>) course this Fall 2017.

## DATA AND BASIC WRANGLING

From the Genomic Data Commons (GDC) website (<https://gdc.cancer.gov/about-gdc>):

The National Cancer Institute's (NCI's) Genomic Data Commons (GDC) is a data sharing platform that promotes precision medicine in oncology. It is not just a database or a tool; it is an expandable knowledge network supporting the import and standardization of genomic and clinical data from cancer research programs.

I installed a few bioconductor packages. References: Bioconductor packages here (<https://bioconductor.org/install/#install-bioconductor-packages>) and here (<https://bioconductor.org/packages/release/bioc/html/GenomicDataCommons.html>), and pdf information on GenomicDataCommons here (<https://www.biorxiv.org/content/biorxiv/early/2017/04/04/117200.full.pdf>).

```
library(magrittr)
library(devtools)
#source("https://bioconductor.org/biocLite.R")
#biocLite(c("GenomicFeatures", "AnnotationDbi", "GenomeInfoDbData"))
#biocLite("GenomicDataCommons")
library(GenomicDataCommons)
```

```
## Warning: package 'GenomicDataCommons' was built under R version 3.4.2
```

```
GenomicDataCommons::status()
```

```
## $commit
## [1] "a38d9114206f253599cfcb12e454fc10582be38d"
##
## $data_release
## [1] "Data Release 9.0 - October 24, 2017"
##
## $status
## [1] "OK"
##
## $tag
## [1] "1.10.0"
##
## $version
## [1] 1
```

```
library(GenomicDataCommons)
library(magrittr)
ge_manifest = files() %>%
  GenomicDataCommons::filter( ~ cases.project.project_id == 'TCGA-OV' &
    type == 'gene_expression') %>%
  manifest()
```

```
#library(BiocParallel)
#register(MulticoreParam())
#destdir = tempdir()
#fnames = bplapply(ge_manifest$id, gdcdata,
  #destination_dir=destdir,
  #BPPARAM = MulticoreParam(progressbar=TRUE))
```

Note. At this stage, I kept having error messages, for example:

Error: BiocParallel errors element index: 1, 2, 3, 4, 5, 6, ... first error: SSL certificate problem: Invalid certificate cha

- I have tries to troubleshoot this SSL certificate issue, but after several hours, I had to give up as I was getting nowhere. I kept the code chunk just in case I am able to resolve this SSL issue at a later time.

Let's just make a simpler nested data.frame with information about the patients, diagnoses, samples, etc.

```
qfiles = files() %>%
  GenomicDataCommons::filter( ~ cases.project.project_id == 'TCGA-DLBC' &
    type == 'gene_expression' &
    analysis.workflow_type == 'HTSeq - Counts')
manifest_df = qfiles %>% manifest()
nrow(manifest_df)
```

```
## [1] 48
```

```
str(manifest_df , max.level = 1)
```

```
## Classes 'gdc_manifest', 'tbl_df', 'tbl' and 'data.frame': 48 obs. of 5 variables:
## $ id : chr "8d8b0e13-fb54-45fe-855e-718dbf3bc219" "bf9bae2b-2f0f-4250-a2bd-2d1e80aa9b0f" "e2c43df6-95a8
-4190-a488-7cf186627840" "36393056-9f92-4a9f-bf18-fe69765c8f1b" ...
## $ filename: chr "ce79c39f-0752-4789-a46e-dde431b886da.htseq.counts.gz" "3ed4d69f-25bc-43b5-aa05-749ec88030a
3.htseq.counts.gz" "38b4af20-2579-4efd-8657-e93c55035e24.htseq.counts.gz" "a39253da-8dc4-46c2-bd29-491a61ea4471.h
tseq.counts.gz" ...
## $ md5 : chr "7dd6c5e9bc20a31c1eee57e7a7c24703" "c9ea596aff0f76922e6205c016e665fd" "09695d040afb27cbc9f4c
96136c74216" "aedd5ddc4620fe5a54ac4d04f52042bd" ...
## $ size : int 246274 251197 246390 245569 247532 240827 245332 250856 251303 248814 ...
## $ state : chr "live" "live" "live" "live" ...
## - attr(*, "spec")=List of 2
## ..- attr(*, "class")= chr "col_spec"
```

Creating a data query

```
pquery = projects()
presults = pquery %>% results()
```

```
# total number of files of a specific type
res = files() %>% facet(c('type','data_type')) %>% aggregations()
res$type
```

```
##               key doc_count
## 1 annotated_somatic_mutation 63581
## 2 simple_somatic_mutation    63581
## 3 aligned_reads              45988
## 4 copy_number_segment        44752
## 5 gene_expression            34722
## 6 mirna_expression           22976
## 7 methylation_beta_value     12359
## 8 biospecimen_supplement     11370
## 9 clinical_supplement        11211
## 10 aggregated_somatic_mutation 186
## 11 masked_somatic_mutation   132
```

Select only the gene\_expression data.

```
qfiles = files() %>% filter(~ type == 'gene_expression')
# here is what the filter looks like after translation
str(get_filter(qfiles))
```

```
## List of 2
## $ op :Classes 'scalar', 'character' chr "="
## $ content:List of 2
## ..$ field: chr "type"
## ..$ value: chr "gene_expression"
```

```
grep('pro',available_fields('files'),value=TRUE)
```

```
## [1] "cases.diagnoses.progression_free_survival"
## [2] "cases.diagnoses.progression_free_survival_event"
## [3] "cases.diagnoses.progression_or_recurrence"
## [4] "cases.project.dbgap_accession_number"
## [5] "cases.project.disease_type"
## [6] "cases.project.intended_release_date"
## [7] "cases.project.name"
## [8] "cases.project.primary_site"
## [9] "cases.project.program.dbgap_accession_number"
## [10] "cases.project.program.name"
## [11] "cases.project.program.program_id"
## [12] "cases.project.project_id"
## [13] "cases.project.releasable"
## [14] "cases.project.released"
## [15] "cases.project.state"
## [16] "cases.samples.days_to_sample_procurement"
## [17] "cases.samples.method_of_sample_procurement"
## [18] "cases.samples.portions.slides.number_proliferating_cells"
## [19] "cases.tissue_source_site.project"
```

The aggregation function will group data of the same type together.

```
files() %>% facet('cases.project.project_id') %>% aggregations()
```

```
## $cases.project.project_id
##      key doc_count
## 1      FM-AD    36134
## 2      TCGA-BRCA  27207
## 3      TCGA-LUAD  14804
## 4      TCGA-UCEC  13604
## 5      TCGA-LUSC  13124
## 6      TCGA-HNSC  12895
## 7      TCGA-LGG   12603
## 8      TCGA-THCA  12703
## 9      TCGA-OV    13054
## 10     TCGA-PRAD  12568
## 11     TCGA-COAD  11824
## 12     TCGA-SKCM  11265
## 13     TCGA-KIRC  12272
## 14     TCGA-STAD  10731
## 15     TCGA-BLCA  10193
## 16     TCGA-GBM   9657
## 17     TCGA-LIHC  9511
## 18     TCGA-CESC  7349
## 19     TCGA-KIRP  7368
## 20     TCGA-SARC  6282
## 21     TCGA-ESCA  4473
## 22     TCGA-PAAD  4433
## 23     TCGA-PCPG  4422
## 24     TCGA-READ  4012
## 25     TCGA-LAML  3954
## 26     TCGA-TGCT  3636
## 27     TARGET-NBL 2806
## 28     TCGA-THYM  2974
## 29     TARGET-AML 1873
## 30     TCGA-ACC   2108
## 31     TARGET-WT  1324
## 32     TCGA-MESO  2050
## 33     TCGA-UVM   1928
## 34     TCGA-KICH  1853
## 35     TCGA-UCS   1364
## 36     TCGA-CHOL  1157
## 37     TCGA-DLBC  1163
## 38     TARGET-OS    4
## 39     TARGET-RT   174
## 40     TARGET-CCSK    2
```

```
files() %>% facet('cases.project.project_id') %>% aggregations() %>% str(max.level = 1)
```

```
## List of 1
## $ cases.project.project_id:'data.frame': 40 obs. of 2 variables:
```

I only want o select the TCGA-DLBC subset of data.

```
qfiles = files() %>% filter( ~ cases.project.project_id == 'TCGA-DLBC' & type == 'gene_expression')
str(get_filter(qfiles))
```

```
## List of 2
## $ op :Classes 'scalar', 'character' chr "and"
## $ content:List of 2
## ..$ :List of 2
## .. ..$ op :Classes 'scalar', 'character' chr "="
## .. ..$ content:List of 2
## .. .. ..$ field: chr "cases.project.project_id"
## .. .. ..$ value: chr "TCGA-DLBC"
## ..$ :List of 2
## .. ..$ op :Classes 'scalar', 'character' chr "="
## .. ..$ content:List of 2
## .. .. ..$ field: chr "type"
## .. .. ..$ value: chr "gene_expression"
```

```
qfiles %>% count()
```

```
## [1] 144
```

```
qfiles %>% str(max.level = 1)
```

```
## List of 5
## $ fields : chr [1:23] "access" "acl" "created_datetime" "data_category" ...
## $ filters:List of 2
## $ facets : NULL
## $ legacy : logi FALSE
## $ expand : NULL
## - attr(*, "class")= chr [1:3] "gdc_files" "GDCQuery" "list"
```

```
manifest_df = qfiles %>% manifest()
head(manifest_df)
```

```
## # A tibble: 6 x 5
##               id
##             <chr>
## 1 8d8b0e13-fb54-45fe-855e-718dbf3bc219
## 2 bf9bae2b-2f0f-4250-a2bd-2d1e80aa9b0f
## 3 e2c43df6-95a8-4190-a488-7cf186627840
## 4 36393056-9f92-4a9f-bf18-fe69765c8f1b
## 5 7f073ffc-1f5c-44d0-9fa7-8f22631a16f0
## 6 a8b51e82-05e0-44fc-8da7-b59d4351409f
## # ... with 4 more variables: filename <chr>, md5 <chr>, size <int>,
## #   state <chr>
```

```
qfiles = files() %>% filter( ~ cases.project.project_id == 'TCGA-DLBC' &
                             type == 'gene_expression' &
                             analysis.workflow_type == 'HTSeq - Counts')
manifest_df = qfiles %>% manifest()
nrow(manifest_df)
```

```
## [1] 48
```

```
fnames = gdcdata(manifest_df$id[1:2],progress=FALSE)
```



```
res = cases() %>% facet("project.project_id") %>% aggregations()
head(res)
```

```
## $project.project_id
##           key doc_count
## 1      FM-AD    18004
## 2  TARGET-NBL    1127
## 3   TCGA-BRCA   1098
## 4  TARGET-AML    988
## 5  TARGET-WT    652
## 6   TCGA-GBM    617
## 7   TCGA-OV    608
## 8   TCGA-LUAD   585
## 9   TCGA-UCEC   560
## 10  TCGA-KIRC   537
## 11  TCGA-HNSC   528
## 12   TCGA-LGG   516
## 13  TCGA-THCA   507
## 14  TCGA-LUSC   504
## 15  TCGA-PRAD   500
## 16  TCGA-SKCM   470
## 17  TCGA-COAD   461
## 18  TCGA-STAD   443
## 19  TCGA-BLCA   412
## 20  TARGET-OS   381
## 21  TCGA-LIHC   377
## 22  TCGA-CESC   307
## 23  TCGA-KIRP   291
## 24  TCGA-SARC   261
## 25  TCGA-LAML   200
## 26  TCGA-ESCA   185
## 27  TCGA-PAAD   185
## 28  TCGA-PCPG   179
## 29  TCGA-READ   172
## 30  TCGA-TGCT   150
## 31  TCGA-THYM   124
## 32  TCGA-KICH   113
## 33   TCGA-ACC    92
## 34  TCGA-MESO    87
## 35   TCGA-UVM    80
## 36  TARGET-RT    75
## 37  TCGA-DLBC    58
## 38   TCGA-UCS    57
## 39  TCGA-CHOL    51
## 40  TARGET-CCSK    13
```

```
library(ggplot2)
ggplot(res$project.project_id,aes(x = key, y = doc_count)) +
  geom_bar(stat='identity') +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



```
## List of 4
## $ results      :'data.frame':   58 obs. of  19 variables:
## $ query        :List of 5
## $ attr(*, "class")= chr [1:3] "gdc_cases" "GDCQuery" "list"
## $ pages        :List of 7
## $ aggregations: list()
## - attr(*, "class")= chr [1:3] "GDCcasesResponse" "GDCResponse" "list"
```

```
#View(d1)
#View(d2)
str(d2, max.level = 1)
```

```
## List of 19
## $ updated_datetime : chr [1:58] "2017-03-04T16:39:19.244769-06:00" "2017-03-04T16:39:19.244769-06:00" "20
17-03-04T16:39:19.244769-06:00" "2017-03-04T16:39:19.244769-06:00" ...
## $ submitter_analyte_ids:List of 58
## $ analyte_ids         :List of 58
## $ submitter_id        : chr [1:58] "TCGA-G8-6914" "TCGA-G8-6907" "TCGA-GR-A4D6" "TCGA-GR-A4D5" ...
## $ case_id             : chr [1:58] "3622cf29-600f-4410-84d4-a9afeb41c475" "31bbad4e-3789-42ec-9faa-1cb86970f
723" "c1c06604-5ae2-4a53-b9c0-eb210d38e3f0" "f855dad1-6ffc-493e-ba6c-970874bc9210" ...
## $ id                  : chr [1:58] "3622cf29-600f-4410-84d4-a9afeb41c475" "31bbad4e-3789-42ec-9faa-1cb86970f
723" "c1c06604-5ae2-4a53-b9c0-eb210d38e3f0" "f855dad1-6ffc-493e-ba6c-970874bc9210" ...
## $ disease_type        : chr [1:58] "Lymphoid Neoplasm Diffuse Large B-cell Lymphoma" "Lymphoid Neoplasm Diff
use Large B-cell Lymphoma" "Lymphoid Neoplasm Diffuse Large B-cell Lymphoma" "Lymphoid Neoplasm Diffuse Large B-c
ell Lymphoma" ...
## $ sample_ids          :List of 58
## $ portion_ids         :List of 58
## $ submitter_portion_ids:List of 58
## $ created_datetime    : logi [1:58] NA NA NA NA NA NA ...
## $ slide_ids           :List of 58
## $ state               : chr [1:58] "live" "live" "live" "live" ...
## $ aliquot_ids         :List of 58
## $ primary_site        : chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
## $ samples             :List of 58
## $ submitter_aliquot_ids:List of 58
## $ submitter_sample_ids :List of 58
## $ submitter_slide_ids :List of 58
## - attr(*, "row.names")= int [1:58] 1 2 3 4 5 6 7 8 9 10 ...
## - attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
```

```
typeof(d2)
```

```
## [1] "list"
```

```
str(d2, list.len = 1)
```

```
## List of 19
## $ updated_datetime : chr [1:58] "2017-03-04T16:39:19.244769-06:00" "2017-03-04T16:39:19.244769-06:00" "20
17-03-04T16:39:19.244769-06:00" "2017-03-04T16:39:19.244769-06:00" ...
## [list output truncated]
## - attr(*, "row.names")= int [1:58] 1 2 3 4 5 6 7 8 9 10 ...
## - attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
```

I will make another nested list d4.

```
d3 = cases() %>% GenomicDataCommons::filter(~ project.project_id=='TCGA-GBM') %>%
  GenomicDataCommons::select(c(default_fields(cases()), 'samples.sample_type')) %>%
  response_all()
d4 = d3 %>% results()
typeof(d4)
```

```
## [1] "list"
```

```
d5 = cases() %>% GenomicDataCommons::filter(~ project.project_id=='TCGA-LUAD') %>%  
  GenomicDataCommons::select(c(default_fields(cases()), 'samples.sample_type')) %>%  
  response_all()  
d6 = d5 %>% results()  
typeof(d6)
```

```
## [1] "list"
```

```
list_d <- list(d2, d4, d6)  
typeof(list_d)
```

```
## [1] "list"
```

```
#View(list_d)
```

## Part 2. Name and position shortcuts

For simplicity, let's start by looking at d2 only

```
str(d2[[1]], list.len = 1) # This is the first list in this nested data.frame, and it the values are from "update  
d_datetime"
```

```
## chr [1:58] "2017-03-04T16:39:19.244769-06:00" ...
```

```
map(d2, 1)
```

```

## $updated_datetime
## [1] "2017-03-04T16:39:19.244769-06:00"
##
## $submitter_analyte_ids
## [1] "TCGA-G8-6914-01A-11R" "TCGA-G8-6914-14A-01D" "TCGA-G8-6914-14A-01W"
## [4] "TCGA-G8-6914-01A-11W" "TCGA-G8-6914-01A-11D"
##
## $analyte_ids
## [1] "9cbced97-9fff-4612-8129-fb72ad85633d"
## [2] "b793a5fc-0002-4710-af92-0322e43dade6"
## [3] "fbb9365b-8023-4da8-a7ec-13e720b7a095"
## [4] "89cb105d-12e3-444d-8d70-dd833688da54"
## [5] "2248b334-0ffa-4f55-af13-48e6b44c5b88"
##
## $submitter_id
## [1] "TCGA-G8-6914"
##
## $case_id
## [1] "3622cf29-600f-4410-84d4-a9afeb41c475"
##
## $id
## [1] "3622cf29-600f-4410-84d4-a9afeb41c475"
##
## $disease_type
## [1] "Lymphoid Neoplasm Diffuse Large B-cell Lymphoma"
##
## $sample_ids
## [1] "717bdd50-8a66-4652-b2e3-d8bb5738b4c2"
## [2] "a72c401f-9712-4aff-842a-dd9ae500b4cd"
##
## $portion_ids
## [1] "46301a26-2459-423e-9f8d-f0470032911e"
## [2] "ed9f2b1a-05bc-442a-8ed5-bbee278e2817"
## [3] "e176261a-7212-428d-9db9-99126092e0e5"
##
## $submitter_portion_ids
## [1] "TCGA-G8-6914-14A-01" "TCGA-G8-6914-01A-11"
## [3] "TCGA-G8-6914-01A-21-A45K-20"
##
## $created_datetime
## [1] NA
##
## $slide_ids
## [1] "d02f3d16-ec64-416e-86d7-5413603d6a39"
## [2] "5b13elea-ee78-40c7-b162-91591b39bb54"
##
## $state
## [1] "live"
##
## $aliquot_ids
## [1] "5ac8fa6a-2d61-44e4-b0ef-0d9fcbf7c53a"
## [2] "8f8eb4b4-64cf-4199-8d89-0bcb1357b9c9"
## [3] "6f2b10b9-ceb2-45c8-96b8-4a49f4d62d4c"
## [4] "d4c6b197-60f8-468b-a4ba-3c219d451171"
## [5] "366ac237-58d3-45ae-bf82-9f85fc562612"
## [6] "5431207a-4e82-408c-91b6-f5437cb7f5b5"
## [7] "23beea99-6187-4600-ab43-3d7452f6a26c"
## [8] "16ea266a-69ef-42a9-81c7-affe59adb1ce"
## [9] "cbfb4849-20fa-4429-8943-dcf106bb37c6"
## [10] "d15202c0-099f-46c9-99c0-ccbdf3e82b1"
## [11] "1f8c5cb0-4040-49b8-b51d-da8cf0529a6a"
##
## $primary_site
## [1] "Lymph Nodes"
##
## $samples
##      sample_type
## 1 Bone Marrow Normal
## 2      Primary Tumor
##
## $submitter_aliquot_ids

```

```
## [1] "TCGA-G8-6914-01A-11R-2212-13" "TCGA-G8-6914-01A-11W-2233-10"
## [3] "TCGA-G8-6914-14A-01W-2233-10" "TCGA-G8-6914-01A-11D-2210-10"
## [5] "TCGA-G8-6914-14A-01D-2208-26" "TCGA-G8-6914-14A-01D-2210-10"
## [7] "TCGA-G8-6914-01A-11D-2208-26" "TCGA-G8-6914-01A-11R-2213-07"
## [9] "TCGA-G8-6914-14A-01D-2209-01" "TCGA-G8-6914-01A-11D-2209-01"
## [11] "TCGA-G8-6914-01A-11D-2211-05"
##
## $submitter_sample_ids
## [1] "TCGA-G8-6914-14A" "TCGA-G8-6914-01A"
##
## $submitter_slide_ids
## [1] "TCGA-G8-6914-01A-01-TS1" "TCGA-G8-6914-01A-01-BS1"
```

Note. This provides the first element of each list in the `d2` data.frame, but since there are multiple levels to the data.frame, it

For example, if we were to manually pull out the first element of “primary\_site” and “submitter\_aliquot\_ids”, these functions illustrated below would be equivalent.

```
map(d2["primary_site"], 1)
```

```
## $primary_site
## [1] "Lymph Nodes"
```

```
d2[["primary_site"]][[1]]
```

```
## [1] "Lymph Nodes"
```

```
map(d2["submitter_aliquot_ids"], 1)
```

```
## $submitter_aliquot_ids
## [1] "TCGA-G8-6914-01A-11R-2212-13" "TCGA-G8-6914-01A-11W-2233-10"
## [3] "TCGA-G8-6914-14A-01W-2233-10" "TCGA-G8-6914-01A-11D-2210-10"
## [5] "TCGA-G8-6914-14A-01D-2208-26" "TCGA-G8-6914-14A-01D-2210-10"
## [7] "TCGA-G8-6914-01A-11D-2208-26" "TCGA-G8-6914-01A-11R-2213-07"
## [9] "TCGA-G8-6914-14A-01D-2209-01" "TCGA-G8-6914-01A-11D-2209-01"
## [11] "TCGA-G8-6914-01A-11D-2211-05"
```

```
d2[["submitter_aliquot_ids"]][[1]]
```

```
## [1] "TCGA-G8-6914-01A-11R-2212-13" "TCGA-G8-6914-01A-11W-2233-10"
## [3] "TCGA-G8-6914-14A-01W-2233-10" "TCGA-G8-6914-01A-11D-2210-10"
## [5] "TCGA-G8-6914-14A-01D-2208-26" "TCGA-G8-6914-14A-01D-2210-10"
## [7] "TCGA-G8-6914-01A-11D-2208-26" "TCGA-G8-6914-01A-11R-2213-07"
## [9] "TCGA-G8-6914-14A-01D-2209-01" "TCGA-G8-6914-01A-11D-2209-01"
## [11] "TCGA-G8-6914-01A-11D-2211-05"
```

## Let’s move on to the recursive list\_d

Let’s look at the first level of our nested list\_d.

```
str(list_d, max.level = 1)
```

```
## List of 3
## $ :List of 19
## .. attr(*, "row.names")= int [1:58] 1 2 3 4 5 6 7 8 9 10 ...
## .. attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
## $ :List of 19
## .. attr(*, "row.names")= int [1:617] 1 2 3 4 5 6 7 8 9 10 ...
## .. attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
## $ :List of 19
## .. attr(*, "row.names")= int [1:585] 1 2 3 4 5 6 7 8 9 10 ...
## .. attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
```

```
str(list_d[[3]], list.len = 1) # Look at the first level (updated_datetime) of the 3rd list in list_d, which is the LUAD dataset.
```

```
## List of 19
## $ updated_datetime : chr [1:585] "2017-03-04T16:39:19.244769-06:00" "2017-03-04T16:39:19.244769-06:00" "2017-03-09T09:44:12.300985-06:00" "2017-03-04T16:39:19.244769-06:00" ...
## [list output truncated]
## - attr(*, "row.names")= int [1:585] 1 2 3 4 5 6 7 8 9 10 ...
## - attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
```

```
#list_d[[1]][c("samples")]
map(list_d[["updated_time"]][[1]], 1)
```

```
## list()
```

```
list_d[["submitter_aliquot_ids"]][[1]]
```

```
## NULL
```

We can extract multiple values of the LUAD (3rd list of list\_d) using map

```
str(list_d[[1]][c("state", "primary_site")], max.level = 1) # extract the state and primary site of the first list (TCGA-DLBC)
```

```
## List of 2
## $ state : chr [1:58] "live" "live" "live" "live" ...
## $ primary_site: chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
```

```
x <- map(list_d, `[,`, c("state", "primary_site")) # extrate the state and primary site for all lists
str(x[1:2]) # shows the 1st and 2nd list attribute
```

```
## List of 2
## $ :List of 2
## ..$ state : chr [1:58] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
## $ :List of 2
## ..$ state : chr [1:617] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:617] "Brain" "Brain" "Brain" "Brain" ...
```

The extract function of magrittr can also be used, which provides the same result.

```
x <- map(list_d, magrittr::extract, c("state", "primary_site"))
str(x[1:2])
```

```
## List of 2
## $ :List of 2
## ..$ state : chr [1:58] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
## $ :List of 2
## ..$ state : chr [1:617] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:617] "Brain" "Brain" "Brain" "Brain" ...
```

Exercise. Use your list inspection skills to determine the position of the elements named “state” and “primary\_site”. Map [ over the lists, requesting elements by position instead of name. “state” and “primary\_site” are at position 13 and 15 respectively in each list.

```
str(list_d[[1]][c(13, 15)], max.level = 1) # only for TCGA-DLBC
```

```
## List of 2
## $ state : chr [1:58] "live" "live" "live" "live" ...
## $ primary_site: chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
```

```
x <- map(list_d, `[`, c(13, 15)) # for all 3 TCGA lists
str(x[1:3])
```

```
## List of 3
## $ :List of 2
## ..$ state      : chr [1:58] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
## $ :List of 2
## ..$ state      : chr [1:617] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:617] "Brain" "Brain" "Brain" "Brain" ...
## $ :List of 2
## ..$ state      : chr [1:585] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:585] "Lung" "Lung" "Lung" "Lung" ...
```

We can also use piping with these functions !

```
list_d %>%
  map(`[`, c(13, 15)) %>%
  str()
```

```
## List of 3
## $ :List of 2
## ..$ state      : chr [1:58] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:58] "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" "Lymph Nodes" ...
## $ :List of 2
## ..$ state      : chr [1:617] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:617] "Brain" "Brain" "Brain" "Brain" ...
## $ :List of 2
## ..$ state      : chr [1:585] "live" "live" "live" "live" ...
## ..$ primary_site: chr [1:585] "Lung" "Lung" "Lung" "Lung" ...
```

## Part 3. Type-specific map

At this stage, it's worth exploring if the lists only have character data, or other types of data (e.g. numeric). We can take a quick peak:

```
sapply(list_d[[1]], class)
```

```
##      updated_datetime submitter_analyte_ids      analyte_ids
##      "character"      "list"      "list"
##      submitter_id      case_id      id
##      "character"      "character"      "character"
##      disease_type      sample_ids      portion_ids
##      "character"      "list"      "list"
## submitter_portion_ids      created_datetime      slide_ids
##      "list"      "logical"      "list"
##      state      aliquot_ids      primary_site
##      "character"      "list"      "character"
##      samples submitter_aliquot_ids submitter_sample_ids
##      "list"      "list"      "list"
##      submitter_slide_ids
##      "list"
```

Note. It seems like at least the top levels are characters, but it is good to keep in mind that if we use specific map function. I checked if `map_chr` works the same here, but it received an error message (`Error: Result 1 is not a length 1 atomic vector`) because not only the `list_d` contains character, but it also contains vector, and therefore, using the general `map()` function is more appropriate here.

```
list_d %>%
  map_chr(`[`, c(13, 15)) %>%
  str()
```

## Part 4. Data frame output

Let's stack up some of these lists on top of each other with `map_df()`.

```
map_df(list_d, `[`, c(5, 13, 15)) # here I am selection the case_id, state and primary_site
```



```
## # A tibble: 1,260 x 3
##               case_id state primary_site
##               <chr> <chr>      <chr>
## 1 3622cf29-600f-4410-84d4-a9afeb41c475 live Lymph Nodes
## 2 31bbad4e-3789-42ec-9faa-1cb86970f723 live Lymph Nodes
## 3 c1c06604-5ae2-4a53-b9c0-eb210d38e3f0 live Lymph Nodes
## 4 f855dad1-6ffc-493e-ba6c-970874bc9210 live Lymph Nodes
## 5 29aff186-c321-4ff9-b81b-105e27e620ff live Lymph Nodes
## 6 4263949c-f962-40dd-9998-02ad3fba4537 live Lymph Nodes
## 7 e6365b38-bc44-400c-b4aa-18ce8ff5bfce live Lymph Nodes
## 8 58e66976-4507-4552-ac53-83a49a142dde live Lymph Nodes
## 9 eda9496e-be80-4a13-bf06-89f0cc9e937f live Lymph Nodes
## 10 ea54dbad-1b23-41cc-9378-d4002a8fca51 live Lymph Nodes
## # ... with 1,250 more rows
```

I tried to create the same stacked up list with the explicit function, but since my elements (e.g. “case\_id”) are lists, I was only able to produce a data.frame with nested lists.

```
library(dplyr)
library(tibble)
df_list_d <- list_d %>% {
  tibble(
    case_id = map(., "case_id"),
    state = map(., "state"),
    primary_site = map(., "primary_site"))
}
class(df_list_d)
```

```
## [1] "tbl_df"      "tbl"        "data.frame"
```

## Part 5. “Repositories for each user”

So in this exercise, we are suppose to switch from gh\_users to gh\_repos, the latter having multiple nested lists (at least 4 levels from what I see).

I will keep the same nested object (called list\_d) because although my data is less layered and smaller, there is one item (called “samples”) which has a 4th level of modest size, with each sample id containing a list of 2 items: what type of sample was used for normal DNA and for cancer DNA studies.

Let’s extract some specific data values:

Task: submitter\_analyte\_ids is the 2nd item in each list. For each list, retrieve the 1st sample listed in the 3rd submitter\_analyte\_ids.

```
list_d %>%
  map(c(2, 3, 1))
```

```
## [[1]]
## [1] "TCGA-GR-A4D6-10A-01W"
##
## [[2]]
## [1] "TCGA-02-0321-01A-01R"
##
## [[3]]
## [1] "TCGA-95-7043-01A-11H"
```

## Part 6. List inside a data frame

As mentioned previously, we do have a data frame with lists inside: df\_list\_d.

However, it would be nice to have the TCGA cancer type (DLBC, GBM, LUAD) also in that data frame. Interestingly enough, the name of the TCGA dataset is not stored anywhere in the data, so we will simply select the primary\_site of cancer then.

```
(primary_site_cancer <- map(list_d, c(15, 1, 1)))
```

```
## [[1]]
## [1] "Lymph Nodes"
##
## [[2]]
## [1] "Brain"
##
## [[3]]
## [1] "Lung"
```

```
(cancer_df_list_d <- list_d %>%
  set_names(primary_site_cancer) %>%
  enframe("primary_site_cancer", "list_d"))
```

```
## # A tibble: 3 x 2
##   primary_site_cancer      list_d
##             <chr>         <list>
## 1      Lymph Nodes <S3: GDCCasesResults>
## 2          Brain <S3: GDCCasesResults>
## 3          Lung  <S3: GDCCasesResults>
```

You might have noticed the presence of S3: preceding the list. There is actually 3 levels of information here.

```
sapply(list_d, class)
```

```
##      [,1]      [,2]      [,3]
## [1,] "GDCCasesResults" "GDCCasesResults" "GDCCasesResults"
## [2,] "GDCResults"      "GDCResults"      "GDCResults"
## [3,] "list"            "list"            "list"
```

This is actually referring to a more advanced object in R, which I will not dive into here, but if you would like more information, please click here (<http://adv-r.had.co.nz/S3.html>).

How do we create “one row’s worth” of data for one cancer dataset? How do we do that for all lists for a single cancer dataset?

Let’s start with a simpler example. We will select the 3rd cancer type (LUAD = Lung adenocarcinoma) and only one element of each list `submitter_analyte_ids`. Then we will create a 4 rows tibble with each row representing the values corresponding to the first element of the list `submitter_analyte_ids`.

```
one_cancer <- cancer_df_list_d$list_d[[3]]
View(one_cancer)
one_submitter_analyte_ids <- one_cancer$submitter_analyte_ids[[1]][1:3]
one_submitter_analyte_ids
```

```
## [1] "TCGA-97-A4M5-01A-11D" "TCGA-97-A4M5-10A-01W" "TCGA-97-A4M5-01A-11H"
```

```
#one_cancer$submitter_analyte_ids <- one_cancer$submitter_analyte_ids[[2]][1:3]
View(one_cancer)
str(one_cancer, max.level=1)
```

```
## List of 19
## $ updated_datetime      : chr [1:585] "2017-03-04T16:39:19.244769-06:00" "2017-03-04T16:39:19.244769-06:00" "2
017-03-09T09:44:12.300985-06:00" "2017-03-04T16:39:19.244769-06:00" ...
## $ submitter_analyte_ids:List of 585
## $ analyte_ids          :List of 585
## $ submitter_id         : chr [1:585] "TCGA-97-A4M5" "TCGA-44-2657" "TCGA-95-7043" "TCGA-44-A47B" ...
## $ case_id              : chr [1:585] "5fe77d4a-a8a5-4c90-8ff2-9c3bbbb309ef" "f40301ba-831e-4afd-9ce8-5f3c1a05
ff7e" "c650b1ff-8a4c-4ee9-b7c1-268c28c83827" "967d6548-5a84-4b7e-bc3f-2e522859fce6" ...
## $ id                   : chr [1:585] "5fe77d4a-a8a5-4c90-8ff2-9c3bbbb309ef" "f40301ba-831e-4afd-9ce8-5f3c1a05
ff7e" "c650b1ff-8a4c-4ee9-b7c1-268c28c83827" "967d6548-5a84-4b7e-bc3f-2e522859fce6" ...
## $ disease_type         : chr [1:585] "Lung Adenocarcinoma" "Lung Adenocarcinoma" "Lung Adenocarcinoma" "Lung
Adenocarcinoma" ...
## $ sample_ids           :List of 585
## $ portion_ids          :List of 585
## $ submitter_portion_ids:List of 585
## $ created_datetime     : logi [1:585] NA NA NA NA NA NA ...
## $ slide_ids            :List of 585
## $ state                : chr [1:585] "live" "live" "live" "live" ...
## $ aliquot_ids          :List of 585
## $ primary_site         : chr [1:585] "Lung" "Lung" "Lung" "Lung" ...
## $ samples              :List of 585
## $ submitter_aliquot_ids:List of 585
## $ submitter_sample_ids :List of 585
## $ submitter_slide_ids  :List of 585
## - attr(*, "row.names")= int [1:585] 1 2 3 4 5 6 7 8 9 10 ...
## - attr(*, "class")= chr [1:3] "GDCcasesResults" "GDCResults" "list"
```

```
str(one_submitter_analyte_ids, max.level = 1, list.len = 1)
```

```
## chr [1:3] "TCGA-97-A4M5-01A-11D" "TCGA-97-A4M5-10A-01W" ...
```

```
one_submitter_analyte_ids[c(1,3,4)] # We present exactly 3 submitter_analyte and the corresponding TCGA sample id
entifiers
```

```
## [1] "TCGA-97-A4M5-01A-11D" "TCGA-97-A4M5-01A-11H" NA
```

```
map_df(one_cancer, `[`, c(1,3,4))
```

```
## # A tibble: 3 x 19
##               updated_datetime submitter_analyte_ids analyte_ids
##               <chr>                <list>         <list>
## 1 2017-03-04T16:39:19.244769-06:00          <chr [6]>   <chr [6]>
## 2 2017-03-09T09:44:12.300985-06:00          <chr [6]>   <chr [6]>
## 3 2017-03-04T16:39:19.244769-06:00          <chr [6]>   <chr [6]>
## # ... with 16 more variables: submitter_id <chr>, case_id <chr>, id <chr>,
## #   disease_type <chr>, sample_ids <list>, portion_ids <list>,
## #   submitter_portion_ids <list>, created_datetime <lgl>,
## #   slide_ids <list>, state <chr>, aliquot_ids <list>, primary_site <chr>,
## #   samples <list>, submitter_aliquot_ids <list>,
## #   submitter_sample_ids <list>, submitter_slide_ids <list>
```

We can scale it up for all 3 cancer dataset (DLBC, GBM and LUAD), and see that the rows represent one single case.

```
d3 <- cancer_df_list_d %>%
  mutate(cancer_info = list_d %>%
    map(. %>% map_df(`[`, c(1,3,4))))
d3$cancer_info[c(1,2,3)]
```

```
## [[1]]
## # A tibble: 3 x 19
##       updated_datetime submitter_analyte_ids analyte_ids
##               <chr>           <list>       <list>
## 1 2017-03-04T16:39:19.244769-06:00      <chr [5]>   <chr [5]>
## 2 2017-03-04T16:39:19.244769-06:00      <chr [5]>   <chr [5]>
## 3 2017-03-04T16:39:19.244769-06:00      <chr [5]>   <chr [5]>
## # ... with 16 more variables: submitter_id <chr>, case_id <chr>, id <chr>,
## #   disease_type <chr>, sample_ids <list>, portion_ids <list>,
## #   submitter_portion_ids <list>, created_datetime <lgl>,
## #   slide_ids <list>, state <chr>, aliquot_ids <list>, primary_site <chr>,
## #   samples <list>, submitter_aliquot_ids <list>,
## #   submitter_sample_ids <list>, submitter_slide_ids <list>
##
## [[2]]
## # A tibble: 3 x 19
##       updated_datetime submitter_analyte_ids analyte_ids
##               <chr>           <list>       <list>
## 1 2017-03-04T16:39:19.244769-06:00      <chr [6]>   <chr [6]>
## 2 2017-03-04T16:39:19.244769-06:00      <chr [3]>   <chr [3]>
## 3 2017-03-04T16:39:19.244769-06:00      <chr [6]>   <chr [6]>
## # ... with 16 more variables: submitter_id <chr>, case_id <chr>, id <chr>,
## #   disease_type <chr>, sample_ids <list>, portion_ids <list>,
## #   submitter_portion_ids <list>, created_datetime <lgl>,
## #   slide_ids <list>, state <chr>, aliquot_ids <list>, primary_site <chr>,
## #   samples <list>, submitter_aliquot_ids <list>,
## #   submitter_sample_ids <list>, submitter_slide_ids <list>
##
## [[3]]
## # A tibble: 3 x 19
##       updated_datetime submitter_analyte_ids analyte_ids
##               <chr>           <list>       <list>
## 1 2017-03-04T16:39:19.244769-06:00      <chr [6]>   <chr [6]>
## 2 2017-03-09T09:44:12.300985-06:00      <chr [6]>   <chr [6]>
## 3 2017-03-04T16:39:19.244769-06:00      <chr [6]>   <chr [6]>
## # ... with 16 more variables: submitter_id <chr>, case_id <chr>, id <chr>,
## #   disease_type <chr>, sample_ids <list>, portion_ids <list>,
## #   submitter_portion_ids <list>, created_datetime <lgl>,
## #   slide_ids <list>, state <chr>, aliquot_ids <list>, primary_site <chr>,
## #   samples <list>, submitter_aliquot_ids <list>,
## #   submitter_sample_ids <list>, submitter_slide_ids <list>
```

## THE END - Finally ;)

*I have done everything I could (and more) to make this homework both relevant for my learning and to fulfill the requirements of the course, but this has been an extremely difficult task. I hope you will understand that this is my 14th year of postsecondary schooling and at this point in my educational path, I am trying to focus on learning things that have direct applications to my research.*