

# Package ‘cleaver’

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**Version** 1.49.0

**Title** Cleavage of Polypeptide Sequences

**Maintainer** Sebastian Gibb <mail@sebastiangibb.de>

**Depends** R (>= 3.0.0), methods, Biostrings (>= 1.29.8)

**Imports** S4Vectors, IRanges

**Suggests** testthat (>= 0.8), knitr, BiocStyle (>= 0.0.14), rmarkdown,  
BRAIN, UniProt.ws (>= 2.36.5)

**Description** In-silico cleavage of polypeptide sequences. The cleavage  
rules are taken from:  
[http://web.expasy.org/peptide\\_cutter/peptidecutter\\_enzymes.html](http://web.expasy.org/peptide_cutter/peptidecutter_enzymes.html)

**License** GPL (>= 3)

**URL** <https://codeberg.org/sgibb/cleaver/>

**BugReports** <https://codeberg.org/sgibb/cleaver/issues/>

**LazyLoad** yes

**VignetteBuilder** knitr

**biocViews** Proteomics

**git\_url** <https://git.bioconductor.org/packages/cleaver>

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**Author** Sebastian Gibb [aut, cre] (ORCID:  
<<https://orcid.org/0000-0001-7406-4443>>)

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|                 |                                          |
|-----------------|------------------------------------------|
| cleaver-package | <i>Cleavage of polypeptide sequences</i> |
|-----------------|------------------------------------------|

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### Description

This package cleaves polypeptide sequences. It provides three functions: [cleave](#), [cleavageRanges](#) and [cleavageSites](#).

### Details

The cleavage rules are taken from: [https://web.expasy.org/peptide\\_cutter/peptidocutter\\_enzymes.html](https://web.expasy.org/peptide_cutter/peptidocutter_enzymes.html)

Package: cleaver  
License: GPL (>= 3)  
URL: <https://codeberg.org/sgibb/cleaver/>

### Author(s)

Sebastian Gibb <[mail@sebastiangibb.de](mailto:mail@sebastiangibb.de)>

### References

<https://codeberg.org/sgibb/cleaver/>

Gasteiger E., Hoogland C., Gattiker A., Duvaud S., Wilkins M.R., Appel R.D., Bairoch A.; "Protein Identification and Analysis Tools on the ExPASy Server". (In) John M. Walker (ed): The Proteomics Protocols Handbook, Humana Press (2005).

[https://web.expasy.org/peptide\\_cutter/peptidocutter\\_enzymes.html](https://web.expasy.org/peptide_cutter/peptidocutter_enzymes.html)

### See Also

[cleave](#), [cleavageRanges](#) and [cleavageSites](#).

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|                |                                          |
|----------------|------------------------------------------|
| cleave-methods | <i>Cleavage of polypeptide sequences</i> |
|----------------|------------------------------------------|

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### Description

This functions cleave polypeptide sequences. Use [cleavageSites](#) to find the cleavage sites, [cleavageRanges](#) to find the cleavage ranges and [cleave](#) to get the cleavage products.

**Usage**

```
## S4 method for signature 'character'
cleave(x, enzym = "trypsin", missedCleavages = 0,
       custom = NULL, unique = TRUE)

## S4 method for signature 'AAString'
cleave(x, enzym = "trypsin", missedCleavages = 0,
       custom = NULL, unique = TRUE)

## S4 method for signature 'AAStringSet'
cleave(x, enzym = "trypsin", missedCleavages = 0,
       custom = NULL, unique = TRUE)

## S4 method for signature 'character'
cleavageRanges(x, enzym = "trypsin", missedCleavages = 0,
               custom = NULL)

## S4 method for signature 'AAString'
cleavageRanges(x, enzym = "trypsin", missedCleavages = 0,
               custom = NULL)

## S4 method for signature 'AAStringSet'
cleavageRanges(x, enzym = "trypsin", missedCleavages = 0,
               custom = NULL)

## S4 method for signature 'character'
cleavageSites(x, enzym = "trypsin", custom = NULL)

## S4 method for signature 'AAString'
cleavageSites(x, enzym = "trypsin", custom = NULL)

## S4 method for signature 'AAStringSet'
cleavageSites(x, enzym = "trypsin", custom = NULL)
```

**Arguments**

|                 |                                                                                                                                                                                                                                                                                                                             |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x               | polypeptide sequences.                                                                                                                                                                                                                                                                                                      |
| enzym           | character, cleavage rule.                                                                                                                                                                                                                                                                                                   |
| missedCleavages | numeric, number of missed cleavages.                                                                                                                                                                                                                                                                                        |
| custom          | character, of length 1 or 2. Could be used to define own cleavage rules. The first element would be the pattern and the optional second element would be an exception (non-cleavage) pattern. Perl-like regular expressions are supported, see <a href="#">gregexpr</a> for details. If custom is set the enzym is ignored. |
| unique          | logical, if TRUE all duplicated cleavage products per peptide are removed.                                                                                                                                                                                                                                                  |

## Details

The cleavage rules are taken from: [https://web.expasy.org/peptide\\_cutter/peptidecutter\\_enzymes.html](https://web.expasy.org/peptide_cutter/peptidecutter_enzymes.html)

Cleavage rules (cleavage between P1 and P1'):

| Rule name                  | P4              | P3        | P2        | P1                | P1'             |
|----------------------------|-----------------|-----------|-----------|-------------------|-----------------|
| arg-c proteinase           | -               | -         | -         | R                 | -               |
| asp-n endopeptidase        | -               | -         | -         | -                 | D               |
| bnps-skatole-c             | -               | -         | -         | W                 | -               |
| caspase1                   | F,W,Y,L         | -         | H,A,T     | D                 | not P,E,D,Q,K,R |
| caspase2                   | D               | V         | A         | D                 | not P,E,D,Q,K,R |
| caspase3                   | D               | M         | Q         | D                 | not P,E,D,Q,K,R |
| caspase4                   | L               | E         | V         | D                 | not P,E,D,Q,K,R |
| caspase5                   | L,W             | E         | H         | D                 | -               |
| caspase6                   | V               | E         | H,I       | D                 | not P,E,D,Q,K,R |
| caspase7                   | D               | E         | V         | D                 | not P,E,D,Q,K,R |
| caspase8                   | I,L             | E         | T         | D                 | not P,E,D,Q,K,R |
| caspase9                   | L               | E         | H         | D                 | -               |
| caspase10                  | I               | E         | A         | D                 | -               |
| chymotrypsin-high          | -               | -         | -         | F,Y               | not P           |
|                            | -               | -         | -         | W                 | not M,P         |
| chymotrypsin-low           | -               | -         | -         | F,L,Y             | not P           |
|                            | -               | -         | -         | W                 | not M,P         |
|                            | -               | -         | -         | M                 | not P,Y         |
|                            | -               | -         | -         | H                 | not D,M,P,W     |
| clostripain                | -               | -         | -         | R                 | -               |
| cnbr                       | -               | -         | -         | M                 | -               |
| enterokinase               | D,E             | D,E       | D,E       | K                 | -               |
| factor xa                  | A,F,G,I,L,T,V,M | D,E       | G         | R                 | -               |
| formic acid                | -               | -         | -         | D                 | -               |
| glutamyl endopeptidase     | -               | -         | -         | E                 | -               |
| granzyme-b                 | I               | E         | P         | D                 | -               |
| hydroxylamine              | -               | -         | -         | N                 | G               |
| iodosobenzoic acid         | -               | -         | -         | W                 | -               |
| lysc                       | -               | -         | -         | K                 | -               |
| lysn                       | -               | -         | -         | -                 | K               |
| lysarginase                | -               | -         | -         | -                 | K,R             |
| neutrophil elastase        | -               | -         | -         | A,V               | -               |
| ntcb                       | -               | -         | -         | -                 | C               |
| pepsin1.3                  | -               | not H,K,R | not P     | not R             | F,L             |
| pepsin                     | -               | not H,K,R | not P     | not R             | F,L,W,Y         |
|                            | -               | not H,K,R | not P     | F,L,W,Y           | -               |
|                            | -               | not H,K,R | not P     | F,L               | -               |
| proline endopeptidase      | -               | -         | not H,K,R | P                 | not P           |
| proteinase k               | -               | -         | -         | A,E,F,I,L,T,V,W,Y | -               |
| staphylococcal peptidase i | -               | -         | not E     | E                 | -               |
| thermolysin                | -               | -         | -         | not D,E           | A,F,I,L,M,V     |
| thrombin                   | -               | -         | G         | R                 | G               |

|                |                 |                 |   |     |         |
|----------------|-----------------|-----------------|---|-----|---------|
|                | A,F,G,I,L,T,V,M | A,F,G,I,L,T,V,W | P | R   | not D,E |
| trypsin        | -               | -               | - | K,R | not P   |
|                | -               | -               | W | K   | P       |
|                | -               | -               | M | R   | P       |
| trypsin-high   | -               | -               | - | K,R | not P   |
|                | -               | -               | W | K   | P       |
|                | -               | -               | M | R   | P       |
| trypsin-low    | -               | -               | - | K,R | not P   |
|                | -               | -               | W | K   | P       |
|                | -               | -               | M | R   | P       |
| trypsin-simple | -               | -               | - | K,R | -       |

Exceptions:

| Rule name    | Enzyme name | P4 | P3  | P2 | P1 | P1' | P2' |
|--------------|-------------|----|-----|----|----|-----|-----|
| trypsin      | -           | -  | C,D | K  | D  | -   | -   |
|              |             | -  | -   | C  | K  | H,Y | -   |
|              |             | -  | -   | C  | R  | K   | -   |
|              |             | -  | -   | R  | R  | H,R | -   |
| trypsin-high | -           | -  | C,D | K  | D  | -   | -   |
|              |             | -  | -   | C  | K  | H,Y | -   |
|              |             | -  | -   | C  | R  | K   | -   |
|              |             | -  | -   | R  | R  | H,R | -   |

| Rule name           | Enzyme name                                                    |
|---------------------|----------------------------------------------------------------|
| arg-c proteinase    | Arg-C proteinase                                               |
| asp-n endopeptidase | Asp-N endopeptidase                                            |
| bnps-skatole-c      | BNPS-Skatole                                                   |
| caspase1            | Caspase 1                                                      |
| caspase2            | Caspase 2                                                      |
| caspase3            | Caspase 3                                                      |
| caspase4            | Caspase 4                                                      |
| caspase5            | Caspase 5                                                      |
| caspase6            | Caspase 6                                                      |
| caspase7            | Caspase 7                                                      |
| caspase8            | Caspase 8                                                      |
| caspase9            | Caspase 9                                                      |
| caspase10           | Caspase 10                                                     |
| chymotrypsin-high   | Chymotrypsin-high specificity (C-term to [FYW], not before P)  |
| chymotrypsin-low    | Chymotrypsin-low specificity (C-term to [FYWML], not before P) |
| clostripain         | Clostripain (Clostridiopeptidase B)                            |
| cnbr                | CNBr                                                           |
| enterokinase        | Enterokinase                                                   |
| factor xa           | Factor Xa                                                      |
| formic acid         | Formic acid                                                    |

|                            |                                                                                    |
|----------------------------|------------------------------------------------------------------------------------|
| glutamyl endopeptidase     | Glutamyl endopeptidase                                                             |
| granzyme-b                 | Granzyme B                                                                         |
| hydroxylamine              | Hydroxylamine                                                                      |
| iodosobenzoic acid         | Iodosobenzoic acid                                                                 |
| lysc                       | LysC                                                                               |
| lysn                       | LysN                                                                               |
| lysarginase                | LysargiNase                                                                        |
| neutrophil elastase        | Neutrophil elastase                                                                |
| ntcb                       | NTCB (2-nitro-5-thiocyanobenzoic acid)                                             |
| pepsin1.3                  | Pepsin (pH == 1.3)                                                                 |
| pepsin                     | Pepsin (pH > 2)                                                                    |
| proline endopeptidase      | Proline-endopeptidase                                                              |
| proteinase k               | Proteinase K                                                                       |
| staphylococcal peptidase i | Staphylococcal Peptidase I                                                         |
| thermolysin                | Thermolysin                                                                        |
| thrombin                   | Thrombin                                                                           |
| trypsin                    | Trypsin                                                                            |
| trypsin-high               | Trypsin, higher specificity as defined in PeptideMass, identical to <i>trypsin</i> |
| trypsin-low                | Trypsin, C-term to K/R if C-term is not P, as defined in PeptideMass               |
| trypsin-simple             | Trypsin, C-term to K/R, even before P, as defined in PeptideMass                   |

## Value

**cleave** If *x* is a character it returns a list of the same length as *x*. Each element contains a character vector with the corresponding cleavage products of the polypeptides. If *x* is an [AAString](#) or an [AAStringSet](#) an [AAStringSet](#) or an [AAStringSetList](#) instance of the same length as *x* is returned. Each element contains an [AAString](#) or an [AAStringSet](#) instance with the corresponding cleavage products of the polypeptides.

**cleavageRanges** If *x* is a character it returns a list of the same length as *x*. Each element contains a two-column matrix with the start and end positions of the peptides. If *x* is an [AAString](#) or an [AAStringSet](#) instance an [IRanges](#) or an [IRangesList](#) of the same length as *x* is returned.

**cleavageSites** Returns a list of the same length as *x*. Each element contains an integer vector with the cleavage positions.

Overview:

| Input                       | cleave                          | cleavageRanges              | cleavageSites   |
|-----------------------------|---------------------------------|-----------------------------|-----------------|
| character                   | list of character               | list of matrix              | list of integer |
| <a href="#">AAString</a>    | <a href="#">AAStringSet</a>     | <a href="#">IRanges</a>     | list of integer |
| <a href="#">AAStringSet</a> | <a href="#">AAStringSetList</a> | <a href="#">IRangesList</a> | list of integer |

## Author(s)

Sebastian Gibb <[mail@sebastiangibb.de](mailto:mail@sebastiangibb.de)>

## References

Gasteiger E., Hoogland C., Gattiker A., Duvaud S., Wilkins M.R., Appel R.D., Bairoch A.; "Protein Identification and Analysis Tools on the ExPASy Server". (In) John M. Walker (ed): The Proteomics Protocols Handbook, Humana Press (2005).

[https://web.expasy.org/peptide\\_cutter/peptidecutter\\_enzymes.html](https://web.expasy.org/peptide_cutter/peptidecutter_enzymes.html)

PeptideMass [https://web.expasy.org/peptide\\_mass/peptide-mass-doc.html#table1](https://web.expasy.org/peptide_mass/peptide-mass-doc.html#table1)

## See Also

[AAString](#), [AAStringSet](#), [AAStringSetList](#), [IRanges](#), [IRangesList](#)

## Examples

```
library("cleaver")

## Gastric juice peptide 1 (UniProtKB/Swiss-Prot: GAJU_HUMAN/P01358)
gaju <- "LAAGKVEDSD"

cleave(gaju, "trypsin")
# $LAAGKVEDSD
# [1] "LAAGK" "VEDSD"

cleavageRanges(gaju, "trypsin")
# $LAAGKVEDSD
#      start end
# [1,]     1  5
# [2,]     6 10

cleavageSites(gaju, "trypsin")
# $LAAGKVEDSD
# [1] 5

cleave(gaju, "trypsin", missedCleavages=1)
# $LAAGKVEDSD
# [1] "LAAGKVEDSD"

cleavageRanges(gaju, "trypsin", missedCleavages=1)
# $LAAGKVEDSD
#      start end
# [1,]     1 10

cleave(gaju, "trypsin", missedCleavages=0:1)
# $LAAGKVEDSD
# [1] "LAAGK" "VEDSD" "LAAGKVEDSD"

cleavageRanges(gaju, "trypsin", missedCleavages=0:1)
# $LAAGKVEDSD
#      start end
# [1,]     1  5
# [2,]     6 10
# [3,]     1 10
```

```

cleave(gaju, "pepsin")
# $LAAGKVEDSD
# [1] "LAAGKVEDSD"
# (no cleavage)

## use AAStrngSet
gaju <- AAStrngSet("LAAGKVEDSD")

cleave(gaju)
# AAStrngSetList of length 1
# ["LAAGKVEDSD"] LAAGK VEDSD

## Beta-enolase (UniProtKB/Swiss-Prot: ENOB_THUAL/P86978)
enob <- "SITKIKAREILD"

cleave(enob, "trypsin")
# $SITKIKAREILD
# [1] "SITK" "IK" "AR" "EILD"

cleave(enob, "trypsin", missedCleavages=2)
# $SITKIKAREILD
# [1] "SITKIKAR" "IKAREILD"

cleave(enob, "trypsin", missedCleavages=0:2)
# $SITKIKAREILD
# [1] "SITK" "IK" "AR" "EILD" "SITKIK" "IKAR"
# [7] "AREILD" "SITKIKAR" "IKAREILD"

## define own cleavage rule: cleave at K
cleave(enob, custom="K")
# $SITKIKAREILD
# [1] "SITK" "IK" "AREILD"

cleavageRanges(enob, custom="K")
# $SITKIKAREILD
# start end
# [1,] 1 4
# [2,] 5 6
# [3,] 7 12

## define own cleavage rule: cleave at K but not if followed by A
cleave(enob, custom=c("K", "K(?=A)"))
# $SITKIKAREILD
# [1] "SITK" "IKAREILD"

cleavageRanges(enob, custom=c("K", "K(?=A)"))
# $SITKIKAREILD
# start end
# [1,] 1 4

```

```
# [2,]      5 12

cleavageSites(enob, custom=c("K", "K(?:=A)"))
# $SITKIKAREILD
# [1] 4
```

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