



## The Genomics Toolkit

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# Chapter 1

## Introduction

Recent advances in DNA sequencing have revolutionized the field of genomics, making it possible for research groups to generate large amounts of sequenced data, very rapidly and at substantially lower cost [?]. The storage of genomic data is being addressed using specific file formats, such as FASTQ and FASTA. Therefore, its analysis and manipulation is crucial [?]. Many frameworks for analysis and manipulation emerged, namely GALAXY [?], GATK [?], HTSeq [?], MEGA [?], among others. Several of these frameworks require licenses, while others do not provide a low level access to the information, since they are commonly approached by scripting or programming languages not efficient for the purpose. Moreover, several lack on variety, namely the ability to perform multiple tasks using only one toolkit.

We describe **GTO**, a complete toolkit for genomics, namely for FASTA-FASTQ formats and sequences (DNA, amino acids, text), with many complementary tools. The toolkit is for Linux- and Unix-based systems, built for ultra-fast computations. **GTO** supports pipes for easy integration with the sub-programs belonging to **GTO** as well as external tools. **GTO** works as the *LEGOs*, since it allows the construction of multiple pipelines with many combinations.

**GTO** includes tools for information display, randomization, edition, conversion, extraction, search, calculation, and visualization. **GTO** is prepared to deal with very large datasets, typically in the scale Gigabytes or Terabytes (but not limited).

The complete toolkit is an optimized command line version, using the prefix “gto\_” followed by the suffix with the respective name of the program. **GTO** is implemented in C language and it is available, under the MIT license, at:

```
http://bioinformatics.ua.pt/gto
```

### 1.1 Installation

For **GTO** installation, run:

```
git clone https://github.com/bioinformatics-ua/gto.git
cd gto/src/
```

## 1.2 License

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## Chapter 2

# FASTQ tools

Current available tools for FASTQ format analysis and manipulation include:

1. `gto_fastq_to_fasta`: it converts a FASTQ file format to a pseudo FASTA file.
2. `gto_fastq_to_mfasta`: it converts a FASTQ file format to a pseudo Multi-FASTA file.
3. `gto_fastq_exclude_n`: it discards the FASTQ reads with the minimum number of "N" symbols.
4. `gto_fastq_extract_quality_scores`: it extracts all the quality-scores from FASTQ reads.
5. `gto_fastq_info`: it analyses the basic information of FASTQ file format.
6. `gto_fastq_maximum_read_size`: it filters the FASTQ reads with the length higher than the value defined.
7. `gto_fastq_minimum_quality_score`: it discards reads with average quality-score below of the defined.
8. `gto_fastq_minimum_read_size`: it filters the FASTQ reads with the length smaller than the value defined.
9. `gto_fastq_rand_extra_chars`: it substitutes in the FASTQ files, the DNA sequence the outside ACGT chars by random ACGT symbols.
10. `gto_fastq_from_seq`: it converts a genomic sequence to pseudo FASTQ file format.
11. `gto_fastq_mutate`: it creates a synthetic mutation of a FASTQ file given specific rates of mutations, deletions and additions.
12. `gto_fastq_split`: it splits Paired End files according to the direction of the strand ('/1' or '/2').
13. `gto_fastq_pack`: it packages each FASTQ read in a single line.
14. `gto_fastq_unpack`: it unpacks the FASTQ reads packaged using the `gto_fastq_pack` tool.

15. `gto_fastq_quality_score_info`: it analyses the quality-scores of a FASTQ file.
16. `gto_fastq_quality_score_min`: it analyses the minimal quality-scores of a FASTQ file.
17. `gto_fastq_quality_score_max`: it analyses the maximal quality-scores of a FASTQ file.
18. `gto_fastq_cut`: it cuts read sequences in a FASTQ file.
19. `gto_fastq_minimum_local_quality_score_forward`: it filters the reads considering the quality score average of a defined window size of bases.
20. `gto_fastq_minimum_local_quality_score_reverse`: it filters the reverse reads, considering the average window size score defined by the bases.

## 2.1 Program `gto_fastq_to_fasta`

The `gto_fastq_to_fasta` converts a FASTQ file format to a pseudo FASTA file. However, it does not align the sequence. Also, it extracts the sequence and adds a pseudo header.

For help type:

```
./gto_fastq_to_fasta -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_to_fasta` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_to_fasta [options] [--] args]
or: ./gto_fastq_to_fasta [options]

It converts a FASTQ file format to a pseudo FASTA file.
It does NOT align the sequence.
It extracts the sequence and adds a pseudo header.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output.fasta             Output FASTA file format (stdout)

Example: ./gto_fastq_to_fasta < input.fastq > output.fasta
```

An example of such an input file is:



```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_to_fasta` program a FASTA file.

Using the input above, an output example for this is the following:

```
> Computed with Fastq2Fasta
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
GTTTCAGGGATACGACGTTTGTATTTTAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
```

## 2.2 Program `gto_fastq_to_mfasta`

The `gto_fastq_to_mfasta` onverts a FASTQ file format to a pseudo Multi-FASTA file. However, it does not align the sequence. Also, it extracts the sequence and adds a pseudo header.

For help type:

```
./gto_fastq_to_mfasta -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_fastq_to_mfasta` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_to_mfasta [options] [--] args]
or: ./gto_fastq_to_mfasta [options]

It converts a FASTQ file format to a pseudo Multi-FASTA file.
It does NOT align the sequence.
It extracts the sequence and adds each header in a Multi-FASTA format.
```

<code>-h, --help</code>	show this help message and exit
-------------------------	---------------------------------

```
Basic options
< input.fastq      Input FASTQ file format (stdin)
> output.mfasta    Output Multi-FASTA file format (stdout)
```

```
Example: ./gto_fastq_to_mfasta < input.fastq > output.mfasta
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_to_mfasta` program is a Multi-FASTA file.

Using the input above, an output example for this is the following:

```
>SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
>SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTTATCAT
```

## 2.3 Program `gto_fastq_exclude_n`

The `gto_fastq_exclude_n` discards the FASTQ reads with the minimum number of "N" symbols. Also, if present, it will erase the second header (after +).

For help type:

```
./gto_fastq_exclude_n -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_exclude_n` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_exclude_n [options] [--] args]
or: ./gto_fastq_exclude_n [options]
```

It discards the FASTQ reads with the minimum number of "N" symbols.  
If present, it will erase the second header (after +).

```
-h, --help          show this help message and exit
```

```

Basic options
-m, --max=<int>      The maximum of of "N" symbols in the read
< input.fastq        Input FASTQ file format (stdin)
> output.fastq       Output FASTQ file format (stdout)

```

```

Example: ./gto_fastq_exclude_n -m <max> < input.fastq > output.fastq

```

```

Console output example :
<FASTQ non-filtered reads>
Total reads      : value
Filtered reads   : value

```

An example of such an input file is:

```

@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII9IG9ICIIIIIIIIIIIIIIIIIIIIIDIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII6IBIIIIIIIIIIIIIIIIIIIIIIIGII>IIIII-I)8I

```

## Output

The output of the `gto_fastq_exclude_n` program is a set of all the filtered FASTQ reads, followed by the execution report. The execution report only appears in the console.

Using the input above with the max value as 5, an output example for this is the following:

```

@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII6IBIIIIIIIIIIIIIIIIIIIIIIIGII>IIIII-I)8I
Total reads      : 2
Filtered reads   : 1

```

## 2.4 Program `gto_fastq_extract_quality_scores`

The `gto_fastq_extract_quality_scores` extracts all the quality-scores from FASTQ reads.

For help type:

```

./gto_fastq_extract_quality_scores -h

```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_fastq_extract_quality_scores` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_extract_quality_scores [options] [--] args]
or: ./gto_fastq_extract_quality_scores [options]

It extracts all the quality-scores from FASTQ reads.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output.fastq            Output FASTQ file format (stdout)

Example: ./gto_fastq_extract_quality_scores < input.fastq > output.fastq

Console output example:
<FASTQ quality scores>
Total reads                  : value
Total Quality-Scores        : value
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTCAAGGATACGACGTTTGTATTTTAAAGATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII-I)8I
```

## Output

The output of the `gto_fastq_extract_quality_scores` program is a set of all the quality scores from the FASTQ reads, followed by the execution report. The execution report only appears in the console.

Using the input above, an output example for this is the following:

```
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII-I)8I
Total reads                  : 2
Total Quality-Scores        : 144
```

## 2.5 Program `gto_fastq_info`

The `gto_fastq_info` analyses the basic information of FASTQ file format.

For help type:

```
./gto_fastq_info -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_fastq_info` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_info [options] [--] args]
       or: ./gto_fastq_info [options]

It analyses the basic information of FASTQ file format.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output                   Output read information (stdout)

Example: ./gto_fastq_info < input.fastq > output

Output example:
Total reads      : value
Max read length : value
Min read length : value
Min QS value    : value
Max QS value    : value
QS range        : value
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAAGATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_info` program is a set of information related to the file read.

Using the input above, an output example for this is the following:

```
Total reads      : 2
Max read length  : 72
Min read length  : 72
```

```

Min QS value      : 41
Max QS value      : 73
QS range          : 33

```

## 2.6 Program gto fastq maximum read size

The `gto_fastq_maximum_read_size` filters the FASTQ reads with the length higher than the value defined. For help type:

```
./gto_fastq_maximum_read_size -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_maximum_read_size` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_maximum_read_size [options] [--] args]
or: ./gto_fastq_maximum_read_size [options]

It filters the FASTQ reads with the length higher than the value defined.
If present, it will erase the second header (after +).

    -h, --help            show this help message and exit

Basic options
    -s, --size=<int>      The maximum read length
    < input.fastq         Input FASTQ file format (stdin)
    > output.fastq        Output FASTQ file format (stdout)

Example: ./gto_fastq_maximum_read_size -s <size> < input.fastq > output.fastq

Console output example :
<FASTQ non-filtered reads>
Total reads      : value
Filtered reads   : value
```

An example of such an input file is:

[illegible]

## Output

The output of the `gto_fastq_maximum_read_size` program is a set of all the filtered FASTQ reads, followed by the execution report. The execution report only appears in the console.

Using the input above with the size values as 60, an output example for this is the following:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=60
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGG
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII9IG9ICIIIIIIIIIIIIIIIIIIIDIII
Total reads      : 2
Filtered reads   : 1
```

## 2.7 Program gto fastq minimum quality score

The `gto_fastq_minimum_quality_score` discards reads with average quality-score below of the defined. For help type:

```
./gto_fastq_minimum_quality_score -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_fastq_minimum_quality_score` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_minimum_quality_score [options] [--] args]
      or: ./gto_fastq_minimum_quality_score [options]

It discards reads with average quality-score below value.

-h, --help                show this help message and exit

Basic options
-m, --min=<int>           The minimum average quality-score (Value 25 or 30 is commonly used)
< input.fastq            Input FASTQ file format (stdin)
> output.fastq           Output FASTQ file format (stdout)

Example: ./gto_fastq_minimum_quality_score -m <min> < input.fastq > output.fastq

Console output example:
<FASTQ non-filtered reads>
Total reads      : value
Filtered reads  : value
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
54599<>77977==6=?I6IBI::33344235521677999>>><<<@A@BBCDGGBFFH>IIIII-I)8I
```

## Output

The output of the `gto_fastq_minimum_quality_score` program is a set of all the filtered FASTQ reads, followed by the execution report.

Using the input above with the minimum average value as 30, an output example for this is the following:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
Total reads      : 2
Filtered reads   : 1
```

## 2.8 Program `gto_fastq_minimum_read_size`

The `gto_fastq_minimum_read_size` filters the FASTQ reads with the length smaller than the value defined. For help type:

```
./gto_fastq_minimum_read_size -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_minimum_read_size` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_minimum_read_size [options] [--] args]
or: ./gto_fastq_minimum_read_size [options]

It filters the FASTQ reads with the length smaller than the value defined.
If present, it will erase the second header (after +).

    -h, --help                show this help message and exit

Basic options
```



```
-s, --size=<int>      The minimum read length
< input.fastq         Input FASTQ file format (stdin)
> output.fastq        Output FASTQ file format (stdout)
```

Example: `./gto_fastq_minimum_read_size -s <size> < input.fastq > output.fastq`

Console output example:

```
<FASTQ non-filtered reads>
Total reads      : value
Filtered reads  : value
```

[illegible]

The output of the `gto_fastq_minimum_read_size` program is a set of all the filtered FASTQ reads, followed by the execution report. The execution report only appears in the console.

```
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTCCAGGGATACGACGTTTGTATTTTAAGAATCTGAAGCAGAAAGTCGATGATAATACGCGTCGTTTTATCAT
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII6IBIIIIIIIIIIIIIIIIIIIIIIIGII>IIIII-I)8I
Total reads      : 2
Filtered reads   : 1
```

The `gto_fastq_rand_extra_chars` substitutes in the FASTQ files, the DNA sequence the outside ACGT chars by random ACGT symbols.

```
./gto_fastq_rand_extra_chars -h
```

### Input parameters

The attribution is given according to:

```
Usage: ./gto_fastq_rand_extra_chars [options] [--] args]
      or: ./gto_fastq_rand_extra_chars [options]

It substitutes in the FASTQ files, the DNA sequence the outside ACGT chars by random ACGT symbols.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output.fastq            Output FASTQ file format (stdout)

Example: ./gto_fastq_rand_extra_chars < input.fastq > output.fastq
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
NTTCAGGGATACGACGNTTGTATTTTAAAGATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_rand_extra_chars` program is a FASTQ file.

Using the input above, an output example for this is the following:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GTGTGATGGCCGCTGCCGATGGCGCATAATCCCACCAACATACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGATTGTATTTTAAAGATCTGCAGCAGAAGTCGATGATAATACGCGCCGTTTATCAG
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## 2.10 Program `gto_fastq_from_seq`

The `gto_fastq_from_seq` converts a genomic sequence to pseudo FASTQ file format.

For help type:

```
./gto_fastq_from_seq -h
```

In the following subsections, we explain the input and output paramters.

## Input parameters

The `gto_fastq_from_seq` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence group file.

The attribution is given according to:

```
Usage: ./gto_fastq_from_seq [options] [--] args]
       or: ./gto_fastq_from_seq [options]

It converts a genomic sequence to pseudo FASTQ file format.

-h, --help                show this help message and exit

Basic options
< input.seq              Input sequence file (stdin)
> output.fastq           Output FASTQ file format (stdout)

Optional options
-n, --name=<str>         The read's header
-l, --lineSize=<int>     The maximum of chars for line

Example: ./gto_fastq_from_seq -l <lineSize> -n <name> < input.seq > output.fastq
```

An example of such an input file is:

```
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGTGGTTTGAGTGACCTCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCACGCAAGTT
TAATTACAGACCTGAA
```

## Output

The output of the `gto_fastq_from_seq` program is a pseudo FASTQ file.

An example, using the size line as 80 and the read's header as "SeqToFastq", for the input, is:

```
@SeqToFastq1
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq2
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq3
GTGGTTTGAGTGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
```

```

+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq4
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq5
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCCGGCCTCCTGCTG
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq6
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq7
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGTGGTTTGAGTGGACCTCCAGGCCAGTGCCG
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq8
GGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq9
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCACGCAAGTT
+
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
@SeqToFastq10
TAATTACAGACCTGAA
+
FFFFFFFFFFFFFFFFFFFF

```

## 2.11 Program `gto_fastq_mutate`

The `gto_fastq_mutate` creates a synthetic mutation of a FASTQ file given specific rates of mutations, deletions and additions. All these parameters are defined by the user, and they are optional.

For help type:

```
./gto_fastq_mutate -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_mutate` program needs two streams for the computation, namely the input and output standard. However, optional settings can be supplied too, such as the starting point to the random generator, and the edition, deletion and insertion rates. Also, the user can choose to use the ACGTN alphabet in the synthetic mutation. The input stream is a FASTQ File.

The attribution is given according to:

```

Usage: ./gto_fastq_mutate [options] [--] args]
       or: ./gto_fastq_mutate [options]

Creates a synthetic mutation of a FASTQ file given specific rates of mutations,
deletions and additions

        -h, --help                show this help message and exit

Basic options
        < input.fasta              Input FASTQ file format (stdin)
        > output.fasta             Output FASTQ file format (stdout)

Optional
        -s, --seed=<int>           Starting point to the random generator
        -m, --mutation-rate=<dbl> Defines the mutation rate (default 0.0)
        -d, --deletion-rate=<dbl> Defines the deletion rate (default 0.0)
        -i, --insertion-rate=<dbl> Defines the insertion rate (default 0.0)
        -a, --ACGTN-alphabet       When active, the application uses the ACGTN alphabet

Example: ./gto_fastq_mutate -s <seed> -m <mutation rate> -d <deletion rate> -i
<insertion rate> -a < input.fastq > output.fastq

```

An example of such an input file is:

```

@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I

```

## Output

The output of the `gto_fastq_mutate` program is a FASTQ file with the synthetic mutation of input file. Using the input above with the seed value as 1 and the mutation rate as 0.5, an output example for this is the following:

```

@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGACTTTGAGGTGTGGCGATAGACTGAAACACTTCAGGGTAAAATCACTCGCAAAAGTGCTATGGTTATGG
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGAGCCTTTACCGTAGGGGTGTAAGATTTTATACAAAAAGTCCAGGTCAAGAGGAATCGGACAACCGA
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I

```

## 2.12 Program gto\_fastq\_split

The `gto_fastq_split` splits Paired End files according to the direction of the strand ('/1' or '/2'). It writes by default singleton reads as forward stands.

For help type:

```
./gto_fastq_split -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_split` program needs a stream for the computation, namely the input standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_split [options] [--] args]
or: ./gto_fastq_split [options]
```

It writes by default singleton reads as forward stands.

```
-h, --help          show this help message and exit
```

Basic options

```
-f, --forward=<str>  Output forward file
-r, --reverse=<str>  Output reverse file
< input.fastq        Input FASTQ file format (stdin)
> output              Output read information (stdout)
```

```
Example: ./gto_fastq_split -f <output_forward.fastq> -r <output_reverse.fastq> < input.fastq > output
```

Output example :

```
Total reads      : value
Singleton reads   : value
Forward reads     : value
Reverse reads     : value
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72 1
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCAACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72 2
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTTATCAN
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_split` program is a set of information related to the file read. Using the input above, an output example for this is the following:

```
Total reads      : 2
Singleton reads  : 0
Forward reads    : 65536
Reverse reads    : 1
```

Also, this program generates two FASTQ files, with the reverse and forward reads. An example of the forward reads, for the input, is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72 1
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
```

## 2.13 Program `gto_fastq_pack`

The `gto_fastq_pack` packages each FASTQ read in a single line. It can show the read score first or the dna sequence, depending on the execution mode.

For help type:

```
./gto_fastq_pack -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_fastq_pack` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_pack [options] [--] args]
or: ./gto_fastq_pack [options]
```

It packages each FASTQ read in a single line.

```
-h, --help          show this help message and exit
```

#### Basic options

```
< input.fastq      Input FASTQ file format (stdin)
> output.fastqpack  Output packaged FASTQ file format (stdout)
```

#### Optional

```
-s, --scores        When active, the application show the scores first
```

```
Example: ./gto_fastq_pack -s < input.fastq > output.fastqpack
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_pack` program is a packaged FASTQ file.

Using the input above, an output example for this is the following:

```
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72+ 0
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72+ 1
```

Another example for the same input, but using the scores first (flag "s"), is:

```
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72+ 0
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72+ 1
```

## 2.14 Program `gto_fastq_unpack`

The `gto_fastq_unpack` unpacks the FASTQ reads packaged using the `gto_fastq_pack` tool.

For help type:

```
./gto_fastq_unpack -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_unpack` program needs two streams for the computation, namely the input and output standard. The input stream is a packaged FASTQ file.

The attribution is given according to:



```

Usage: ./gto_fastq_unpack [options] [--] args]
       or: ./gto_fastq_unpack [options]

It unpacks the FASTQ reads packaged using the gto_fastq_pack tool.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output.fastq            Output FASTQ file format (stdout)

Optional
    -s, --scores              When active, the application show the scores first

Example: ./gto_fastq_unpack -s < input.fastqpack > output.fastq

```

An example of such an input file is:

```

GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72+ 0
NTTCAGGGATACGACGNTTGTATTTTAAAGATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72+ 1

```

## Output

The output of the `gto_fastq_unpack` program is a FASTQ file.

Using the input above, an output example for this is the following:

```

@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
NTTCAGGGATACGACGNTTGTATTTTAAAGATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I

```

## 2.15 Program `gto_fastq_quality_score_info`

The `gto_fastq_quality_score_info` analyses the quality-scores of a FASTQ file.

For help type:

```
./gto_fastq_quality_score_info -h
```

In the following subsections, we explain the input and output paramters.

## Input parameters

The `gto_fastq_quality_score_info` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_quality_score_info [options] [--] args]
       or: ./gto_fastq_quality_score_info [options]

It analyses the quality-scores of a FASTQ file.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output                   Output read information (stdout)

Optional
    -m, --max=<int>          The lenght of the maximum window

Example: ./gto_fastq_quality_score_info -m <max> < input.fastq > output

Output example :
Total reads      : value
Max read length : value
Min read length : value
Min QS value    : value
Max QS value    : value
QS range        : value
```

An example of such an input file is:

```
@111 071112_SLXA-EAS1_s_7:5:1:817:345 length=72 1
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+111
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@222 071112_SLXA-EAS1_s_7:5:1:801:338 length=72 2
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTTCAN
+222
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_quality_score_info` program is a set of information related to the file read. Using the input above with the max window value as 30, an output example for this is the following:

```
Total reads      : 2
Max read length  : 72
Min read length  : 72
Min QS value     : 41
Max QS value     : 73
```

```

QS range      : 33
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
--+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73

```

## 2.16 Program gto\_fastq\_quality\_score\_max

The `gto_fastq_quality_score_max` analyses the maximal quality-scores of a FASTQ file.

For help type:

```
./gto_fastq_quality_score_max -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_fastq_quality_score_max` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```

Usage: ./gto_fastq_quality_score_max [options] [--] args]
or: ./gto_fastq_quality_score_max [options]

It analyses the maximal quality-scores of a FASTQ file.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output                   Output read information (stdout)

Optional
    -m, --max=<int>           The maximum window length (default 40)

Example: ./gto_fastq_quality_score_max -m <max> < input.fastq > output

```

An example of such an input file is:

```

@111 071112_SLXA-EAS1_s_7:5:1:817:345 length=72 1
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIII9IG9ICIIIIIIIIIIABAAABCIIIIFFGIIAACBBIIIIII6IBIIIIII>IIIIII/
@222 071112_SLXA-EAS1_s_7:5:1:801:338 length=72 2
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTATCAN
+
IIIIIIIIABAAABCIIIIFFGIIAACBBIIIIII6IBIIIIIIIIIIIIIIIIIIIIIGII>IIIII-1)8I

```

## Output

The output of the `gto_fastq_quality_score_max` program is a set of information related to the file read, considering the maximal quality scores.

Using the input above with the max window value as 30, an output example for this is the following:

```
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
--+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
73 73 73 73 73 73 73 73 73 73 73 73 66 73 73 73 73 73 73 73 73 73 73 73 73 73 73 73
```

## 2.17 Program `gto_fastq_quality_score_min`

The `gto_fastq_quality_score_min` analyses the minimal quality-scores of a FASTQ file.

For help type:

```
./gto_fastq_quality_score_min -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_quality_score_min` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_quality_score_min [options] [--] args]
or: ./gto_fastq_quality_score_min [options]

It analyses the minimal quality-scores of a FASTQ file.

    -h, --help                show this help message and exit

Basic options
    < input.fastq             Input FASTQ file format (stdin)
    > output                   Output read information (stdout)

Optional
    -m, --max=<int>          The maximum window length (default 40)

Example: ./gto_fastq_quality_score_min -m <max> < input.fastq > output
```

An example of such an input file is:

```
@111 071112_SLXA-EAS1_s_7:5:1:817:345 length=72 1
GNNTGATGGCCGCTGCCGATGGCGNANAATCCCACCAANATACCCTTAACAACCTTAAGGGTTNTCAAATAGA
+
IIIIIIIIIIII9IG9ICIIIIIIIIIIABAAABCIIIIFFGIIAACBBIIIIII6IBIIIIII>IIIIII/
@222 071112_SLXA-EAS1_s_7:5:1:801:338 length=72 2
NTTCAGGGATACGACGNTTGTATTTTAAGAATCTGNAGCAGAAGTCGATGATAATACGCGNCGTTTTATCAN
```

```
+
IIIIIIABAAABCIIIFFGIIAACBBIIII6IBIIIIIIIIIIIIIIIIIIIGII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_quality_score_min` program is a set of information related to the file read, considering the minimum quality scores.

Using the input above with the max window value as 30, an output example for this is the following:

```
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
--+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
73 73 73 73 73 73 73 65 66 65 65 65 57 67 71 57 73 67 70 70 71 73 73 65 65 67 66 66 73 65
```

## 2.18 Program `gto_fastq_cut`

The `gto_fastq_cut` cuts read sequences in a FASTQ file. It requires that the initial and end positions for the cut.

For help type:

```
./gto_fastq_cut -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_cut` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_cut [options] [--] args]
or: ./gto_fastq_cut [options]

It cuts read sequences in a FASTQ file.

-h, --help                show this help message and exit

Basic options
-i, --initial=<int>       Starting position to the cut
-e, --end=<int>           Ending position to the cut
< input.fastq            Input FASTQ file format (stdin)
> output.fastq           Output FASTQ file format (stdout)

Example: ./gto_fastq_cut -i <initial> -e <end> < input.fastq > output.fastq
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGGATACGACGTTTGTATTTTAAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_cut` program is a FASTQ file cut.

Using the initial value as 10 and the end value as 30, an example for this input, is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
CGCTGCCGATGGCGTCAAATC
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
ACGACGTTTGTATTTTAAAGAA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
```

## 2.19 Program `gto_fastq_minimum_local_quality_score_forward`

The `gto_fastq_minimum_local_quality_score_forward` filters the reads considering the quality score average of a defined window size of bases.

For help type:

```
./gto_fastq_minimum_local_quality_score_forward -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fastq_minimum_local_quality_score_forward` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_minimum_local_quality_score_forward [options] [--] args]
or: ./gto_fastq_minimum_local_quality_score_forward [options]

It filters the reads considering the quality score average of a defined window size
of bases.

-h, --help                show this help message and exit
```

#### Basic options

```
-k, --window-size=<int>    The window size of bases (default 5)
-w, --min-avg=<int>        The minimum average of quality score (default 25)
-m, --min-q=<int>          The minimum value of the quality score (default 33)
< input.fastq              Input FASTQ file format (stdin)
> output.fastq             Output FASTQ file format (stdout)
```

Example: `./gto_fastq_minimum_local_quality_score_forward -k <window-size> -w <min-avg> -m <min-q> < input.fastq > output.fastq`

#### Console output example:

```
Minimum QS      : value
<FASTQ output>
Total reads     : value
Trimmed reads   : value
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACTTAACCACTTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGATACGACGTTTGTATTTTAAAGATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII-I)8I
```

## Output

The output of the `gto_fastq_minimum_local_quality_score_forward` program is a FASTQ file with the reads filtered following a quality score average of a defined window of bases. The execution report only appears in the console.

Using the input above with the default values, an output example for this is the following:

```
Minimum QS      : 33
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACTTAACCACTTAAGGGTTTTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGATACGACGTTTGTATTTTAAAGATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTT
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIII
Total reads     : 2
Trimmed reads   : 1
```

## 2.20 Program `gto_fastq_minimum_local_quality_score_reverse`

The `gto_fastq_minimum_local_quality_score_reverse` filters the reverse reads, considering the quality score average of a defined window size of bases.

For help type:

```
./gto_fastq_minimum_local_quality_score_reverse -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_fastq_minimum_local_quality_score_reverse` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTQ file.

The attribution is given according to:

```
Usage: ./gto_fastq_minimum_local_quality_score_reverse [options] [--] args]
or: ./gto_fastq_minimum_local_quality_score_reverse [options]
```

It filters the reverse reads, considering the quality score average of a defined window size of bases.

`-h, --help` show this help message and exit

### Basic options

`-k, --windowsize=<int>` The window size of bases (default 5)  
`-w, --minavg=<int>` The minimum average of quality score (default 25)  
`-m, --minqs=<int>` The minimum value of the quality score (default 33)  
`< input.fastq` Input FASTQ file format (stdin)  
`> output.fastq` Output FASTQ file format (stdout)

Example: `./gto_fastq_minimum_local_quality_score_reverse -k <windowsize> -w <minavg> -m <minqs> < input.fastq > output.fastq`

### Console output example:

```
Minimum QS      : value
<FASTQ output>
Total reads     : value
Trimmed reads   : value
```

An example of such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTAAGGGTTTTCAAATAGA
+SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIIII/
@SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
GTTTCAGGATACGACGTTTGTATTTTAAAGATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

## Output

The output of the `gto_fastq_minimum_local_quality_score_reverse` program is a FASTQ file with the reads filtered following a quality score average of a defined window of bases. The execution report only



appears in the console.

Using the input above with the default values, an output example for this is the following:

```
Minimum QS: 33
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTCAAATAGA
+
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII9IG9ICIIIIIIIIIIIIIIIIIIIIIIIDIIIIIII>IIIIII/
Total reads      : 2
Trimmed reads    : 1
```

## Chapter 3

# FASTA tools

Current available FASTA tools, for analysis and manipulation, are:

1. `gto_fasta_to_seq`: it converts a FASTA or Multi-FASTA file format to a seq.
2. `gto_fasta_from_seq`: it converts a genomic sequence to pseudo FASTA file format.
3. `gto_fasta_extract`: it extracts sequences from a FASTA file, which the range is defined by the user in the parameters.
4. `gto_fasta_extract_by_read`: it extracts sequences from each read in a Multi-FASTA file (splited by `\n`), which the range is defined by the user in the parameters.
5. `gto_fasta_info`: it shows the readed information of a FASTA or Multi-FASTA file format.
6. `gto_fasta_mutate`: it reates a synthetic mutation of a fasta file given specific rates of editions, deletions and additions.
7. `gto_fasta_rand_extra_chars`: it substitues in the DNA sequence the outside ACGT chars by random ACGT symbols.
8. `gto_fasta_extract_read_by_pattern`: it extracts reads from a Multi-FASTA file format given a pattern in the header.
9. `gto_fasta_find_n_pos`: it reports the "N" regions in a sequence or FASTA (seq) file.
10. `gto_fasta_split_reads`: it splits a Multi-FASTA file to multiple FASTA files.
11. `gto_fasta_rename_human_headers`: it changes the headers of FASTA or Multi-FASTA file to simple chrX by order, where X is the number.
12. `gto_fasta_extract_pattern_coords`: it extracts the header and coordinates from a Multi-FASTA file format given a pattern/motif in the sequence.

### 3.1 Program gto\_fasta\_to\_seq

The `gto_fasta_to_seq` converts a FASTA or Multi-FASTA file format to a sequence.

For help type:

```
./gto_fasta_to_seq -h
```

In the following subsections, we explain the input and output parameters.

#### Input parameters

The `gto_fasta_to_seq` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTA or Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_to_seq [options] [--] args]
      or: ./gto_fasta_to_seq [options]

It converts a FASTA or Multi-FASTA file format to a seq.

      -h, --help                show this help message and exit

Basic options
      < input.fasta             Input FASTA or Multi-FASTA file format (stdin)
      > output.seq              Output sequence file (stdout)

Example: ./gto_fasta_to_seq < input.mfasta > output.seq
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGAACCTCCGGGGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAAGTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGT
GGCCCCACCGCGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTG
GTGGTTTGAGTGGAACCTCCCAGGCCAGTGCCGGGGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAAGTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

#### Output

The output of the `gto_fasta_to_seq` program is a group sequence.

Using the input above, an output example for this is the following:

```

ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAAACCTCACCCATGAATGCTCAGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGTGGTTTGAGTGGACCTCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAAACCTCACCCATGAATGCTCAGCAAGTT
TAATTACAGACCTGAA

```

## 3.2 Program gto\_fasta\_from\_seq

The `gto_fasta_from_seq` converts a genomic sequence to pseudo FASTA file format.

For help type:

```
./gto_fasta_from_seq -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_fasta_from_seq` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence group file.

The attribution is given according to:

```

Usage: ./gto_fasta_from_seq [options] [--] args]
or: ./gto_fasta_from_seq [options]

It converts a genomic sequence to pseudo FASTA file format.

    -h, --help                show this help message and exit

Basic options
    < input.seq              Input sequence file (stdin)
    > output.fasta           Output FASTA file format (stdout)

Optional options
    -n, --name=<str>         The read's header
    -l, --lineSize=<int>     The maximum of chars for line

Example: ./gto_fasta_from_seq -l <lineSize> -n <name> < input.seq > output.fasta

```

An example of such an input file is:

```

ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC

```

```
TAAACCTCACCCATGAATGCTCAGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACGGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGTGGTTTGAGTGGACCTCCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCAGCAAGTT
TAATTACAGACCTGAA
```

## Output

The output of the `gto_fasta_from_seq` program is a pseudo FASTA file.

Using the input above with the size line as 80 and the read's header as "SeqToFasta", an output example for this is the following:

```
>SeqToFasta
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCAGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACGGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGTGGTTTGAGTGGACCTCCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCAGCAAGTT
TAATTACAGACCTGAA
```

## 3.3 Program `gto_fasta_extract`

The `gto_fasta_extract` extracts sequences from a FASTA file, which the range is defined by the user in the parameters.

For help type:

```
./gto_fasta_extract -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fasta_extract` program needs two parameters, which defines the begin and the end of the extraction, and two streams for the computation, namely the input and output standard. The input stream is a FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_extract [options] [--] args]
or: ./gto_fasta_extract [options]

It extracts sequences from a FASTA file.

-h, --help          show this help message and exit
```

#### Basic options

<code>-i, --init=&lt;int&gt;</code>	The first position to start the extraction (default 0)
<code>-e, --end=&lt;int&gt;</code>	The last extract position (default 100)
<code>&lt; input.fasta</code>	Input FASTA or Multi-FASTA file format (stdin)
<code>&gt; output.seq</code>	Output sequence file (stdout)

Example: `./gto_fasta_extract -i <init> -e <end> < input.fasta > output.seq`

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGTCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAATTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

## Output

The output of the `gto_fasta_extract` program is a group sequence.

Using the input above with the value 0 as the extraction starting point and the 50 as the ending, an output example for this is the following:

```
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGG
```

## 3.4 Program `gto_fasta_extract_by_read`

The `gto_fasta_extract_by_read` extracts sequences from a FASTA or Multi-FASTA file, which the range is defined by the user in the parameters.

For help type:

```
./gto_fasta_extract_by_read -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fasta_extract_by_read` program needs two parameters, which defines the begin and the end of the extraction, and two streams for the computation, namely the input and output standard. The input stream is a FASTA or Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_extract_by_read [options] [--] args]
or: ./gto_fasta_extract_by_read [options]
```

It extracts sequences from each read in a Multi-FASTA file (splited by `\n`)

```

-h, --help          show this help message and exit

Basic options
-i, --init=<int>    The first position to start the extraction (default 0)
-e, --end=<int>    The last extract position (default 100)
< input.fasta      Input FASTA or Multi-FASTA file format (stdin)
> output.fasta     Output FASTA or Multi-FASTA file format (stdout)

Example: ./gto_fasta_extract_by_read -i <init> -e <end> < input.mfasta > output.mfasta

```

An example of such an input file is:

```

>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCCGGCCTCCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTTCCTCGCTTG
GTGGTTTGAGTGGACCTCCCAGGCCAGTGCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA

```

## Output

The output of the `gto_fasta_extract_by_read` program is FASTA or Multi-FASTA file with the extracted sequences.

Using the input above with the value 0 as the extraction starting point and the 50 as the ending, an output example for this is the following:

```

>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGG
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCC

```

## 3.5 Program `gto_fasta_info`

The `gto_fasta_info` shows the readed information of a FASTA or Multi-FASTA file format.

For help type:

```
./gto_fasta_info -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_fasta_info` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTA or Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_info [options] [--] args]
       or: ./gto_fasta_info [options]

It shows read information of a FASTA or Multi-FASTA file format.

    -h, --help                show this help message and exit

Basic options
    < input.fasta             Input FASTA or Multi-FASTA file format (stdin)
    > output                  Output read information (stdout)

Example: ./gto_fasta_info < input.mfasta > output

Output example :
Number of reads      : value
Number of bases     : value
MIN of bases in read : value
MAX of bases in read : value
AVG of bases in read : value
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGTTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGTT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTG
GTGGTTTGAGTGGACCTCCCAGGCCAGTGCCGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

## Output

The output of the `gto_fasta_info` program is a set of information related to the file read.

Using the input above, an output example for this is the following:

```
Number of reads      : 2
Number of bases     : 736
MIN of bases in read : 368
```



```
MAX of bases in read : 368
AVG of bases in read : 368.0000
```

### 3.6 Program gto\_fasta\_mutate

The `gto_fasta_mutate` creates a synthetic mutation of a FASTA file given specific rates of editions, deletions and additions. All these parameters are defined by the user, and their are optional.

For help type:

```
./gto_fasta_mutate -h
```

In the following subsections, we explain the input and output parameters.

#### Input parameters

The `gto_fasta_mutate` program needs two streams for the computation, namely the input and output standard. However, optional settings can be supplied too, such as the starting point to the random generator, and the edition, deletion and insertion rates. Also, the user can choose to use the ACGTN alphabet in the synthetic mutation. The input stream is a FASTA or Multi-FASTA File.

The attribution is given according to:

```
Usage: ./gto_fasta_mutate [options] [--] args]
or: ./gto_fasta_mutate [options]

Creates a synthetic mutation of a fasta file given specific rates of editions,
deletions and additions

    -h, --help                show this help message and exit

Basic options
    < input.fasta             Input FASTA or Multi-FASTA file format (stdin)
    > output.fasta            Output FASTA or Multi-FASTA file format (stdout)

Optional
    -s, --seed=<int>          Starting point to the random generator
    -e, --edit-rate=<dbl>     Defines the edition rate (default 0.0)
    -d, --deletion-rate=<dbl> Defines the deletion rate (default 0.0)
    -i, --insertion-rate=<dbl> Defines the insertion rate (default 0.0)
    -a, --ACGTN-alphabet      When active, the application uses the ACGTN alphabet

Example: ./gto_fasta_mutate -s <seed> -e <edit rate> -d <deletion rate> -i
<insertion rate> -a < input.mfasta > output.fasta
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGTTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGCCAGGGCGGCAGGAAGCAGGCCAGTGCC
```

```

GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCAGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCCGGCCTCCTGCTGTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCCTCGCTTG
GTGGTTTGTAGTGGACCTCCCAGGCCAGTGCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCAGCAAGTTTAATTACAGACCTGAA

```

## Output

The output of the `gto_fasta_mutate` program is a FASTA or Multi-FASTA file with the synthetic mutation of input file.

Using the input above with the seed value as 1 and the edition rate as 0.5, an output example for this is the following:

```

>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACGCAACGNATTCCTGCTGATCATANTGTNCCGCNCCCCNCGCAGGGGNCNCNNGCACACATNGTACCATTGTCCAC
NCTTNCANGTNANCGCTAGCAGGCTACNGTTTNTCCTCNCCTANNCANNCNGCGTNNNTACACTGGCACGTGCAGGCA
TNGGTGCGCNGGNCTCCGGNAACGGCACCGGAGACGAAGCTCGGNGGNTATACAGGTGTCANGAAACATCCCCGCGNC
GNGTGNCNNGAANCCANAGAGTATCTCACTCACAAACCCTGCGTGACNTCTAGAGNANGACCTTACNCACNTCCCNTT
NNGTACCACACCAATGAACGCTGCAGAAAGTCTGTTTNNAGGNGNGCA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ATTTGAAGGCAANCGGNCCAGNAATNCGNGGGTGCGCTCNTGTNGGCTACGGNCATCGCGGCCCTGCTNTANTAAGCN
TGAACCACCGNTCGNNGCACTTAGCAATNGCGNAANCCGTGGCACGGCGGAGACNAANCCGCTANTNNTTTCCCGCTNA
ATGGNTGTACAAGACCNACTANACCANCCTCCGTCAACCACTGGAGCGCANGATGGNNGCTGNCTAGNAGNCNNTGAG
GCGCTCCNTCCTANAAANCCGTGGNCGAGCNCCTATGGNAGNGTGGGGGTTTTACCGGAAGACCNTCGNGCCCTATGGG
AGCAATCANAANCTAGAAAGCTTACNGATGGTGANGAANTAGACTANG

```

## 3.7 Program `gto_fasta_rand_extra_chars`

The `gto_fasta_rand_extra_chars` substitutes in the DNA sequence the outside ACGT chars by random ACGT symbols. It works both in FASTA and Multi-FASTA file formats.

For help type:

```
./gto_fasta_rand_extra_chars -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fasta_rand_extra_chars` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTA or Multi-FASTA file.

The attribution is given according to:

```

Usage: ./gto_fasta_rand_extra_chars [options] [--] args]
or: ./gto_fasta_rand_extra_chars [options]

```

It substitutes in the DNA sequence the outside ACGT chars by random ACGT symbols.  
It works both in FASTA and Multi-FASTA file formats

-h, --help                      show this help message and exit

#### Basic options

< input.fasta                  Input FASTA or Multi-FASTA file format (stdin)  
> output.fasta                Output FASTA or Multi-FASTA file format (stdout)

Example: ./gto\_fasta\_rand\_extra\_chars < input.mfasta > output.mfasta

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ANAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGNCCCTGGAGGGTCCNCCGCTGCCCTGCTGCCATTGNCNCC
NGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCNGGAAGCGGCAGGAA
GNGGTTTGAAGTGGACCTCCNGGCCCCCTCATAGGAGAGGAAGCNGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGNC
GCGAATCCGNGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCENN
TAAANNNTACCCATGAATGCTCACGCAANTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
GCGAATCCGNGCGCCGGGACAGAATCTCCTTCTCCACCCCCCENNNTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACC
NGCCCCACCTAAGGAAAAGCAGCCTCCAGGAACCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCNGGAAGCGG
ANAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGNCCCTGGCNCAGGGTCCNCCGCTGCCCTGCTGCCATTGN
GAGGAAGCNGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGNCNGGTTTGAAGTGGACCTCCNGGCCCCCTCATAGGA
TCACGCAANTTTAATTACAGACCTGAATAAANNNTACCCATGAATGC
```

## Output

The output of the gto\_fasta\_rand\_extra\_chars program is a FASTA or Multi-FASTA file.

Using the input above, an output example for this is the following:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ATAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGGTCCCCCGCTGCCCTGCTGCCATTGTCCCC
TGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCGGGAAGCGGCAGGAA
GAGGTTTGAAGTGGACCTCCCGGCCCCCTCATAGGAGAGGAAGCCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGTC
GCGAATCCGGGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCTTG
TAAAAGATACCCATGAATGCTCACGCAANTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
GCGAATCCGTGCGCCGGGACAGAATCTCCTTCTCCACCCCCCATCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACC
GGCCCCACCTAAGGAAAAGCAGCCTCCAGGAACCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCGGGAAGCGG
AGAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGTCCCTGGCTCCAGGGTCTCCGCTGCCCTGCTGCCATTGC
GAGGAAGCGGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCGCGGTTTGAAGTGGACCTCCTGGCCCCCTCATAGGA
TCACGCAACTTTAATTACAGACCTGAATAAATGTACCCATGAATGC
```

## 3.8 Program gto\_fasta\_extract\_read\_by\_pattern

The gto\_fasta\_extract\_read\_by\_pattern extracts reads from a Multi-FASTA file format given a pattern in the header. Also, this pattern is case insensitive.

For help type:

```
./gto_fasta_extract_read_by_pattern -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_fasta_extract_read_by_pattern` program needs two streams for the computation, namely the input and output standard. The input stream is a Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_extract_read_by_pattern [options] [--] args]
       or: ./gto_fasta_extract_read_by_pattern [options]
```

It extracts reads from a Multi-FASTA file format given a pattern in the header (ID).

```
-h, --help          show this help message and exit
```

### Basic options

```
-p, --pattern=<str>  Pattern to search in the file header
< input.fasta        Input Multi-FASTA file format (stdin)
> output.fasta        Output Multi-FASTA file format (stdout)
```

```
Example: ./gto_fasta_extract_read_by_pattern -p <pattern> < input.mfasta > output.fasta
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCGGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCCTGGAGGGT
GGCCCCACCGCGCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTG
GTGGTTTGAAGTGGACCTCCAGGCCAGTGCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

## Output

The output of the `gto_fasta_extract_read_by_pattern` program is a Multi-FASTA file.

Using the input above with the pattern value as "264", an output example for this is the following:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

### 3.9 Program gto\_fasta\_find\_n\_pos

The `gto_fasta_find_n_pos` reports the "N" regions in a sequence or FASTA (seq) file.

For help type:

```
./gto_fasta_find_n_pos -h
```

In the following subsections, we explain the input and output parameters.

#### Input parameters

The `gto_fasta_find_n_pos` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTA file or a sequence.

The attribution is given according to:

```
Usage: ./gto_fasta_find_n_pos [options] [--] args]
or: ./gto_fasta_find_n_pos [options]

It reports the 'N' regions in a sequence or FASTA (seq) file.

    -h, --help                show this help message and exit

Basic options
    < input.fasta             Input FASTQ file format or a sequence (stdin)
    > output                  Output report of 'N' positions (stdout)

Example: ./gto_fasta_find_n_pos < input.fasta > output

The output obeys the following structure:
Begin    End Positions
<value> <value> <value>
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
NCNNNACGGCCTCCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GNCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTNGTTTGAGTGGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACNTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCAGCAAGTTTAATTACAGACCTGAN
```

#### Output

The output of the `gto_fasta_find_n_pos` program is a structured report of "N" appearances in the sequence or FASTA file. The first column is the first position of the "N" appearance, the second is the position of the last "N" in the interval found, and the last column is the count of "N" in this interval.

Using the input above, an output example for this is the following:

```

1    1    1
3    5    3
82   82   1
163  163  1
289  289  1

```

### 3.10 Program gto\_fasta\_split\_reads

The `gto_fasta_split_reads` splits a Multi-FASTA file to multiple FASTA files.

For help type:

```
./gto_fasta_split_reads -h
```

In the following subsections, we explain the input and output parameters.

#### Input parameters

The `gto_fasta_split_reads` program needs one stream for the computation, namely the input standard. This input stream is a Multi-FASTA file.

The attribution is given according to:

```

Usage: ./gto_fasta_split_reads [options] [--] args]
       or: ./gto_fasta_split_reads [options]

It splits a Multi-FASTA file to multiple FASTA files.

    -h, --help                show this help message and exit

Basic options
    < input.fasta             Input Multi-FASTA file format (stdin)

Optional options
    -l, --location=<str>     Location to store the files

Example: ./gto_fasta_split_reads < input.mfasta

```

An example of such an input file is:

```

>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCGGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTG
GTGGTTTGAGTGGACCTCCAGGCCAGTGCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCGGGACAGAATGCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCTGCAAA

```

```
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

## Output

The output of the `gto_fasta_split_reads` program is a report summary of the execution, and the files created in the defined location.

Using the input above, an output example for this is the following:

```
1 : Splitting to file:./out1.fasta
2 : Splitting to file:./out2.fasta
```

### 3.11 Program `gto_fasta_rename_human_headers`

The `gto_fasta_rename_human_headers` changes the headers of FASTA or Multi-FASTA file to simple chrX by order, where X is the number.

For help type:

```
./gto_fasta_rename_human_headers -h
```

In the following subsections, we explain the input and output parameters.

#### Input parameters

The `gto_fasta_rename_human_headers` program needs two streams for the computation, namely the input and output standard. The input stream is a FASTA or Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_rename_human_headers [options] [--] args]
or: ./gto_fasta_rename_human_headers [options]

It changes the headers of FASTA or Multi-FASTA file to simple chr$1 by order.

-h, --help          show this help message and exit

Basic options
< input.fasta       Input FASTA or Multi-FASTA file format (stdin)
> output.fasta      Output FASTA or Multi-FASTA file format (stdout)

Example: ./gto_fasta_rename_human_headers < input.mfasta > output.mfasta
```

An example of such an input file is:

```
> AB000264 | acc = AB000264 | descr = Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGTCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAAGTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

```
> AB000263 | acc = AB000263 | descr = Homo sapiens mRNA
ACAAGATGCCATTGTCCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCTCGCTTG
GTGGTTTGAGTGGACCTCCCAGGCCAGTGCCGGGGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

## Output

The output of the `gto_fasta_rename_human_headers` program is a FASTA or Multi-FASTA file. Using the input above, an output example for this is the following:

```
>chr1
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCCGGGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>chr2
ACAAGATGCCATTGTCCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCTCGCTTG
GTGGTTTGAGTGGACCTCCCAGGCCAGTGCCGGGGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

## 3.12 Program `gto_fasta_extract_pattern_coords`

The `gto_fasta_extract_pattern_coords` extracts the header and coordinates from a Multi-FASTA file format given a pattern/motif in the sequence.

For help type:

```
./gto_fasta_extract_pattern_coords -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_fasta_extract_pattern_coords` program needs two streams for the computation, namely the input and output standard. The input stream is a Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_fasta_extract_pattern_coords [options] [--] args]
or: ./gto_fasta_extract_pattern_coords [options]
```

It extracts the header and coordinates from a Multi-FASTA file format given a pattern/motif in the sequence.

```
-h, --help          show this help message and exit
```



#### Basic options

```
-p, --pattern=<str>   Pattern to search in the file header  
< input.fasta         Input Multi-FASTA file format (stdin)  
> output.coords       Output coordinates (stdout)
```

Example: `./gto_fasta_extract_pattern_coords -p <pattern> < input.fasta > output.coords`

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA  
ACAAGACGGCCTCCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC  
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA  
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC  
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAAGTTCTTCTGGAAGACCTTCTCCACCCCCCAGC  
TAAACCTCACCCATGAATGCTCGCAACACGCAAGTTTAATTCGCAAGTTAGACCTGAACGGGAGGTGGCCACGCAAGTT
```

## Output

The output of the `gto_fasta_extract_pattern_coords` program is a Multi-FASTA file.

Using the input above, with the pattern ACA, an output example for this is the following:

```
1   3   >AB000264 |acc=AB000264|descr=Homo sapiens mRNA  
131 133 >AB000264 |acc=AB000264|descr=Homo sapiens mRNA  
259 261 >AB000264 |acc=AB000264|descr=Homo sapiens mRNA  
347 349 >AB000264 |acc=AB000264|descr=Homo sapiens mRNA
```

## Chapter 4

# Genomic sequence tools

Current available genomic sequence tools, for analysis and manipulation, are:

1. `gto_genomic_gen_random_dna`: it generates a synthetic DNA.
2. `gto_genomic_rand_seq_extra_chars`: it substitutes in the DNA sequence the outside ACGT chars by random ACGT symbols.
3. `gto_genomic_dna_mutate`: it creates a synthetic mutation of a sequence file given specific rates of mutations, deletions and additions.
4. `gto_genomic_extract`: it extracts sequences from a sequence file, which the range is defined by the user in the parameters.
5. `gto_genomic_period`: it calculates the best order depth of a sequence, using FCMs.
6. `gto_genomic_count_bases`: it counts the number of bases in sequence, FASTA or FASTQ files.

### 4.1 Program `gto_genomic_gen_random_dna`

The `gto_genomic_gen_random_dna` generates a synthetic DNA.

For help type:

```
./gto_genomic_gen_random_dna -h
```

In the following subsections, we explain the input and output paramters.

#### Input parameters

The `gto_genomic_gen_random_dna` program needs one stream for the computation, namely the output standard.

The attribution is given according to:

```
Usage: ./gto_genomic_gen_random_dna [options] [--] args]
or: ./gto_genomic_gen_random_dna [options]
```

It generates a synthetic DNA.

-h, --help show this help message and exit

#### Basic options

> output.seq Output synthetic DNA sequence (stdout)

#### Optional

-s, --seed=<int> Starting point to the random generator (Default 0)  
-n, --nSymbols=<int> Number of symbols generated (Default 100)  
-f, --frequency=<str> The frequency of each base. It should be represented  
in the following format: <fa,fc,fg,ft>.

Example: ./gto\_genomic\_gen\_random\_dna -s <seed> -n <nsybomls> -f <fa,fc,fg,ft> > output.seq

## Output

The output of the `gto_genomic_gen_random_dna` program is a sequence group file which the synthetic DNA.

Using the input above with the seed value as 1 and the number of symbols as 400, an output example for this is the following:

```
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGGGCTCTGTCTCCTTATGAAGTCAACAATTTGCTGGGACTTGCGGC
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGGGCTCTGTCTCCTTATGAAGTCAACAATTTGCTGGGACTTGCGGC
GACTTCATCGTGGTCTCTGTTCATTATGCGCTCCAACGCATAACTTTGCGCCAGAAGATAGATAGAATGGTGTAAAGAACT
GTAATATATATAATGAACCTTCGGCGAGTCTGTGGAGTTTTTGTTCATTAGAGAGCCAAGAGGTCGGACGTCCTCACGTA
GCCCCGAGACGGGCAGGGCGATGGCGACTGAACGGGCTCCATATCACTTTGAGCTTTTATGCTTTTCGACTCCTCCAGGAGC
TGAACAACCTTGTTCCCGGCAAAGCCCACTGCGTCATGGAGCTCACGGTCTACATTTCATGACTGACTAACCGTAAACTGC
```

## 4.2 Program `gto_genomic_rand_seq_extra_chars`

The `gto_genomic_rand_seq_extra_chars` substitutes in the DNA sequence the outside ACGT chars by random ACGT symbols. It works in sequence file formats.

For help type:

```
./gto_genomic_rand_seq_extra_chars -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_genomic_rand_seq_extra_chars` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence file.

The attribution is given according to:

```

Usage: ./gto_genomic_rand_seq_extra_chars [options] [--] args]
       or: ./gto_genomic_rand_seq_extra_chars [options]

It substitutes in the DNA sequence the outside ACGT chars by random ACGT symbols.
It works in sequence file formats

        -h, --help            show this help message and exit

Basic options
        < input.seq          Input sequence file (stdin)
        > output.seq          Output sequence file (stdout)

Example: ./gto_genomic_rand_seq_extra_chars < input.seq > output.seq

```

An example of such an input file is:

```

ANAAGACGNNNTCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
NNCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCNNNNNGGAGAGGAAGCTCGGGAGNGTNNNGGCCAGGCGGCAGNNNNCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TANNNNCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGNNNAAGCAGCCTCCTGACTTTCCTCGCTTGNNNNTTTGAGTGGACCTCCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCACGCAAGTT
NNATTACNNNCCTGNN

```

## Output

The output of the `gto_genomic_rand_seq_extra_chars` program is a sequence file.

Using the input above, an output example for this is the following:

```

ATAAGACGGCTTCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
CTCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCGACGGGAGAGGAAGCTCGGGAGTGTGTTGGCCAGGCGGCAGGAGACCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAATATCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGCGGAAGCAGCCTCCTGACTTTCCTCGCTTGGTTTTTTGAGTGGACCTCCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCACGCAAGTT
CGATTACGGCCCTGTC

```

## 4.3 Program `gto_genomic_dna_mutate`

The `gto_genomic_dna_mutate` creates a synthetic mutation of a sequence file given specific rates of mutations, deletions and additions. All these parameters are defined by the user, and their are optional.

For help type:

```
./gto_genomic_dna_mutate -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_genomic_dna_mutate` program needs two streams for the computation, namely the input and output standard. However, optional settings can be supplied too, such as the starting point to the random generator, and the edition, deletion and insertion rates. Also, the user can choose to use the ACGTN alphabet in the synthetic mutation. The input stream is a sequence File.

The attribution is given according to:

```
Usage: ./gto_genomic_dna_mutate [options] [--] args]
       or: ./gto_genomic_dna_mutate [options]

Creates a synthetic mutation of a sequence file given specific rates of mutations,
deletions and additions

    -h, --help                show this help message and exit

Basic options
    < input.seq               Input sequence file (stdin)
    > output.seq              Output sequence file (stdout)

Optional
    -s, --seed=<int>         Starting point to the random generator
    -m, --mutation-rate=<dbl> Defines the mutation rate (default 0.0)
    -d, --deletion-rate=<dbl> Defines the deletion rate (default 0.0)
    -i, --insertion-rate=<dbl> Defines the insertion rate (default 0.0)
    -a, --ACGTN-alphabet     When active, the application uses the ACGTN alphabet

Example: ./gto_genomic_dna_mutate -s <seed> -m <mutation rate> -d <deletion rate> -i
<insertion rate> -a < input.seq > output.seq
```

An example of such an input file is:

```
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGCGGCTCTGTCTCCTTATGAAGTCAACAATTCGCTGGGACTTGCGGC
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGCGGCTCTGTCTCCTTATGAAGTCAACAATTCGCTGGGACTTGCGGC
GACTTCATCGTGGTCTCTGTTCATTATGCGCTCCAACGCATAACTTTGCGCCAGAAGATAGATAGAATGGTGTAAGAACT
GTAATATATATAATGAACTTCGGCGAGTCTGTGGAGTTTTTGTGTCATTAGAGAGCCAAGAGGTCGGACGTCCTCACGTA
GCCCCGAGACGGGCAGGGCGATGGCGACTGAACGGGCTCCATATCACTTTGAGCTTTTATGCTTTTCGACTCCTCCAGGAGC
TGAACAACCTTGTTCCCGGCAAGCCCACTGCGTCATGGAGCTCACGGTCTACATTCATGACTGACTAACCCTAAACTGC
```

## Output

The output of the `gto_genomic_dna_mutate` program is a sequence file with the synthetic mutation of input file.

Using the input above with the seed value as 1 and the mutation rate as 0.5, an output example for this is the following:

```

TCACGACTGTGCGGTTGGCACACCAGATAGGTGCTTCTACGTTTTGTATCTAATTTACAATTCTCGCTGGGAGTTCATTC
GCTATTGATGGGACTAGAAAACCCATCCGTAGCTTGCCGCCGTTTAAAGAATAAACTCCACTTGCACCGAGACGTAGCGC
AACCAAGGCTATGTTCTTTGACCTTATGCGGTCCAACGCAGGAGTAGACCCCGTAGTTAGGTACTATCGCAGAATAGGC
TTAAGCAGCCGTGCTGAACGCTGGAGGGTCTGTTTAATTACTGAGTGAATGGAGAGCTAAGAGTTCGGAGCACCGCACGA
GGCTCAAGAGCGGAAGGGCGTCAGCCTGGCGACCCTGCCTACCGCTCGAGTCTGTCTTCACTACAGTCCGTGGAGGAC
CCCCAACGACCTAGTATCCTACAAAGCCGCATACGACTTACAGAACAGGCTGTATCGTCAGGAGTGTGTACACGAAGAGT
A

```

## 4.4 Program gto\_genomic\_extract

The `gto_genomic_extract` extracts sequences from a sequence file, which the range is defined by the user in the parameters.

For help type:

```
./gto_genomic_extract -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_genomic_extract` program needs two parameters, which defines the begin and the end of the extraction, and two streams for the computation, namely the input and output standard. The input stream is a sequence file.

The attribution is given according to:

```

Usage: ./gto_genomic_extract [options] [--] args]
       or: ./gto_genomic_extract [options]

It extracts sequences from a sequence file.

    -h, --help           show this help message and exit

Basic options
    -i, --init=<int>     The first position to start the extraction (default 0)
    -e, --end=<int>      The last extract position (default 100)
    < input.seq          Input sequence file (stdin)
    > output.seq         Output sequence file (stdout)

Example: ./gto_genomic_extract -i <init> -e <end> < input.seq > output.seq

```

An example of such an input file is:

```

TCTTTACTCGCGCGTTGGAGAAAATACAATAGTGGCGCTCTGTCTCCTTATGAAGTCAACAATTCGCTGGGACTTGCGGC
TCTTTACTCGCGCGTTGGAGAAAATACAATAGTGGCGCTCTGTCTCCTTATGAAGTCAACAATTCGCTGGGACTTGCGGC
GACTTCATCGTGGTCTCTGTCTCATTATGCGCTCCAACGCATAACTTTGCGCCAGAAGATAGATAGAATGGTGTAAAGAACT
GTAATATATATAATGAACTTCGGCGAGTCTGTGGAGTTTTTGTGTCATTAGAGAGCCAAGAGGTGGACGTCCTCACGTA

```

```
GCCCCGAGACGGGCAGGGCGATGGCGACTGAACGGGCTCCATATCACTTTGAGCTTTTATGCTTTGACTCCTCCAGGAGC
TGAACAACCTTGTTCCCGGCAAAGCCCACTGCGTCATGGAGCTCACGGTCTACATTCATGACTGACTAACCGTAAACTGC
```

## Output

The output of the `gto_genomic_extract` program is a group sequence.

Using the input above with the value 0 as the extraction starting point and the 50 as the ending, an output example for this is the following:

```
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGCGGCTCTGTCTCCTTAT
```

## 4.5 Program `gto_genomic_period`

The `gto_genomic_period` calculates the best order depth of a sequence, using FCMs. It only works "ACGT", while the rest will be discarded.

This application has a dependency to represent the results. It requires the Gnuplot to show the execution result.

For help type:

```
./gto_genomic_period -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_genomic_period` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence file.

The attribution is given according to:

```
Usage: ./gto_genomic_period [options] [--] args]
       or: ./gto_genomic_period [options]

It calculates the best order depth of a sequence, using FCMs. It only works "ACGT",
while the rest will be discarded.

    -h, --help          show this help message and exit

Basic options
    < input.seq         Input sequence file format (stdin)
    > output             Output is given by log2(4)*K(x)/|x| (stdout)

Example: ./gto_genomic_period < input.seq > output
```

An example of such an input file is:

```
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGCGGCTCTGTCTCCTTATGAAGTCAACAATTTGCTGGGACTTGCGGC
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGCGGCTCTGTCTCCTTATGAAGTCAACAATTTGCTGGGACTTGCGGC
GACTTCATCGTGGTCTCTGTCTATTATGCGCTCCAACGCATAACTTTGCGCCAGAAGATAGATAGAATGGTGTAAAGAACT
GTAATATATATAATGAACTTCGGCGAGTCTGTGGAGTTTTTGTTCATTAGAGAGCCAAGAGGTCGGACGTCCTCACGTA
GCCCCGAGACGGGCAGGGCGATGGCGACTGAACGGGCTCCATATCACTTTGAGCTTTTATGCTTTGACTCCTCCAGGAGC
TGAACAACCTTGTTCCCGGCAAAGCCCACTGCGTCATGGAGCTCACGGTCTACATTGACTGACTAACCGTAAACTGC
```

## Output

The output of the `gto_genomic_period` program is a execution report, followed by the plot with this information.

Using the input above, an report example for this is the following:

```
Running order: 1 ... Done!
Running order: 2 ... Done!
Running order: 3 ... Done!
Running order: 4 ... Done!
Running order: 5 ... Done!
Running order: 6 ... Done!
Running order: 7 ... Done!
Running order: 8 ... Done!
Running order: 9 ... Done!
Running order: 10 ... Done!
Running order: 11 ... Done!
Running order: 12 ... Done!
Running order: 13 ... Done!
Running order: 14 ... Done!
Running order: 15 ... Done!
Running order: 16 ... Done!
Running order: 17 ... Done!
Running order: 18 ... Done!
Running order: 19 ... Done!
Running order: 20 ... Done!
1 2.246
2 2.225
3 2.237
4 2.079
5 1.821
6 1.733
7 1.717
8 1.708
9 1.717
10 1.712
11 1.717
12 1.721
13 1.725
14 1.729
15 1.733
16 1.738
17 1.742
18 1.746
19 1.75
```



In the Figure 4.1 is represented the plot for the execution above.

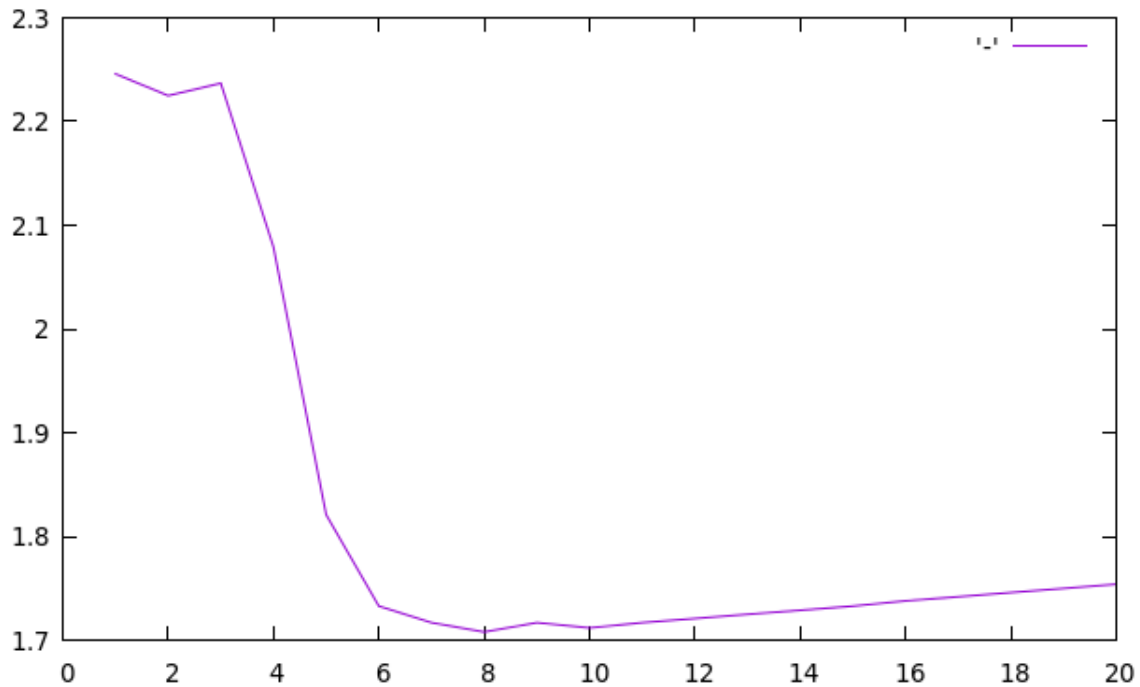


Figure 4.1: `gto_genomic_period` execution plot.

## 4.6 Program `gto_genomic_count_bases`

The `gto_genomic_count_bases` counts the number of bases in sequence, FASTA or FASTQ files. For help type:

```
./gto_genomic_count_bases -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_genomic_count_bases` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence, FASTA or FASTQ file.

The attribution is given according to:

```
Usage: ./gto_genomic_count_bases [options] [--] args]
or: ./gto_genomic_count_bases [options]
```

```
It counts the number of bases in sequence, FASTA or FASTQ files.
```

```
-h, --help    Show this help message and exit
```

```

Basic options
  < input      Input sequence, FASTA or FASTQ file format (stdin)
  > output     Output read information (stdout)

```

```

Example: ./gto_genomic_count_bases < input.seq > output

```

```

Output example :
File type       : value
Number of bases : value
Number of a/A   : value
Number of c/C   : value
Number of g/G   : value
Number of t/T   : value
Number of n/N   : value
Number of others : value

```

An example of such an input file is:

```

TCTTTACTCGCGCGTTGGAGAAATACAATAGTGC GGCTCTGTCTCCTTATGAAGTCAACAATTTGCGTGGGACTTGCGGC
TCTTTACTCGCGCGTTGGAGAAATACAATAGTGC GGCTCTGTCTCCTTATGAAGTCAACAATTTGCGTGGGACTTGCGGC
GACTTCATCGTGGTCTCTGTTCATTATGCGCTCCAACGCATAACTTTGCGCCAGAAGATAGATAGAATGGTGTAAAGAACT
GTAATATATATAATGAACCTTCGGCGAGTCTGTGGAGTTTTTGTTCATTAGAGAGCCAAGAGGTCGGACGTCCTCACGTA
GCCCCGAGACGGGCAGGGCGATGGCGACTGAACGGGCTCCATATCACTTTGAGCTTTTATGCTTTGACTCCTCCAGGAGC
TGAACAACCTTGTTCCCGGCAAAGCCCACTGCGTCATGGAGCTCACGGTCTACATTCATGACTGACTAACCGTAAACTGC

```

## Output

The output of the `gto_genomic_count_bases` program is report which describes the number of each base in the file, and the file type.

Using the input above, an output example for this is the following:

```

File type       : DNA
Number of bases : 480
Number of a/A   : 114
Number of c/C   : 116
Number of g/G   : 120
Number of t/T   : 130
Number of n/N   : 0
Number of others : 0

```

## Chapter 5

# Amino acid sequence tools

Current available amino acid sequence tools, for analysis and manipulation, are:

1. `gto_amino_acid_to_group`: it converts an amino acid sequence to a group sequence.
2. `gto_amino_acid_to_pseudo_dna`: it converts an amino acid (protein) sequence to a pseudo DNA sequence.

### 5.1 Program `gto_amino_acid_to_group`

The `gto_amino_acid_to_group` converts an amino acid sequence to a group sequence.

For help type:

```
./gto_amino_acid_to_group -h
```

In the following subsections, we explain the input and output parameters.

#### Input parameters

The `gto_amino_acid_to_group` program needs two streams for the computation, namely the input and output standard. The input stream is an amino acid sequence. The attribution is given according to:

```
Usage: ./gto_amino_acid_to_group [options] [--] args]
or: ./gto_amino_acid_to_group [options]

It converts a amino acid sequence to a group sequence.

    -h, --help                show this help message and exit

Basic options
    < input.prot              Input amino acid sequence file (stdin)
    > output.group            Output group sequence file (stdout)

Example: ./gto_amino_acid_to_group < input.prot > output.group
Table:
Prot      Group
```

```

R      P
H      P  Amino acids with electric charged side chains: POSITIVE
K      P
-      -
D      N
E      N  Amino acids with electric charged side chains: NEGATIVE
-      -
S      U
T      U
N      U  Amino acids with electric UNCHARGED side chains
Q      U
-      -
C      S
U      S
G      S  Special cases
P      S
-      -
A      H
V      H
I      H
L      H
M      H  Amino acids with hydrophobic side chains
F      H
Y      H
W      H
-      -
*      *  Others
X      X  Unknown

```

It can be used to group amino acids by properties, such as electric charge (positive and negative), uncharged side chains, hydrophobic side chains and special cases. An example of such an input file is:

```

IPFLKKQFALADKLVLKSLRQLLGGRIMMPCCGAKLEPAIGLFFHAIGINIKLGYGMTETTATVSCWHDFQFNPNSIG
TLMPPAEVKIGENNEILVRGGMVMKGYKKPEETAQAFTEDGFLKTGDAGEFDEQGNLFITDRIKELMKTSNGKYIAPQY
IESKIGKDKFIEQIAIIADAKKYVSALIVPCFDSLEEYAKQLNIKYHDRLELLKNSDILKMFE

```

## Output

The output of the `gto_amino_acid_to_group` program is a group sequence.

Using the input above, an output example for this is the following:

```

HSHHHPPUHHHHNPHHHUPHPUHHSSPHPHSSSSHPHNSHHSHHHPHSHSHUHPHSHSHUNUUHUUHUSHPNHUHUSUUHS
UHHSPHNHPSNUUNHHHPSSHHHPSSHPPSNNUHUHHUNNSHHPUSNHSNHNNUUUHHHUNPHPNHHPUUUSPHHHSUH
HNUPHSPNPHNUHHHHHNPPHHUHHHHSSHNUHNNHHPUHUHPNPNHHPUNHHHPHN

```

## 5.2 Program `gto_amino_acid_to_pseudo_dna`

The `gto_amino_acid_to_pseudo_dna` converts an amino acid (protein) sequence to a pseudo DNA sequence.

For help type:

```
./gto_amino_acid_to_pseudo_dna -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_amino_acid_to_pseudo_dna` program needs two streams for the computation, namely the input and output standard. The input stream is an amino acid sequence. The attribution is given according to:

```
Usage: ./gto_amino_acid_to_pseudo_dna [options] [--] args]
or: ./gto_amino_acid_to_pseudo_dna [options]

It converts a protein sequence to a pseudo DNA sequence.

    -h, --help          show this help message and exit

Basic options
    < input.prot        Input amino acid sequence file (stdin)
    > output.dna        Output DNA sequence file (stdout)

Example: ./gto_amino_acid_to_pseudo_dna < input.prot > output.dna
Table:
Prot    DNA
A       GCA
C       TGC
D       GAC
E       GAG
F       TTT
G       GGC
H       CAT
I       ATC
K       AAA
L       CTG
M       ATG
N       AAC
P       CCG
Q       CAG
R       CGT
S       TCT
T       ACG
V       GTA
W       TGG
Y       TAC
*       TAG
X       GGG
```

It can be used to generate pseudo-DNA with characteristics passed by amino acid (protein) sequences. An example of such an input file is:

```
IPFLLKKQFALADKLVL SKLRQLLGGRIMMPCGGAKLEPAIGLFFHAIGINIKLGYGMTETTATVSCWHDFQFNPNSIG
TLMPKAEVKIGENNEILVRGGMVMKGYKKPEETAQAFTEDGFLKTGDAGEFDEQGNLFITDRIKELMKTSNGKYIAPQY
IESKIGKDKFIEQIAIIADAKKYVSALIVPCFDSLEEYAKQLNIKYHDRLELLKNSDILKMFE
```

## Output

The output of the `gto_amino_acid_to_pseudo_dna` program is a DNA sequence.

Using the input above, an output example for this is the following:

```
ATCCCGTTTCTGCTGAAAAACAGTTTGCAGTGGCAGACAACTGGTACTGTCTAACTGCGTCAGCTGCTGGGCGGCCG
TATCAAAATGATGCCGTGCGGCGGCGCAAACTGGAGCCGGCAATCGGCCTGTTTTTCATGCAATCGGCATCAACATCA
AACTGGGCTACGGCATGACGGAGACGACGGCAACGGTATCTTGCTGGCATGACTTTCAGTTTAACCCGAACCTCTATCGGC
ACGCTGATGCCGAAAGCAGAGGTAAAAATCGGCGAGAACACGAGATCCTGGTACGTGGCGGCATGGTAATGAAAGGCTA
CTACAAAAAACCGGAGGAGACGGCACAGGCATTTACGGAGGACGGCTTTCTGAAAACGGGCGACGCAGGCGAGTTTGACG
AGCAGGGCAACCTGTTTATCACGGACCGTATCAAAGAGCTGATGAAAACGTCTAACGGCAAATACATCGCACCGCAGTAC
ATCGAGTCTAAAATCGGCAAAGACAAATTTATCGAGCAGATCGCAATCATCGCAGACGCAAAAAATACGTATCTGCACT
GATCGTACCGTGCTTTGACTCTCTGGAGGAGTACGCAAAACAGCTGAACATCAAATACCATGACCGTCTGGAGCTGCTGA
AAAACTCTGACATCCTGAAAAATGTTTGAG
```

## Chapter 6

# General purpose tools

1. `gto_char_to_line`: it splits a sequence into lines, creating an output sequence which has a char for each line.
2. `gto_reverse`: it reverses the order of a sequence.
3. `gto_new_line_on_new_x`: it splits different rows with a new empty row.
4. `gto_upper_bound`: it sets an upper bound in a file with a value per line.
5. `gto_lower_bound`: it sets an lower bound in a file with a value per line.
6. `gto_brute_force_string`: it generates all combinations, line by line, for an inputted alphabet and specific size.
7. `gto_real_to_binary_with_threshold`: it converts a sequence of real numbers into a binary sequence, given a threshold.
8. `gto_sum`: it adds decimal values in file, line by line, splitted by spaces or tabs.
9. `gto_filter`: it filters numerical sequences.
10. `gto_word_search`: it search for a word in a file.
11. `gto_permute_by_blocks`: it permutates by block sequence, FASTA and Multi-FASTA files.
12. `gto_info`: it gives the basic properties of the file, namely size, cardinality, distribution percentage of the symbols, among others.
13. `gto_segment`: it segments a filtered sequence.
14. `gto_comparative_map`: it creates a visualization for comparative maps.
15. `gto_max`: it computes the maximum value in each row between two files.
16. `gto_min`: it computes the minimum value in each row between two files.

17. gto\_xs: it ...
18. gto\_geco: it ...
19. gto\_gede: it ...

## 6.1 Program gto\_char\_to\_line

The `gto_char_to_line` splits a sequence into lines, creating an output sequence which has a char for each line.

For help type:

```
./gto_char_to_line -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_char_to_line` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence file.

The attribution is given according to:

```
Usage: ./gto_char_to_line [options] [--] args]
or: ./gto_char_to_line [options]
```

It splits a sequence into lines, creating an output sequence which has a char for each line.

```
-h, --help          show this help message and exit
```

#### Basic options

```
< input.seq        Input sequence file (stdin)
> output.seq       Output sequence file (stdout)
```

```
Example: ./gto_char_to_line < input.seq > output.seq
```

An example of such an input file is:

```
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGTGGTTTGAGTGGACCTCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAACCTCACCCATGAATGCTCACGCAAGTT
TAATTACAGACCTGAA
```



## Output

The output of the `gto_char_to_line` program is a group sequence splited by `\n` foreach character. Using the input above, an output example for this is the following:

```
A
C
A
A
G
A
C
G
G
C
C
T
C
C
T
G
C
T
G
C
T
...
```

## 6.2 Program `gto_reverse`

The `gto_reverse` reverses the order of a sequence file.

For help type:

```
./gto_reverse -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_reverse` program needs two streams for the computation, namely the input and output standard.

The input stream is a sequence file.

The attribution is given according to:

```
Usage: ./gto_reverse [options] [--] args]
      or: ./gto_reverse [options]

It reverses the order of a sequence file.

      -h, --help          show this help message and exit
```

```

Basic options
  < input.seq      Input sequence file (stdin)
  > output.seq     Output sequence file (stdout)

Example: ./gto_reverse < input.seq > output.seq

```

An example of such an input file is:

```

ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCCGGCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGTGGTTTGAAGTGGACCTCCAGGCCAGTGCCG
GGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACTTCTTCTGGAAGACCTTCTCCTCCTGCAAATAAAACCTCACCCATGAATGCTCACGCAAGTT
TAATTACAGACCTGAA

```

## Output

The output of the `gto_reverse` program is a group sequence.

Using the input above, an output example for this is the following:

```

AAGTCCAGACATTAATTTGAACGCACTCGTAAGTACCCACTCCAAAATAAACGTCTCTCTTCCAGAAGGTCTTCTTCA
AGGACGTCCCGTAAGACAGGGCCGCGCGCTAACGACCCCCCACGCGGAAGGACGGCGGACCGGTGGAGGGCTCGAAGG
AGAGGATACTCCCCGGGCGGTGACCGGACCTCCAGGTGAGTTTGGTGGTTCGCTCCTTTCAGTCTCCGACGAAAAGGA
ATAAGGACGGCGAAGGACGTATACGAGCGACAGAGCCGGCCACCCGGTGGGAGGTCCCGTCCCGTCGCCACCGGCACC
GGGGCCTCTCGTCGTCGTCCTCCTCCGGCCCCCTGTTACCGTAGAACAAAGTCCAGACATTAATTTGAACGCACTCGTAA
GTACCCACTCCAAAATCGACCCCCCACCTCTTCCAGAAGGTCTTCTTCAAGGACGTCCCGAAACGTCTCTAAGACAGG
GCCGCGCGCCTAAGCGCGGTGACCGGACGAAGGACGGCGGACCGGTGGAGGGCTCGAAGGAGAGGATACTCCCCGGGCCT
CCAGGTGAGTTTGGTGAAGGACGGCGAAGGACGTATACGAGCGACAGAGCCGGGTTCGCTCCTTTCAGTCTCCGACGAA
AAGGAATCCACCCCGGCCCTGTTACCGTCGTCCCGTCGCCACCTGGGAGGTCCCGGCACCGGGGCCTCTCGTCGTCGTC
GTCTCCGGCAGAACAA

```

## 6.3 Program `gto_new_line_on_new_x`

The `gto_new_line_on_new_x` splits different rows with a new empty row.

For help type:

```

./gto_new_line_on_new_x -h

```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_new_line_on_new_x` program needs two streams for the computation, namely the input and output standard. The input stream is a matrix file format with 3 columns.

The attribution is given according to:

```
Usage: ./gto_new_line_on_new_x [options] [--] args]
or: ./gto_new_line_on_new_x [options]
```

It splits different rows with a new empty row.

```
-h, --help    show this help message and exit
```

Basic options

```
< input      Input file with 3 column matrix format (stdin)
> output     Output file with 3 column matrix format (stdout)
```

Example: ./gto\_new\_line\_on\_new\_x < input > output

An example of such an input file is:

```
1  2  2
1  2  2
4  4  1
10 12  2
15 15  1
45 47  3
45 47  3
45 47  3
45 47  3
55 55  1
```

## Output

The output of the `gto_new_line_on_new_x` program is a 3 column matrix, with an empty line between different rows.

Using the input above, an output example for this is the following:

```
1.000000    2.000000    2.000000
1.000000    2.000000    2.000000

4.000000    4.000000    1.000000

10.000000   12.000000    2.000000

15.000000   15.000000    1.000000

45.000000   47.000000    3.000000
45.000000   47.000000    3.000000
45.000000   47.000000    3.000000
45.000000   47.000000    3.000000

55.000000   55.000000    1.000000
```

## 6.4 Program gto\_upper\_bound

The `gto_upper_bound` sets an upper bound in a file with a value per line.

For help type:

```
./gto_upper_bound -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_upper_bound` program needs two streams for the computation, namely the input and output standard. The input stream is a numeric file.

The attribution is given according to:

```
Usage: ./gto_upper_bound [options] [--] args]
or: ./gto_upper_bound [options]

It sets an upper bound in a file with a value per line.

    -h, --help                show this help message and exit

Basic options
    -u, --upperbound=<int>    The upper bound value
    < input.num               Input numeric file (stdin)
    > output.num              Output numeric file (stdout)

Example: ./gto_upper_bound -u <upperbound> < input.num > output.num
```

An example of such an input file is:

```
0.123
3.432
2.341
1.323
7.538
4.122
0.242
0.654
5.633
```

### Output

The output of the `gto_upper_bound` program is a set of numbers truncated at the a defined upper bound. Using the input above, an output example for this is the following:

```
Using upper bound: 4
0.123000
3.432000
2.341000
```

```
1.323000
4.000000
4.000000
0.242000
0.654000
4.000000
```

## 6.5 Program `gto_lower_bound`

The `gto_lower_bound` sets an lower bound in a file with a value per line.

For help type:

```
./gto_lower_bound -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_lower_bound` program needs two streams for the computation, namely the input and output standard. The input stream is a numeric file.

The attribution is given according to:

```
Usage: ./gto_lower_bound [options] [--] args]
or: ./gto_lower_bound [options]

It sets an lower bound in a file with a value per line.

    -h, --help                show this help message and exit

Basic options
    -l, --lowerbound=<int>    The lower bound value
    < input.num               Input numeric file (stdin)
    > output.num              Output numeric file (stdout)

Example: ./gto_lower_bound -l <lowerbound> < input.num > output.num
```

An example of such an input file is:

```
0.123
3.432
2.341
1.323
7.538
4.122
0.242
0.654
5.633
```

## Output

The output of the `gto_lower_bound` program is a set of numbers truncated at the a defined lower bound. Using the input above, an output example for this is the following:

```
Using lower bound: 2
2.000000
3.432000
2.341000
2.000000
7.538000
4.122000
2.000000
2.000000
5.633000
```

## 6.6 Program `gto_brute_force_string`

The `gto_brute_force_string` generates all combinations, line by line, for an inputted alphabet and specific size.

For help type:

```
./gto_brute_force_string -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_brute_force_string` program needs some paramenters for the computation, namely the alphabet and the key size.

The attribution is given according to:

```
Usage: ./gto_brute_force_string [options] [--] args]
or: ./gto_brute_force_string [options]

It generates all combinations, line by line, for an inputted alphabet and specific size.

-h, --help          show this help message and exit

Basic options
-a, --alphabet=<str> The input alphabet
-s, --size=<int>     The combinations size
> output            Output all the combinations (stdout)

Example: ./gto_brute_force_string -a <alphabet> -s <size> > output
```

## Output

The output of the `gto_brute_force_string` program is a set of all possible word combinations with a defined size, using the input alphabet.

Using the input above with the alphabet "abAB" with the word size of 3, an output example for this is the following:

```
aaa
aab
aaA
aaB
aba
...
BBb
BBA
BBB
```

## 6.7 Program `gto_real_to_binary_with_threshold`

The `gto_real_to_binary_with_threshold` converts a sequence of real numbers into a binary sequence, given a threshold. The numbers below to the threshold will be 0.

For help type:

```
./gto_real_to_binary_with_threshold -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_real_to_binary_with_threshold` program needs program needs two streams for the computation, namely the real sequence as input. These numbers should be splitted by lines.

The attribution is given according to:

```
Usage: ./gto_real_to_binary_with_threshold [options] [--] args]
or: ./gto_real_to_binary_with_threshold [options]
```

It converts a sequence of real numbers into a binary sequence given a threshold.

```
-h, --help                show this help message and exit
```

#### Basic options

```
-t, --threshold=<dbl>    The threshold in real format
< input.num              Input numeric file (stdin)
> output.bin              Output binary file (stdout)
```

```
Example: ./gto_real_to_binary_with_threshold -t <threshold> < input.num > output.bin
```

An example of such an input file is:

```
12.25
1.2
5.44
5.51
7.97
2.34
8.123
```

## Output

The output of the `gto_real_to_binary_with_threshold` program is a binary sequence.

Using the input above with the threshold of 5.5, an output example for this is the following:

```
1
0
0
1
1
0
1
```

## 6.8 Program `gto_sum`

The `gto_sum` adds decimal values in file, line by line, splitted by spaces or tabs.

For help type:

```
./gto_sum -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_sum` program needs program needs two streams for the computation, namely the input, which is a decimal file.

The attribution is given according to:

```
Usage: ./gto_sum [options] [--] args]
or: ./gto_sum [options]
```

It adds decimal values in file, line by line, splitted by spaces or tabs.

```
-h, --help          show this help message and exit
```

#### Basic options

```
< input.num        Input numeric file (stdin)
> output.num        Output numeric file (stdout)
```

#### Optional



```
-r, --sumrows      When active, the application adds all the values line by line
-a, --sumall       When active, the application adds all values
```

```
Example: ./gto_sum -a < input.num > output.num
```

An example of such an input file is:

```
0.123   5   5
3.432
2.341   3   2
1.323
7.538   5
4.122
0.242
0.654
5.633   10
```

## Output

The output of the `gto_sum` program is a sum of the elements in the input file.

Executing the application with the provided input and with the flag to add only the elements in each row, the output of this execution is:

```
10.123000
3.432000
7.341000
1.323000
12.538000
4.122000
0.242000
0.654000
15.633000
```

## 6.9 Program `gto_filter`

The `gto_filter` filters numerical sequences using a low-pass filter.

For help type:

```
./gto_filter -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_filter` program needs two streams for the computation, namely the input and output standard.

The input stream is a numeric file.

The attribution is given according to:

```
Usage: ./gto_filter [options] [--] args]
       or: ./gto_filter [options]
```

It filters numerical sequences using a low-pass filter.

-h, --help                      show this help message and exit

#### Basic options

< input.num                    Input numeric file (stdin)  
> output.num                  Output numeric file (stdout)

#### Optional

-w, --windowsize=<int>        Window size (default 0)  
-d, --drop=<int>              Discard elements (default 0.0)  
-t, --windowtype=<int>        Window type (0=Hamm, 1=Hann, 2=Black, 3=rec) (default 0 (Hamm))  
-c, --onecolumn                Read from one column  
-p, --printone                Print one column  
-r, --reverse                 Reverse mode

Example: ./gto\_filter -w <windowsize> -d <drop> -t <windowtype> -c -p -r < input.num > output.num

An example of such an input file is:

```
1    1.77
5    2.18
10   2.32
15   3.15
20   2.52
25   4.43
30   1.23
```

## Output

The output of the `gto_filter` program is a numeric file, identical of the input.

Using the input above with the window size of 3, an output example for this is the following:

```
Got 7 entries from file
1    2.085
5    2.256
10   2.507
15   2.757
20   2.905
25   2.860
30   2.674
```

## 6.10 Program `gto_word_search`

The `gto_word_search` search for a word in a file. It is case sensitive.

For help type:

```
./gto_word_search -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_word_search` program needs two streams for the computation, namely the input and output standard. The input stream is a text file.

The attribution is given according to:

```
Usage: ./gto_word_search [options] [--] args]
       or: ./gto_word_search [options]

Searching for a word in a text file. It is case sensitive.

    -h, --help            show this help message and exit

Basic options
    -w, --word=<str>      Word to search in the file
    < input.txt           Input text file (stdin)
    > output.txt          Output text file (stdout)

Example: ./gto_word_search -w <word> < input.txt > output.txt
```

An example of such an input file is:

```
No guts, no story. Chris Brady
My life is my message. Mahatma Gandhi
Screw it, let's do it. Richard Branson
Boldness be my friend. William Shakespeare
Keep going. Be all in. Bryan Hutchinson
My life is my argument. Albert Schweitzer
Fight till the last gasp. William Shakespeare
Leave no stone unturned. Euripides
```

## Output

The output of the `gto_word_search` program is a text file with the matching paragraphs and the location of the word found.

Using the input above with the word "Shakespeare", an output example for this is the following:

```
Found match in range [ 1536 : 2048 ]
Boldness be my friend. William Shakespeare

Found match in range [ 3072 : 3584 ]
Fight till the last gasp. William Shakespeare
```

## 6.11 Program gto\_permute\_by\_blocks

The `gto_permute_by_blocks` permutes by block sequence, FASTA and Multi-FASTA files. For help type:

```
./gto_ -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_permute_by_blocks` program needs two streams for the computation, namely the input and output standard. The input stream is a sequence, FASTA or Multi-FASTA file.

The attribution is given according to:

```
Usage: ./gto_permute_by_blocks [options] [--] args]
or: ./gto_permute_by_blocks [options]

It permutes by block sequence, FASTA and Multi-FASTA files.

-h, --help                show this help message and exit

Basic options
-b, --numbases=<int>      The number of bases in each block
-s, --seed=<int>          Starting point to the random generator
< input                   Input sequence, FASTA or Multi-FASTA file format (stdin)
> output                  Output sequence, FASTA or Multi-FASTA file format (stdout)

Example: ./gto_permute_by_blocks -b <numbases> -s <seed> < input.fasta > output.fasta
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCGCAACACGCAAGTTTAATTCGCAAGTTAGACCTGAACGGGAGGTGGCCACGCAAGTT
```

### Output

The output of the `gto_permute_by_blocks` program is a sequence, FASTA or Multi-FASTA file permuted following some parameters.

Using the input above with the base number as 80, an output example for this is the following:

```
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
ACAAGACGGCCTCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
```

```
TAAAACCTCACCCATGAATGCTCGCAACACGCAAGTTTAATTGCAAGTTAGACCTGAACGGGAGGTGGCCACGCAAGTT
```

## 6.12 Program gto\_info

The `gto_info` gives the basic properties of the file, namely size, cardinality, distribution percentage of the symbols, among others.

For help type:

```
./gto_info -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_info` program needs two streams for the computation, namely the input and output standard.

The input stream is a file withou any specific format.

The attribution is given according to:

```
Usage: ./gto_info [options] [--] args]
or: ./gto_info [options]
```

It gives the basic properties of the file, namely size, cardinality, distribution percentage of the symbols, among others.

```
-h, --help      show this help message and exit
```

#### Basic options

```
< input        Input file (stdin)
> output        Output read information (stdout)
```

#### Optional

```
-a, --ascii      When active, the application shows the ASCII codes
```

```
Example: ./gto_info < input > output
```

#### Output example :

```
Number of symbols : value
```

```
Alphabet size     : value
```

```
Alphabet          : value
```

#### Symbol distribution:

```
<Symbol/Code ASCII> <Symbol count> <Distribution percentage>
```

An example of such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGACCTCCGGGGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
```

```
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAAGCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCGCAACACGCAAGTTTAATTGCAAGTTAGACCTGAACGGGAGGTGGCCACGCAAGTT
```

## Output

The output of the `gto_info` program is a set of information related to the file read.

Using the input above, an output example for this is the following:

```
Number of symbols : 453
Alphabet size      : 28
Alphabet           : |srponmiedcaTRNHGCBA>=6420 \n
Symbol distribution:
| : 2      0.4415011
s : 3      0.66225166
r : 1      0.22075055
p : 1      0.22075055
o : 2      0.4415011
n : 1      0.22075055
m : 2      0.4415011
i : 1      0.22075055
e : 2      0.4415011
d : 1      0.22075055
c : 3      0.66225166
a : 2      0.4415011
T : 66     14.569536
R : 1      0.22075055
N : 1      0.22075055
H : 1      0.22075055
G : 117    25.827815
C : 131    28.918322
B : 2      0.4415011
A : 89     19.646799
> : 1      0.22075055
= : 2      0.4415011
6 : 2      0.4415011
4 : 2      0.4415011
2 : 2      0.4415011
0 : 6      1.3245033
  : 4      0.88300221
\n : 5     1.1037528
```

## 6.13 Program `gto_segment`

The `gto_segment` segments a filtered sequence.

For help type:

```
./gto_segment -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_segment` program needs two streams for the computation, namely the input and output standard.

The input stream is a numeric file.

The attribution is given according to:

```
Usage: ./gto_segment [options] [--] args]
      or: ./gto_segment [options]

It segments a filtered sequence.

      -h, --help                show this help message and exit

Basic options
      -t, --threshold=<dbl>    The segment threshold
      < input.num              Input numeric file (stdin)
      > output                  Output the segment file (stdout)

Example: ./gto_segment -t <threshold> < input.num > output
```

An example of such an input file is:

```
1    1.77
5    2.18
10   2.32
15   3.15
20   2.52
25   4.43
30   1.23
```

## Output

The output of the `gto_segment` program is the interval of values “below the threshold.

Using the input above with a threshold of 3, an output example for this is the following:

```
0:10
```

### 6.14 Program `gto_comparative_map`

The `gto_comparative_map` creates a visualization for comparative maps.

For help type:

```
./gto_comparative_map -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_comparative_map` program needs an input file with the plot positions, respecting a defined structure.

The attribution is given according to:

```
Usage: ./gto_comparative_map [options] [--] args]
       or: ./gto_comparative_map [options]

It creates a visualization for comparative maps.

    -h, --help                Show this help message and exit

Basic options
    <FILE>                    Contigs filename with positions (.pos),

Optional

    -h                        Give this help,
    -V                        Display version number,
    -v                        Verbose mode (more information),
    -l <link>                 Link type between maps [0;4],
    -w <width>                 Chromosome width,
    -s <space>                 Space between chromosomes,
    -m <mult>                 Color id multiplication factor,
    -b <begin>                 Color id beggining,
    -c <minimum>              Minimum block size to consider,
    -i                        Do NOT show inversion maps,
    -r                        Do NOT show regular maps,
    -o <FILE>                 Output image filename with map,

Example: ./gto_comparative_map -o map.svg map.config
```

An example of such an input file is:

```
#SCF      5000000 5000000
aaa       1      1000000 1      1000000 bbbb      3000000 4000000 3000000 4000000
bbb       1500000 2000000 1500000 2000000 cccc      1500000 2000000 1500000 2000000
aaa       2000000 3000000 2000000 3000000 bbbb      3000000 2000000 3000000 2000000
```

## Output

The output of the `gto_comparative_map` program is a executing report, and a svg plot with the maps. Using the input above, an output example for this is the following:

```
==[ PROCESSING ]=====
Printing plot ...
Found 2 regular regions.
Found 1 inverted regions.
Done!
```



```
==[ STATISTICS ]=====
Total cpu time: 0 second(s).
```

In the Figure 6.1 is represented the plot for the execution above.

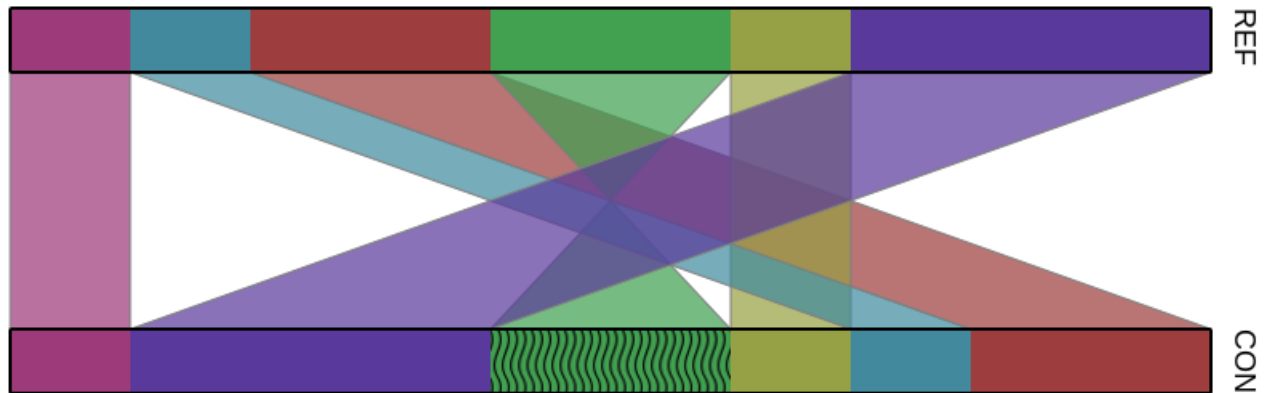


Figure 6.1: `gto_comparative_map` execution plot.

## 6.15 Program `gto_max`

The `gto_max` computes the maximum value in each row between two files.

For help type:

```
./gto_max -h
```

In the following subsections, we explain the input and output parameters.

### Input parameters

The `gto_max` program needs two streams for the computation, namely the input, which are two decimal files.

The attribution is given according to:

```
Usage: ./gto_max [options] [--] args]
or: ./gto_max [options]
```

It computes the maximum value in each row between two files.

```
-h, --help          Show this help message and exit
```

#### Basic options

```
-f, --first_file=<str>  File to compute the max
-s, --second_file=<str> The second file to do the max computation
> output.num           Output numeric file (stdout)
```

```
Example: ./gto_max -f input1.num -s input2.num > output.num
```

An example of such an input files are:

File 1:

```
0.123
3.432
2.341
1.323
7.538
4.122
0.242
0.654
5.633
```

File 2:

```
2.123
5.312
2.355
0.124
1.785
3.521
0.532
7.324
2.312
```

## Output

The output of the `gto_max` program is the numeric file with the maximum value for each row between both input files.

Executing the application with the provided input, the output of this execution is:

```
2.123000
5.312000
2.355000
1.323000
7.538000
4.122000
0.532000
7.324000
5.633000
```

## 6.16 Program `gto_min`

The `gto_min` computes the minium value in each row between two files.

For help type:

```
./gto_min -h
```

In the following subsections, we explain the input and output parameters.

## Input parameters

The `gto_min` program needs two streams for the computation, namely the input, which are two decimal files.

The attribution is given according to:

```
Usage: ./gto_min [options] [--] args]
or: ./gto_min [options]

It computes the minimum value in each row between two files.

-h, --help                Show this help message and exit

Basic options
-f, --first_file=<str>    File to compute the max
-s, --second_file=<str>   The second file to do the max computation
> output.num             Output numeric file (stdout)

Example: ./gto_min -f input1.num -s input2.num > output.num
```

An example of such an input files are:

File 1:

```
0.123
3.432
2.341
1.323
7.538
4.122
0.242
0.654
5.633
```

File 2:

```
2.123
5.312
2.355
0.124
1.785
3.521
0.532
7.324
2.312
```

## Output

The output of the `gto_min` program is the numeric file with the minimum value for each row between both input files.

Executing the application with the provided input, the output of this execution is:

```
0.123000
3.432000
2.341000
0.124000
1.785000
3.521000
0.242000
0.654000
2.312000
```

## 6.17 Program `gto_xs`

The `gto_xs` .

For help type:

```
./gto_xs -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_xs` program needs program needs two streams for the computation, namely the input and output standard. ...

The attribution is given according to:

```
TODO
```

An example of such an input file is:

```
TO DO
```

## Output

The output of the `gto_xs` program is ...

Using the input above, an output example for this is the following:

```
TO DO
```

## 6.18 Program gto\_geco

The `gto_geco` .

For help type:

```
./gto_geco -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_geco` program needs program needs two streams for the computation, namely the input and output standard. ...

The attribution is given according to:

```
TODO
```

An example of such an input file is:

```
TO DO
```

### Output

The output of the `gto_geco` program is ...

Using the input above, an output example for this is the following:

```
TO DO
```

## 6.19 Program gto\_gede

The `gto_gede` .

For help type:

```
./gto_gede -h
```

In the following subsections, we explain the input and output paramters.

### Input parameters

The `gto_gede` program needs program needs two streams for the computation, namely the input and output standard. ...

The attribution is given according to:

```
TODO
```

An example of such an input file is:

```
TO DO
```

## Output

The output of the `gto_gede` program is ...

Using the input above, an output example for this is the following:

```
TO DO
```