



A toolkit for DNA sequence analysis and manipulation

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Version 1.7.17

Contents

1	Introduction	2
1.1	Installation	2
1.2	License	2
2	FASTQ tools	4
2.1	Program goose-fastq2fasta	5
2.2	Program goose-fastq2mfasta	6
3	FASTA tools	8
3.1	Program goose-fastq2seq	8
3.2	Program goose-fastextract	9
3.3	Program goose-fastextractbyread	10
3.4	Program goose-fastainfo	12
3.5	Program goose-mutatefasta	13
3.6	Program goose-randfastaextrachars	14
4	Genomic sequence tools	17
5	Amino acid sequence tools	18
5.1	Program goose-AminoAcidToGroup	18
5.2	Program goose-ProteinToPseudoDNA	19
6	General purpose tools	22
6.1	Program goose-reverse	22
	Bibliography	23

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. Its storage have been made using specific file formats, such as FASTQ and FASTA. Therefore, its analysis and manipulation is crucial [?]. Several frameworks for analysis and manipulation emerged, namely **GALAXY** [?], **GATK** [?], **HTSeq** [?], **MEGA** [?], among others. In the majority, these frameworks require licenses and do not provide a low level access to the information, since they are commonly approached by scripting or interfaces.

We describe **GOOSE**, a (free) novel toolkit for analyzing and manipulating FASTA-FASTQ formats and sequences (DNA, amino acids, text), with many complementary tools. The toolkit is for Linux-based systems, built for fast processing. **GOOSE** supports pipes for easy integration. It includes tools for information display, randomizing, edition, conversion, extraction, searching, calculation and visualization. **GOOSE** is prepared to deal with very large datasets, typically in the scale Gigabytes or Terabytes.

The toolkit is a command line version, using the prefix “goose-” followed by the suffix with the respective name of the program. **GOOSE** is implemented in C language and it is available, under GPLv3, at:

```
https://pratas.github.io/goose
```

1.1 Installation

For **GOOSE** installation, run:

```
git clone https://github.com/pratas/goose.git
cd goose/src/
make
```

1.2 License

The license is **GPLv3**. In resume, everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed. For details on the license, consult: <http://www.gnu.org/>

[licenses/gpl-3.0.html](#).

Chapter 2

FASTQ tools

Current available tools for FASTQ format analysis and manipulation include:

1. `goose-fastq2fasta`: it converts a FASTQ file format to a pseudo FASTA file.
2. `goose-fastq2mfasta`: it converts a FASTQ file format to a pseudo Multi-FASTA file.
3. `goose-fastqclustreads`
4. `goose-FastqExcludeN`
5. `goose-FastqExtractQualityScores`
6. `goose-FastqInfo`
7. `goose-FastqMaximumReadSize`
8. `goose-FastqMinimumLocalQualityScoreForward`
9. `goose-FastqMinimumLocalQualityScoreReverse`
10. `goose-FastqMinimumQualityScore`
11. `goose-FastqMinimumReadSize`
12. `goose-count`
13. `goose-extractreadbypattern`
14. `goose-fastqpack`
15. `goose-fastqsimulation`
16. `goose-FastqSplit`
17. `goose-FastqTrimm`
18. `goose-fastqunpack`

19. `goose-filter`
20. `goose-findnpos`
21. `goose-genrandomdna`
22. `goose-getunique`
23. `goose-info`
24. `goose-mfmotifcoords`
25. `goose-mutatefastq`
26. `goose-newlineonnewx`
27. `goose-period`
28. `goose-permuteseqbyblocks`
29. `goose-randfastqextrachars`
30. `goose-real2binthreshold`
31. `goose-reducematrixbythreshold`
32. `goose-renamehumanheaders`
33. `goose-searchphash`
34. `goose-seq2fasta`
35. `goose-seq2fastq`
36. `goose-SequenceToGroupSequence`
37. `goose-splitreads`
38. `goose-wsearch`

2.1 Program `goose-fastq2fasta`

The `goose-fastq2fasta` 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:

```
./goose-fastq2fasta -h
```

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

Input parameters

The `goose-fastq2fasta` 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: ./goose-fastq2fasta [options] [--] args]
      or: ./goose-fastq2fasta [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: ./goose-fastq2fasta < input.fastq > output.fasta
```

An example on 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
GTTTCAGGGATACGACGTTTGTATTTTAAAGTCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

Output

The output of the `goose-fastq2fasta` program a FASTA file.

An example, for the input, is:

```
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCTTAACAACCTTAAGGGTTTTCAAATAGA
GTTTCAGGGATACGACGTTTGTATTTTAAAGTCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTTATCAT
```

2.2 Program `goose-fastq2mfasta`

The `goose-fastq2mfasta` 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:

```
./goose-fastq2mfasta -h
```

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

Input parameters

The `goose-fastq2mfasta` 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: ./goose-fastq2mfasta [options] [--] args]
      or: ./goose-fastq2mfasta [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.

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

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

Example: ./goose-fastq2mfasta < input.fastq > output.mfasta
```

An example on such an input file is:

```
@SRR001666.1 071112_SLXA-EAS1_s_7:5:1:817:345 length=72
GGGTGATGGCCGCTGCCGATGGCGTCAAATCCCACCAAGTTACCCCTTAACAACCTTAAGGGTTTTCAAATAGA
+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
GTTACAGGATACGACGTTTGTATTTTAAGAATCTGAAGCAGAAGTCGATGATAATACGCGTCGTTTATCAT
+SRR001666.2 071112_SLXA-EAS1_s_7:5:1:801:338 length=72
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII>IIIII-I)8I
```

Output

The output of the `goose-fastq2mfasta` program is a Multi-FASTA file.

An example, for the input, is:

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


Chapter 3

FASTA tools

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

1. `goose-fasta2seq`: it converts a FASTA or Multi-FASTA file format to a seq.
2. `goose-fastaextract`: it extracts sequences from a FASTA file, which the range is defined by the user in the parameters.
3. `goose-fastaextractbyread`: 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.
4. `goose-fastainfo`: it shows the readed information of a FASTA or Multi-FASTA file format.
5. `goose-mutatefasta`: it reates a synthetic mutation of a fasta file given specific rates of editions, deletions and additions.
6. `goose-randfastaextrachars`: it substitutes in the DNA sequence the outside ACGT chars by random ACGT symbols.

3.1 Program `goose-fasta2seq`

The `goose-fasta2seq` converts a FASTA or Multi-FASTA file format to a seq.

For help type:

```
./goose-fasta2seq -h
```

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

Input parameters

The `goose-fasta2seq` 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: ./goose-fasta2seq [options] [--] args]
      or: ./goose-fasta2seq [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: ./goose-fasta2seq < input.fasta > output.seq
```

An example on such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCGGCCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCTGACTTTCTCTCGCTTG
GTGGTTTGAGTGGACCTCCCAGGCCAGTGCCGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCTGCAAA
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

Output

The output of the `goose-fasta2seq` program is a group sequence.

An example, for the input, is:

```
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAAACAAGATGCCATTGTCCCCGGCCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGTGGTTTGAGTGGACCTCCCAGGCCAGTGCCG
GGCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCTGCAAAATAAACCTCACCCATGAATGCTCACGCAAGTT
TAATTACAGACCTGAA
```

3.2 Program `goose-fastaextract`

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

For help type:

```
./goose-fastextract -h
```

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

Input parameters

The `goose-fastextract` 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: ./goose-fastextract [options] [--] args]
or: ./goose-fastextract [options]

It extracts sequences from a FASTA 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.fasta      Input FASTA or Multi-FASTA file format (stdin)
> output.seq       Output sequence file (stdout)

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

An example on such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCCAATCCGCGCGCCGGGACAGAATCTCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

Output

The output of the `goose-fastextract` program is a group sequence.

An example, using the value 0 as extraction starting point and the 50 as the end, for the provided input, is:

```
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGG
```

3.3 Program `goose-fastextractbyread`

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

For help type:

```
./goose-fastaextractbyread -h
```

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

Input parameters

The `goose-fastaextractbyread` 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: ./goose-fastaextractbyread [options] [--] args]
or: ./goose-fastaextractbyread [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: ./goose-fastaextractbyread -i <init> -e <end> < input.fasta > output.fasta
```

An example on such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGT
GGCCCCACCGCGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCCTCGCTTG
GTGGTTTGAGTGGACCTCCAGGCCAGTGCCGGGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

Output

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

An example, using the value 0 as extraction starting point and the 50 as the end, for the provided input, is:

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

3.4 Program goose-fastainfo

The `goose-fastainfo` shows the readed information of a FASTA or Multi-FASTA file format. For help type:

```
./goose-fastainfo -h
```

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

Input parameters

The `goose-fastainfo` 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: ./goose-fastainfo [options] [--] args]
or: ./goose-fastainfo [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: ./goose-fastainfo < input.fasta > output
```

An example on such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGTTCCACGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGTAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCCCTGGAGGGT
GGCCCCACCGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTG
GTGGTTTGTAGTGGACCTCCAGGCCAGTGCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAAATTACAGACCTGAA
```

Output

The output of the `goose-fastainfo` program is a set of informations related with the file readed.

An example, for the input, is:

```
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
```

3.5 Program `goose-mutatefasta`

The `goose-mutatefasta` 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 they are optional.

For help type:

```
./goose-mutatefasta -h
```

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

Input parameters

The `goose-mutatefasta` 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: ./goose-mutatefasta [options] [--] args]
or: ./goose-mutatefasta [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: ./goose-mutatefasta -s <seed> -e <edit rate> -d <deletion rate> -i <insertion rate> -a <input.fasta>
```

An example on such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACAAGACGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCCTGGAGGTTCCACGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ACAAGATGCCATTGTCCCCGGCCTCCTGCTGCTGCTGCTCCTCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGTT
GGCCCCACGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTG
GTGGTTTGAGTGGACCTCCAGGCCAGTGCCGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAG
GCGCACCCCCCAGCAATCCGCGCGCCGGGACAGAATGCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCTCCTGCAAA
TAAACCTCACCCATGAATGCTCACGCAAGTTTAATTACAGACCTGAA
```

Output

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

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

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ACGCAACGNATTCCTGCTGATCATANTGTNCCGCNCCCCNGCGACGGGNCCTCNCNNGCACACATNGTACCATTGTCCAC
NCTTNCANGTNANCGCTAGCAGGCTACNGTTTNTCCTCNCTANNCANNCNGGCGTNNNTACACTGGCACGTGCAGGCA
TNGGTGGCGNGNCCCTCCGGNAACGGCACCGGAGACGAAGCTCGGNGGNTATACAGGTGTCANGAAACATCCCCGCGNC
GNGTGNCNNGAANCCANAGAGTATCTCACTCACAAACCCTGCGTGACNTCTAGAGNANGACCTTACNCACCNTCCNNT
NNGTACCACACCAATGAACGCTGCAGAAAGTCTGTTTTNAGGNGNGCA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
ATTTGAAGGCAANCGGNCCAGNAATNCGGNGGTGCGNGCTCNTGTNGGCTACGGNCATCGGGCCCTGCTNTANTAAGCN
TGAACCACCGNTCGNNGCACTTAGCAATNGCGNAANCCGTCGGCACGGCGGAGACNAANCCGCTANTNNTTTCCGCTNA
ATGGNTGTACAAGACCNACTANACCANCCCTCCGTCACCACACTGGAGCGCANGATGGNNGCTGNCAGNAGCNNTGAG
GCGCTCCNTCCTANAAANCCGTGGNCGAGCNCCCTATGGNAGNGTGGGGGTTTTACCGGAAGACCNCTCGNGCCCTATGGG
AGCAATCANAANCTAGAAAGCTTACNGATGGTGANGAANTAGACTANG
```

3.6 Program `goose-randfastaextrachars`

The `goose-randfastaextrachars` 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:

```
./goose-randfastaextrachars -h
```

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

Input parameters

The `goose-randfastaextrachars` 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: ./goose-randfastaextrachars [options] [--] args]
      or: ./goose-randfastaextrachars [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: ./goose-randfastaextrachars < input.fasta > output.fasta
```

An example on such an input file is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ANAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGNCCCTGGAGGGTCCNCCGCTGCCCTGCTGCCATTGNCNCC
NGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCNGGAAGCGGCAGGAA
GNGGTTTGAGTGACCTCCNGGCCCTCATAGGAGAGGAAGCNGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGNC
GCGAATCCGNGCGCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCENN
TAAANNNTACCCATGAATGCTCAGCAANTTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
GCGAATCCGNGCGCGGGACAGAATCTCCTTCTCCACCCCCCENNNTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACC
NGCCCCACCTAAGGAAAAGCAGCCTCCAGGAACGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCNGGAAGCGG
ANAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGNCCCTGGCNCAGGGTCCNCCGCTGCCCTGCTGCCATTGN
GAGGAAGCNGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGNCNGGTTTGAGTGACCTCCNGGCCCTCATAGGA
TCACGCAANTTTAATTACAGACCTGAATAAANNNTACCCATGAATGC
```

Output

The output of the `goose-randfastaextrachars` program is a FASTA or Multi-FASTA file.

An example, for the input, is:

```
>AB000264 |acc=AB000264|descr=Homo sapiens mRNA
ATAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCCCGCTGCCCTGCTGCCATTGTCCCC
TGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCGGGAAGCGGCAGGAA
GAGGTTTGAGTGACCTCCCGGCCCTCATAGGAGAGGAAGCCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGTC
GCGAATCCGGGCGCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCTTG
TAAAAGATCACCCATGAATGCTCAGCAAAATTTAATTACAGACCTGAA
>AB000263 |acc=AB000263|descr=Homo sapiens mRNA
GCGAATCCGTGCGCGGGACAGAATCTCCTTCTCCACCCCCCATCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACC
GGCCCCACCTAAGGAAAAGCAGCCTCCAGGAACGACTTTCTCGCTTGGGCCGAGACAGCGAGCATATGCGGGAAGCGG
AGAAGACGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGTCCCTGGCTCCAGGGTCTCCGCTGCCCTGCTGCCATTGC
```


GAGGAAGCGGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGGCGGGTTTGAGTGGACCTCCTGGCCCCCATAGGA
TCACGCAACTTTAATTACAGACCTGAATAAAATGTCACCCATGAATGC

Chapter 4

Genomic sequence tools

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

1. `goose-mutatedna`
2. `goose-randseqextrachars`
3. `goose-geco`
4. `goose-gede`

Chapter 5

Amino acid sequence tools

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

1. `goose-AminoAcidToGroup`: it converts an amino acid sequence to a group sequence.
2. `goose-ProteinToPseudoDNA`: it converts an amino acid (protein) sequence to a pseudo DNA sequence.

5.1 Program `goose-AminoAcidToGroup`

The `goose-AminoAcidToGroup` converts an amino acid sequence to a group sequence.

For help type:

```
./goose-AminoAcidToGroup -h
```

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

Input parameters

The `goose-AminoAcidToGroup` 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: ./goose-AminoAcidToGroup [options] [--] args]
or: ./goose-AminoAcidToGroup [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: ./goose-AminoAcidToGroup < 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 on such an input file is:

```

IPFLLKKQFALADKLVL SKLRQLLGGR IKMMPCGGAKLEPAIGLFFHAIGINIKLGYGMTETTATVSCWHDFQFNPN SIG
TLMPKAEVKIGENNEILVRGGMV MKGYKKPEETAQAFTEDGFLKTGDAGEFDEQGNLFITDRIKELMKTSNGKYIAPQY
IESKIGKDKFIEQIAIIADAKKYVSALIVPCFDSLEEYAKQLNIKYHDRLELLKNSDILKMFE

```

Output

The output of the `goose-AminoAcidToGroup` program is a group sequence.

An example, for the input, is:

```

HSHHHPPUHHHHNPHHHUPHPUHHSSPHPHSSSSHPHNSHHSHHHPHSHUHPHSHSHUNUHUHUSHPNHUHUSUHS
UHHS PHNHPSNUUNHHHPSSHHHP SHHPPSNNUHUHHUNNSHHPUSNHSNHNNUSUHHHUNPHPNHHPUUUSPHHHSUH
HNUPHSPNPHHN UHHHHHHNPHPHUHHHHSSHNUNNHHPUHUHPHPNPHNHHPUUNHHPHHN

```

5.2 Program `goose-ProteinToPseudoDNA`

The `goose-ProteinToPseudoDNA` converts an amino acid (protein) sequence to a pseudo DNA sequence.

For help type:

```
./goose-ProteinToPseudoDNA -h
```

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

Input parameters

The `goose-ProteinToPseudoDNA` 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: ./goose-ProteinToPseudoDNA [options] [--] args]
or: ./goose-ProteinToPseudoDNA [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: ./goose-ProteinToPseudoDNA < 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 on such an input file is:

```
IPFLLKKQFALADKLVLSKLRQLLGGRICKMMPCGGAKLEPAIGLFFHAIGINIKLGYGMTETTATVSCWHDFQFNPNSIG
TLMPKAEVKIGENNEILVRGGMVMKGYKKPEETAQAFTEDGFLKTGDAGEFDEQGNLFITDRIKELMKTSNGKYIAPQY
IESKIGKDKFIEQIAIIADAKKYVSALIVPCFDSLEEYAKQLNIKYHDRLELLKNSDILKMFE
```

Output

The output of the `goose-ProteinToPseudoDNA` program is a DNA sequence.

An example, for the input, is:

```
ATCCCGTTTCTGCTGAAAAACAGTTTGC ACTGGCAGACAAACTGGTACTGTCTAAACTGCGTCAGCTGCTGGGCGGCCG
TATCAAAATGATGCCGTGCGGCGGCGCAAACTGGAGCCGGCAATCGGCCTGTTTTTTCATGCAATCGGCATCAACATCA
AACTGGGCTACGGCATGACGGAGACGACGGCAACGGTATCTTGCTGGCATGACTTTCAGTTTAACCCGAACCTCTATCGGC
ACGCTGATGCCGAAAGCAGAGGTAAAAATCGGCGAGAACACGAGATCCTGGTACGTGGCGGCATGGTAATGAAAGGCTA
CTACAAAAAACCGAGGAGACGGCACAGGCATTTACGGAGGACGGCTTTCTGAAACGGGCGACGCAGGCGAGTTTGACG
AGCAGGGCAACCTGTTTATCACGGACCGTATCAAAGAGCTGATGAAAACGTCTAACGGCAAATACATCGCACCGCAGTAC
ATCGAGTCTAAATCGGCAAAGACAAATTTATCGAGCAGATCGCAATCATCGCAGACGCAAAAAATACGTATCTGCACT
GATCGTACCGTGCTTTGACTCTCTGGAGGAGTACGCAAAACAGCTGAACATCAAATACCATGACCGTCTGGAGCTGCTGA
AAAACTCTGACATCCTGAAAAATGTTTGAG
```

Chapter 6

General purpose tools

1. `goose-comparativemap`
2. `goose-BruteForceString`
3. `goose-char2line`
4. `goose-sum`
5. `goose-min`
6. `goose-minus`
7. `goose-max`
8. `goose-extract`
9. `goose-segment`
10. `goose-reverse`: it reverses the order of a sequence.

6.1 Program `goose-reverse`

The `goose-reverse` reverses the order of a sequence file.

For help type:

```
./goose-reverse -h
```

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

Input parameters

The `goose-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: ./goose-reverse [options] [--] args]
or: ./goose-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: ./goose-reverse < input.seq > output.seq
```

An example on such an input file is:

```
ACAAGACGGCCTCCTGCTGCTGCTCTCCGGGGCCACGGCCCTGGAGGGTCCACCGCTGCCCTGCTGCCATTGTCCCC
GGCCCCACCTAAGGAAAAGCAGCCTCCTGACTTTCTCTCGCTTGGGCCGAGACAGCGAGCATATGCAGGAAGCGGCAGGAA
GTGGTTTGAGTGGAACCTCCGGGGCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGCAGGCCAGTGCC
GCGAATCCGCGCGCCGGGACAGAATCTCCTGCAAAGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCCACCCCCCAGC
TAAAACCTCACCCATGAATGCTCACGCAAGTTTAAATTACAGACCTGAAACAAGATGCCATTGTCCCCCGGCCCTCCTGCTG
CTGCTGCTCTCCGGGGCCACGGCCACCGCTGCCCTGCCCTGGAGGGTGGCCCCACCGCCGAGACAGCGAGCATATGCA
GGAAGCGGCAGGAATAAGGAAAAGCAGCCTCCTGACTTTCTCTCGCTTGGTGGTTTGAGTGGAACCTCCAGGCCAGTGCCG
GGCCCCCTCATAGGAGAGGAAGCTCGGGAGGTGGCCAGGCGGCAGGAAGGCGCACCCCCCAGCAATCCGCGCGCCGGGAC
AGAATGCCCTGCAGGAACCTTCTTCTGGAAGACCTTCTCTCTGCAAATAAACCTCACCCATGAATGCTCACGCAAGTT
TAATTACAGACCTGAA
```

Output

The output of the **goose-reverse** program is a group sequence.

An example, for the input, is:

```
AAGTCCAGACATTAATTTGAACGCACTCGTAAGTACCCACTCCAAAATAAACGTCTCTCTTCCAGAAGGTCTTCTTCA
AGGACGTCCCGTAAGACAGGGCCGCGCCCTAACGACCCCCCACGCGGAAGGACGGCGGACCGGTGGAGGGCTCGAAGG
AGAGGATACTCCCCGGGCGGTGACCGGACCTCCAGGTGAGTTTGGTGGTTTCGCTCCTTTCAGTCTCCGACGAAAAGGA
ATAAGGACGGCGAAGGACGTATACGAGCGACAGAGCCGGCCACCCGGTGGGAGGTCCCCGTCCCGTCGCCACCGGCACC
GGGGCCTCTCGTCGTCGTCCTCCGGCCCCCTGTTACCGTAGAACAAAGTCCAGACATTAATTTGAACGCACTCGTAA
GTACCCACTCCAAAATCGACCCCCCACCTCTTCCAGAAGGTCTTCTTCAAGGACGTCCCGAAACGTCTCTAAGACAGG
GCCGCGCGCCTAAGCGCCGTGACCGGACGAAGGACGGCGGACCGGTGGAGGGCTCGAAGGAGAGGATACTCCCCGGGCCCT
CCAGGTGAGTTTGGTGAAGGACGGCGAAGGACGTATACGAGCGACAGAGCCGGGTTCGCTCCTTTTCAGTCTCCGACGAA
AAGGAATCCACCCCGGCCCTGTTACCGTCGTCCTCGTCCGACCTGGGAGGTCCCGGCACCGGGGCCTCTCGTCGTCGTC
GTCTCCGGCAGAACA
```