Introduction to R

What is R?

R is both:

- a programming language
- an open source statistical software environment

Over the last decade it has grown to become a standard of statistical computing in academia.

Most of the functionality of R is scattered around numerous packages.

- The basic packages are included within the default R-installation
- However, most packages need to be installed separately.
- Search for packages on CRAN (`http://stat.ethz.ch/CRAN/`)

Getting help with functions and features

R has an inbuilt help facility.

To get more information to any specific named function, for example `mean`, the command is:

```
> help(mean)
```

or, alternatively:

```
> ?mean
```

If you don't know the exact name of the function, for example to plot a histogram, use:

```
> help.search("histogram")
```

or, alternatively:

```
> ??histogram
```

Manual: *An Introduction to R* by Venables, Smith & R Development Core Team (2009). See also

```
> help.start()
```

Vectors

- Vectors and assignment:

  To set up a vector named `x`, say, consisting of four numbers, namely 1.2, 3.1, 4.8, 5.0, use the R command:

  ```
  > x <- c(1.2, 3.1, 4.8, 5)
  > a1 <- c(1, 2, 3, 4)
  > a2 <- 1:4
  ```

  This is an *assignment* statement. The assignment operator is <-. The further assignment

  ```
  > y <- c(x, 0, x)
  ```

  creates a vector of length 9 containing two copies of `x` separated by a zero.
  To extract the k-th element of vector **y** type:

  ```
  > y[k]
  ```

- Vector arithmetic:

  Vectors can be used in arithmetic expressions.
  Note: Operations are executed element-wise.

Arithmetic operators and functions

Elementary arithmetic operators: $+, -, *, /$ and ^ for raising to power.

Common arithmetic functions:

```
log, exp,
sin, cos, tan,
sqrt,
min, max,
length,
sum, prod,
mean, median, sd, var, cor, quantile
sort
...
```

Logical operators:

$<, <=, >, >=, ==$ for exact equality, $!=$ for inequality

Matrices

Creation of a matrix:

```
> m <- matrix(1:6,nrow=2, ncol=3)
> m
```

```
     [,1] [,2] [,3]
[1,]    1    3    5
[2,]    2    4    6
```

```
> m[,2]  # to get the 2nd column
```

```
[1] 3 4
```

```
> m[1,]  # to get the 1st row
```

```
[1] 1 3 5
```

```
> m[2,3] # to get the third element of the 2nd row
```

```
[1] 6
```

You can change entries just by assigning new values:

```
> m[, 1] <- c(1.1, 0)
> m
```

```
     [,1] [,2] [,3]
[1,]  1.1    3    5
[2,]  0.0    4    6
```

Matrices

Dimension of a matrix:

```
> dim(m)
```

```
[1] 2 3
```

To add a new column use `cbind`, to add a new row use `rbind`:

```
> cbind(c(101, 7.1),m)
```

```
      [,1] [,2] [,3] [,4]
[1,] 101.0  1.1    3    5
[2,]   7.1  0.0    4    6
```

```
> rbind(m, c(-1, 0.01, 4))
```

```
     [,1] [,2] [,3]
[1,]  1.1 3.00    5
[2,]  0.0 4.00    6
[3,] -1.0 0.01    4
```

Matrix operations

If, for example, **A** and **B** are matrices of the same size, then

```
> A * B
```

is the matrix of element by element products, while

```
> A %*% B
```

is the matrix product.
Transpose the matrix **A** using

```
> t(A)
```

Get the diagonal elements with:

```
> diag(A)
```

The inverse of **A** can be computed with:

```
> solve(A)
```

Functions in R

Using functions already implemented in R:

- Look at the R help of this function: `?functionname`
- Which arguments have to be provided for the function? `functionname(argument1, argument1, ...)`

Writing your own functions:

```
>     euklid <- function(argument1, argument2, ...){
+       --- calculations
+       return(results)
+     }
```

Writing loops:

- for-loop

  ```
  >   for(i in 1:n){ ... }
  ```

- if-loop

  ```
  >   if(x==5){
  +       ...
  +     }else{
  +       ...
  +     }
  ```

Starting to work with data

Loading the body height datafile. Here, the data to be loaded is in a table (white-space delimited text file):

```
> data <- read.table("handsize_2006.txt", header=TRUE, sep=" ")
```

The data table is now stored in the object `data`. We just read in the table from the file `handsize_2006.txt`. The table had column titles (`header=TRUE`) and was separated by whitespaces (`sep=" "`).

To have a look at the first 6 lines, type:

```
> head(data)
```

```
  sex height hand group tutor gender
1   1  168.0 17.5     1     1      f
2   0  183.5 21.0     1     1      m
3   1  170.0 20.0     1     1      f
4   1  159.0 17.0     1     1      f
5   1  165.0 18.0     1     1      f
6   0  180.0 20.0     1     1      m
```

Accessing the data

You can access the columns by their names. To display the column *gender*, we can use the operator $:

```
> data$gender[1:10]
```

```
 [1] f m f f f m f m m m
Levels: f m
```

Frequency tables of a variable can be calculated using `table()`:

```
> table(data$gender)
```

```
  f   m
139 106
```

There are 139 females and 106 males.

Get a summary for body height:

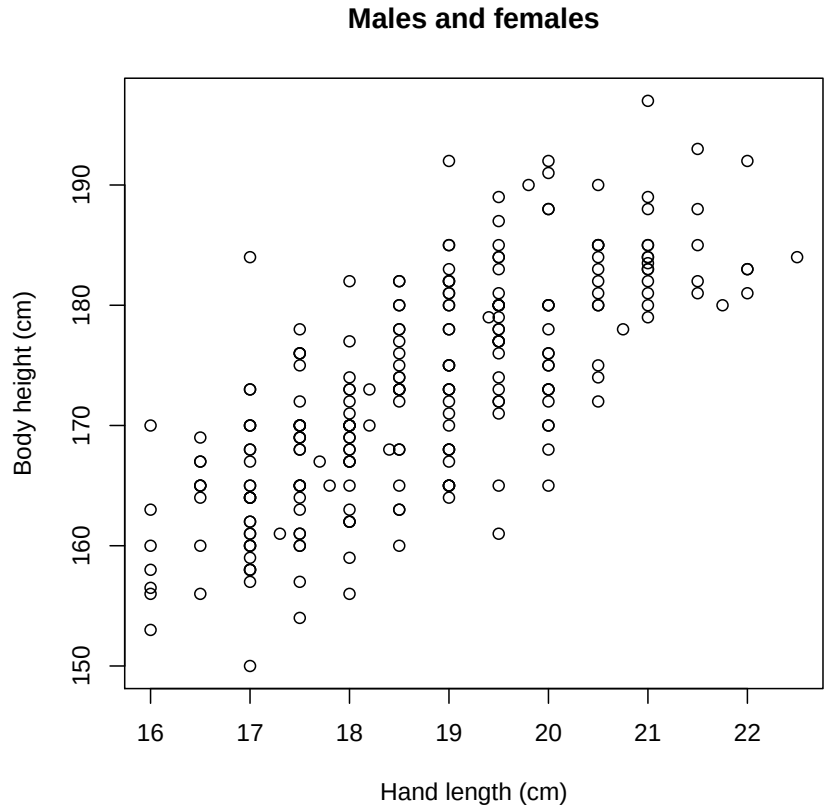
```
> summary(data$height)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  150.0   165.0   173.0   172.8   180.0   197.0
```

Plot

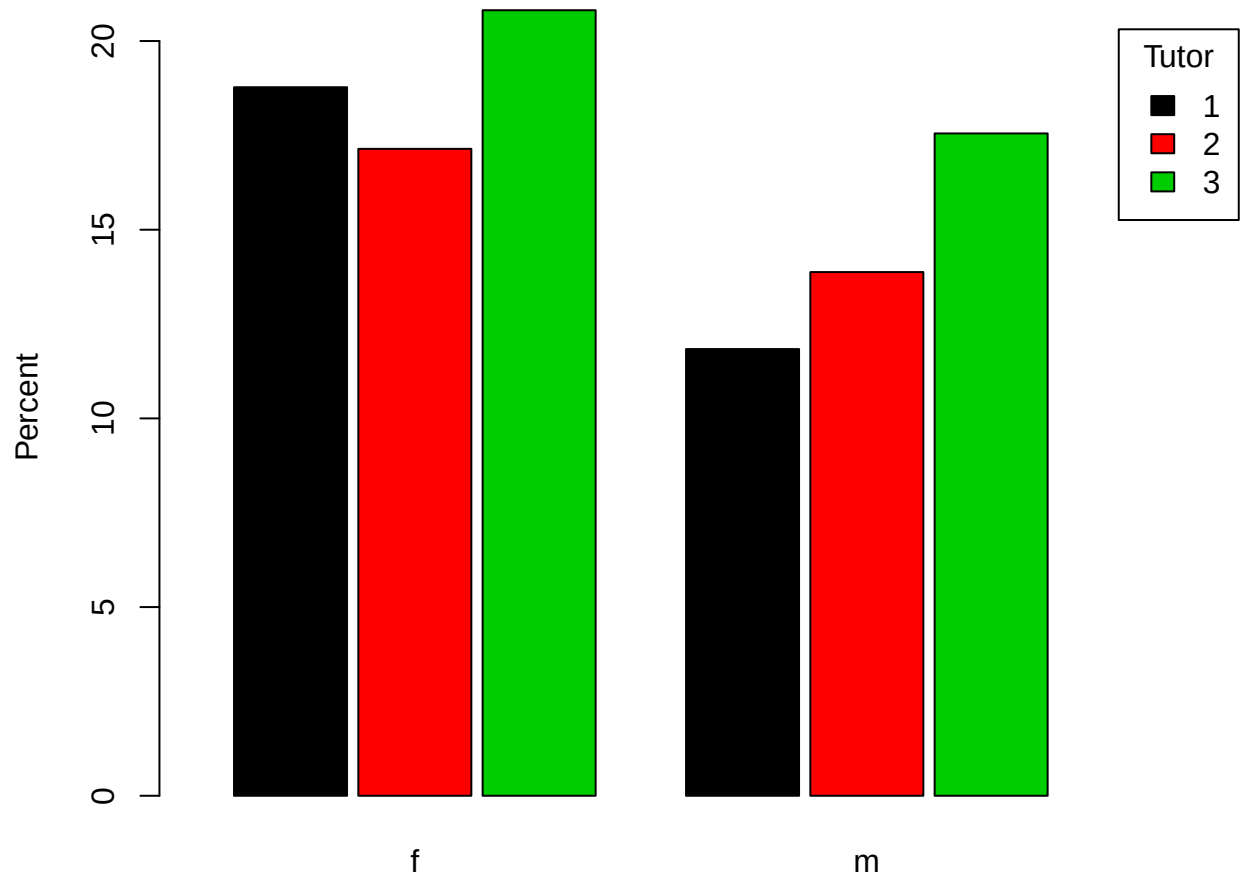
Compare the hand length and body height for males and females:

```
> plot(data$hand, data$height,
+   xlab="Hand length (cm)", ylab="Body height (cm)",
+   main="Males and females", type="p")
```



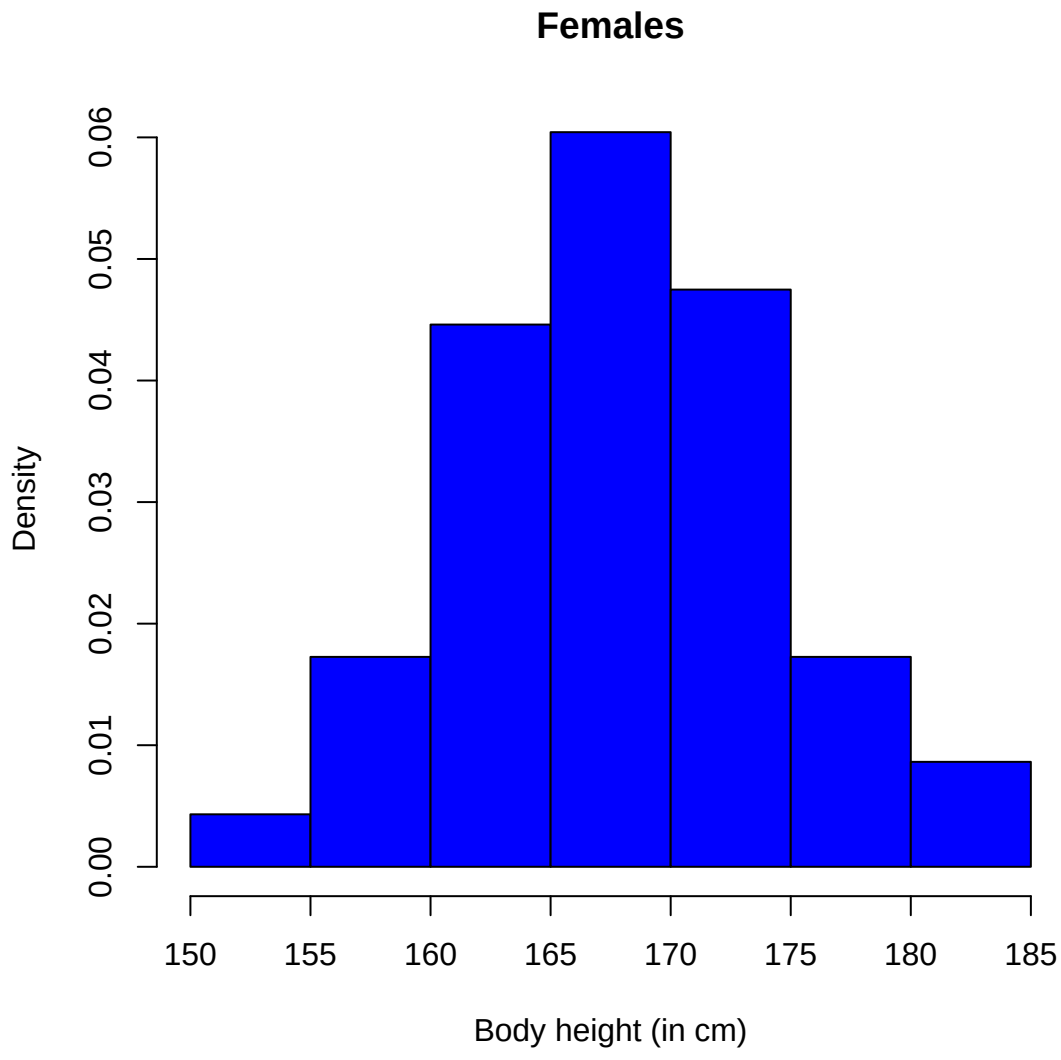
Bar chart

```
> tab <- table(data$tutor,data$gender)
> barplot(tab/sum(tab)*100,beside=T, col=c(1,2,3),
+   space=c(.1,.8), xlab="", ylab="Percent", xlim=c(0.5,9.5),
+   legend=1:3, args.legend=list(title="  Tutor  "))
```



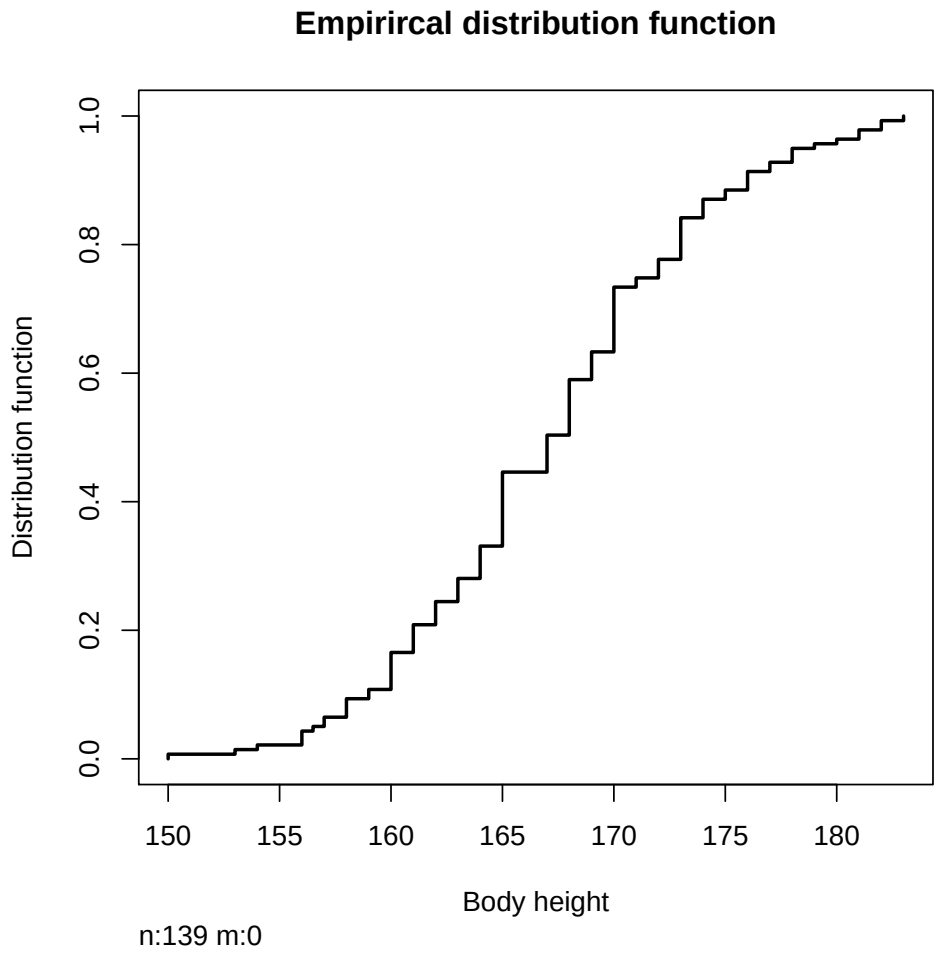
Histogram

```
>    hist(data$height[data$gender=="f"], col=4, xlab="Body height (in cm)",
+              main="Females",prob=T, right=F)
```



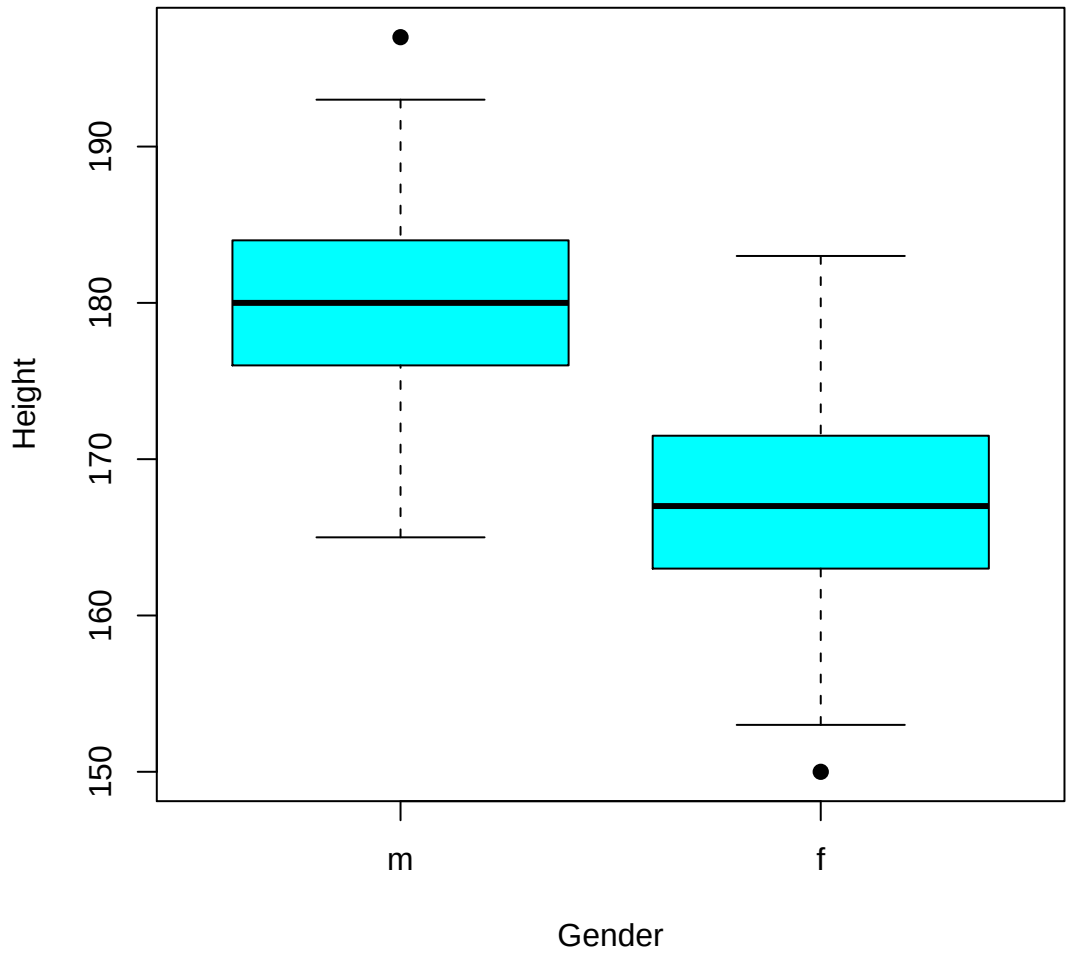
Empirical cumulative distribution function

```
> library(Hmisc)    # load the library which includes the Ecdf function
> Ecdf(data$height[data$gender=="f"], col=1, lwd=2,
+     main="Empirircal distribution function",
+     xlab="Body height", ylab="Distribution function")
```



Boxplot

```
> boxplot(height~sex,data=data,names=c("m","f"),
+   col=5, xlab="Gender", ylab="Height", pch=19)
```



Quitting R

To close R use the command:

```
> q()
```

R asks you whether you would like to save the workspace.

If you save the workspace

- a file called `.RData`, where the workspace is saved, and
- a file called `.Rhistory`, where the commands given in the R session are saved,

are generated. You can load the workspace and continue working with the datasets and results already generated.