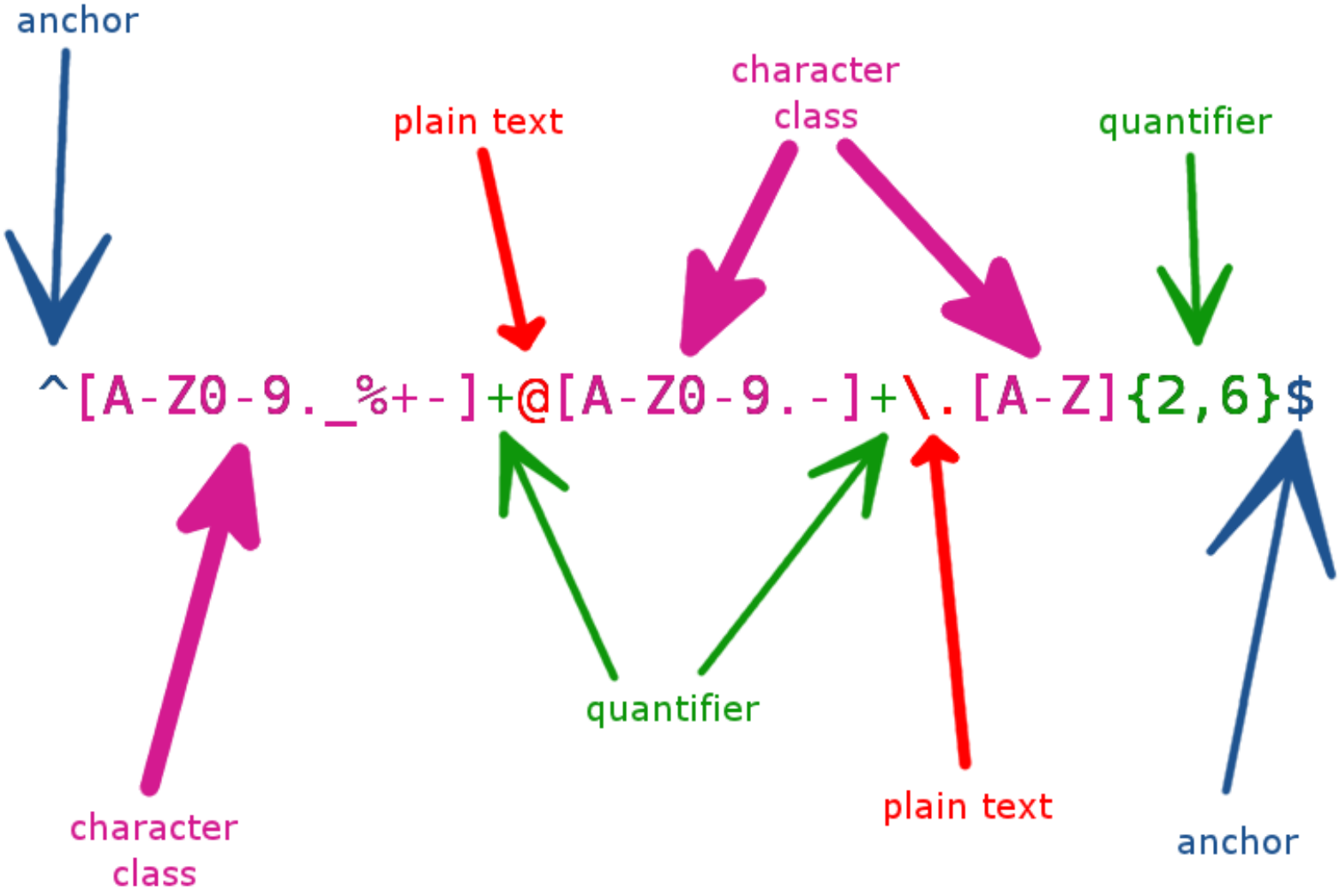
Regular Expressions Primer

Jeremy Stephens
Computer Systems Analyst
Department of Biostatistics

December 18, 2015


anchor
plain text
character class
quantifier
^[A-Z0-9._%+-]+@[A-Z0-9.-]+\.[A-Z]{2,6}$
character class
quantifier
plain text
anchor

What are they?

Regular expressions are a way to describe patterns in text.

Why use them?

- To find stuff

```
haystack <- c("abcdef", "anbeceddelfe", "abcdef")
grep("n.e.e.d.l.e", haystack) #=> [1] 2
```

Why use them?

- To find stuff

```
haystack <- c("abcdef", "anbeceddelfe", "abcdef")
grep("n.e.e.d.l.e", haystack) #=> [1] 2
```

- To remove cruft

```
x <- c("123", "123 oz", "123 ounces")
sub("\\D+$", "", x) #=> [1] "123" "123" "123"
```

Why use them?

- To find stuff

```
haystack <- c("abcdef", "anbeceddelfe", "abcdef")
grep("n.e.e.d.l.e", haystack) #=> [1] 2
```

- To remove cruft

```
x <- c("123", "123 oz", "123 ounces")
sub("\\D+$", "", x) #=> [1] "123" "123" "123"
```

- To extract data

```
x <- "The Predators lost in overtime with 4:43 left on the clock."
gsub("^.+(\\d{1,2}:\\d{2}).+$", "\\1", x) #=> "4:43"
```

```
(?:(?:\r\n)?[ \t])*(?:(?:(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]])))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]])))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*))*@(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*|(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)*\<(?:(?:\r\n)?[ \t])*(?:@(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)*(?:,@(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*:(?:(?:\r\n)?[ \t])*)?(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*))*@(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*\>(?:(?:\r\n)?[ \t])*)|(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)*:(?:(?:\r\n)?[ \t])*(?:(?:(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*))*@(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*|(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)*\<(?:(?:\r\n)?[ \t])*(?:@(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*:(?:(?:\r\n)?[ \t])*)?(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*))*@(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*\>(?:(?:\r\n)?[ \t])*)*:(?:(?:\r\n)?[ \t])*(?:(?:(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|"(?:[^\"\r\\]|\\.|(?:(?:\r\n)?[ \t]))*"(?:(?:\r\n)?[ \t])*))*@(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*)(?:\.(?:(?:\r\n)?[ \t])*(?:[^()<>@,;:\\".\[\] \000-\031]+(?:(?:(?:\r\n)?[ \t])+|\Z|(?=[\["()<>@,;:\\".\[\]]))|\[([^\[\]\r\\]|\\.)*\](?:(?:\r\n)?[ \t])*))*\>(?:(?:\r\n)?[ \t])*)*;\s*)
```

Don't Panic!

Things you (might) need to know

There are 3 main regular expression standards:

- POSIX Basic Regular Expressions
- POSIX Extended Regular Expressions (R uses this by default)
- Perl-based Regular Expressions (R has support for this as well)

Using regular expressions in R

- grep('pattern', text, ...)
- sub('pattern', replacement, text, ...)
- regexpr('pattern', text, ...)

Using regular expressions in other languages

- Ruby:

```ruby
text =~ /pattern/
```

- Javascript:

```javascript
text.match(/pattern/)
```

- Python:

```python
re.match('pattern', text)
```

The simplest regular expression

Plain text!

```
grep("test", c("foo", "bar", "test")) #=> [1] 3
```

The pattern "test" is a perfectly valid regular expression.

Metacharacters

A "metacharacter" in a regular expression is a character with special meaning.

Your first metacharacter: dot

A "dot" (or period) means match any one character.

```
grep("foo.bar", c("fooxbar", "foo bar", "foobar", "foo12bar")) #=> [1] 1 2
```

In the above example, "foo.bar" is the regular expression.

Your first metacharacter: dot (cont.)

Using multiple wildcards:

```
grep("foo..bar",  c("foo12bar", "foo123bar")) #=> [1] 1
grep("foo...bar", c("foo12bar", "foo123bar")) #=> [1] 2
```

Variable-length matching: plus

Use + to indicate **one or more**.

```
grep("foo.+bar", c("fooxbar", "foo bar", "foobar", "foo12bar")) #=> [1] 1 2 4
```

Variable-length matching: plus (cont.)

Using + works on normal characters too:

```
grep("a+rgh", c("argh", "aaargh", "aaaaaaaargh", "ugh")) #=> [1] 1 2 3
```

Quantifiers

Quantifiers are metacharacters that describe "how many", like the $+$ character.

Matching zero or more: asterisk

Use * to indicate **zero or more**.

```
grep("foo.*bar", c("fooxbar", "foo bar", "foobar", "foo12bar")) #=> [1] 1 2 3 4
```

Matching zero or one: question mark

Use ? to indicate **zero or one**.

```
grep("abc?def", c("abdef", "abcdef", "abccdef")) #=> [1] 1 2
```

Matching *n* times: curly braces

Use {} to indicate **exactly *n* times**.

```
grep("10{6}", c("1000", "1000000")) => [1] 2
```

Matching *n* times: curly braces (cont.)

You can also use {} to indicate a range.

```
grep("10{2,4}1", c("101", "1001", "10001", "100001", "1000001")) #=> [1] 2 3 4
```

Intermission

Anchor down

Consider the following:

```
grep("10{3}", c("100", "1000", "10000")) #=> [1] 2 3
```

Anchoring to the end: dollar sign

Use $ to indicate **anchoring at the end**.

```
grep("10{3}$", c("100", "1000", "10000")) #=> [1] 2
```

Anchoring to the beginning: caret

Use ^ to indicate **anchoring at the beginning**.

```
grep("^10{3}", c("1000", "abc1000")) #=> [1] 1
```

Using both anchors

You can use both ^ and $ to anchor at both ends.

```
grep("10{3}",   c("abc1000", "1000", "10000")) #=> [1] 1 2 3
grep("10{3}$",  c("abc1000", "1000", "10000")) #=> [1] 1 2
grep("^10{3}$", c("abc1000", "1000", "10000")) #=> [1] 2
```

Matching groups of characters: brackets

Use [ ] to indicate a **group of characters**, also known as a **character class**.

```
grep("ab[cdef]", c("abc", "abd", "abe", "abf", "abg")) #=> [1] 1 2 3 4
```

Matching groups of characters: brackets (cont.)

You can also use [ ] with a range of characters.

```
grep("ab[c-f]", c("abc", "abd", "abe", "abf", "abg")) #=> [1] 1 2 3 4
```

Matching groups of characters: brackets (cont.)

Using [ ] with multiple ranges:

```
grep("ab[c-fC-F]", c("abc", "abC", "abf", "abF", "abg")) #=> [1] 1 2 3 4
```

Matching groups of characters: brackets (cont.)

Mix and match ranges and characters:

```
grep("ab[c-fC-F123]", c("abc", "abF", "ab1", "ab2")) #=> [1] 1 2 3 4
```

Context in character classes

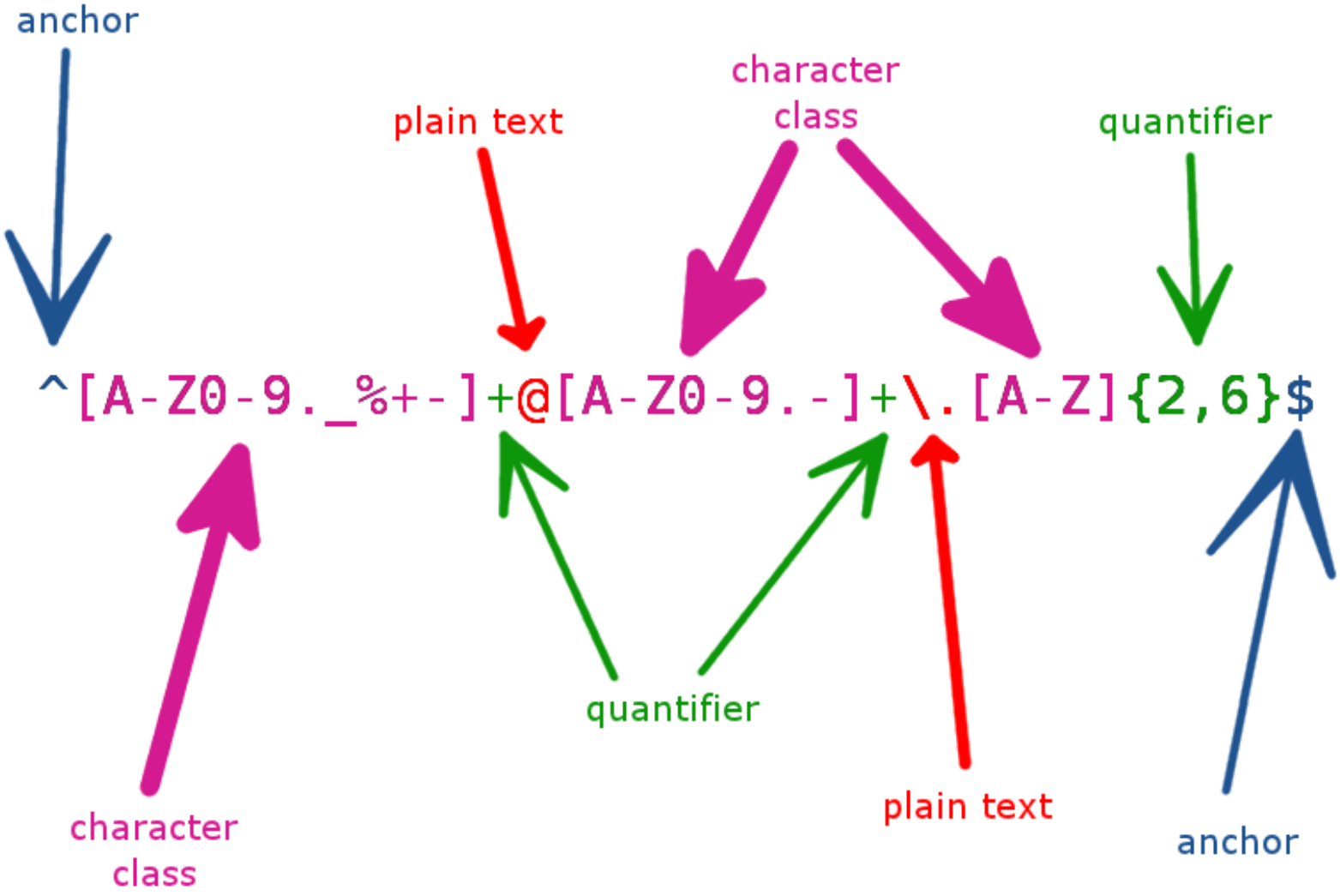
Most metacharacters lose their meaning inside character classes:

```
grep("[.+*]",  c(".", "+", "*", "x")) #=> [1] 1 2 3
grep("[a-c-]", c("a", "b", "c", "-")) #=> [1] 1 2 3 4
```

Using quantifiers with character classes

It's possible to put quantifiers on character classes:

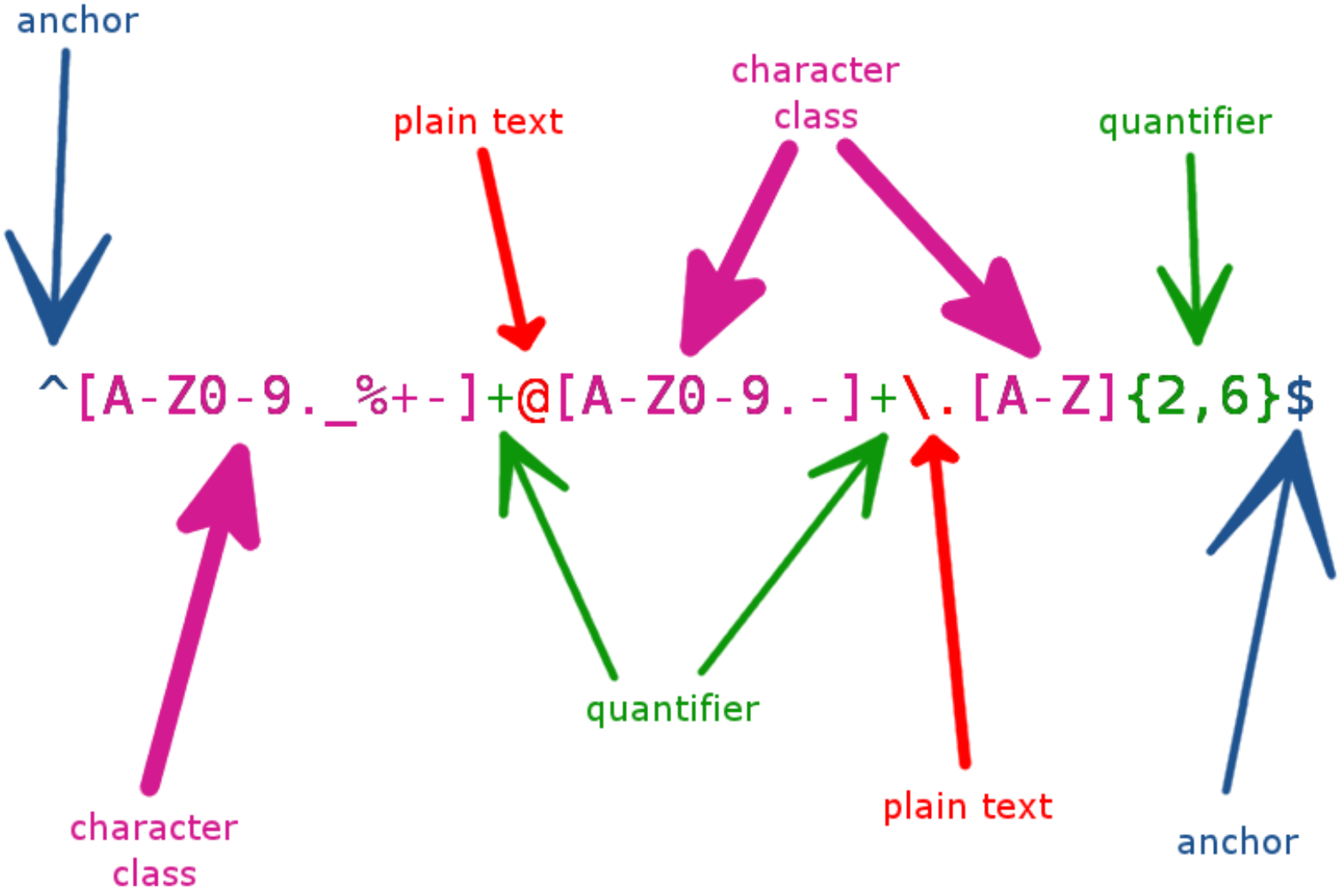
```
grep("[a-z]+", c("123", "abcdef")) #=> [1] 2
```


anchor
plain text
character class
quantifier
^[A-Z0-9._%+-]+@[A-Z0-9.-]+\.[A-Z]{2,6}$
character class
quantifier
plain text
anchor

Negating a character class

Use ^ inside a character class to **negate it**.

```
grep("[^a-z]+", c("123", "abcdef")) #=> [1] 1
```


anchor
plain text
character class
quantifier
^[A-Z0-9._%+-]+@[A-Z0-9.-]+\.[A-Z]{2,6}$
character class
quantifier
plain text
anchor

Built-in character classes

Shortcut	Expanded
\d	[0-9]
\w	[a-zA-Z0-9_]
\s	[\t\n\r\f]
\D	[^0-9]
\W	[^a-zA-Z0-9_]
\S	[^ \t\n\r\f]

A note about backslashes in R

To use built-in character classes in R, you need to **escape** the backslashes.

```
grep("\d",  c("123", "abcdef")) #=> Error!
grep("\\d", c("123", "abcdef")) #=> [1] 1
```

A note about backslashes in R (cont.)

To match a literal backslash in a regular expression in R...

```
grep("\\\\",     c("123", "123\\"))   #=> [1] 2
grep("\\\\\\\\", c("123", "123\\\\")) #=> [1] 2
```

The End