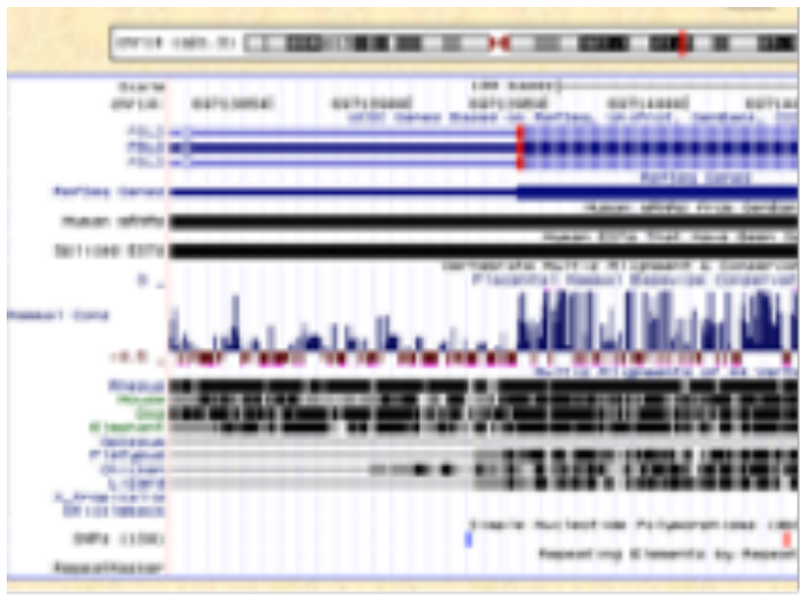
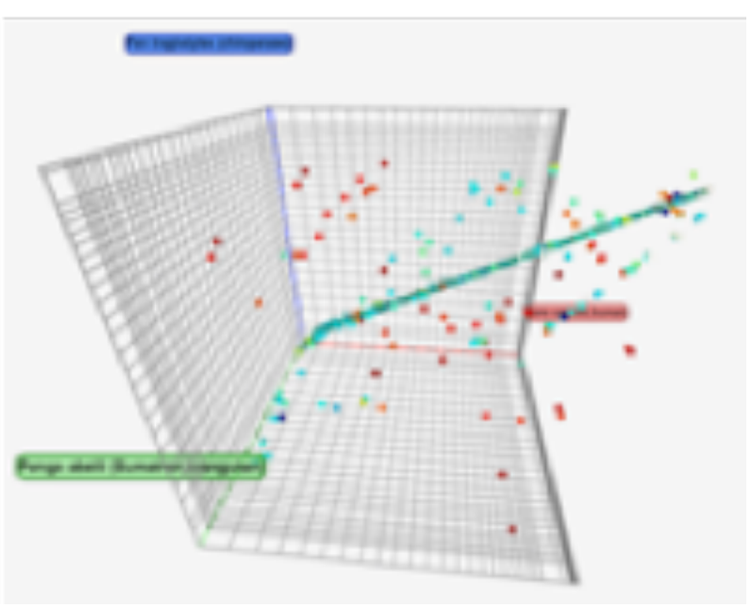
Computational Genomics

Introduction
to
Regular Expressions





Introduction to Regular Expressions

Regular expression

58 languages

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"Regex" redirects here. For the comic book, see Re:Gex.
"." redirects here. For the C++ operator, see Pointer (computer science) § Pointer-to-member.*

A **regular expression** (shortened as **regex** or **regexp**;[1] sometimes referred to as **rational expression**[2][3]) is a sequence of characters that specifies a search pattern in text. Usually such patterns are used by string-searching algorithms for "find" or "find and replace" operations on strings, or for input validation. Regular expression techniques are developed in theoretical computer science and formal language theory.

The concept of regular expressions began in the 1950s, when the American mathematician Stephen Cole Kleene formalized the concept of a regular language. They came into common use with Unix text-processing utilities. Different syntaxes for writing regular expressions have existed since the 1980s, one being the POSIX standard and another, widely used, being the Perl syntax.

```
In the beginning God created the heaven and the
earth.

And the earth was without form, and void; and
darkness was upon the face of the deep. And the
Spirit of God moved upon the face of the waters.

And God said, Let there be light: and there was
light.

And God saw the light, that it was good: and God
divided the light from the darkness.
```

Blue highlights show the match results of the regular expression pattern `/h[aeiou]+/g` (the letter *h* followed by one or more vowels)

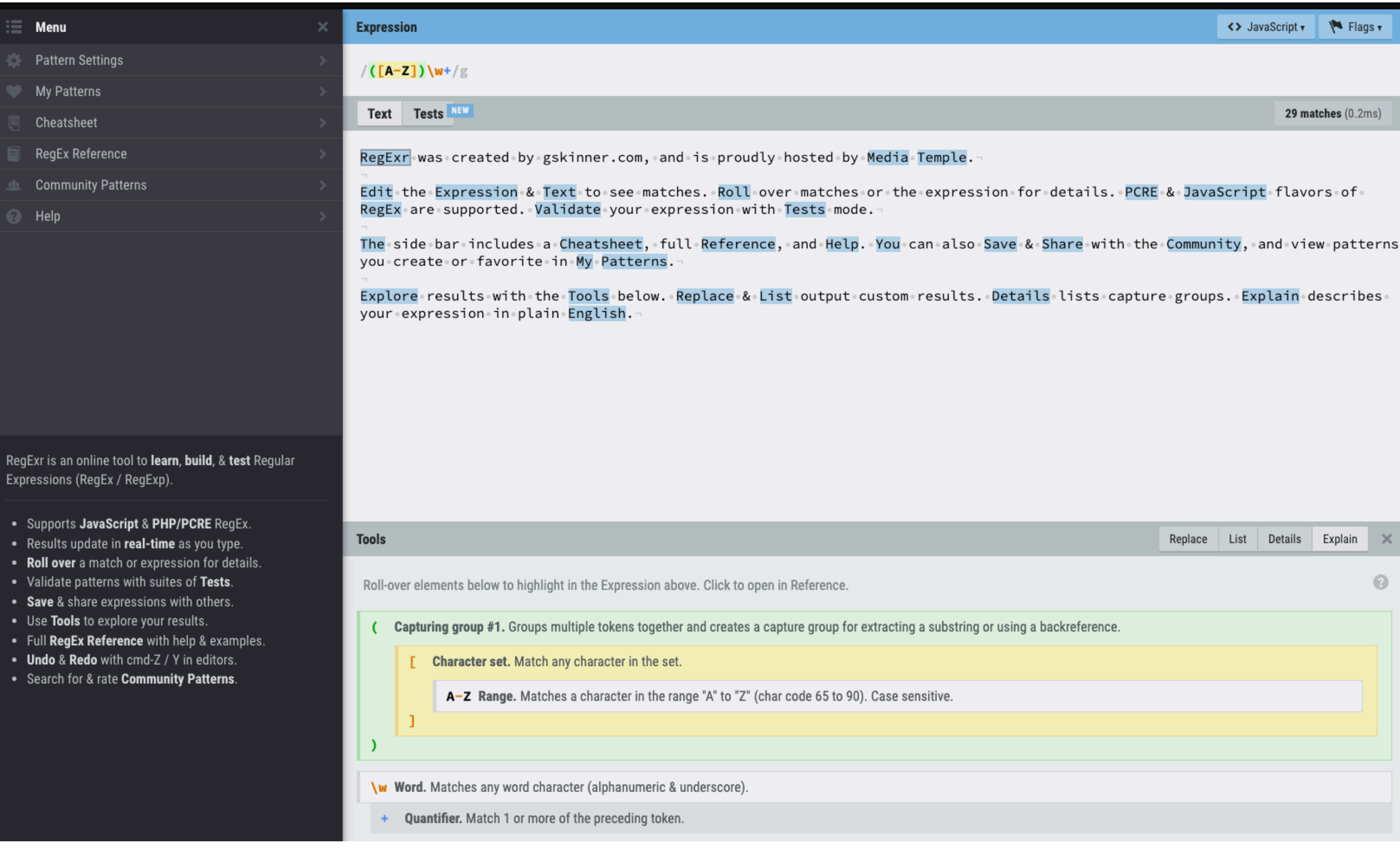
Regular expressions are used in search engines, in search and replace dialogs of word processors and text editors, in text processing utilities such as sed and AWK, and in lexical analysis. Regular expressions are supported in many programming languages.

Introduction to Regular Expressions

Regular Expressions Syntax

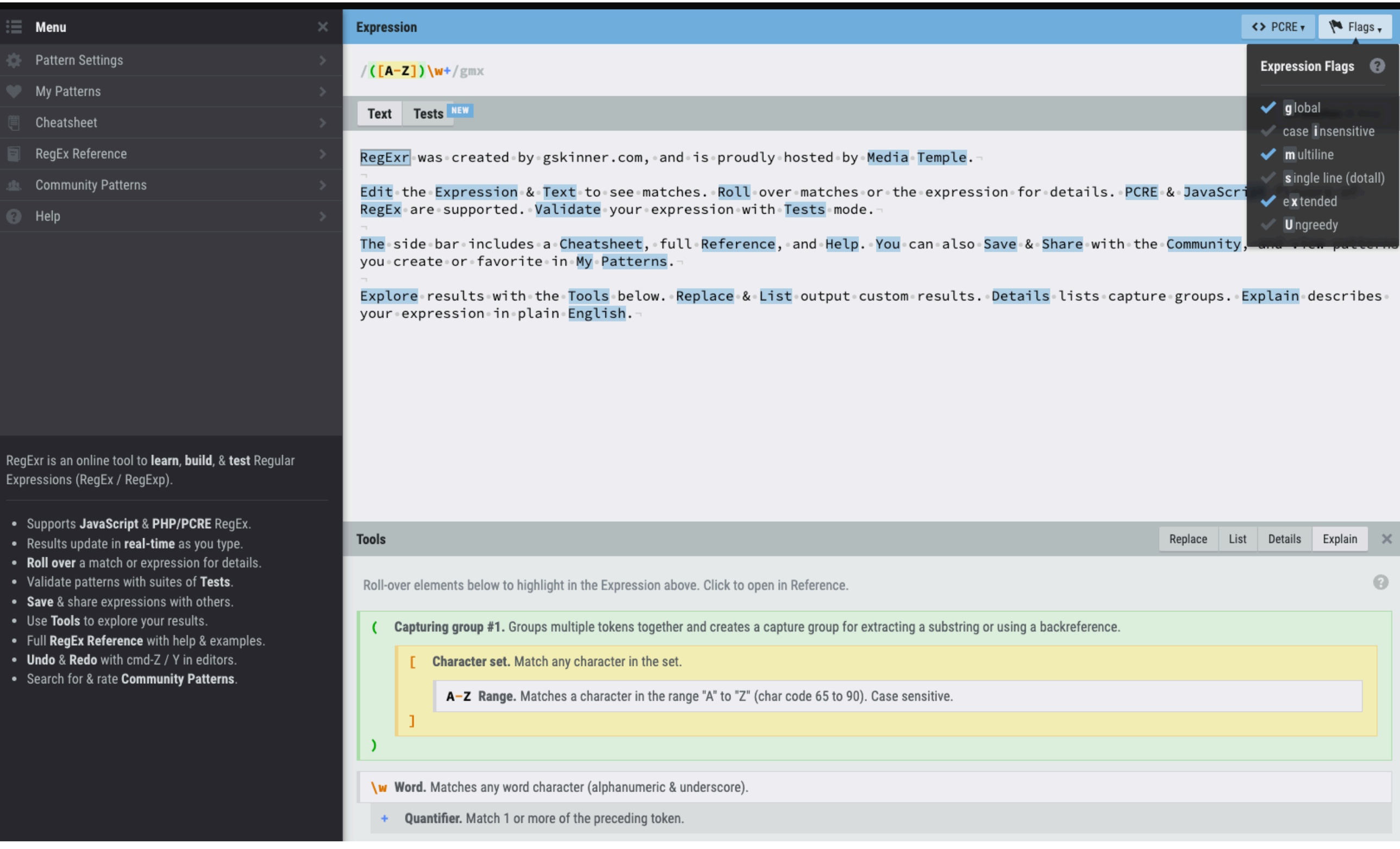
Introduction to Regular Expressions

Go to regexr.com



Introduction to Regular Expressions

Select PCRE and Flags: global, multiline and extended



Introduction to Regular Expressions

A Regular Expression is a pattern describing a certain amount of text

The ( ) { } [ ] . * ? + ^ $ are all special characters

\ can be used to "escape" a special character, allowing that special characters (i.e., ( ) { } [ ] . * ? + ^ $), to be searched for

```
chr1     65564   65573   ENST00000641515.2_cds_1_0_chr1_65565_f    0   +
chr1     69036   70008   ENST00000641515.2_cds_2_0_chr1_69037_f    0   +
chrX     284187  284314  ENST00000429181.6_cds_2_0_chrX_284188_f   0   +
chrX     288732  288787  ENST00000429181.6_cds_3_0_chrX_288733_f   0   +
chrY     284187  284314  ENST00000429181.6_cds_2_0_chrY_284188_f   0   +
chrY     288732  288787  ENST00000429181.6_cds_3_0_chrY_288733_f   0   +
chr10  48054   48114   ENST00000562809.1_cds_2_0_chr10_48055_r   0   -
chr10  48614   48725   ENST00000562809.1_cds_1_0_chr10_48615_r   0   -
chr11  168957  169052  ENST00000410108.5_cds_4_0_chr11_168958_r  0   -
chr11  180208  180404  ENST00000410108.5_cds_3_0_chr11_180209_r  0   -
chr12  66882   67436   ENST00000538872.6_cds_0_0_chr12_66883_f   0   +
chr12  99145   99214   ENST00000538872.6_cds_1_0_chr12_99146_f   0   +
```

Introduction to Regular Expressions

Expression PCRE ▾ Flags ▾

```
/([A-Z])\w+/gmx
```

Text **Tests** **16 matches** (0.1ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\A” matches the beginning of a string (but not an internal line

Regex: \Achr1

Expression

/\Achr1/gmx

PCRE ▾ Flags ▾

Text Tests

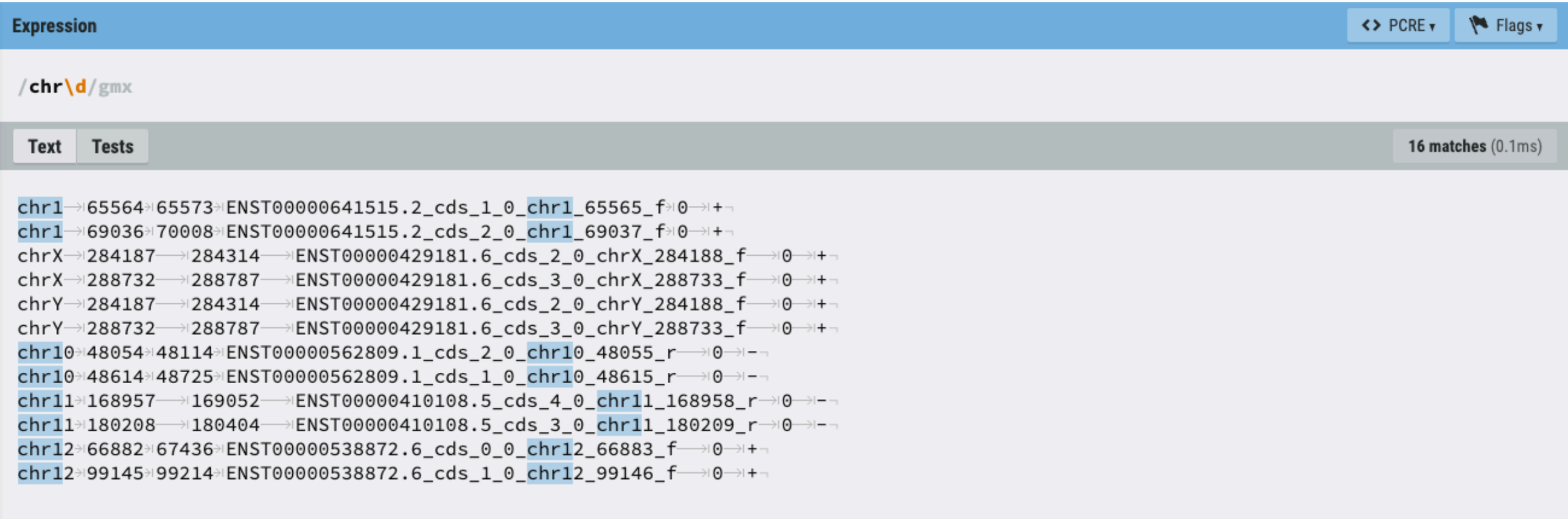
1 match (0.0ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\d” matches a digit class, same as [0–9]

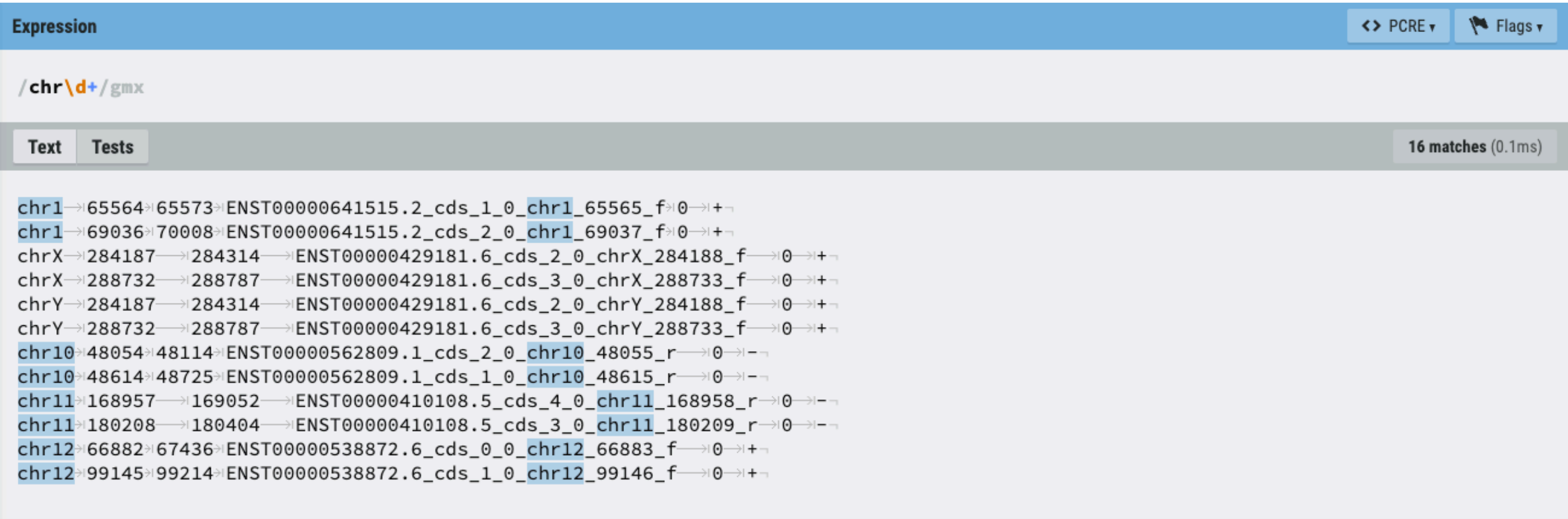
Regex: chr\d



Introduction to Regular Expressions

“\d” matches a digit class, same as [0-9]

Regex: chr\d+



Introduction to Regular Expressions

“\t” matches a tab

Regex: \t

Expression

/\t/gmx

PCRE ▾ Flags ▾

Text | Tests

60 matches (0.2ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\t” matches a tab

Regex: \t+

Expression

/\t+/gmx

PCRE ▾ Flags ▾

Text Tests

60 matches (0.2ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\d” matches a digit class, same as [0–9]

Regex: \t\d+\t

Expression PCRE ▾ Flags ▾

/\t\d+\t/gmx

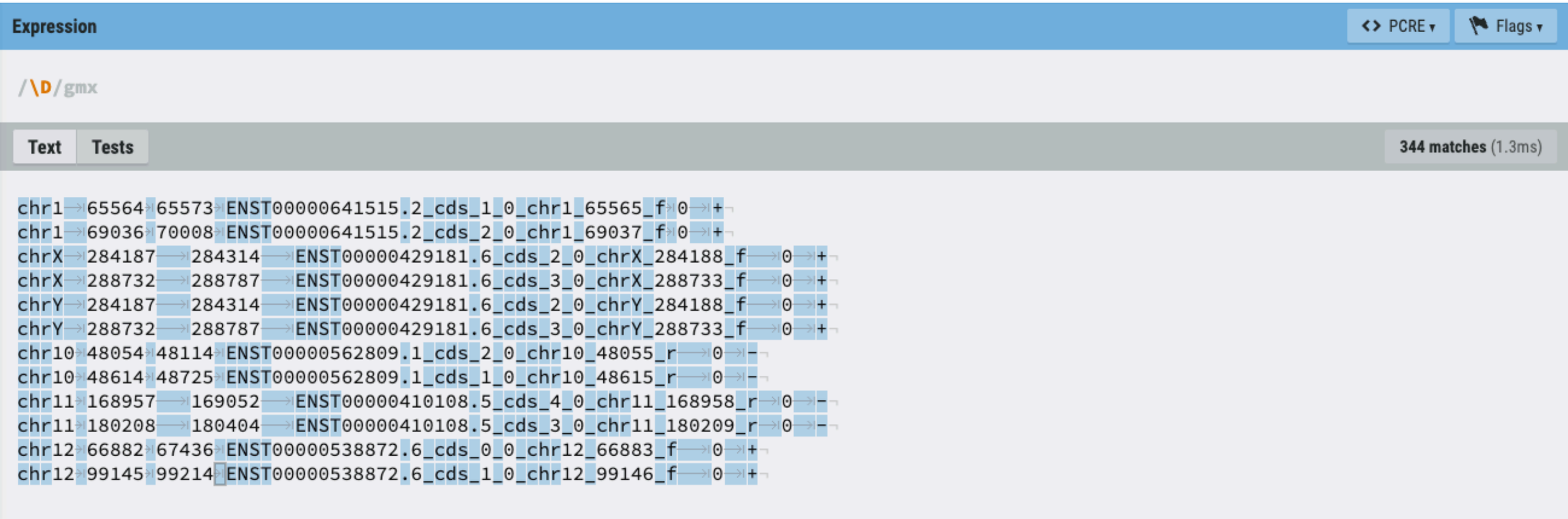
Text **Tests** **24 matches** (0.1ms)

```
chr1	65564	65573	ENST00000641515.2_cds_1_0_chr1_65565_f	0	+
chr1	69036	70008	ENST00000641515.2_cds_2_0_chr1_69037_f	0	+
chrX	284187	284314	ENST00000429181.6_cds_2_0_chrX_284188_f	0	+
chrX	288732	288787	ENST00000429181.6_cds_3_0_chrX_288733_f	0	+
chrY	284187	284314	ENST00000429181.6_cds_2_0_chrY_284188_f	0	+
chrY	288732	288787	ENST00000429181.6_cds_3_0_chrY_288733_f	0	+
chr10	48054	48114	ENST00000562809.1_cds_2_0_chr10_48055_r	0	-
chr10	48614	48725	ENST00000562809.1_cds_1_0_chr10_48615_r	0	-
chr11	168957	169052	ENST00000410108.5_cds_4_0_chr11_168958_r	0	-
chr11	180208	180404	ENST00000410108.5_cds_3_0_chr11_180209_r	0	-
chr12	66882	67436	ENST00000538872.6_cds_0_0_chr12_66883_f	0	+
chr12	99145	99214	ENST00000538872.6_cds_1_0_chr12_99146_f	0	+
```

Introduction to Regular Expressions

“\D” matches a non-digit

Regex: \D



Introduction to Regular Expressions

“\s” matches a whitespace character

Regex: \s

Expression PCRE ▾ Flags ▾

/\s/gmx

Text **Tests** **72 matches** (0.4ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\s” matches a whitespace character

Regex: \s+

Expression PCRE ▾ Flags ▾

/\s+/gmx

Text **Tests** **72 matches** (0.4ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\S” matches anything BUT a whitespace

Regex: \S

Expression <> PCRE ▾ Flags ▾

/\S/gmx

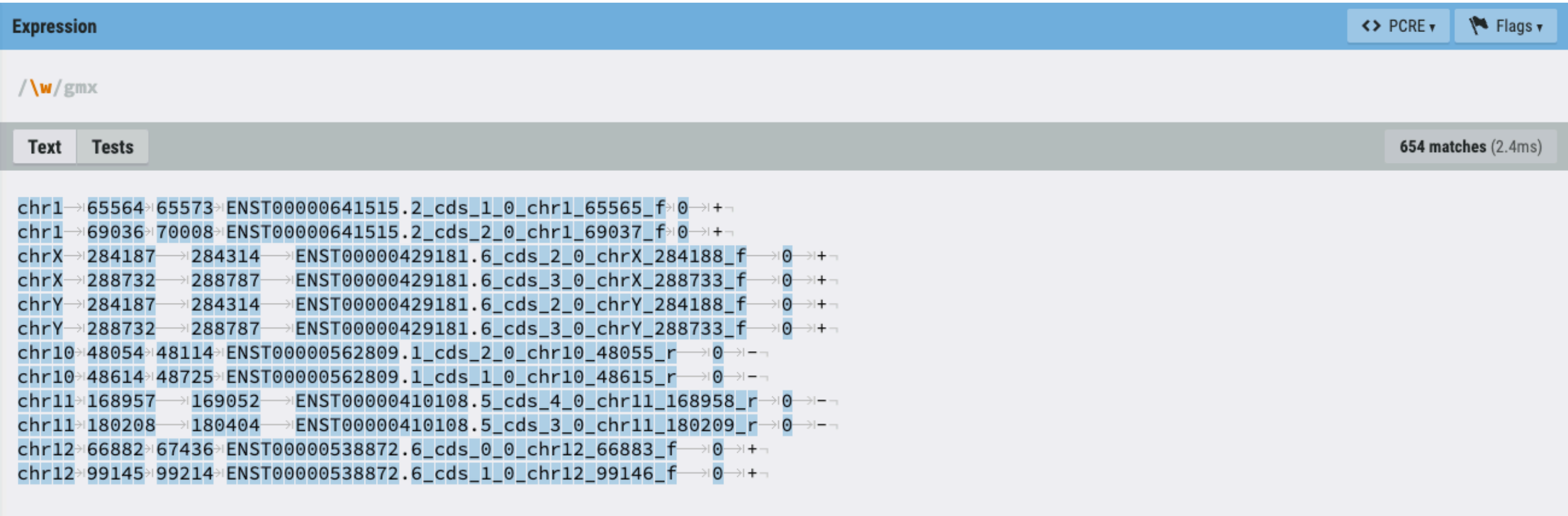
Text | Tests — 678 matches (2.9ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\w” matches an alphanumeric character

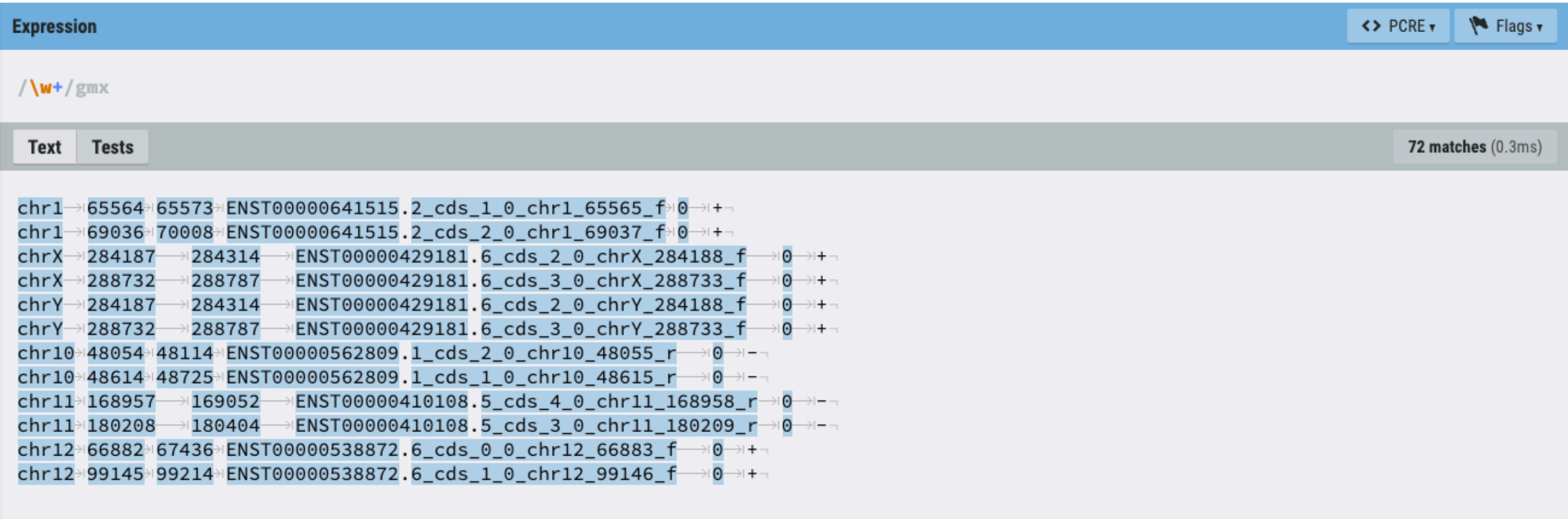
Regex: \w



Introduction to Regular Expressions

"\w" matches an alphanumeric character

Regex: \w+



Introduction to Regular Expressions

"\W" matches anything but an alphanumeric character

Regex: \W

Expression

PCRE ▾ Flags ▾

/\W/gmx

Text Tests

96 matches (0.4ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“\Z” matches the end of a string (but not a internal line)

Regex: `\+\Z`

Expression PCRE ▾ Flags ▾

`/\+\Z/gmx`

Text **Tests** **1 match** (0.0ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“{n}” The preceding item is matched exactly n times

Regex: 6{2}

Expression

PCRE ▾ Flags ▾

/6{2}/gmx

Text Tests

2 matches (0.1ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

“{n,}” The preceding item is matched n or more times

Regex: 6{1,}

Expression PCRE ▾ Flags ▾

/6{1,}/gmx

Text **Tests** **28 matches** (0.1ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

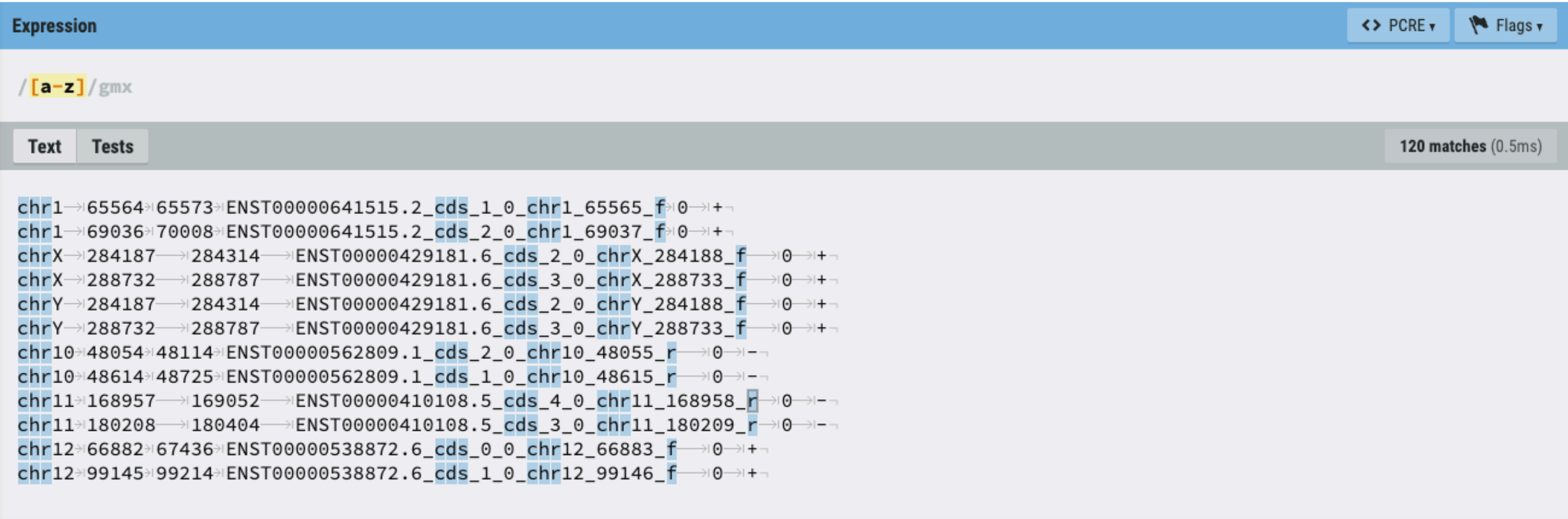
Introduction to Regular Expressions

“[…]” creates a character class

Within the brackets, single characters can be placed

A dash (–) may be used to indicate a range such as a–z

Regex: [a–z]



Introduction to Regular Expressions

“.” Matches any single character except a newline

”*” The preceding item will be matched zero or more times

“?” The preceding item is optional and matched at most once

"+" The preceding item will be matched one or more time

“^” has two meanings:
matches the beginning of a line or string
indicates negation in a character class

For example, [^…] matches every character except the ones inside brackets

“$” matches the end of a line or string
“|” Separates alternate possibilities
“(..)” groups a particular pattern

Regex: ^(chr.)\t([0-9]+)\t+([0-9]+)\t+ENST([0-9]+)

Introduction to Regular Expressions

Regex: ^(chr.)\t([0-9]+)\t+([0-9]+)\t+ENST([0-9]+)

Expression PCRE ▾ Flags ▾

```
/^(chr.)\t([0-9]+)\t+([0-9]+)\t+ENST([0-9]+)/gmx
```

Text **Tests** **6 matches** (0.1ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

Regex: ^(chr.*)\t([0-9]+)\t+([0-9]+)\t+ENST([0-9]+)

Expression PCRE ▾ Flags ▾

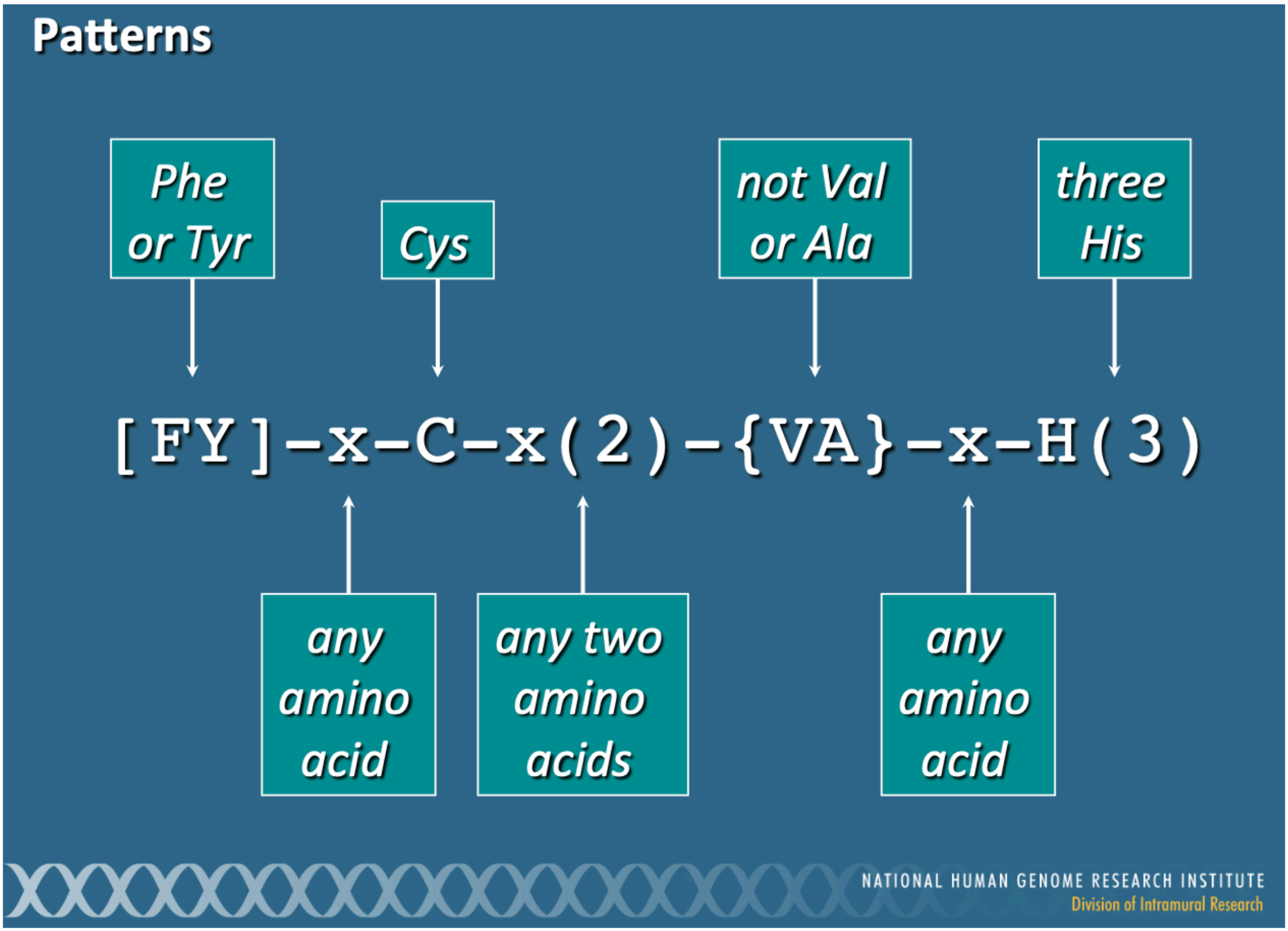
```
/^(chr.*)\t([0-9]+)\t+([0-9]+)\t+ENST([0-9]+)/gmx
```

Text **Tests** **12 matches** (0.3ms)

```
chr1→65564→65573→ENST00000641515.2_cds_1_0_chr1_65565_f→0→+¬
chr1→69036→70008→ENST00000641515.2_cds_2_0_chr1_69037_f→0→+¬
chrX→284187→284314→ENST00000429181.6_cds_2_0_chrX_284188_f→0→+¬
chrX→288732→288787→ENST00000429181.6_cds_3_0_chrX_288733_f→0→+¬
chrY→284187→284314→ENST00000429181.6_cds_2_0_chrY_284188_f→0→+¬
chrY→288732→288787→ENST00000429181.6_cds_3_0_chrY_288733_f→0→+¬
chr10→48054→48114→ENST00000562809.1_cds_2_0_chr10_48055_r→0→-¬
chr10→48614→48725→ENST00000562809.1_cds_1_0_chr10_48615_r→0→-¬
chr11→168957→169052→ENST00000410108.5_cds_4_0_chr11_168958_r→0→-¬
chr11→180208→180404→ENST00000410108.5_cds_3_0_chr11_180209_r→0→-¬
chr12→66882→67436→ENST00000538872.6_cds_0_0_chr12_66883_f→0→+¬
chr12→99145→99214→ENST00000538872.6_cds_1_0_chr12_99146_f→0→+¬
```

Introduction to Regular Expressions

Patterns as formulas:



Introduction to Regular Expressions

HMM Logo Family: Piwi (PF02171)

HMM logo

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BMC Bioinformatics (2004) 5:7