Practical Computing for Scientists

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CSCI 2000U

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UNIVERSITY
OF ONTARIO
INSTITUTE OF TECHNOLOGY

Python

Aliasing

by Greg Wilson

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Because the data can't change

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Often easier (and more useful) than making a second copy

If the data is immutable, aliases don't matter

Because the data can't change

But if data can change, aliases can result in a lot of hard-to-find bugs

Aliasing happens whenever one variable's value is assigned to another variable

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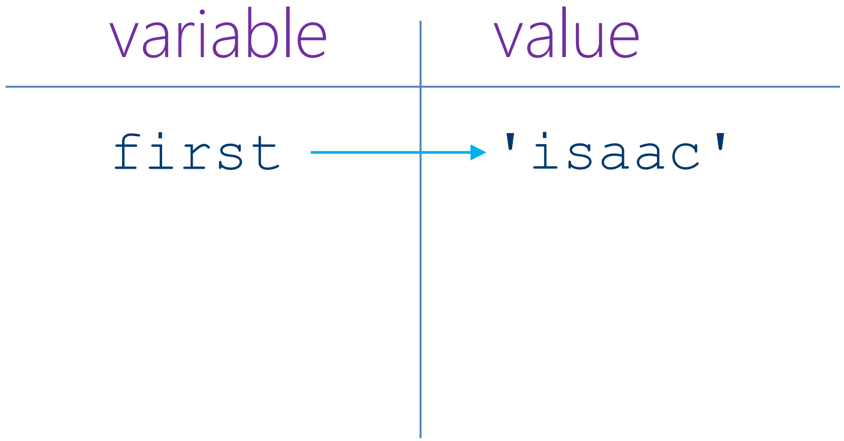
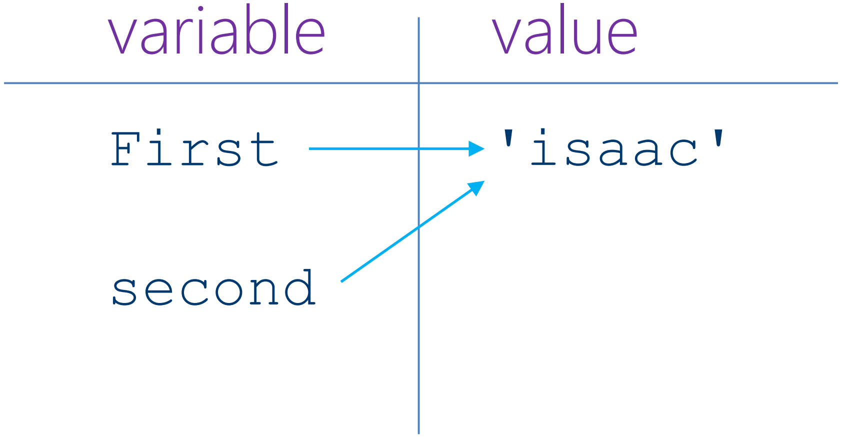
```
first = 'isaac'
```



Aliasing happens whenever one variable's value is assigned to another variable

```
first = 'isaac`
second = first
```

But as we've already seen…



variable

value

First

'isaac'

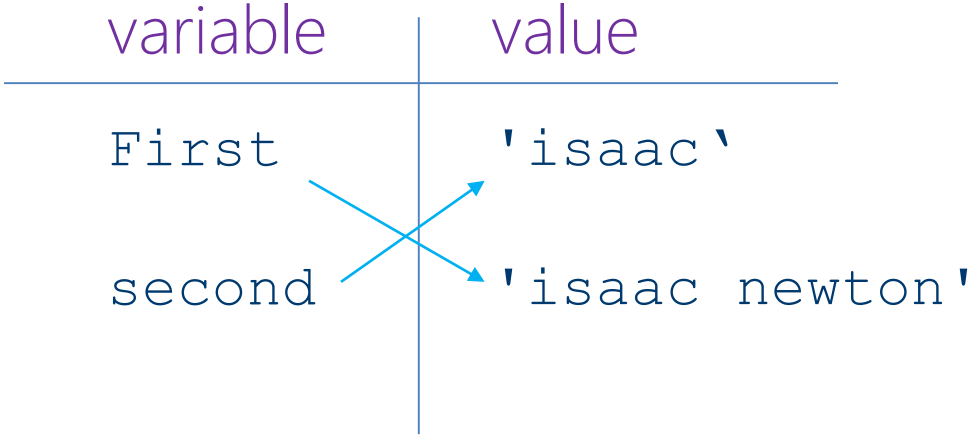
second

Aliasing happens whenever one variable's value is assigned to another variable

```
first = 'isaac`
second = first
```

But as we've already seen…

```
first = first + ' newton'
```



But lists are mutable

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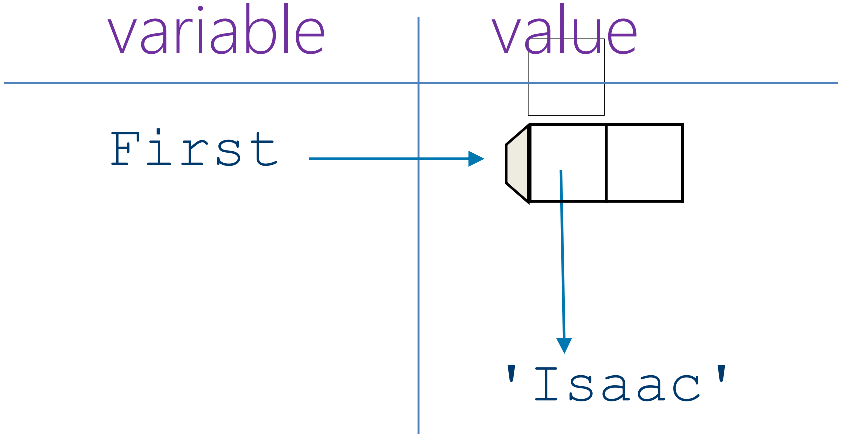
```
first = ['isaac']
```



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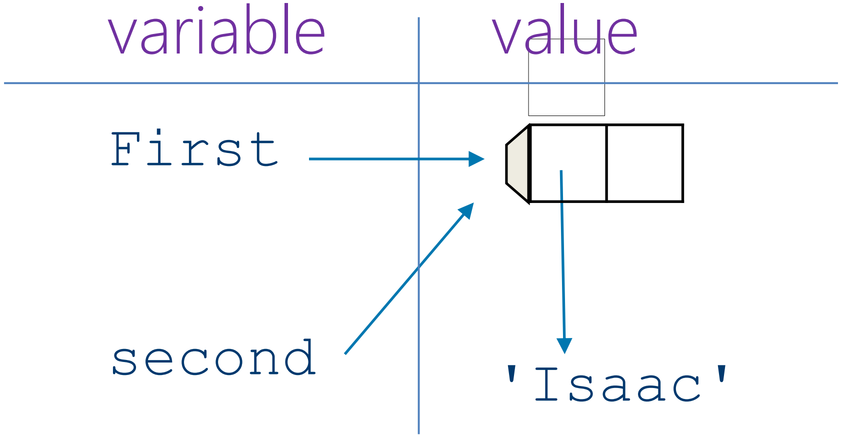
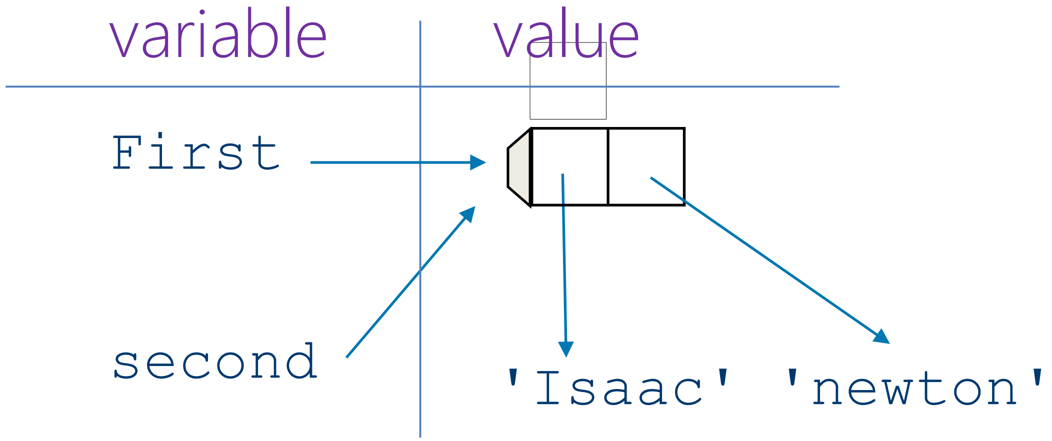


But lists are mutable

```
first = ['isaac']
second = first
first = first.append('newton')
print(first)
['isaac', 'newton']
```



variable

value

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second

'Isaac'

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But lists are mutable

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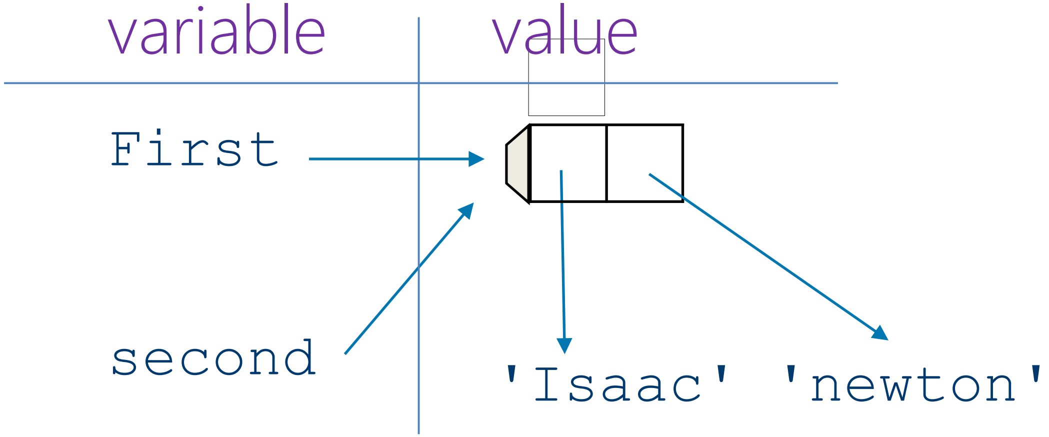
print(first)
['isaac', 'newton']
print(second)
['isaac', 'newton']
```



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print(second)
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Didn't explicitly

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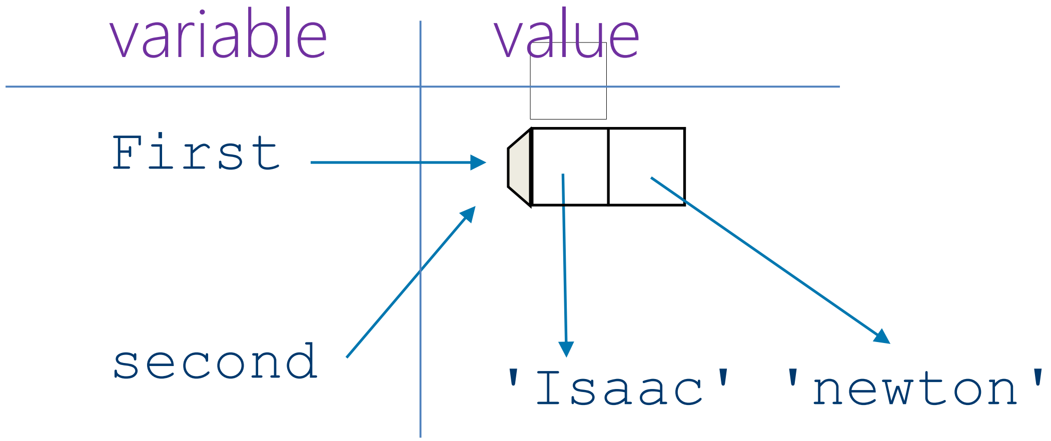

variable

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First

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'Isaac'

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But lists are mutable

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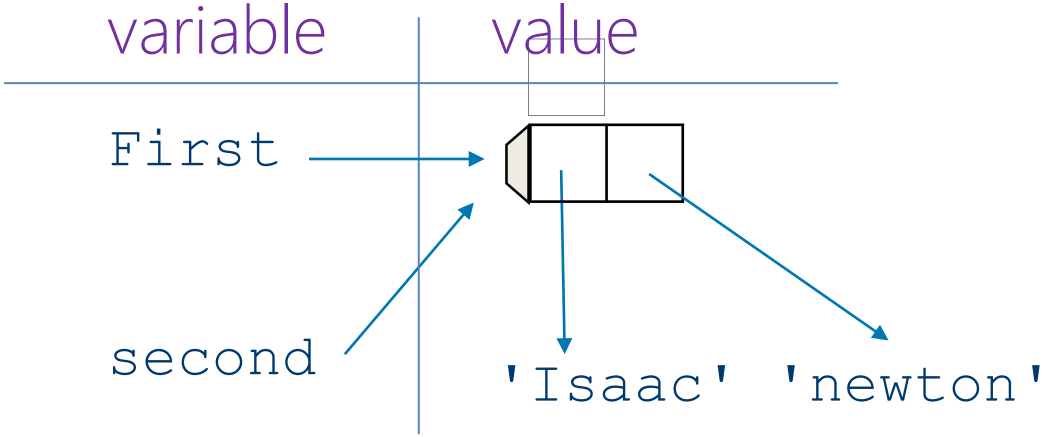
A side effect



Example: use lists of lists to implement a 2D grid

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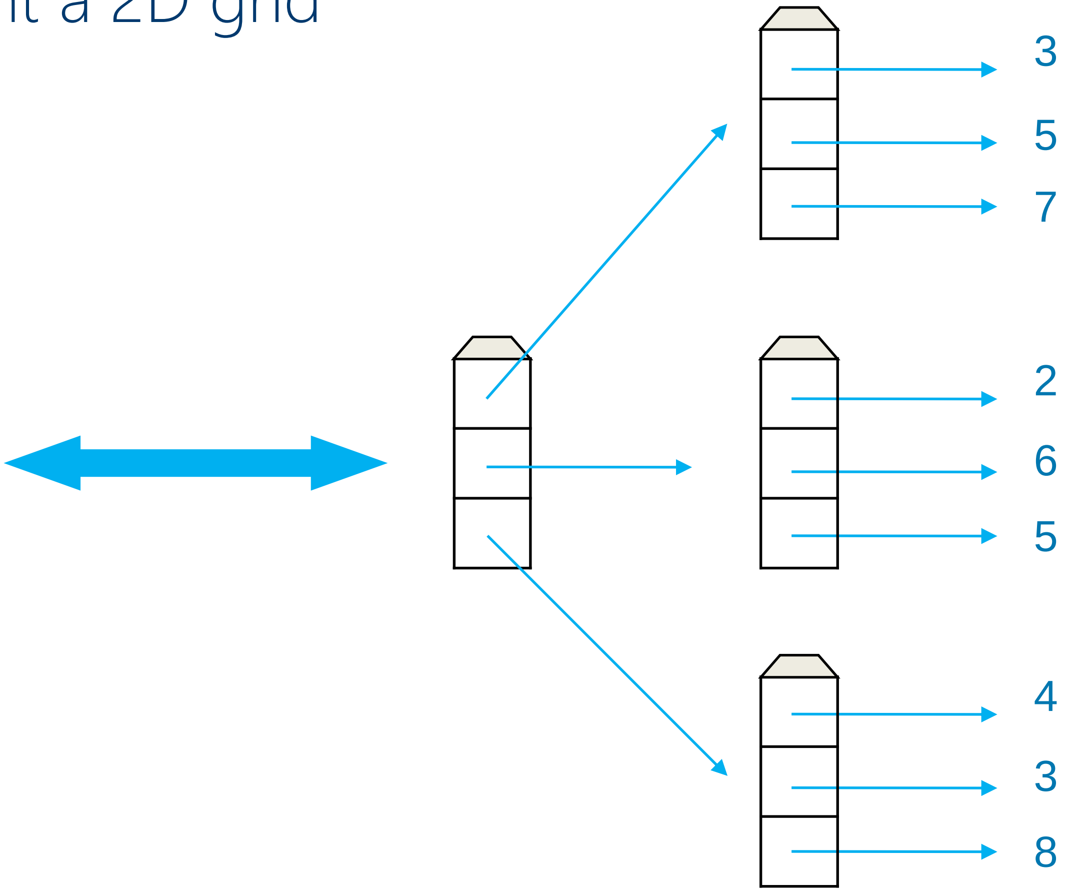
7	5	8
5	6	3
3	2	4



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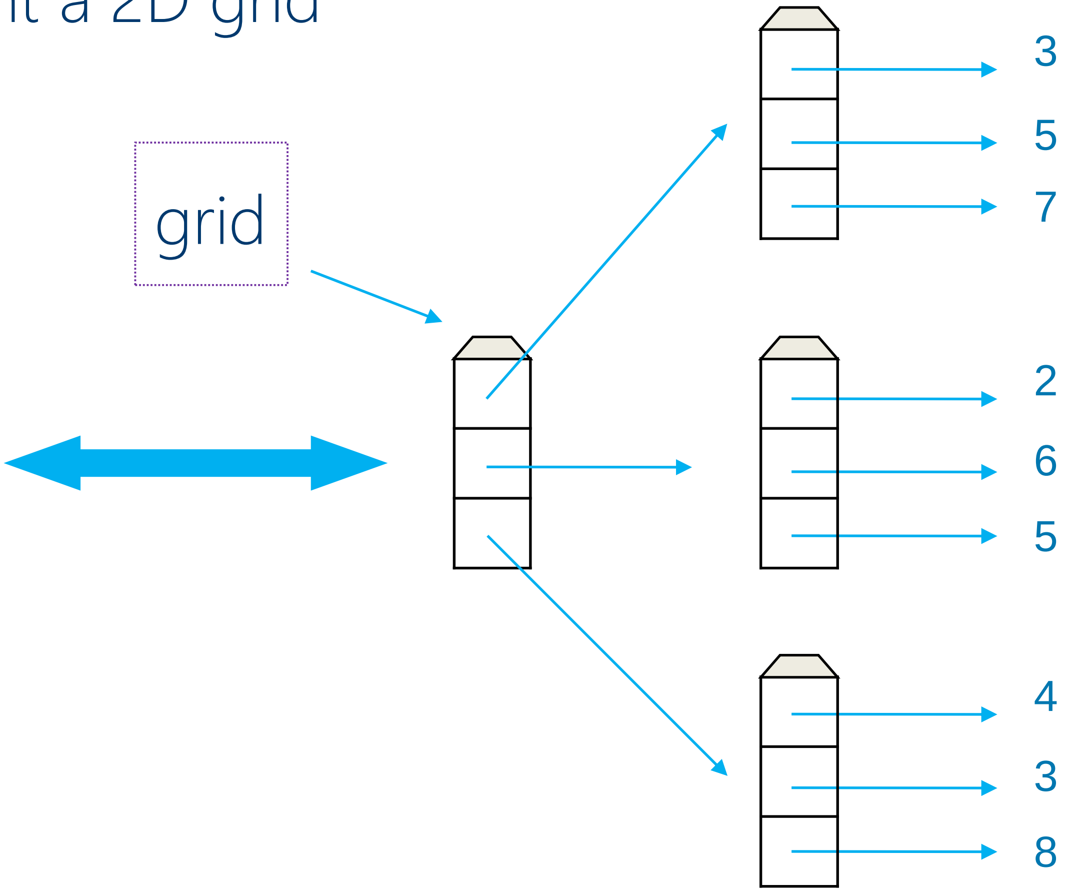

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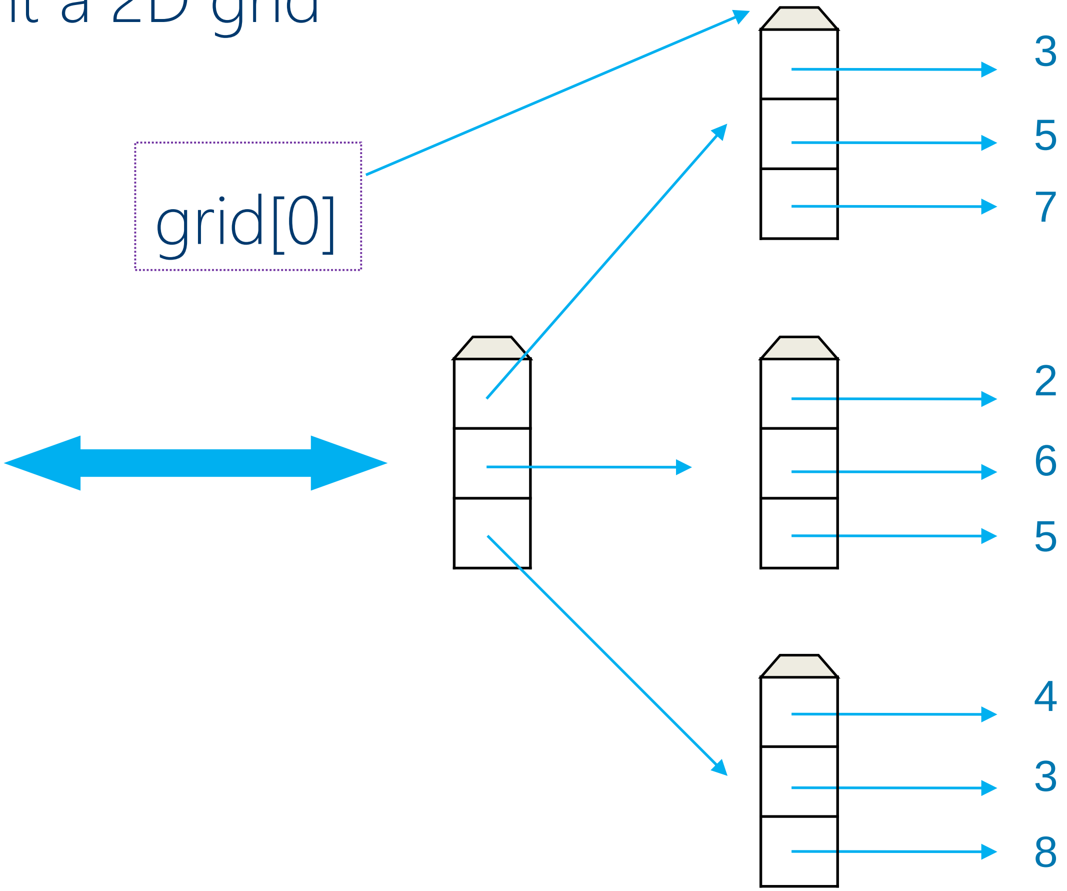

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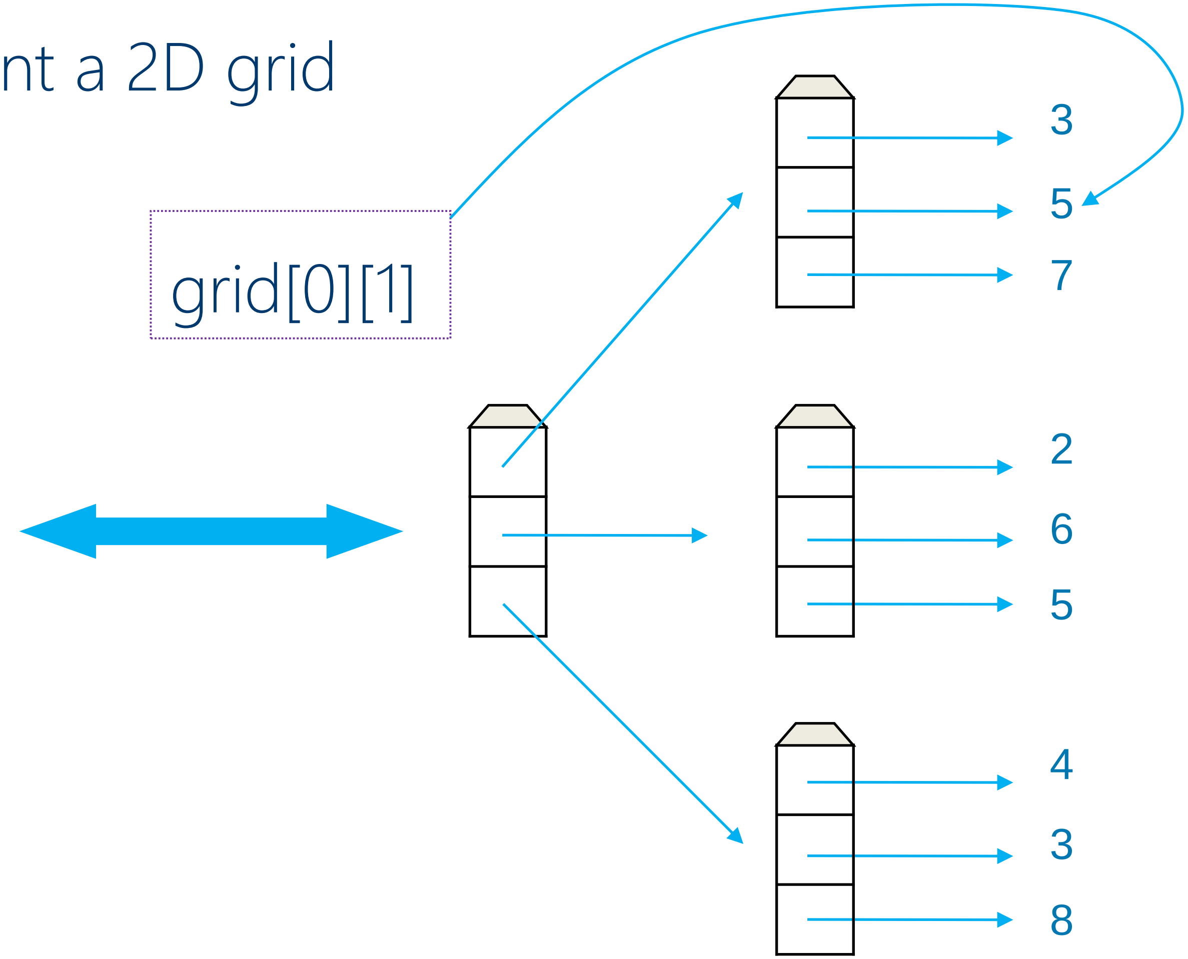

grid[0][1]

```
# Correct code
grid = []
for x in range(N):
  temp = []
  for y in range(N):
    temp.append(1)
  grid.append(temp)
```

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grid = []
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```

Outer "spine" of structure

```
# Correct code
grid = []
for x in range(N):
    temp = []
    for y in range(N):
        temp.append(1)
    grid.append(temp)
```

Add N sub-lists to outer list

```
# Correct code
grid = []
for x in range(N):
  temp = []
  for y in range(N):
    temp.append(1)
  grid.append(temp)
```

Create a sublist of N 1's

```
# Equivalent code
grid = []
for x in range(N):
  grid.append([])
  for y in range(N):
    grid[-1].append(1)
```

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grid = []
for x in range(N):
  grid.append([])
  for y in range(N):
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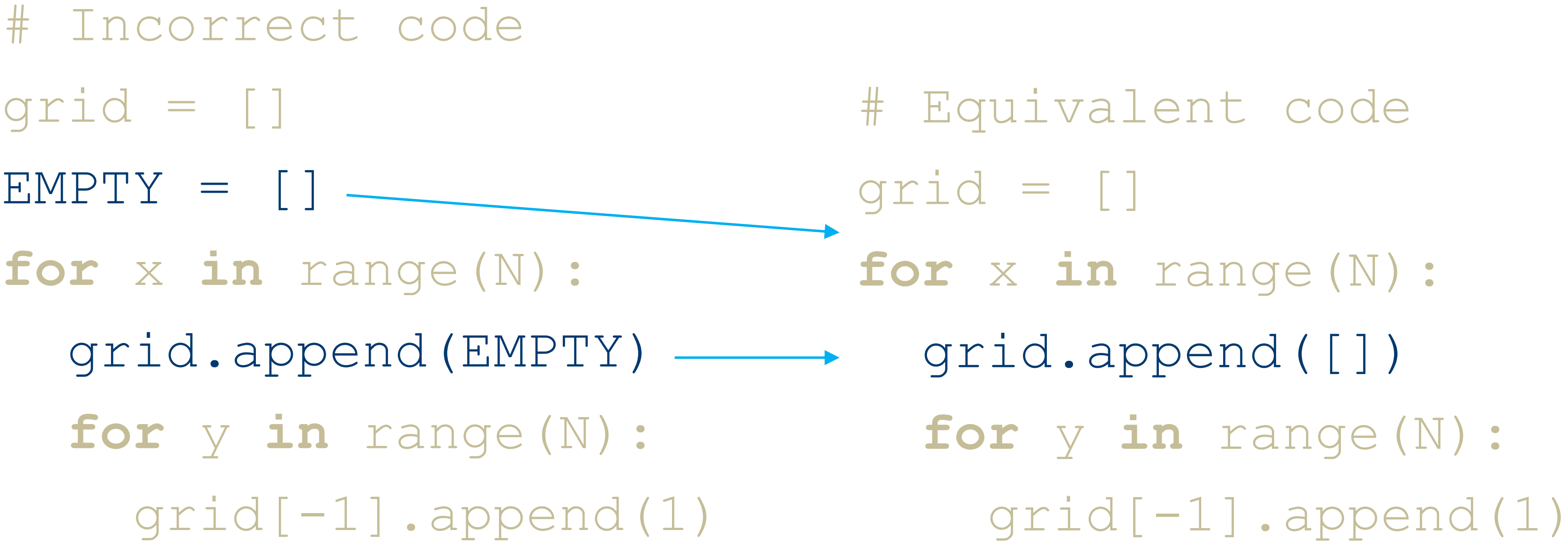
```

Last element of outer list is the sublist currently being filled in

```
# Incorrect code
grid = []
EMPTY = []
for x in range(N):
  grid.append(EMPTY)
  for y in range(N):
    grid[-1].append(1)
```



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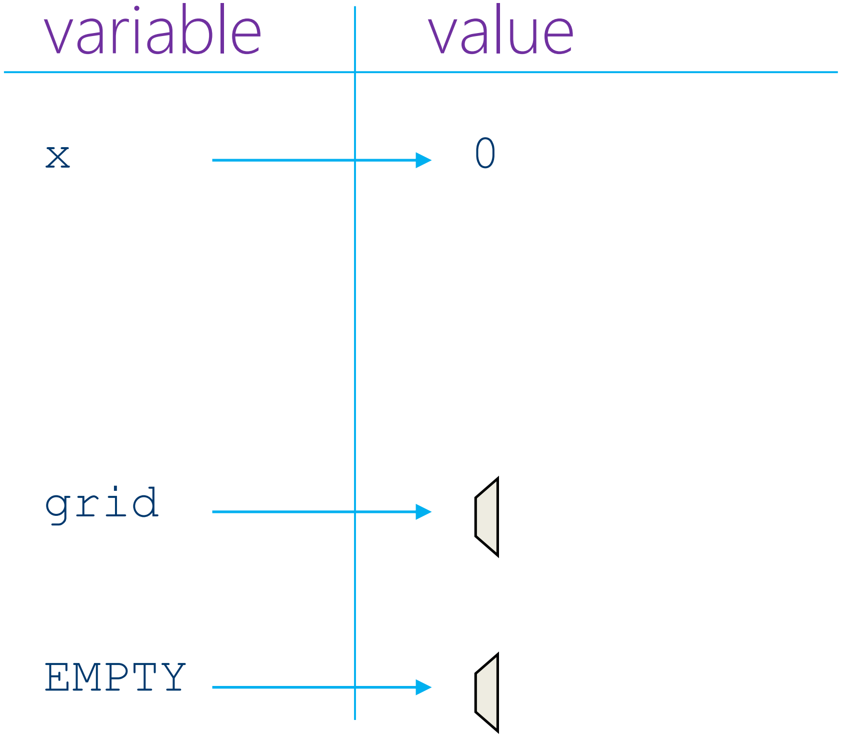
```

Aren't meaningful variable names supposed to be a good thing?



variable

value

x

0

grid

EMPTY

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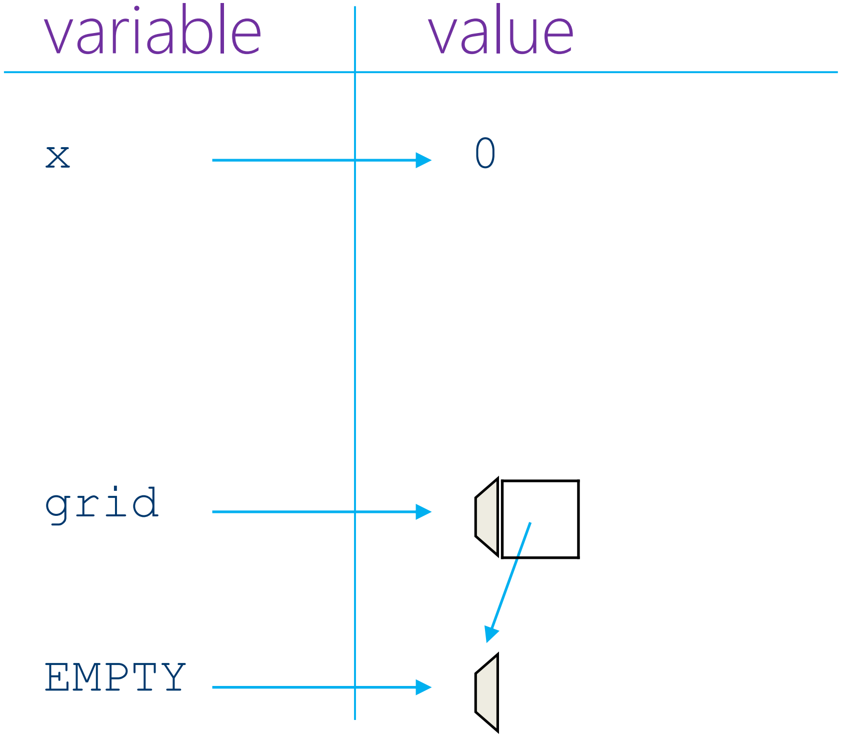

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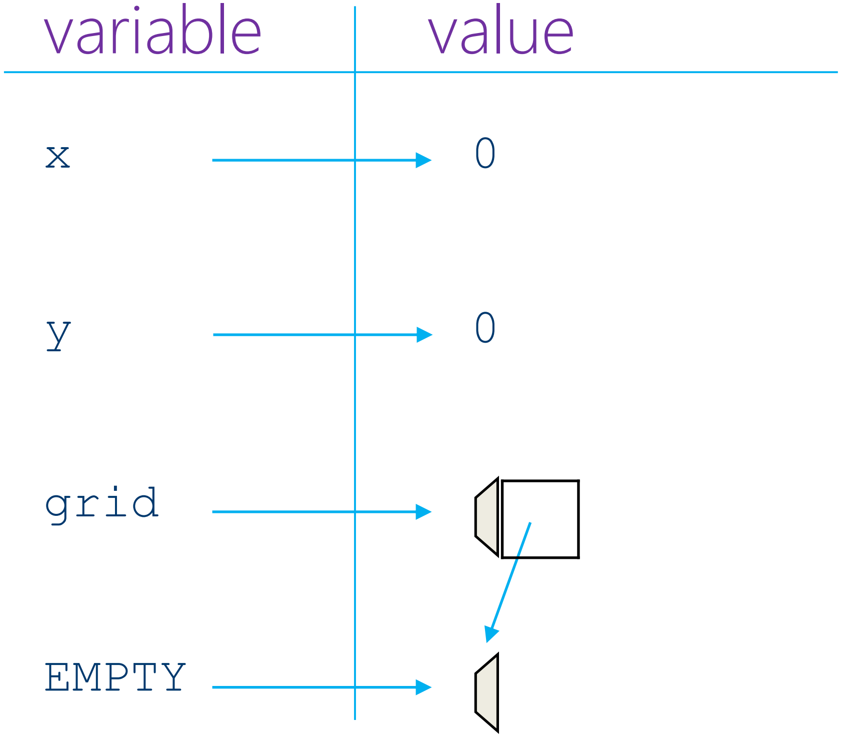

variable

value

x

0

y

0

grid

EMPTY

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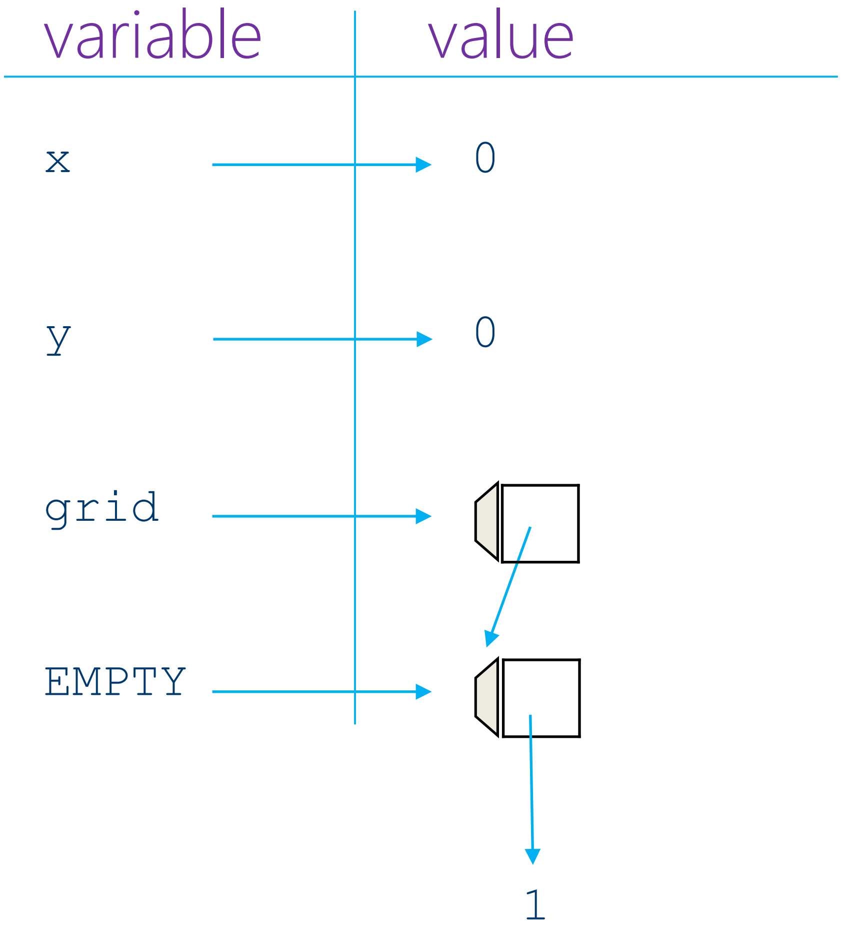

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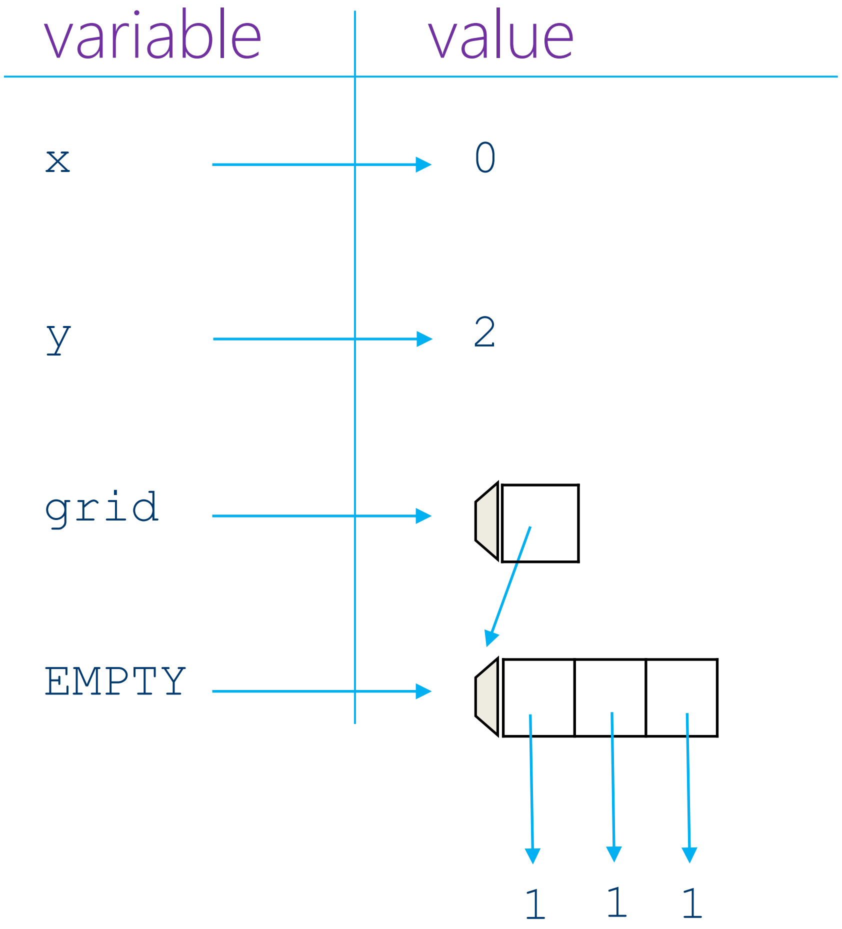

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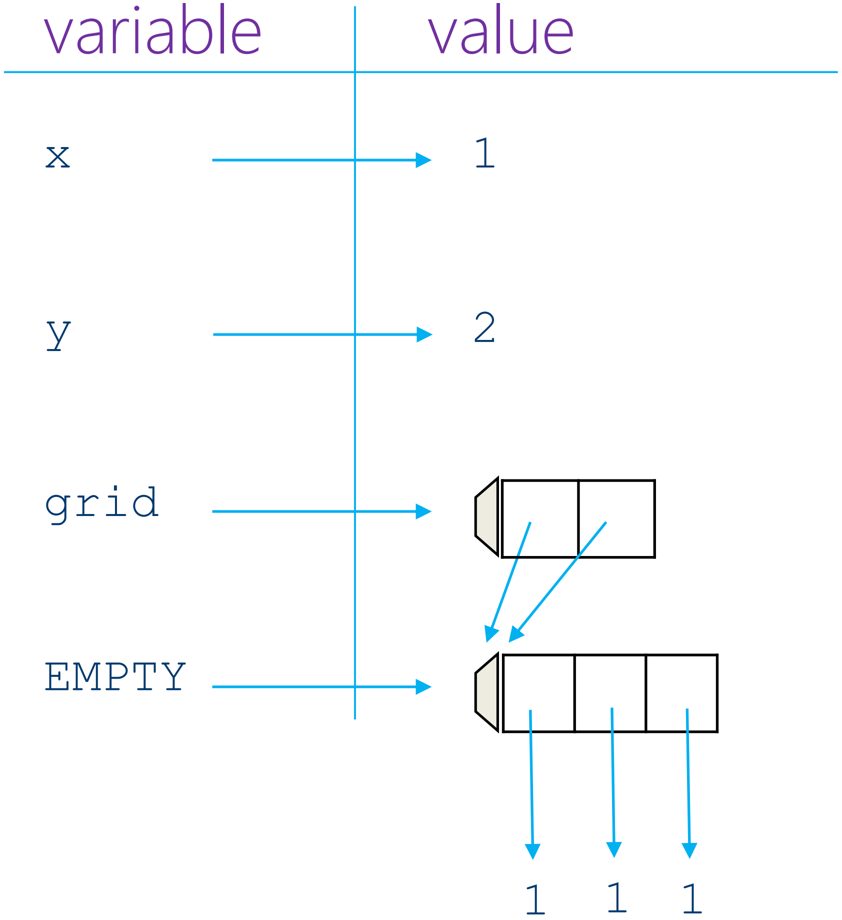

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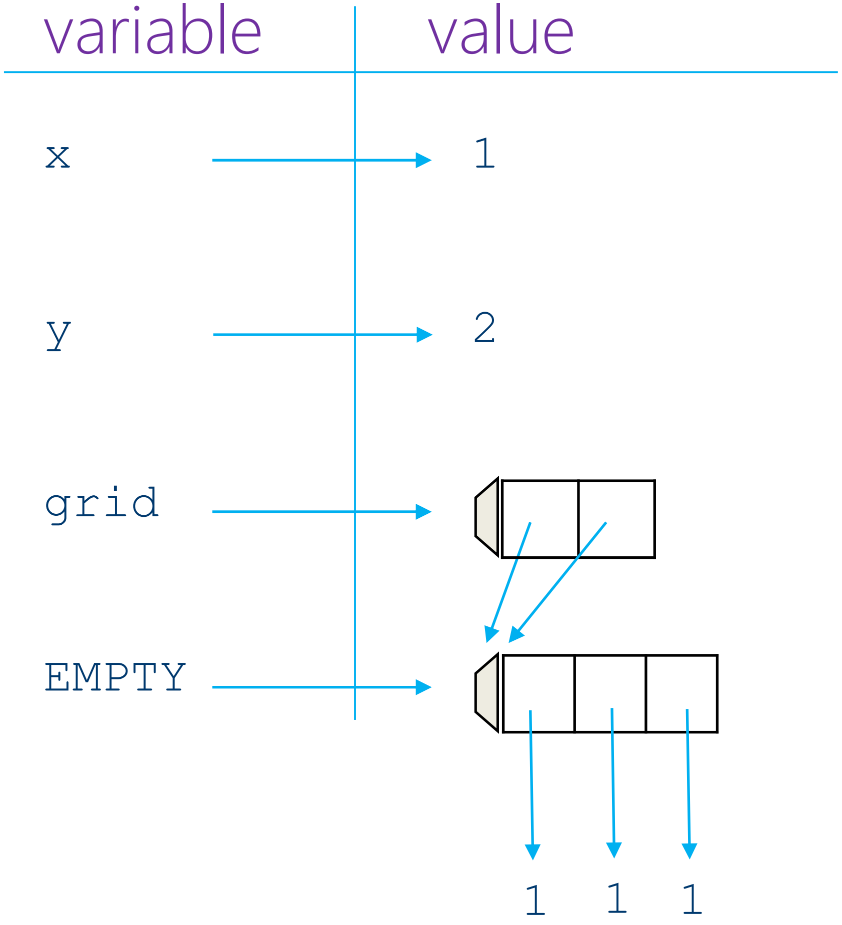

variable

value

x

1

y

2

grid

EMPTY

1 1 1

```
grid = []
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```

You see the problem…

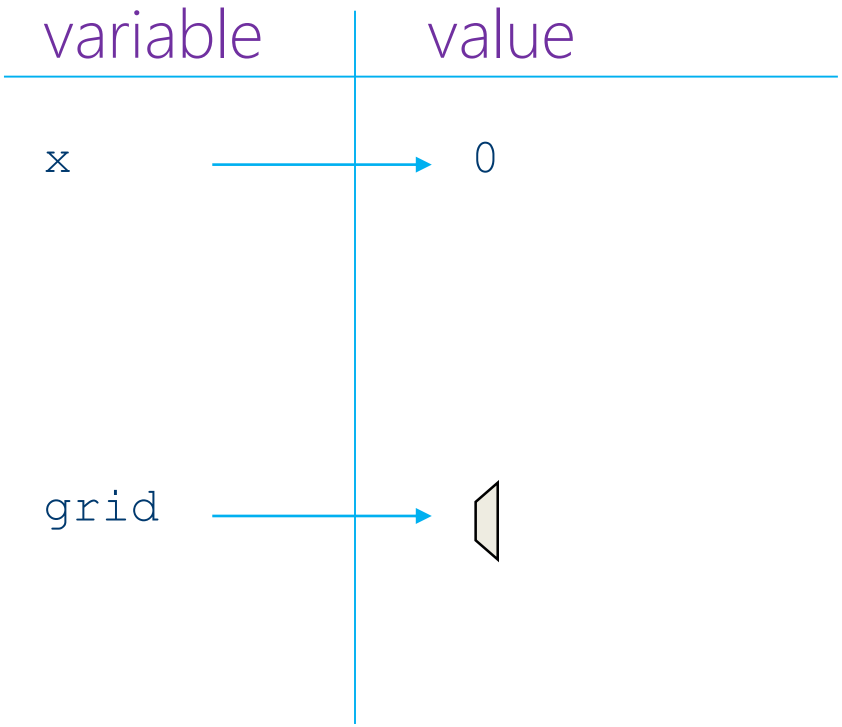
No Aliasing

```
first = []

second = []
```

No Aliasing	Aliasing

`first = []`
`second = []`
	`first = []`
	`second = first`



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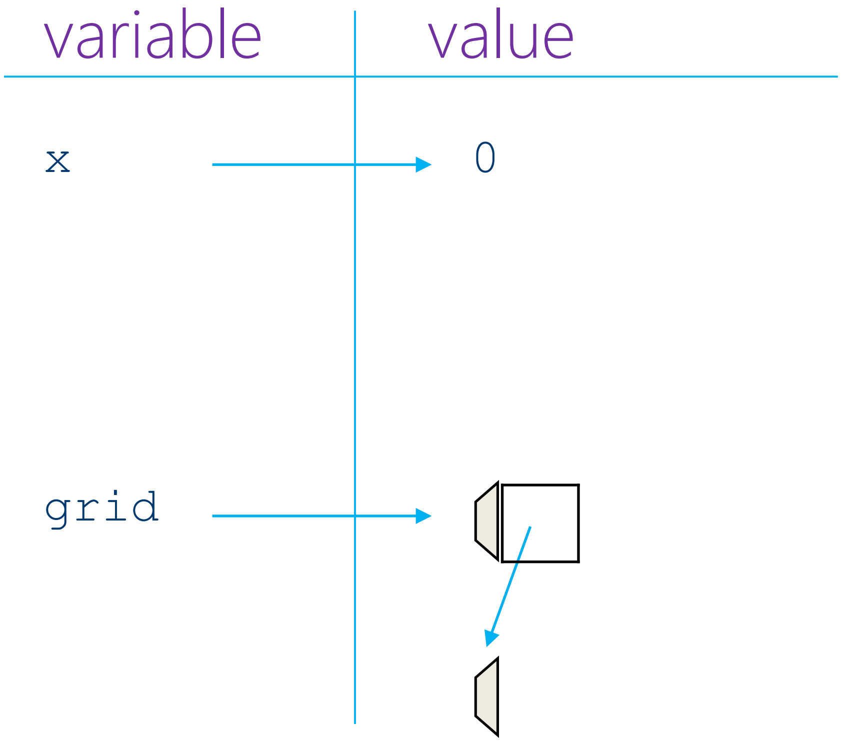

variable

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0

grid

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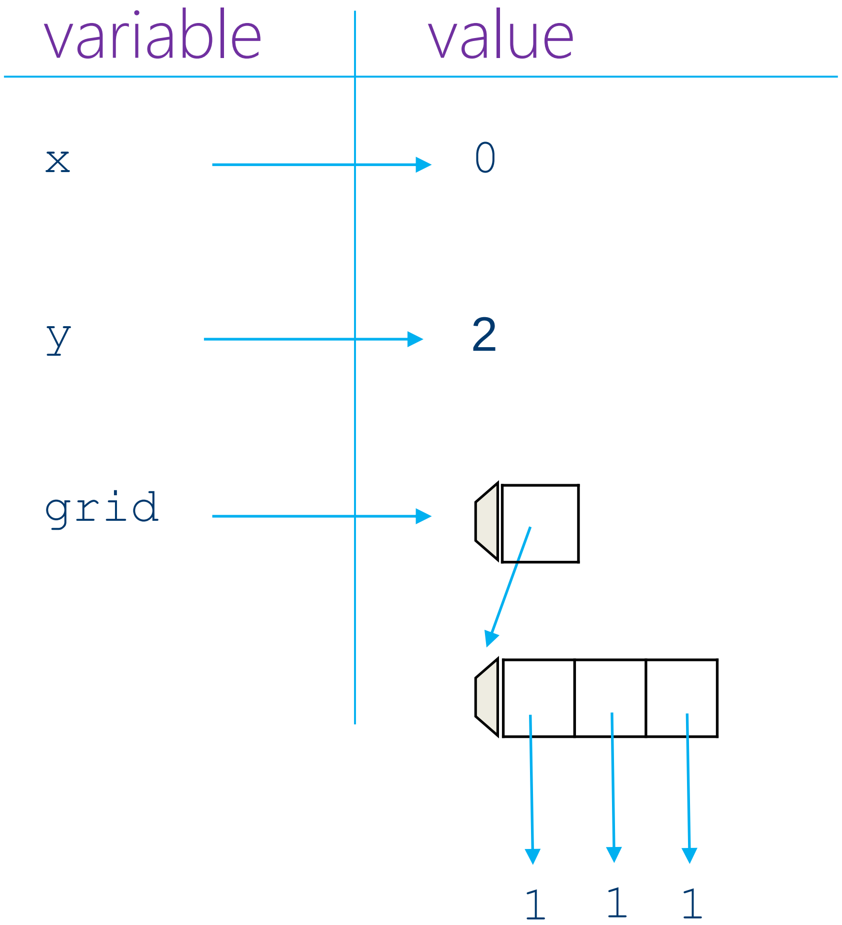

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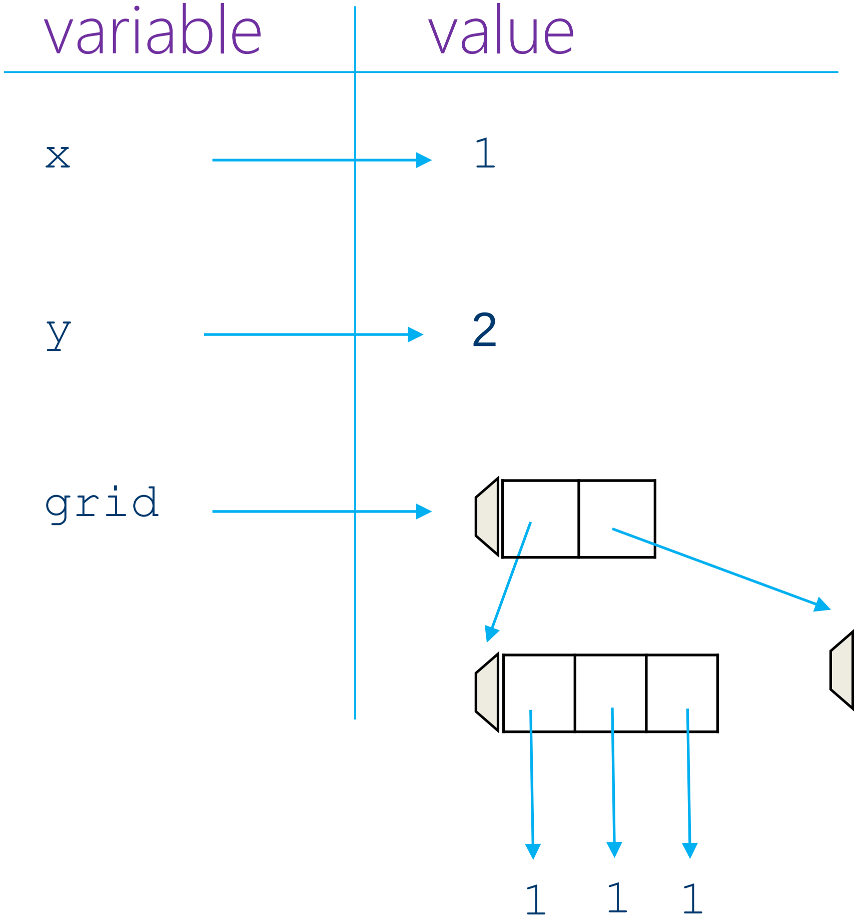

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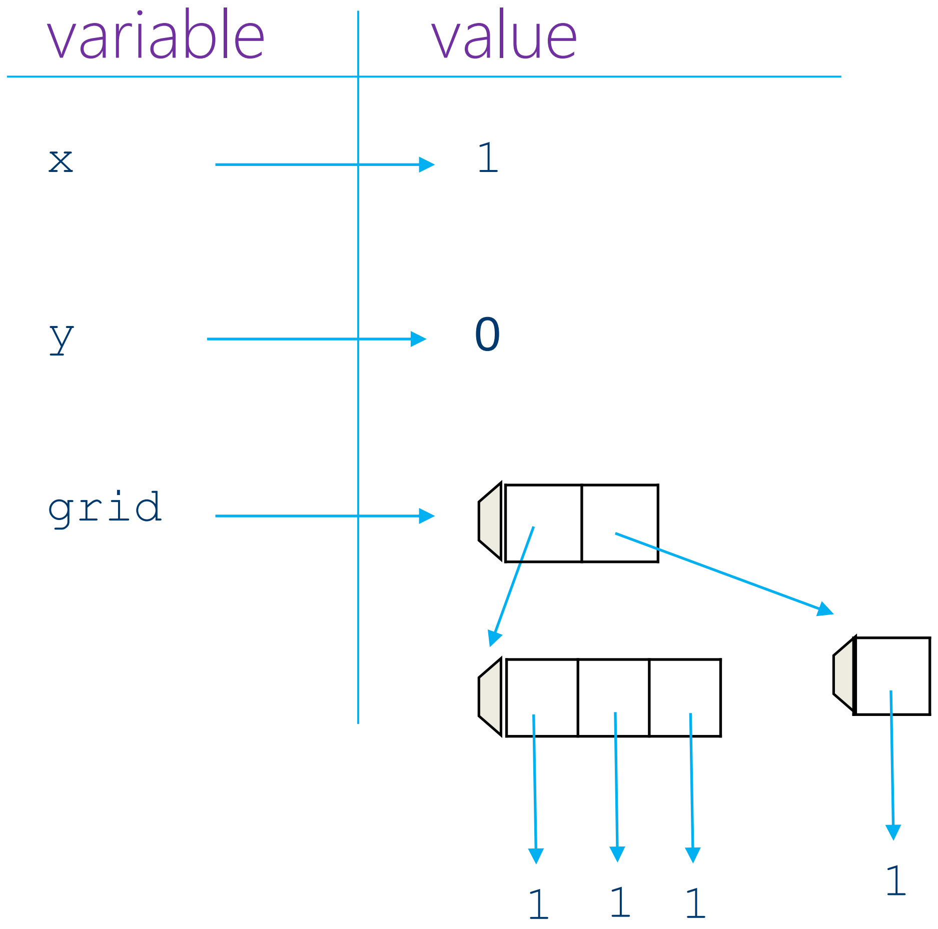

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If aliasing can cause bugs, why allow it?

1. Some languages don't

   Or at least appear not to

2. Aliasing a million-element list is more efficient

   than copying it

3. Sometimes really do want to update a structure

in place

Python

Functions

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Define functions to create higher-level operations

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Instead, it should make it easy for people to create what they need to solve specific problems

Define functions to create higher-level operations

"Create a language in which the solution to your original problem is trivial."

Define functions using `def`

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```
def greet():
  return 'Good evening, master'
```

Define functions using `def`

```
def greet():
  return 'Good evening, master'

temp = greet()
print(temp)
Good evening, master
```

Give them parameters

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```
def greet(name):
  answer = 'Hello, ' + name
  return answer
```

Give them parameters

```
def greet(name):
   answer = 'Hello, ' + name
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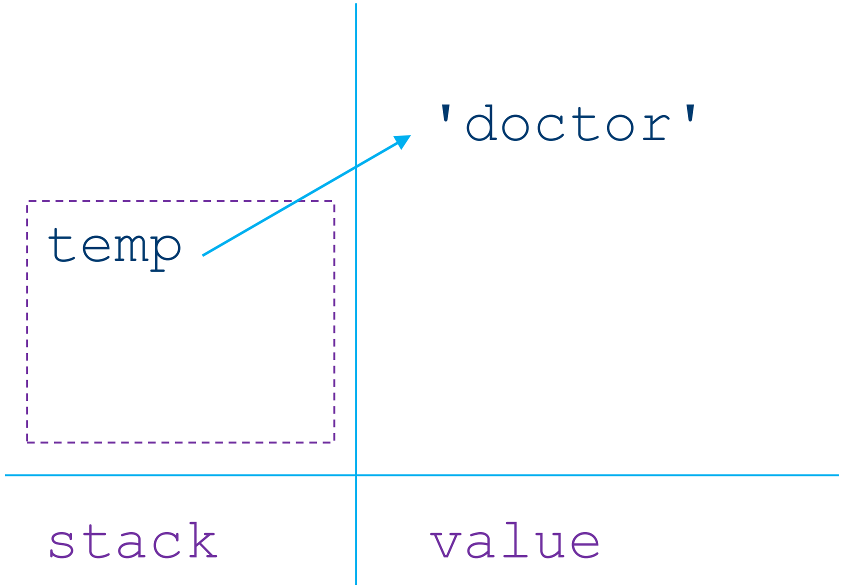
temp = 'doctor'
```



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def greet(name):
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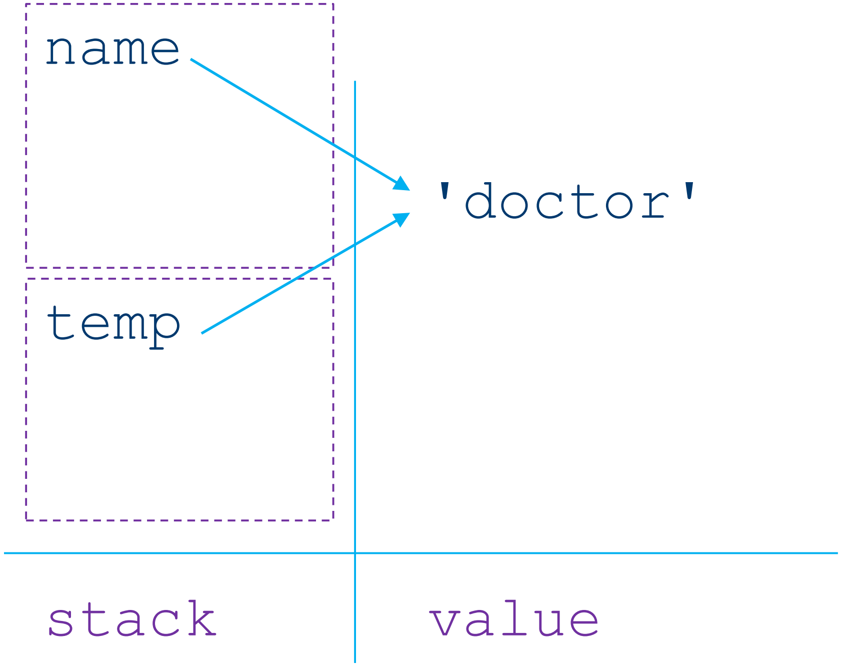
temp = 'doctor'
result = greet(temp)
```



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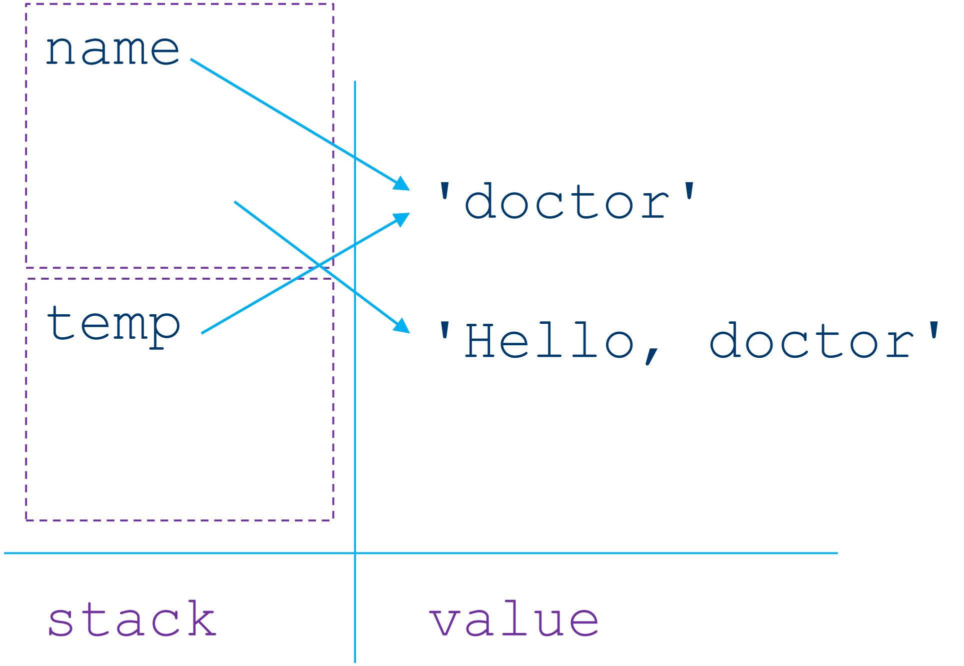

name

temp

'doctor'

'Hello, doctor'

stack

value

Give them parameters

```
def greet(name):
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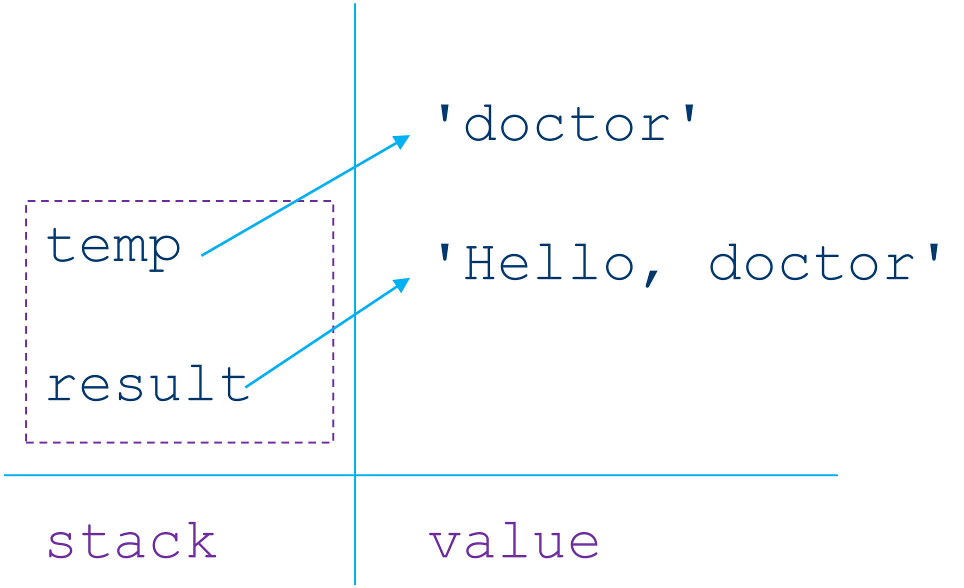

Each function call creates a new stack frame

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```
def add(a):
  b = a + 1
  return b

def double(c):
  d = 2 * add(c)
  return d
```

stack	value

Each function call creates a new stack frame

```
def add(a):
   b = a + 1
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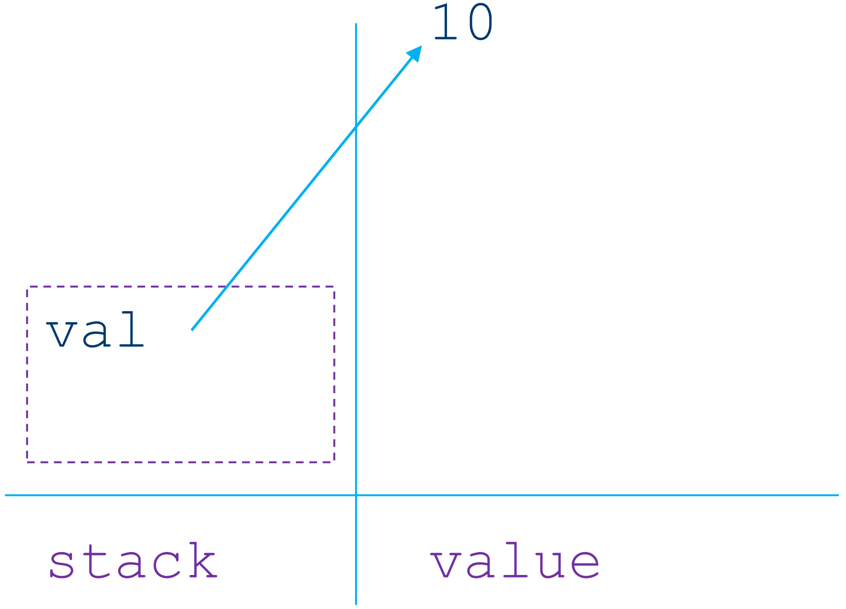
val = 10
```



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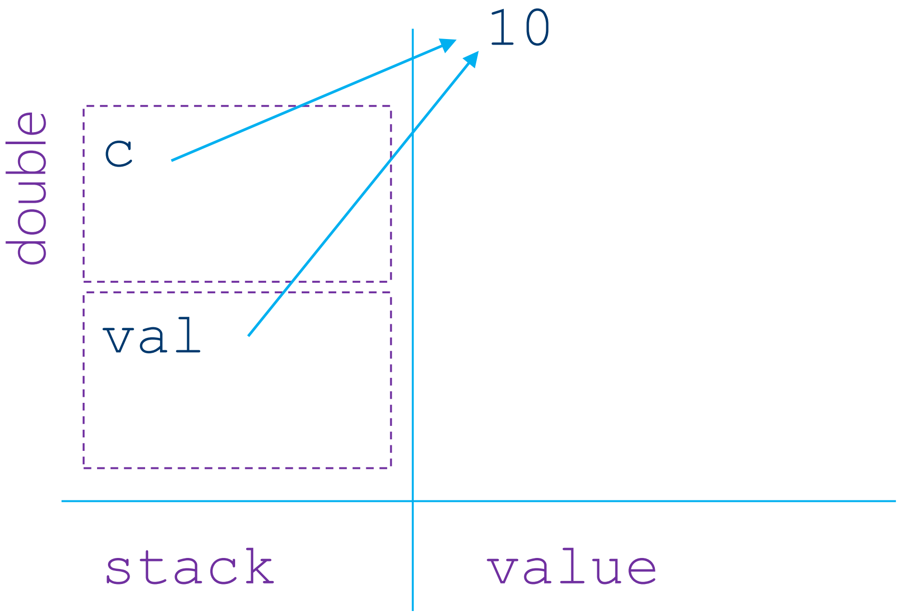

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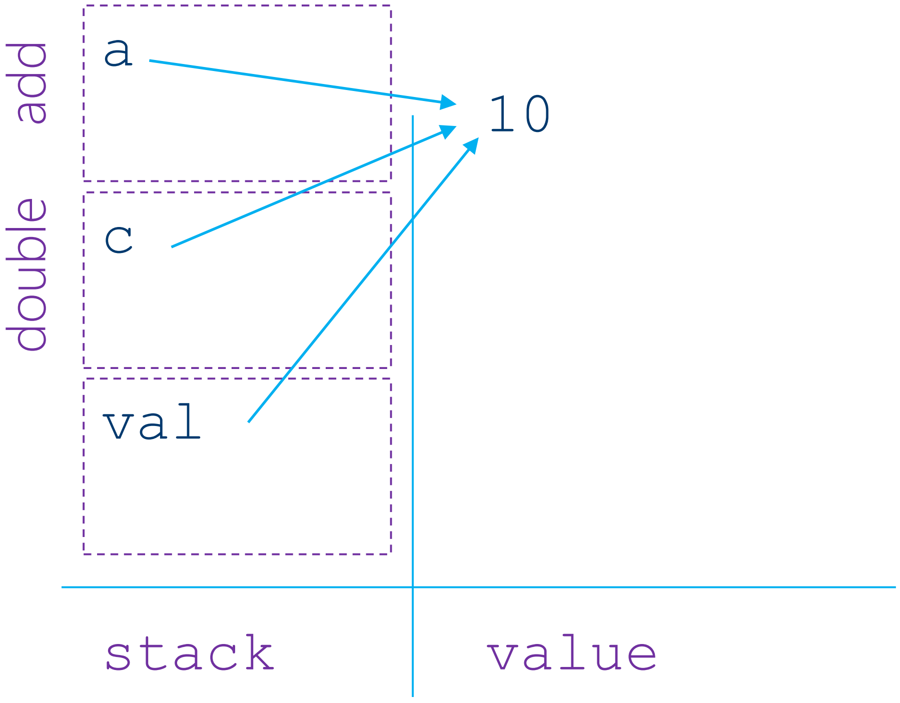

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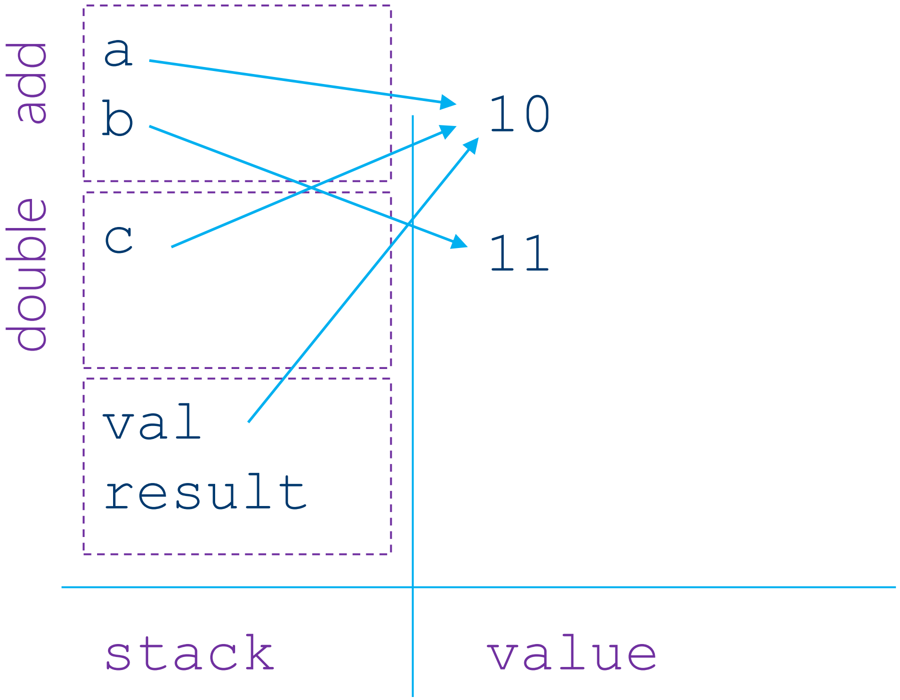
print(result)
```



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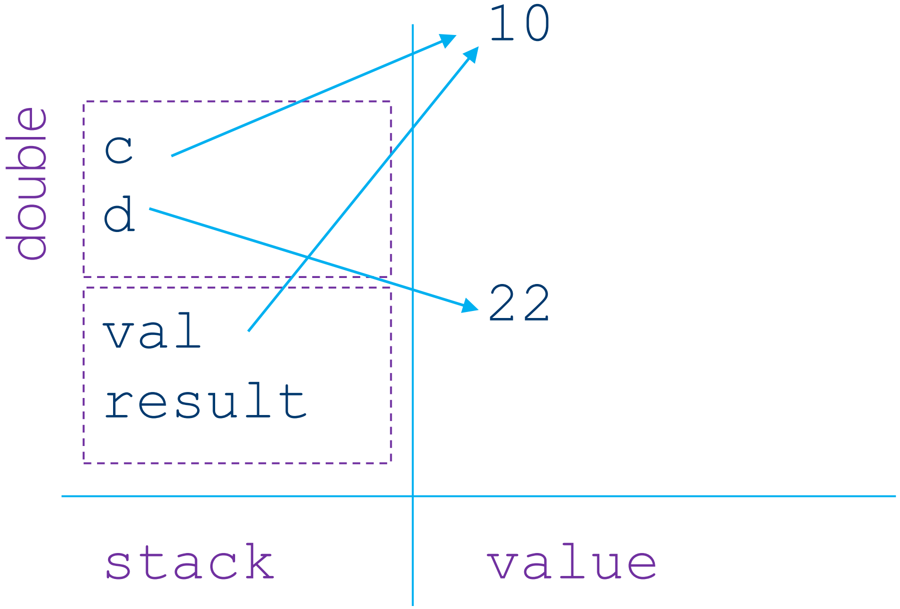

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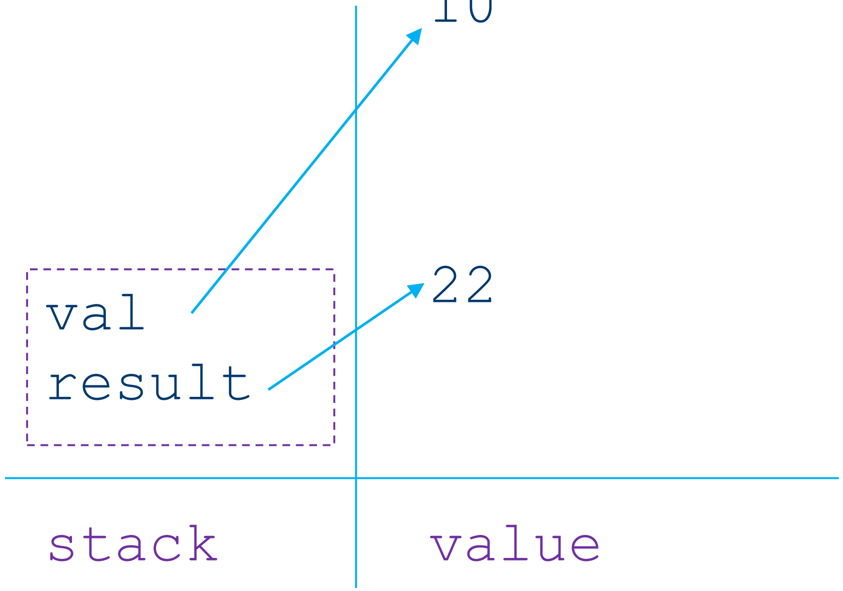

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val = 10
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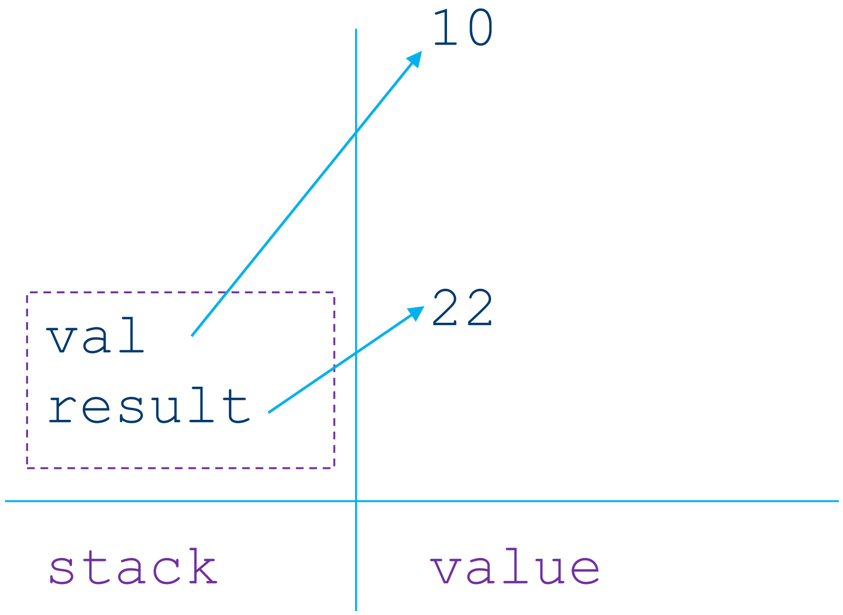
print(result)
22
```



Only see variables in the *current* and *global* frames

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Current beats global

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```
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temp = 'doctor'
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Only see variables in the *current* and *global* frames

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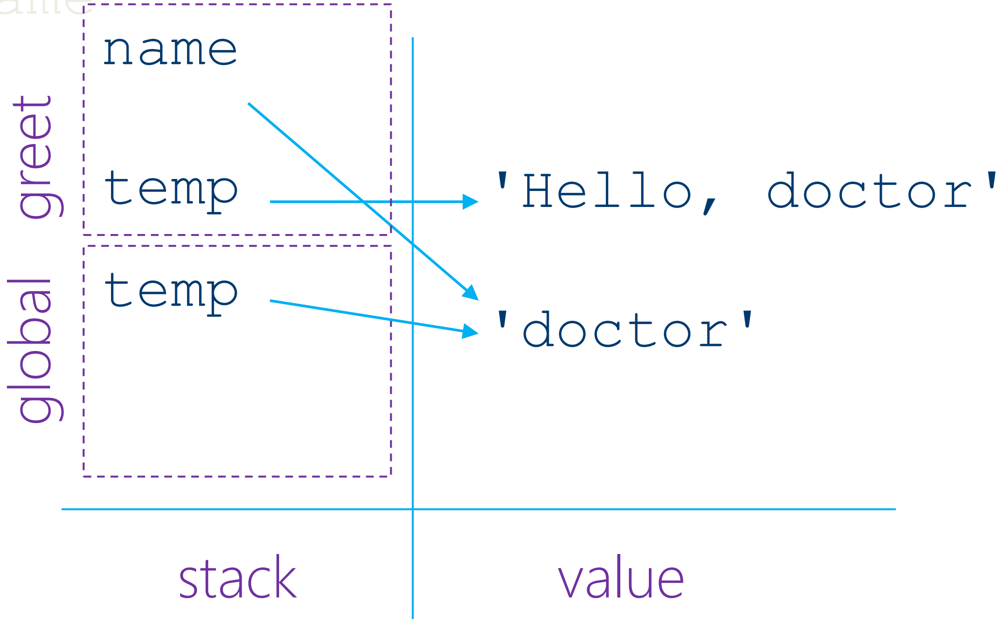

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Current beats global

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    temp = 'Hello, ' + name
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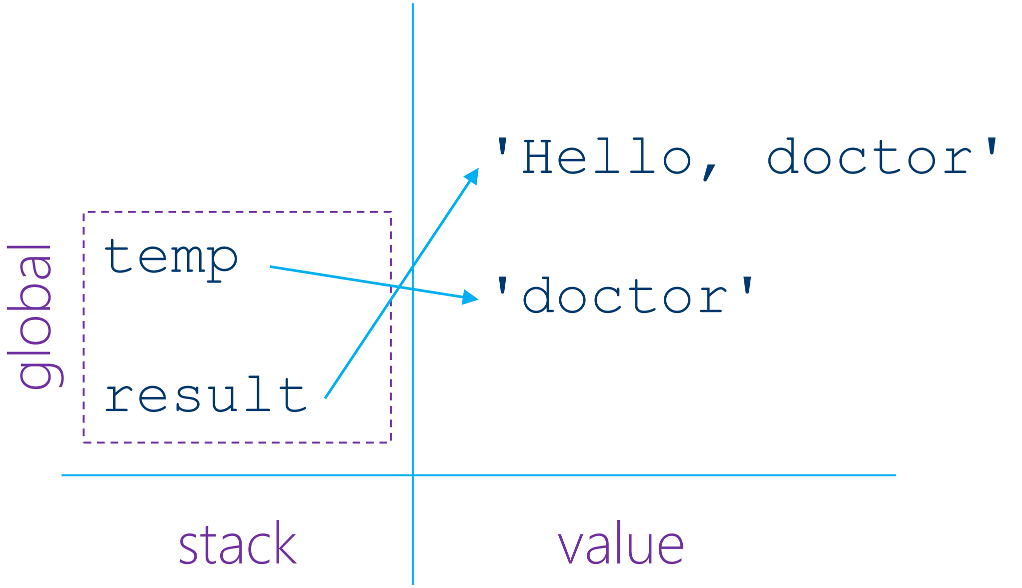
temp = 'doctor'
result = greet(temp)
print(result)
Hello, doctor
```



Can pass values in and accept results directly

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```
def greet(name):
  return 'Hello, ' + name

print(greet('doctor'))
```

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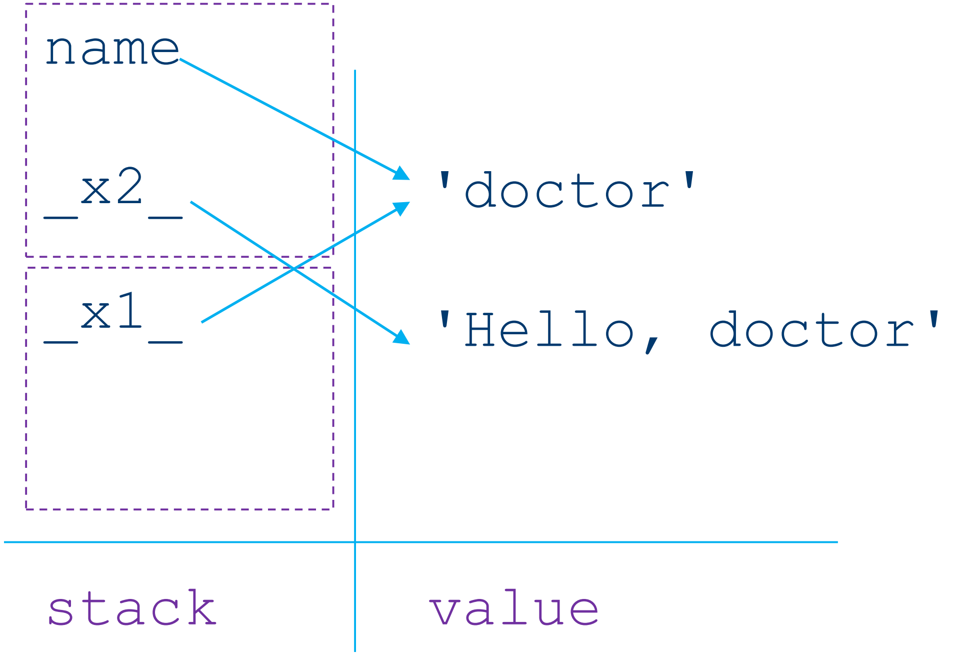
print(greet('doctor'))
```



Can return at any time

Can return at any time

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
  else:
    return -1
```

Can return at any time

```
def sign(num):
  if num > 0:
    return 1  ←
  elif num == 0:
    return 0
  else:
    return -1

print(sign(3))
1
```

Can return at any time

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
  else:
    return -1

print(sign(3))
1
print(sign(-9))
-1
```

Can return at any time

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
  else:
    return -1

print(sign(3))
1
print(sign(-9))
-1
```

Over-use makes functions hard to understand

Can return at any time

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
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  else:
    return -1

print(sign(3))
1
print(sign(-9))
-1
```

Over-use makes functions hard to understand

No prescription possible, but:

Can return at any time

```
def sign(num):
    if num > 0:
        return 1
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        return 0
    else:
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print(sign(3))
1
print(sign(-9))
-1
```

Over-use makes functions hard to understand

No prescription possible, but:

– a few at the beginning to handle special cases

Can return at any time

```
def sign(num):
   if num > 0:
      return 1
   elif num == 0:
      return 0
   else:
      return -1

print(sign(3))
1
print(sign(-9))
-1
```

Over-use makes functions hard to understand

No prescription possible, but:

- a few at the beginning to handle special cases
- one at the end for the "general" result

Every function returns something

Every function returns something

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
# else:
#   return -1
```

Every function returns something

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
# else:
#   return -1

print(sign(3))
1
```

Every function returns something

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
# else:
#   return -1

print(sign(3))
1
print(sign(-9))
None
```

Every function returns something

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
# else:
#   return -1

print(sign(3))
1
print(sign(-9))
None
```

If the function doesn't return a value, Python returns None

Every function returns something

```
def sign(num):
  if num > 0:
    return 1
  elif num == 0:
    return 0
# else:
#   return -1

print(sign(3))
1
print(sign(-9))
None
```

If the function doesn't return a value, Python returns None

Yet another reason why commenting out blocks of code is a bad idea…

Functions and parameters don't have types

Functions and parameters don't have types

```
def double(x):
  return 2 * x
```

Functions and parameters don't have types

```
def double(x):
  return 2 * x

print(double(2))
4
```

Functions and parameters don't have types

```
def double(x):
  return 2 * x

print(double(2))
4
print(double('two'))
twotwo
```

Functions and parameters don't have types

```
def double(x):
  return 2 * x

print(double(2))
4
print(double('two'))
twotwo
```

Only use this when the function's behavior depends *only* on properties that all possible arguments share

Functions and parameters don't have types

```
def double(x):
  return 2 * x

print(double(2))
4
print(double('two'))
twotwo
```

Only use this when the function's behavior depends *only* on properties that all possible arguments share

```
if type(arg) == int:
   ...
elif type(arg) == str:
   ...
...
```

Functions and parameters don't have types

```
def double(x):
  return 2 * x

print(double(2))
4
print(double('two'))
twotwo
```

Warning sign

Only use this when the function's behavior depends *only* on properties that all possible arguments share

```
if type(arg) == int:
  ...
elif type(arg) == str:
  ...
...
```

Functions and parameters don't have types

```
def double(x):
  return 2 * x

print(double(2))
4
print(double('two'))
twotwo
```

Only use this when the function's behavior depends *only* on properties that all possible arguments share

```
if type(arg) == int:
   ...
elif type(arg) == str:
   ...
...
```

Warning sign

There's a better way to do this

Values are copied into parameters

Values are copied into parameters

Which means lists are aliased

Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')
```

Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')

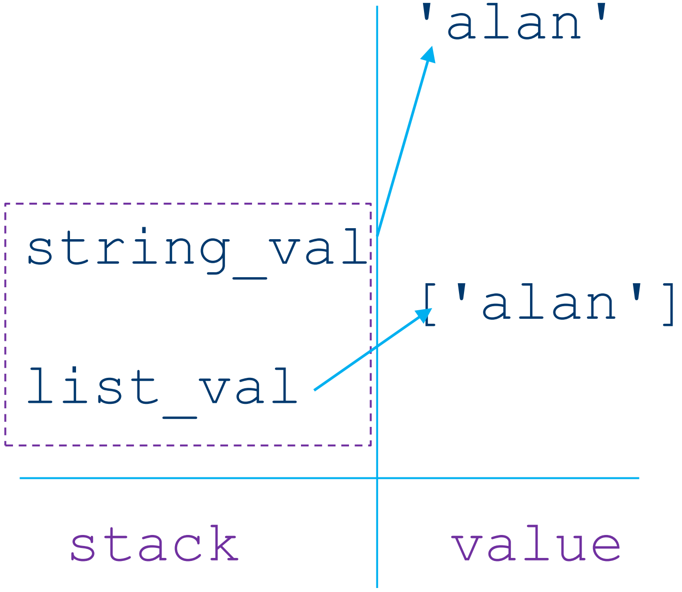
string_val = 'alan'
list_val = ['alan']
appender(string_val, list_val)
```

Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')

string_val = 'alan'
list_val = ['alan']
appender(string_val, list_val)
```

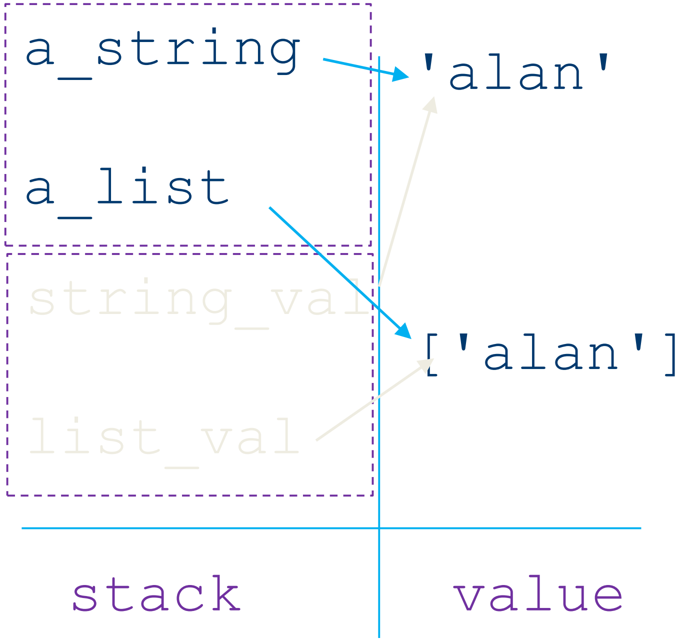


Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')

string_val = 'alan'
list_val = ['alan']
appender(string_val, list_val)
```

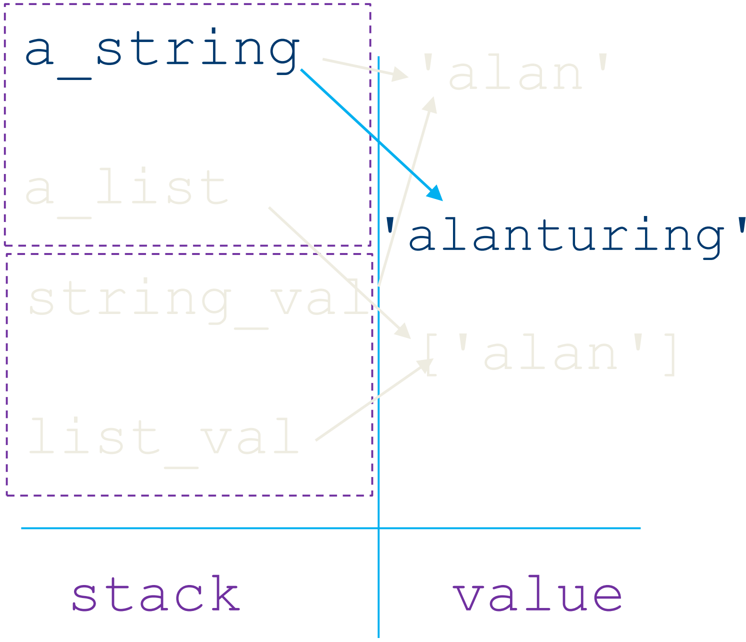


Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')

string_val = 'alan'
list_val = ['alan']
appender(string_val, list_val)
```

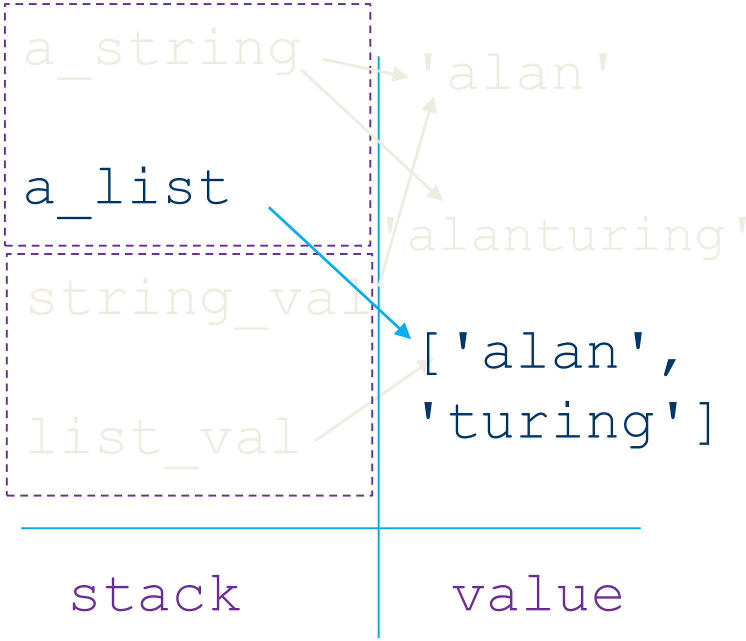


Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')

string_val = 'alan'
list_val = ['alan']
appender(string_val, list_val)
```



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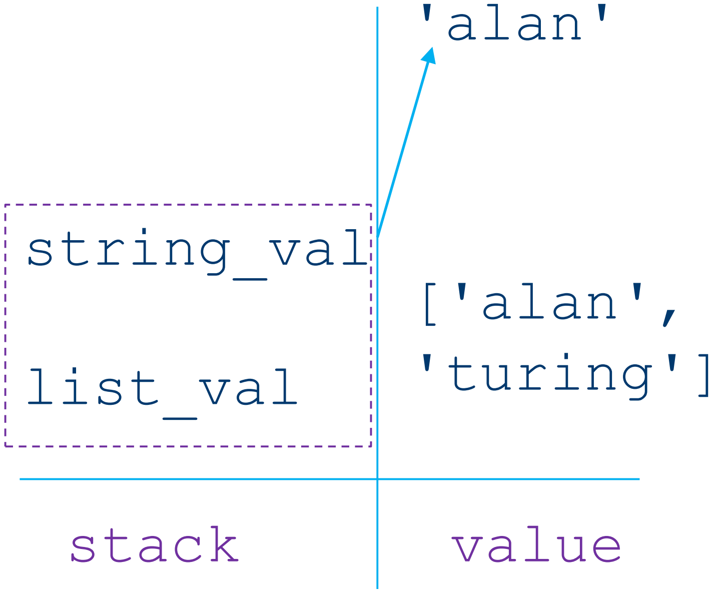
Values are copied into parameters

Which means lists are aliased

```
def appender(a_string, a_list):
    a_string += 'turing'
    a_list.append('turing')

string_val = 'alan'
list_val = ['alan']
appender(string_val, list_val)
print(string_val)
alan
print(list_val)
['alan', 'turing']
```



'alan'

string_val

['alan', 'turing']

list_val

stack

value

Can define default parameter values

Can define default parameter values

```
def adjust(value, amount=2.0):
  return value * amount
```

Can define default parameter values

```
def adjust(value, amount=2.0):
  return value * amount

print(adjust(5))
10
```

Can define default parameter values

```
def adjust(value, amount=2.0):
  return value * amount

print(adjust(5))
10
print(adjust(5, 1.001))
5.005
```

More readable than multiple functions

More readable than multiple functions

```
def adjust_general(value, amount):
  return value * amount

def adjust_default(value):
  return adjust_general(value, 2.0)
```

Parameters that have defaults must come *after* parameters that do not

Parameters that have defaults must come *after* parameters that do not

```
def triplet(left='venus', middle, right='mars'):
  return '%s %s %s' % (left, middle, right)
```

Parameters that have defaults must come *after* parameters that do not

```
def triplet(left='venus', middle, right='mars'):
  return '%s %s %s' % (left, middle, right)

print(triplet('earth'))
venus earth mars
```

OK so far...

Parameters that have defaults must come *after* parameters that do not

```
def triplet(left='venus', middle, right='mars'):
  return '%s %s %s' % (left, middle, right)

print(triplet('earth'))
venus earth mars
```

OK so far...

```
print(triplet('pluto', 'earth'))
```

?

Parameters that have defaults must come *after* parameters that do not

```
def triplet(left='venus', middle, right='mars'):
  return '%s %s %s' % (left, middle, right)

print(triplet('earth'))
venus earth mars
```

OK so far...

```
print(triplet('pluto', 'earth'))
```

?

```
triplet('pluto', 'earth', 'mars')
```

Parameters that have defaults must come *after* parameters that do not

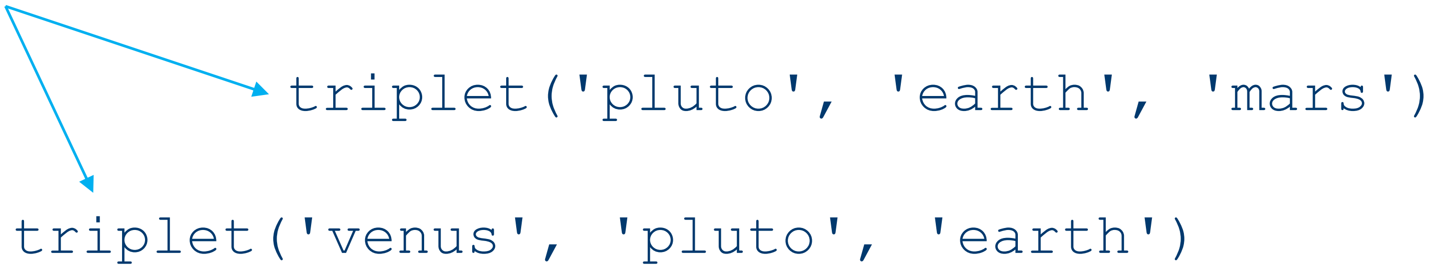
```
def triplet(left='venus', middle, right='mars'):
  return '%s %s %s' % (left, middle, right)

print(triplet('earth'))
venus earth mars
```

OK so far...

```
print(triplet('pluto', 'earth'))
```

?



```
triplet('pluto', 'earth', 'mars')
```

```
triplet('venus', 'pluto', 'earth')
```

"When should I write a function?"

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Human short term memory can hold 7± 2 items

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Human short term memory can hold 7± 2 items

If someone has to keep more than a dozen things

in their mind at once to understand a block of code,

it's too long

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Break it into comprehensible pieces with functions

"When should I write a function?"

Human short term memory can hold 7± 2 items

If someone has to keep more than a dozen things

in their mind at once to understand a block of code,

it's too long

Break it into comprehensible pieces with functions

Even if each function is only called once

Example

```
for x in range(1, GRID_WIDTH-1):
  for y in range(1, GRID_HEIGHT-1):
    if (density[x-1][y] > density_threshold) or \
       (density[x+1][y] > density_threshold):
      if (flow[x][y-1] < flow_threshold) or\
         (flow[x][y+1] < flow_threshold):
        temp = (density[x-1][y] + density[x+1][y]) / 2
        if abs(temp - density[x][y]) > update_threshold:
          density[x][y] = temp
```

Refactoring #1: grid interior

```
for x in range(1, GRID_WIDTH-1):
  for y in range(1, GRID_HEIGHT-1):
    if (density[x-1][y] > density_threshold) or \
       (density[x+1][y] > density_threshold):
      if (flow[x][y-1] < flow_threshold) or\
         (flow[x][y+1] < flow_threshold):
        temp = (density[x-1][y] + density[x+1][y]) / 2
        if abs(temp - density[x][y]) > update_threshold:
          density[x][y] = temp
```

Refactoring #2: tests on X and Y axes

```
for x in grid_interior(GRID_WIDTH):
  for y in grid_interior(GRID_HEIGHT):
    if density_exceeds(density, x, y, density_threshold):
      if flow_exceeds(flow, x, y, flow_threshold):
        temp = (density[x-1][y] + density[x+1][y]) / 2
        if abs(temp - density[x][y]) > tolerance:
          density[x][y] = temp
```

Refactoring #3: update rule

```
for x in grid_interior(GRID_WIDTH):
  for y in grid_interior(GRID_HEIGHT):
    if density_exceeds(density, x, y, density_threshold):
      if flow_exceeds(flow, x, y, flow_threshold):
        update_on_tolerance(density, x, y, tolerance)
```

Refactoring #3: update rule

```
for x in grid_interior(GRID_WIDTH):
  for y in grid_interior(GRID_HEIGHT):
    if density_exceeds(density, x, y, density_threshold):
      if flow_exceeds(flow, x, y, flow_threshold):
        update_on_tolerance(density, x, y, tolerance)
```

Good programmers will write this first

Refactoring #3: update rule

```
for x in grid_interior(GRID_WIDTH):
  for y in grid_interior(GRID_HEIGHT):
    if density_exceeds(density, x, y, density_threshold):
      if flow_exceeds(flow, x, y, flow_threshold):
        update_on_tolerance(density, x, y, tolerance)
```

Good programmers will write this first

Then write the functions it implies

Refactoring #3: update rule

```
for x in grid_interior(GRID_WIDTH):
  for y in grid_interior(GRID_HEIGHT):
    if density_exceeds(density, x, y, density_threshold):
      if flow_exceeds(flow, x, y, flow_threshold):
        update_on_tolerance(density, x, y, tolerance)
```

Good programmers will write this first

Then write the functions it implies

Then refactor any overlap

Midterm Exam

Having a GitHub account is a must!

Blackboard > Course Content > Week 7 (Oct. 26-30) > Monday Oct. 26 > Checkpoint 13