Introduction to Bioinformatics

Introduction to Basic Programming with R

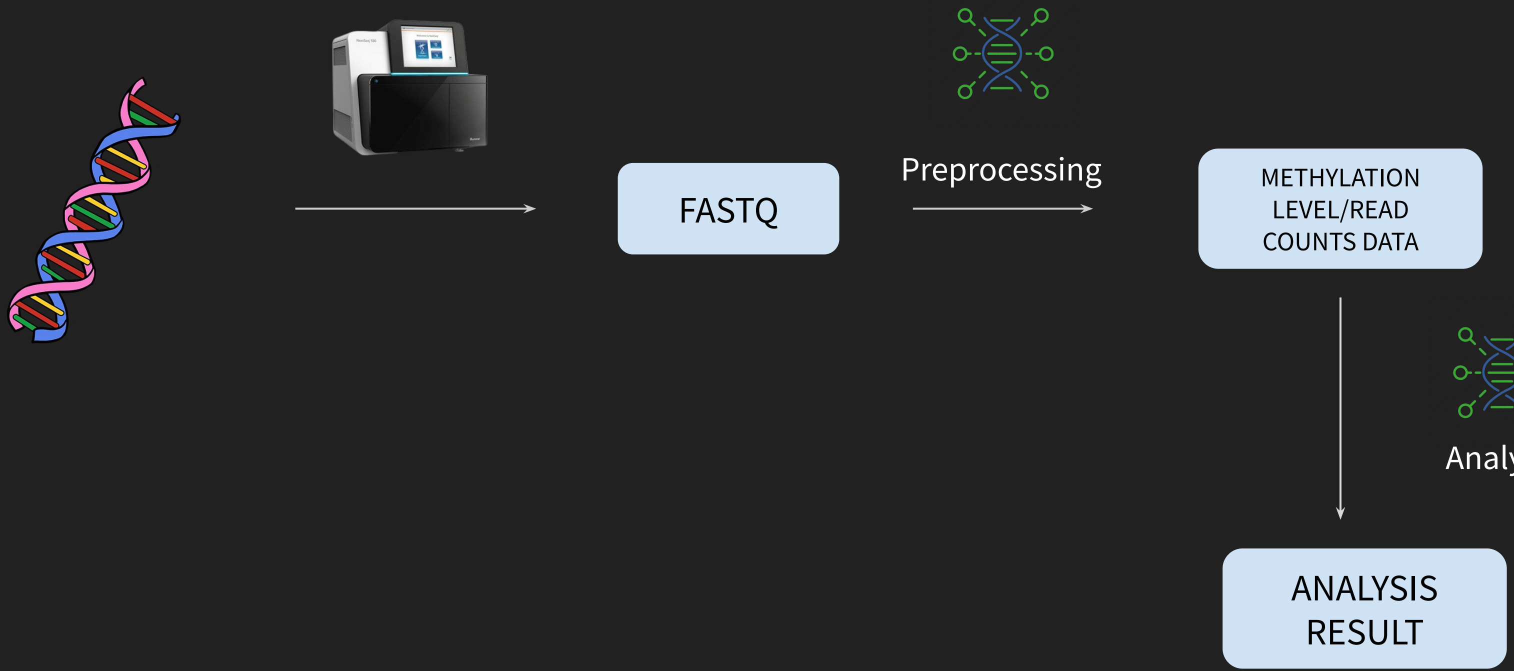
Haries Ramdhani. 2021.

Today’s Outline

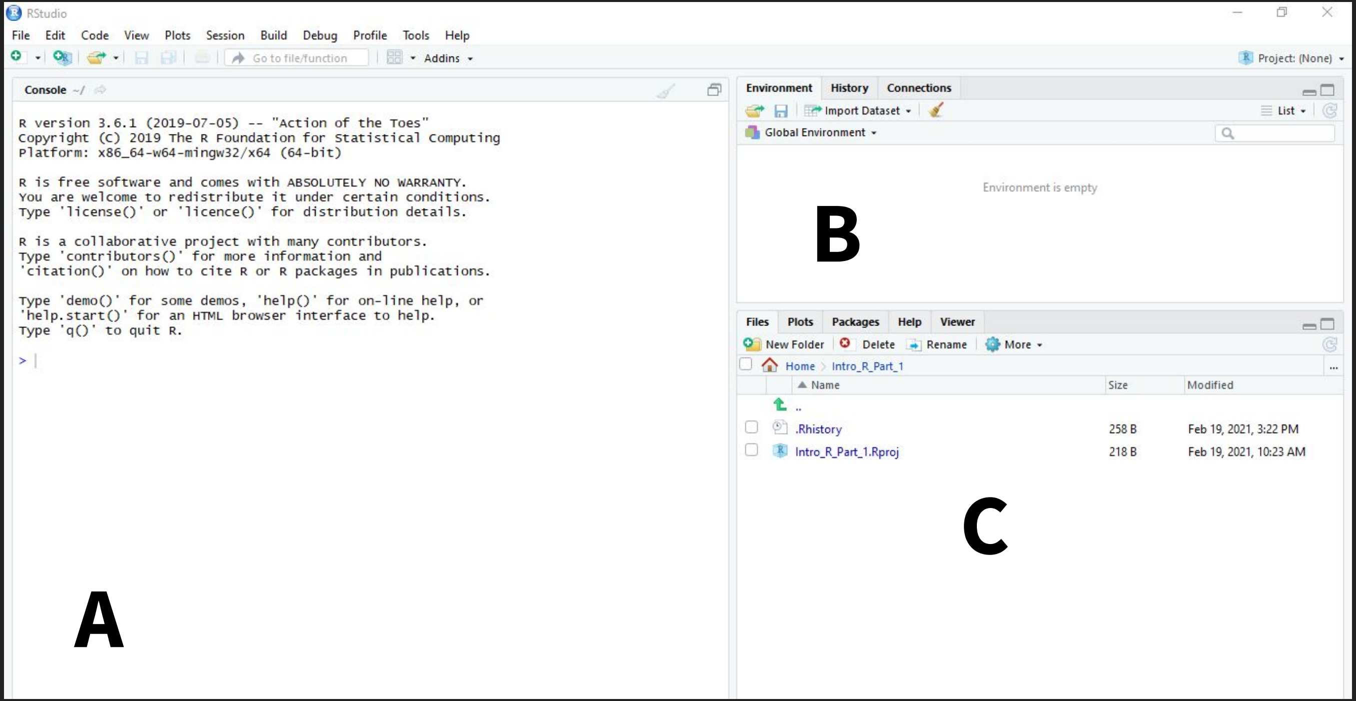
1) Quick Overview of RStudio
2) Programming Fundamentals in R:
    a) R Data Types
    b) R Operations
3) Data Frames and Factors
4) Data Manipulation

A Quick Glimpse

NGS (Bisulfite Sequencing)



Quick Introduction to R Studio


RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
Project: (None)
Console ~/
Environment History Connections
Import Dataset
List
Global Environment
Environment is empty
B
Files Plots Packages Help Viewer
New Folder Delete Rename More
Home › Intro_R_Part_1
A
C

```
R version 3.6.1 (2019-07-05) -- "Action of the Toes"
Copyright (C) 2019 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

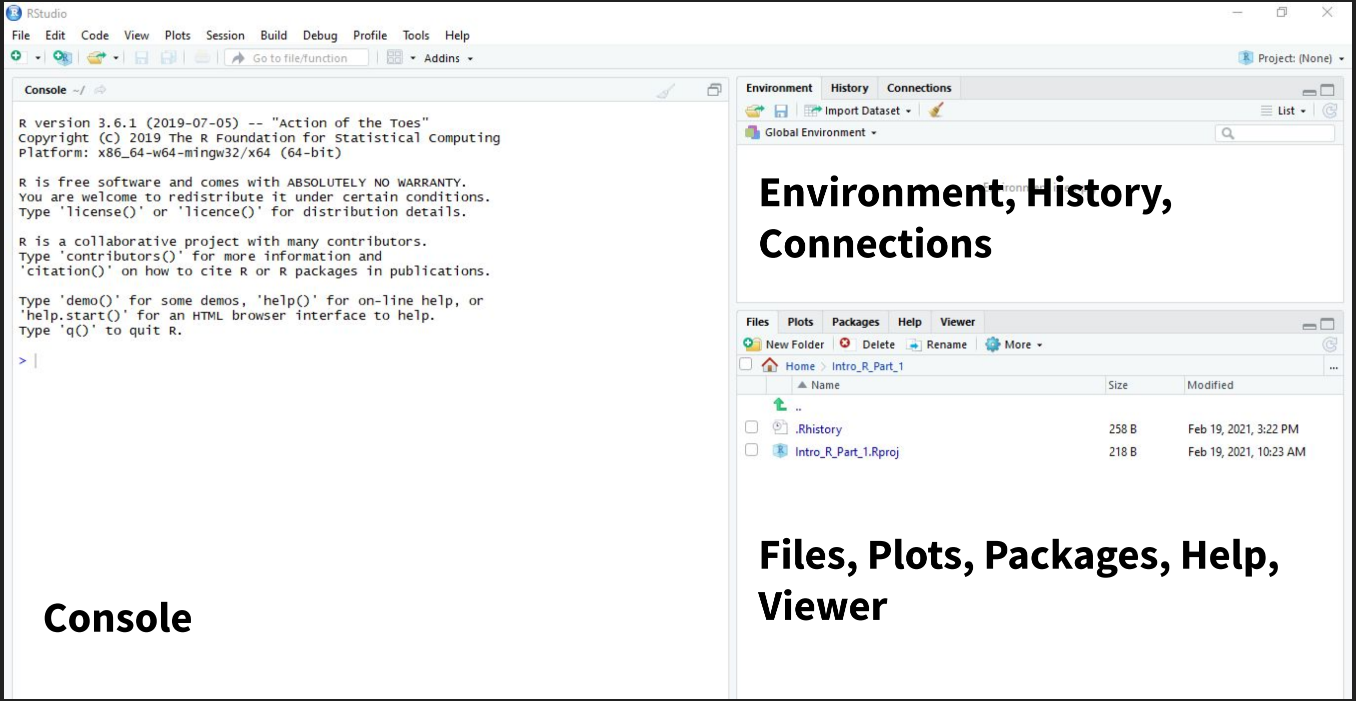
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> |
```

Name	Size	Modified
..		
.Rhistory	258 B	Feb 19, 2021, 3:22 PM
Intro_R_Part_1.Rproj	218 B	Feb 19, 2021, 10:23 AM

Figure 1 Display of RStudio

Quick Introduction to R Studio



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Go to file/function
Addins
Project: (None)
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Environment History Connections
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Home > Intro_R_Part_1
Console
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Figure 1 Display of RStudio

Quick Introduction to RStudio

A typical RStudio layout contains the following:

- **Console** : to type our code and see the output directly

- **Environment** : Provide detailed list of every functions or variables that are defined
- **History**: Provide list of the history of the used commands

- **Files** : Store all the files that are currently available to user
- **Plots** : Where the charts and plots will appear
- **Packages** : List information about the packages installed
- **Help** : Allow to search the help directly from RStudio

More information: R Studio Layout - St. Olaf College

Creating Objects/Variables in R

Objects stores the value of your choice so you can reuse it over and over again

To create an object you need:

1) a name (e.g. ‘number_of_genes’)
2) a value (e.g. ‘25’)
3) the assignment operator (‘<-‘)

```
> number_of_genes <- 25
> number_of_genes
[1] 25
```

Naming Objects/Variables in R

Objects stores the value of your choice so you can reuse it over and over again

1) **Avoid spaces and special characters**

```
> number_of_genes <- 25 ✅
> number of genes <- 25 ❌
> n@mber_of_g#n#s <- 25 ❌
```

Naming Objects/Variables in R

Objects stores the value of your choice so you can reuse it over and over again

1) **Avoid spaces and special characters**
2) **Use short, easy-to-understand names**
3) **Avoid commonly used names**

```
> number_of_genes <- 25 ✅
> number of genes <- 25 ❌
> n@mber_of_g#n#s <- 25 ❌
> mean <- 25 ❌
```

Data Types in R

Similar to other programming languages R has the following data types

Basic Data Types

- **LOGICAL : TRUE/ FALSE**
- **NUMERIC : 4.0, 5, 1018**
- **CHARACTER : ‘ACGTGAC’, ‘TP53’, ‘This is a text’**

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Operations in R

We can perform mathematical operations in R

```
> 1 + 1
[1] 2
```

Addition

```
> 190 - 18
[1] 172
```

Subtraction

```
> 5 * 3
[1] 15
```

Multiplication

```
> 8 / 4
[1] 2
```

Division

Operations in R

We can perform mathematical operations in R

`> 1 + 1`
`[1] 2`
	Addition	`> 5 ^ 2`
		`[1] 25`
			Exponent

`> 190 - 18`
`[1] 172`
	Subtraction	`> 20 %% 2`
		`[1] 0`
			Modulus (Remainder of division)

`> 5 * 3`
`[1] 15`
	Multiplication	`> 7 %/% 5`
		`[1] 1`
			Integer Division

`> 8 / 4`
`[1] 2`
	Division		

Operations in R

We can perform logical operations too in R

`> 1 == 1`	**Exactly equal**
`[1] TRUE`	
`> 190 < 18`	**Less than**
`[1] FALSE`	
`> 5 > 3`	**Greater than**
`[1] TRUE`	
`> 8 != 4`	**Not equal to**
`[1] TRUE`	

Operations in R

We can perform logical operations too in R

```
> 1 == 1          Exactly equal
[1] TRUE
> 190 < 18        Less than
[1] FALSE
> 5 > 3           Greater than
[1] TRUE
> 8 != 4          Not equal to
[1] TRUE
```

```
> 1 <= 1                 Less than equal
[1] TRUE
> 190 >= 18              Greater than
[1] TRUE
> (5 > 3) | (3 > 5)      OR
[1] TRUE
> (2 > 1) & (4 < 3)      AND
[1] FALSE
```

Data Types in R

Similar to other programming languages R has the following data types

More Data Types

- **VECTORS**
- **LISTS**
- **MATRICES**
- **ARRAYS**
- **FACTORS**
- **DATA FRAMES**

Data Types in R - VECTORS

Vector is one of the simplest data types in R, everything that is not defined as other data type is vector

```
> c(‘Apple’, ‘Orange’, ‘Mango’)
> c(1, 2, 3, 4, 5, 6, 7, 8, 9)
```

Data Types in R - LISTS

List can contain many different types of elements inside it

```
> list(c(2,5,3),21.3,sin)

> list(1, ‘apple’, 2.9099090)
```

Data Types in R - MATRICES

A matrix is a two-dimensional rectangular data set. It can be created using a vector input to the matrix function.

```
> matrix( c('a','a','b','c','b','a'), nrow = 2, ncol = 3, byrow = TRUE)
     [,1]  [,2] [,3]
[1,] "a"  "a"  "b"
[2,] "c"  "b"  "a"
```

Data Types in R - FACTORS

When matrix can only take two dimensions, arrays can be any number of dimension.

```
> factor(c('green','green','yellow','red','red','red','green'))
[1] green  green  yellow red    red    red    green
Levels: green red yellow
```

Data Types in R - DATA FRAMES

Data frames are tabular data objects. It’s different from matrix in a way that each column can contain different modes of data.

```
> data.frame(
      gender = c("Male", "Male","Female"),
      height = c(152, 171.5, 165),
      weight = c(81,93, 78),
      Age = c(42,38,26)
  )
```

```
    gender   height  weight  Age
1   Male     152.0     81     42
2   Male     171.5     93     38
3   Female   165.0     78     26
```

Data Frames

Data frames:

- are tabular data objects
- can contain different types of data inside it
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Data Frames

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Reading data from your table is as simple as the following

```
data_frame_variable <- read.csv(“directory/filename”)
```

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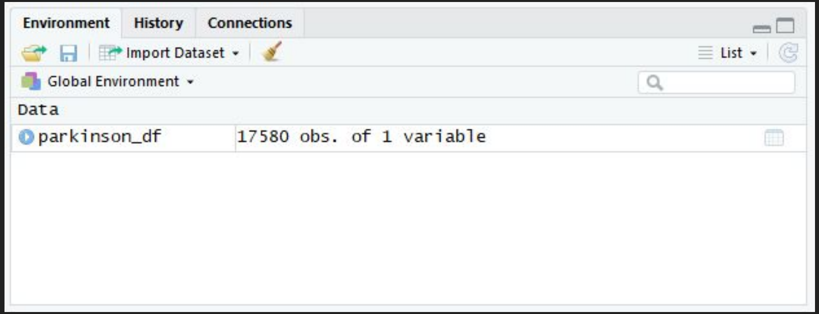
Reading data from your table is as simple as the following
data_frame_variable <- **read.csv(**“directory/filename”**)**

For example to read the shared data we can perform the following:
parkinson_df <- **readcsv(**“parkinson_de_data.tsv”**)**

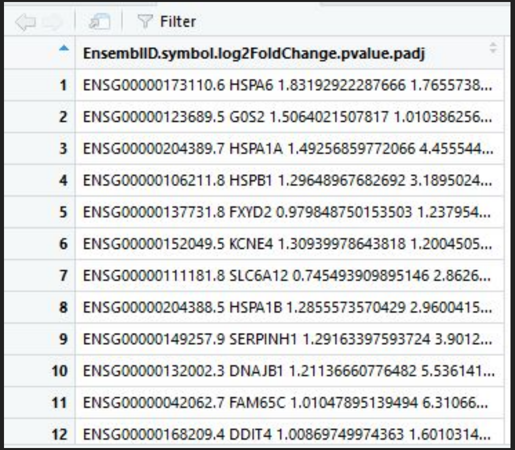
Data Frames

If the import is successful, we can see the variable listed in the environment



```
Data
parkinson_df          17580 obs. of 1 variable
```

Clicking twice we can see our imported data frame



	EnsemblID.symbol.log2FoldChange.pvalue.padj
1	ENSG00000173110.6 HSPA6 1.8319292287666 1.7655738...
2	ENSG00000123689.5 G0S2 1.5064021507817 1.010386256...
3	ENSG00000204389.7 HSPA1A 1.49256859772066 4.455544...
4	ENSG00000106211.8 HSPB1 1.29648967682692 3.1895024...
5	ENSG00000137731.8 FXYD2 0.979848750153503 1.237954...
6	ENSG00000152049.5 KCNE4 1.30939978643818 1.2004505...
7	ENSG00000111181.8 SLC6A12 0.745493909895146 2.8626...
8	ENSG00000204388.5 HSPA1B 1.2855573570429 2.9600415...
9	ENSG00000149257.9 SERPINH1 1.29163397593724 3.9012...
10	ENSG00000132002.3 DNAJB1 1.21136660776482 5.536141...
11	ENSG00000042062.7 FAM65C 1.01047895139494 6.31066...
12	ENSG00000168209.4 DDIT4 1.00869749974363 1.6010314...

But this isn’t what we wanted :(

Data Frames

read.csv can take multiple arguments, the most common ones are:

- ***header*** : whether to use the first line as the header or not
- ***sep*** : what character is being used to separate the columns in the data
- ***dec*** : what character is being used as the decimal point
- ***nrows*** : maximum number of rows to read

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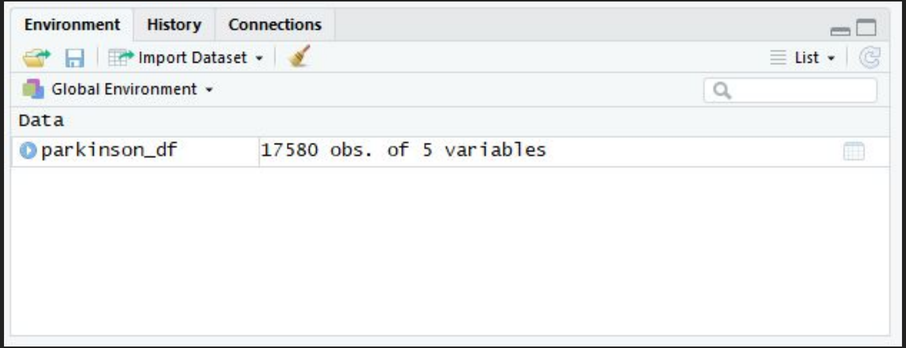
- ***nrows*** : maximum number of rows to read

More information regarding the function can be accessed like usual, just put question mark in front of the function name in RStudio (?**read.csv**)

Data Frames

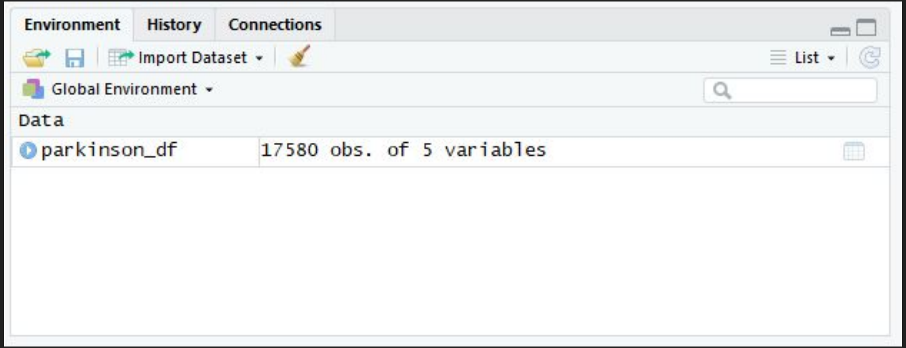
If we read the previous data correctly, the following should appear in our screen:



```
Data
parkinson_df    17580 obs. of 5 variables
```

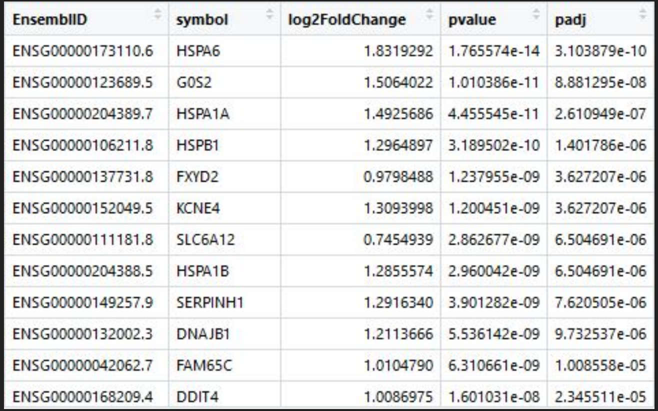
Data Frames

If we read the previous data correctly, the following should appear in our screen:



```
Data
parkinson_df    17580 obs. of 5 variables
```

Clicking the variable twice



EnsemblID	symbol	log2FoldChange	pvalue	padj
ENSG00000173110.6	HSPA6	1.8319292	1.765574e-14	3.103879e-10
ENSG00000123689.5	G0S2	1.5064022	1.010386e-11	8.881295e-08
ENSG00000204389.7	HSPA1A	1.4925686	4.455545e-11	2.610949e-07
ENSG00000106211.8	HSPB1	1.2964897	3.189502e-10	1.401786e-06
ENSG00000137731.8	FXYD2	0.9798488	1.237955e-09	3.627207e-06
ENSG00000152049.5	KCNE4	1.3093998	1.200451e-09	3.627207e-06
ENSG00000111181.8	SLC6A12	0.7454939	2.862677e-09	6.504691e-06
ENSG00000204388.5	HSPA1B	1.2855574	2.960042e-09	6.504691e-06
ENSG00000149257.9	SERPINH1	1.2916340	3.901282e-09	7.620505e-06
ENSG00000132002.3	DNAJB1	1.2113666	5.536142e-09	9.732537e-06
ENSG00000042062.7	FAM65C	1.0104790	6.310661e-09	1.008558e-05
ENSG00000168209.4	DDIT4	1.0086975	1.601031e-08	2.345511e-05

Data Frames

We can examine our data frames using the following functions:

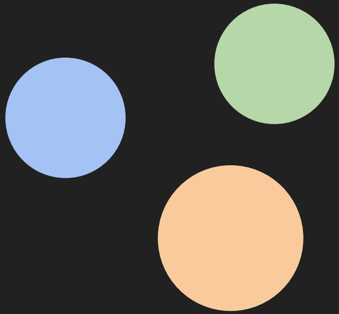
- dim(): shows the dimensions of the data frame by row and column
- str(): shows the structure of the data frame
- summary(): provides summary statistics on the columns of the data frame
- colnames(): shows the name of each column in the data frame
- head(): shows the first 6 rows of the data frame
- tail(): shows the last 6 rows of the data frame
- View(): shows a spreadsheet-like display of the entire data frame

More information : Examine Data Frames in R with These Basic Functions

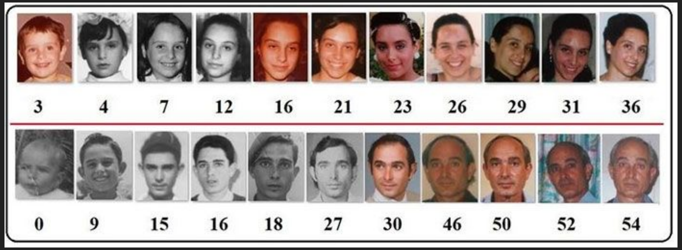
Factors

Factors:

- are usually used to store categorical variables
- are very important when doing statistical modelling
- very efficient when storing character data



Color is categorical



Age is continuous

Subsetting Data Frames

Previously we already talked on how we can perform subsetting in 1 dimensional data (vector) but how do we do it in dataframe?

[Move to practice]

More Function for Data Frames

There are also tremendous amounts of data frame function that we haven't explored, here are the followings:

- Aggregate functions [max(), min(), avg(), sum()]
- Ordering functions [order()]
- Rename columns

Saving data frames:

write.csv(variable, file=filename**)**

DPLYR

dplyr is a grammar of data manipulation, providing a consistent set of verbs that help you solve the most common data manipulation challenges

Previous subsets [ ] $\longrightarrow$

- select()
- filter()
- group_by()
- summarize()
- mutate()

Installing and using DPLYR (and other packages)

Installing is simple, you just have to type the following
install.packages("name_of_the_packages")

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Installing packages from BioConductor is a bit different

```
if (!requireNamespace('BiocManager', quietly = TRUE))
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BiocManager::install("minfi")
```

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BiocManager::install("minfi")
```

To load the installed library we can use

library("package_name")

DPLYR

Common functions in DPLYR

- select() : select our intended column
- filter() : filter the data by some conditions
- group_by() : group the data by column
- summarize() : summarize the results of grouping
- mutate() : mutate a column, create new column with new logic