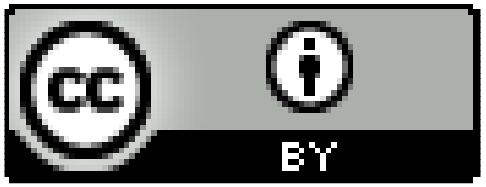
Python

First-Class Functions



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This turns out to be very useful, and very powerful

What happens when a function is defined

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def threshold(signal):
  return 1.0 / sum(signal)
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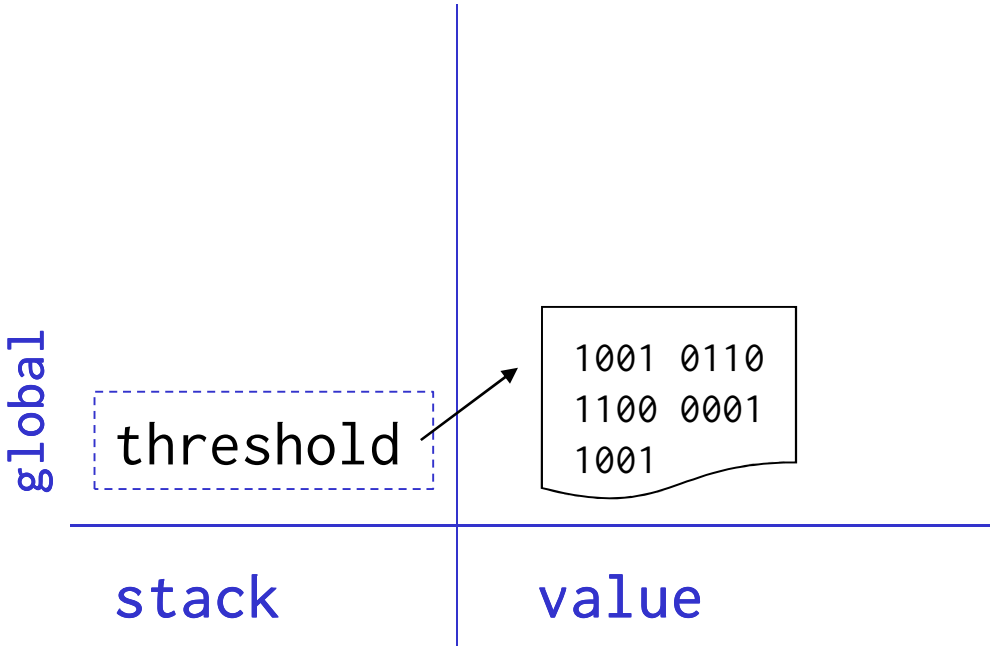
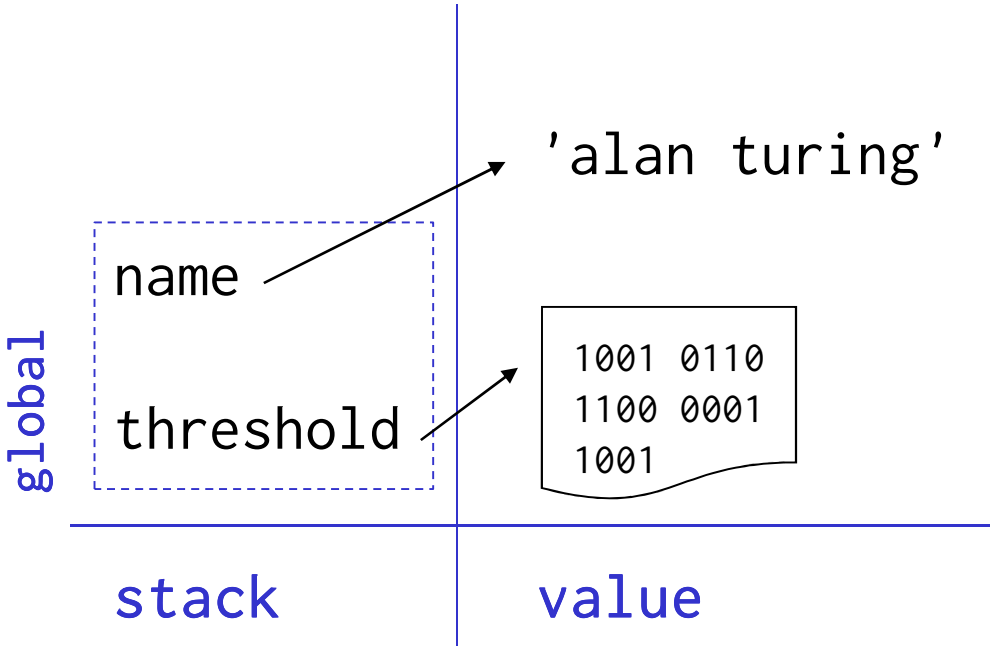


What happens when a function is defined

```
def threshold(signal):
  return 1.0 / sum(signal)
```

Not really very different from:

```
name = 'Alan Turing'
```



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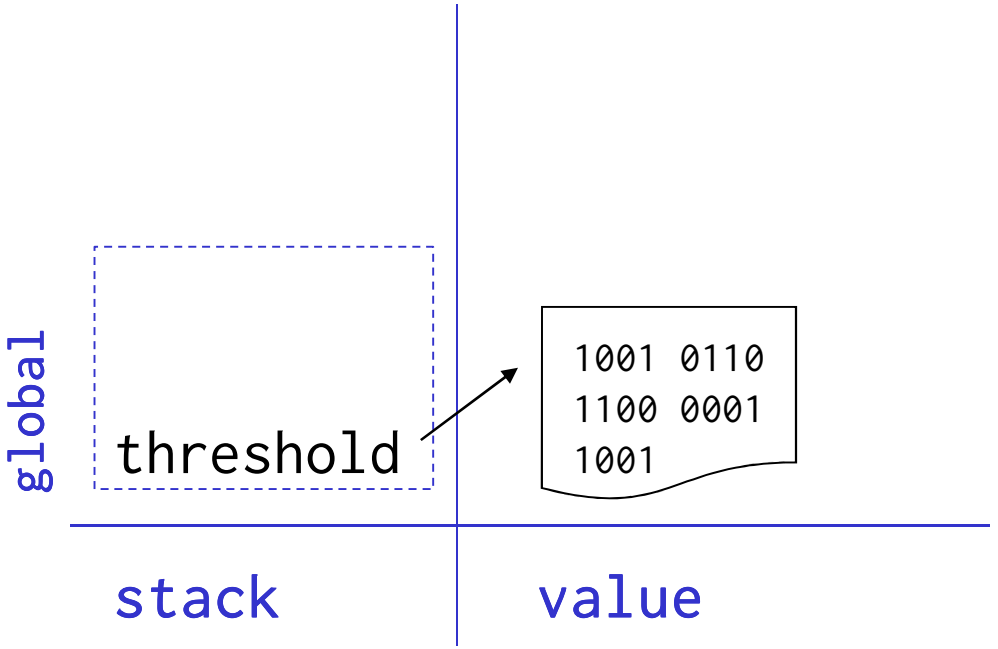

Can assign that value to another variable

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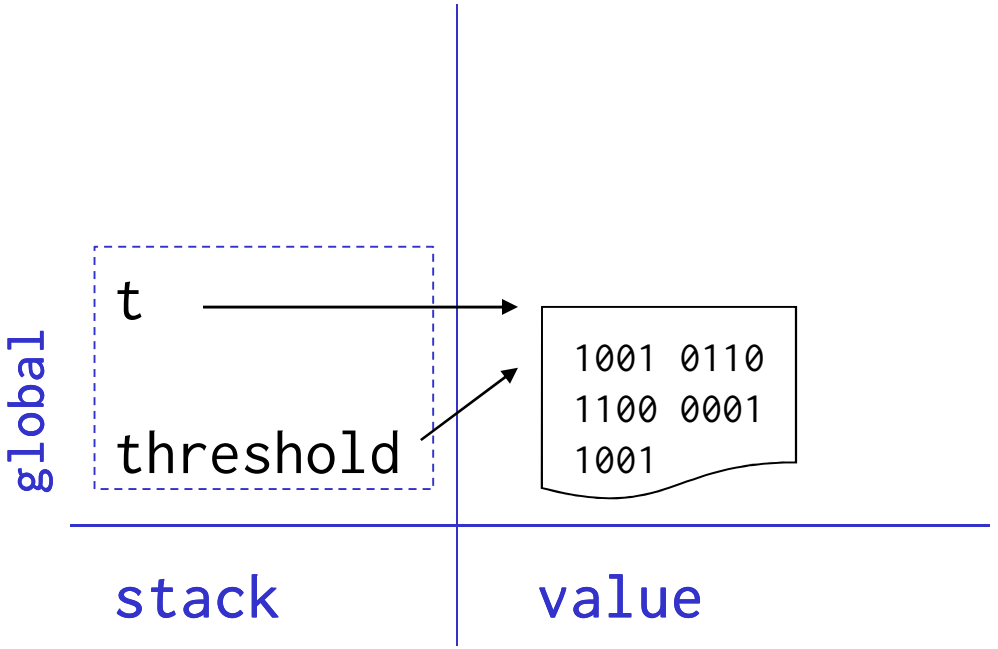
def threshold(signal):
  return 1.0 / sum(signal)

t = threshold
```

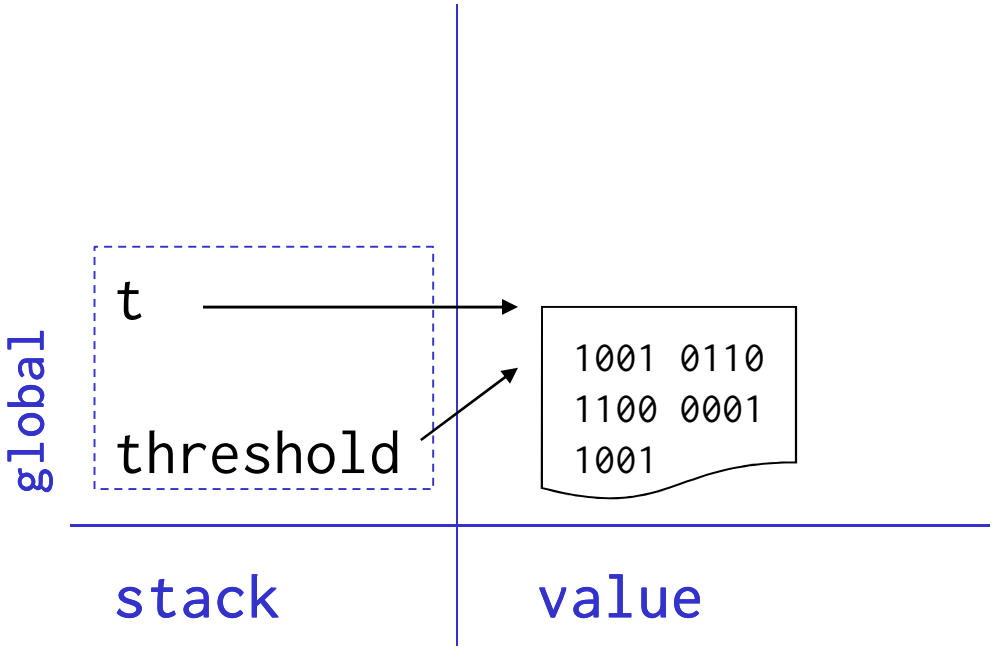


Can assign that value to another variable

```
def threshold(signal):
  return 1.0 / sum(signal)

t = threshold
print t([0.1, 0.4, 0.2])
```

1.42857



Can put (a reference to) the function in a list

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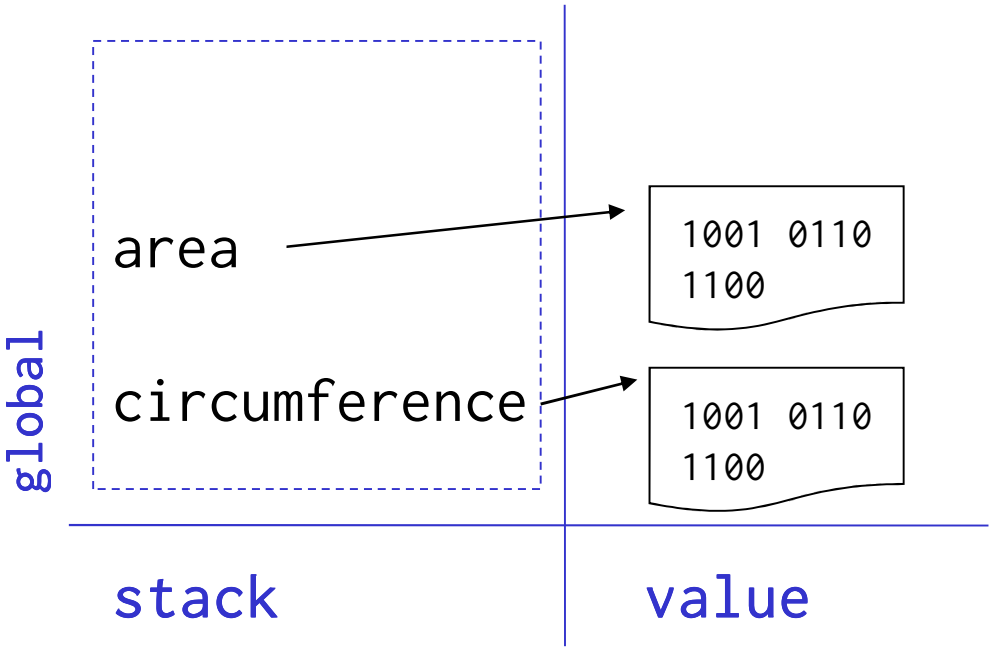
```
def area(r):
  return PI * r * r

def circumference(r):
  return 2 * PI * r
```



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def area(r):
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funcs = [area, circumference]
```

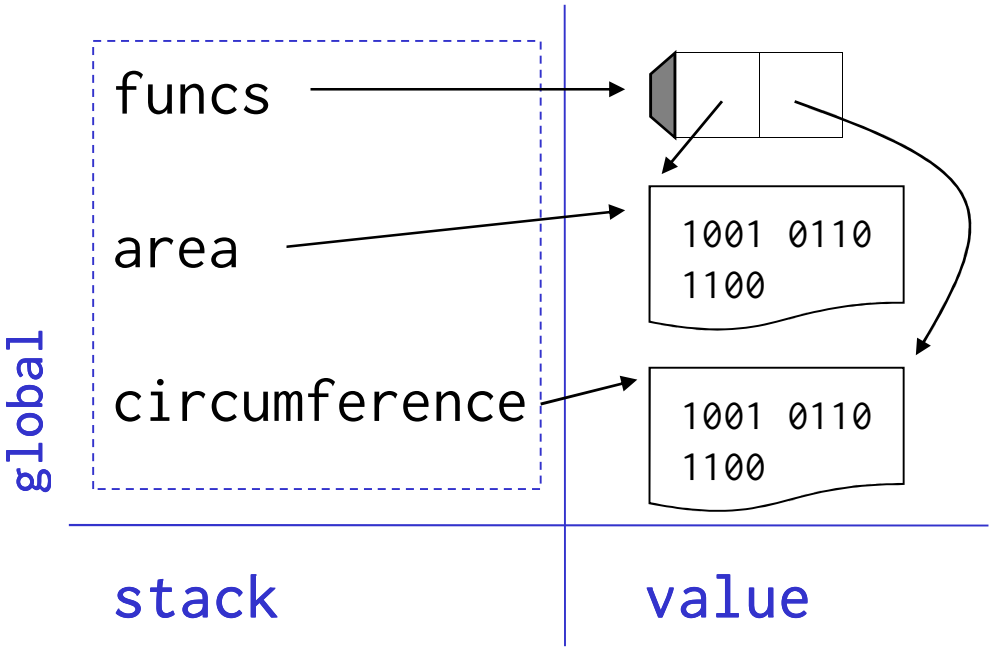

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funcs = [area, circumference]

for f in funcs:
  print f(1.0)
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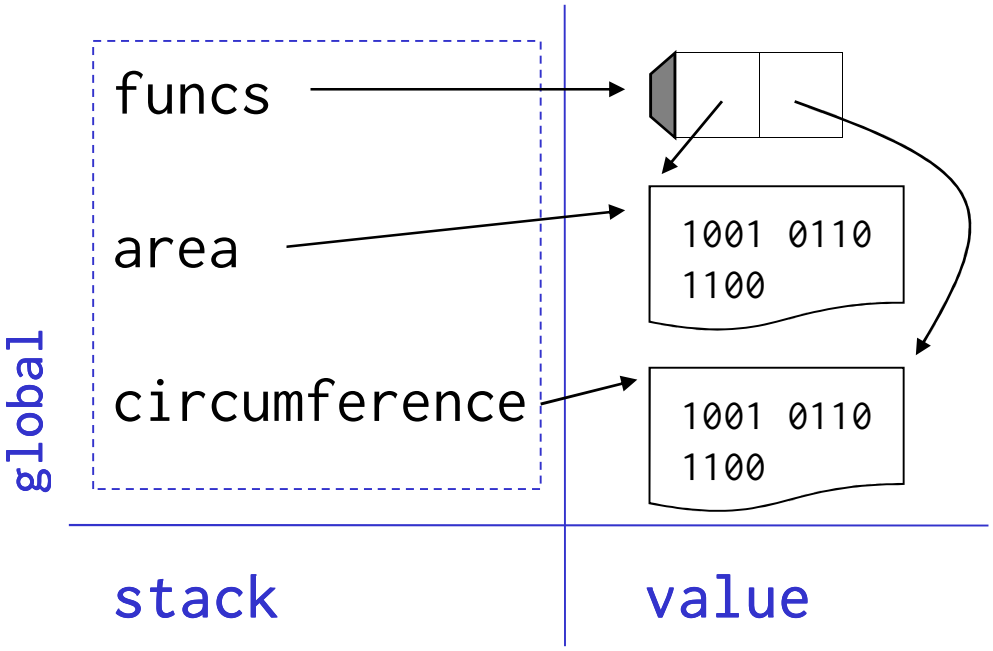

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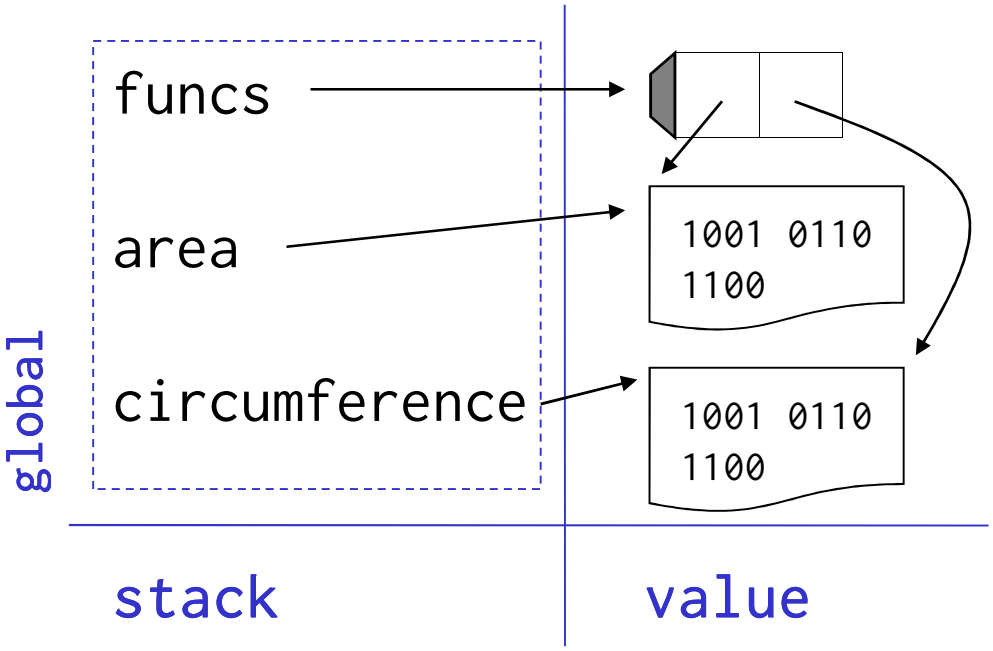
```

```
3.14159
6.28318
```



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def do_all(func, values):
  result = []
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    temp = func(v)
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print do_all(area, [1.0, 2.0, 3.0])
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print do_all(area, [1.0, 2.0, 3.0])
[3.14159, 12.56636, 28.27431]
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print do_all(area, [1.0, 2.0, 3.0])
[3.14159, 12.56636, 28.27431]
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```
def slim(text):
  return text[1:-1]
```

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def do_all(func, values):
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print do_all(area, [1.0, 2.0, 3.0])
```

```
[3.14159, 12.56636, 28.27431]
```

```
def slim(text):
  return text[1:-1]

print do_all(slim, ['abc', 'defgh'])
```

```
b efg
```

Higher-order functions allow re-use of control flow

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```
def combine_values(func, values):
  current = values[0]
  for i in range(1, len(values)):
    current = func(current, v)
  return current
```

Higher-order functions allow re-use of control flow

```
def combine_values(func, values):
  current = values[0]
  for i in range(1, len(values)):
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def add(x, y): return x + y
def mul(x, y): return x * y
```

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def combine_values(func, values):
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def add(x, y): return x + y
def mul(x, y): return x * y

print combine_values(add, [1, 3, 5])
9
```

Higher-order functions allow re-use of control flow

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def combine_values(func, values):
  current = values[0]
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def add(x, y): return x + y
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print combine_values(add, [1, 3, 5])
9
print combine_values(mul, [1, 3, 5])
15
```

Without higher order functions

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	op_1	op_2	op_3
data_structure_A	do_1A	do_2A	do_3A
data_structure_B	do_1B	do_2B	do_3B
data_structure_C	do_1C	do_2C	do_3C

Without higher order functions

	op_1	op_2	op_3
data_structure_A	do_1A	do_2A	do_3A
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total: 9

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total: 9

With higher order functions

	op_1	op_2	op_3
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total: 6

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```
def add_all(*args):
  total = 0
  for a in args:
    total += a
  return total
```

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Like ~~number of arguments~~

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def add_all(*args):
  total = 0
  for a in args:
    total += a
  return total

print add_all()
```

```
0
```

Must need to know *something* about the function

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Like ~~number of arguments~~

```
def add_all(*args):
  total = 0
  for a in args:
    total += a
  return total

print add_all()
0
print add_all(1, 2, 3)
6
```

Combine with "regular" parameters

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def combine_values(func, *values):
  current = values[0]
  for i in range(1, len(values)):
    current = func(current, v)
  return current
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Combine with "regular" parameters

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What does `combine_values(add)` do?

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  current = values[0]
  for i in range(1, len(values)):
    current = func(current, v)
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print combine_values(add, 1, 3, 5)
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```

What does `combine_values(add)` do?

What *should* it do?

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```
def positive(x): return x >= 0
print filter(positive, [-3, -2, 0, 1, 2])
```

```
[0, 1, 2]
```

`filter(F, S)`	select elements of `S` for which `F` is `True`
`map(F, S)`	apply `F` to each element of `S`
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```
def positive(x): return x >= 0
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```

```
[0, 1, 2]
```

```
def negate(x): return -x
print map(negate, [-3, -2, 0, 1, 2])
```

```
[3, 2, 0, -1, -2]
```

`filter(F, S)`	select elements of `S` for which `F` is `True`
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print filter(positive, [-3, -2, 0, 1, 2])
```
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[0, 1, 2]
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def negate(x): return -x
print map(negate, [-3, -2, 0, 1, 2])
```
```
[3, 2, 0, -1, -2]
```

```
def add(x, y): return x+y
print reduce(add, [-3, -2, 0, 1, 2])
```
```
-2
```

What is programming?

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Hard to understand what meta-meta-functions actually *do*

created by

Greg Wilson

October 2010