Python for scientific research

Pattern matching and text manipulation

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Course Schedule

- March 6: The basics of programming in Python
  - how to run Python code
  - data types
  - flow control
  - functions and modules

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- Today: Applying Python to simplify your life
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  - regular expressions
  - working with files
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- March 27th: Advanced subjects
  - working with data using `pandas`
  - object-oriented programming
  - automating tasks in MS-office
  - image manipulation
  - working on student-generated problems

What we've done so far

1. Declare variables using built-in data types and execute operations on them
2. Use flow control commands to dictate the order in which commands are run and when
3. Encapsulate programs into reusable functions, modules and packages
4. **Next:** working with textual data and *pattern matching*

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1 multiline = """This is a
2 multiline string"""
3 multiline2 = '''Another
4 multiline string'''
```

String literals

Different string literals identifying different types of string:

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- UTF-8 and ASCII are encodings which specify how characters translate into 0s and 1s

Example encoding: ASCII

USASCII code chart

b_7 b_6 b_5 → / Bits ↓	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4 b_3 b_2 b_1 ↓ / Row ↓ Column →	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SUB	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	{
1 1 0 0	12	FF	FS	,	<	L	\	l	|
1 1 0 1	13	CR	GS	-	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	~
1 1 1 1	15	SI	US	/	?	O	_	o	DEL

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```

- Here, `\xc3` and `\xb3` are escape sequences that together encode ç as a hex number (see UTF-8 tool)
- The original UTF-8 string can be recovered from `bytes.decode()`

```
1 back_2_utf8 = str_ascii.decode('utf-8') # back to UTF-8
2 # "Let's go to Gijón!"
```

Escaping the escape sequences

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- or by using a raw string literal (prefix: `r"..."`)

```
1 windows_path = r"C:\new_file.csv"
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  - Find/replace substrings

```
1 str_subject = "Great rockpools at Swanpool beach"
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3 str_subject.rfind("pool") # 23
4 str_subject.replace("pool","puddle")  # "Great
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  - Lots of other `str.isX()` functions available. As we see later, however, regular expressions often preferable to search for patterns in text

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3 for i in range(len(s)):
4
5     if i + 10 <= len(s):
6         if s[i:i+2].isdigit() and s[i+2] in ".-" and s[
              i+3:i+5].isdigit() and s[i+5] in ".-" and s[
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7              day = s[i:i+2]
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10             print(year + "-" + month + "-" + day)
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- Gets complicated quickly
- Breaks down for single digit months/days, e.g., `8.9.1980`

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7 # regular expression (given as a r"" [raw literal] string)
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8  all_dates = re.findall(r"(\d{1,2})[-\.](\d{1,2})[-\.](\d{4})
       ",s)
9
10 # print the result
11 for date in all_dates:
12     print(date[2] + "-" + date[1].zfill(2) + "-" + date[0].
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5 re.findall(regex, str_to_match) # ['1foo','2foo']
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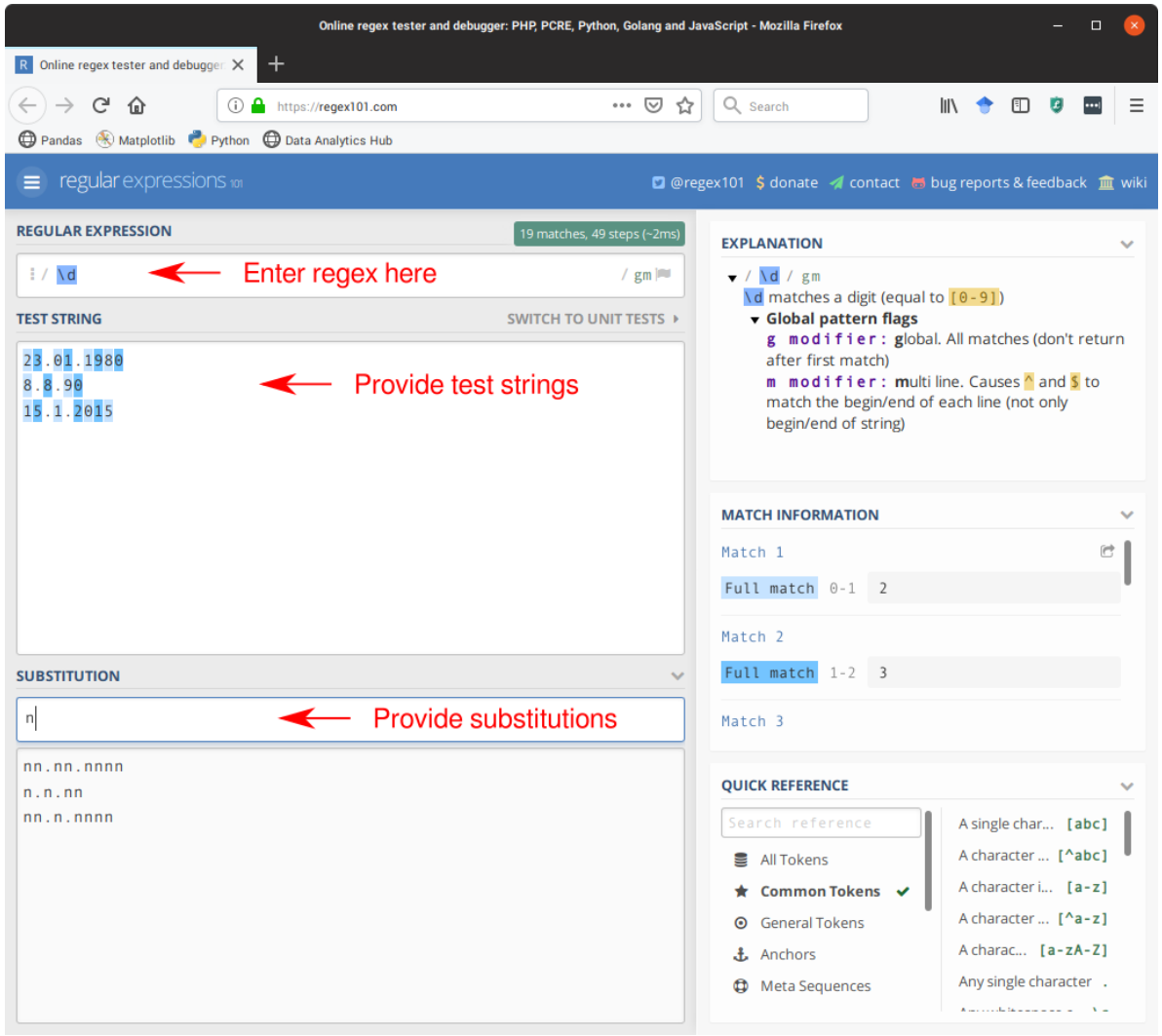
Testing regular expressions

- Practice regular expressions at https://regex101.com/



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9 re.search(regex, str_to_match) # None
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1 str_to_match = "Factor levels are 1foo, 2foo and foo"
```

Regular expressions: functions II

- `re.sub()` replaces occurrences of patterns in a string

```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 # and remembers the digit using a group ()
4 regex = r"(\d)foo" # regex
```

Regular expressions: functions II

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5 # replace foo by bar but keep the digit
6 replacement = r"\1bar" # regex
```

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4 regex = r"(\d)foo" # regex
5 # replace foo by bar but keep the digit
6 replacement = r"\1bar" # regex
7 re.sub(regex, replacement, str_to_match) # Factor
      levels are 1bar, 2bar and foo
```

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- Everything within `()` (a group) is stored in memory

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- Everything within `()` (a group) is stored in memory
- Group contents can be recalled in the replacement, using `\1`,`\2`,`\3`, etc

Regular expressions: syntax

The syntax for different patterns:

- `\d` matches any character that is a digit

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```
1 str_to_match = "Factor levels are snafoo, foosna and
      foo"
```

Regular expressions: syntax

The syntax for different patterns:

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```
1 str_to_match = "Factor levels are snafoo, foosna and
      foo"
2 regex = r"\bfoo\b" # regex
```

Regular expressions: syntax

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- `\d` matches any character that is a digit
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- `\b` matches a word boundary

```
1 str_to_match = "Factor levels are snafoo, foosna and
      foo"
2 regex = r"\bfoo\b" # regex
3 m = re.search(regex, str_to_match) # Factor levels are
      snafoo, foosna and bar
```

Regular expressions: syntax

The syntax for different patterns:

- `\d` matches any character that is a digit
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4 m.group(0) # obtain the complete match
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4 m.group(0) # obtain the complete match
5 m.start() # Match position in string: 37
```

Regular expressions: syntax

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1 str_to_match = "Factor levels are snafoo, foosna and
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3 m = re.search(regex, str_to_match) # Factor levels are
      snafoo, foosna and bar
4 m.group(0) # obtain the complete match
5 m.start() # Match position in string: 37
```

- `\B` does not match a word boundary

Regular expressions: syntax II

The syntax for different patterns:

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```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(regex, str1)
4 m.start() # match position in string: 0
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(regex, str1)
4 m.start() # match position in string: 0
```

- $ matches end of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"foo$" # regex matching the last foo
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
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1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(regex, str1)
4 m.start() # match position in string: 0
```

- $ matches end of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"foo$" # regex matching the last foo
3 m = re.search(regex, str1)
4 m.start() # match position in string: 14
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(regex, str1)
4 m.start() # match position in string: 0
```

- $ matches end of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"foo$" # regex matching the last foo
3 m = re.search(regex, str1)
4 m.start() # match position in string: 14
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
1 str1 = "the number 60 is larger than 59"
2 regex = r"[0-5][0-9]" # matches 00 to 59
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
1 str1 = "the number 60 is larger than 59"
2 regex = r"[0-5][0-9]" # matches 00 to 59
3 m = re.search(regex, str1)
4 m.group(0) # '59'
```

- `[^...]` matches characters not in the range

```
1 seq1 = "cccgggtaacccg"
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
str1 = "the number 60 is larger than 59"
regex = r"[0-5][0-9]" # matches 00 to 59
m = re.search(regex, str1)
m.group(0) # '59'
```

- `[^...]` matches characters not in the range

```
seq1 = "cccgggtaacccg"
regex = r"[^cg]" # do not match c or g
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
str1 = "the number 60 is larger than 59"
regex = r"[0-5][0-9]" # matches 00 to 59
m = re.search(regex, str1)
m.group(0) # '59'
```

- `[^...]` matches characters not in the range

```
seq1 = "cccgggtaacccg"
regex = r"[^cg]" # do not match c or g
m = re.search(regex, seq1)
m.group(0)  # 't', first match when using re.search()
```

Regular expressions: repetitions

Specify number of times patterns are matched

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- $*$ matches preceding regex 0 or more times

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1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
```

Regular expressions: repetitions

Specify number of times patterns are matched

- $*$ matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(str1,regex) #  ['', '', '', '', '', '', '',
      '', '60', '', '500', '', '', '', '', '', '3000', '']
```

Regular expressions: repetitions

Specify number of times patterns are matched

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1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
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1 str1 = "numbers 60, 500 and 3000"
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      '', '60', '', '500', '', '', '', '', '', '3000', '']
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- $?$ matches preceding regex 0 or 1 times

Regular expressions: repetitions

Specify number of times patterns are matched

- * matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(str1,regex) #  ['', '', '', '', '', '', '',
      '', '60', '', '500', '', '', '', '', '', '3000', '']
```

- + matches preceding regex 1 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d+" # matches 1 or more occurrences of
      numbers
3 re.findall(str1,regex) #  ['60', '500', '3000']
```

- ? matches preceding regex 0 or 1 times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d?" # matches 0 or 1 occurrences of numbers
```

Regular expressions: repetitions

Specify number of times patterns are matched

- * matches preceding regex 0 or more times

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1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(str1,regex) #  ['', '', '', '', '', '', '',
      '', '60', '', '500', '', '', '', '', '', '3000', '']
```

- + matches preceding regex 1 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d+" # matches 1 or more occurrences of
      numbers
3 re.findall(str1,regex) #  ['60', '500', '3000']
```

- ? matches preceding regex 0 or 1 times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d?" # matches 0 or 1 occurrences of numbers
3 re.findall(str1,regex) # ['', '', '', '', '', '', '',
      '', '6', '0', '', '', '5', '0', '0', '', '', '', '',
       '', '3', '0', '0', '0', '']
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(str1,regex) # ['60', '500', '3000', '5000']
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Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

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1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(str1,regex) # ['60', '500', '3000', '5000']
```

- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

Regular expressions: repetitions continued

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- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}?" # matches numbers of 2 to 4 digits,
      favoring minimal numbers
```

Regular expressions: repetitions continued

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2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(str1,regex) # ['60', '500', '3000', '5000']
```

- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

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1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}?" # matches numbers of 2 to 4 digits,
      favoring minimal numbers
3 re.findall(str1,regex) # ['60', '50', '30', '00', '50',
      '00']
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

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2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(str1,regex) # ['60', '500', '3000', '5000']
```

- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

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1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}?" # matches numbers of 2 to 4 digits,
      favoring minimal numbers
3 re.findall(str1,regex) # ['60', '50', '30', '00', '50',
      '00']
```

Regex exercise

- Use https://regex101.com/ to write dates in `"23.01.1980,29-03-2019"` as `"1980-01-23,2019-03-29"`

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Regex exercise

- Use https://regex101.com/ to write dates in "23.01.1980,29-03-2019" as "1980-01-23,2019-03-29"
- Then try to do it in Python
- In Python, that is:

```
1 two_dates = "23.01.1980,29-03-2019"
2 date_regex = r"(\d{1,2})[\.-](\d{1,2})[\.-](\d{2,4})"
3 date_substitution = r"\3-\2-\1"
4 re.sub(date_regex, date_substitution, two_dates)
5 # 23-01-1980,29-3-2019
```

Another regex exercise

- Use https://regex101.com/ to match the words 'pit', 'spot', 'spate', but not 'pt', 'Pot', 'peat', 'part'

```
regex = r"s?p(i|o|a)te?"
```