Recap

Data Structures

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Lists `[items]`

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Dictionaries `{key: value}`

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Tuples `(frozen, sequence)`

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Sets `{unique, hashable, values}`

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Dictionaries `{key: value}`

Tuples `(frozen, sequence)`

Sets `{unique, hashable, values}`

Comprehensions `[f(xs) for xs in iter]`

Familiar Functions

Recall

The def keyword is used to define a new function

```
def fn_name(param1, param2):
    value = do_something()
    return value
```

Basic Functions: Nuances

Return

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- All functions return *some* value

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  - Even if that value is `None`

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```
return value1, value2, value3
```

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  - Even if that value is `None`
- No `return` statement or just `return` implicitly returns `None`
- Returning multiple values
  - Use a tuple!

```
return value1, value2, value3
```

The interpreter suppresses printing `None`

Be careful! Callers may not expect a tuple as a return value

Function Execution and Scopes

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- Function execution introduces a new local symbol table

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  - First, look in local symbol table

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  - Next, check symbol tables of enclosing functions (unusual)

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  - Then, search global (top-level) symbol table

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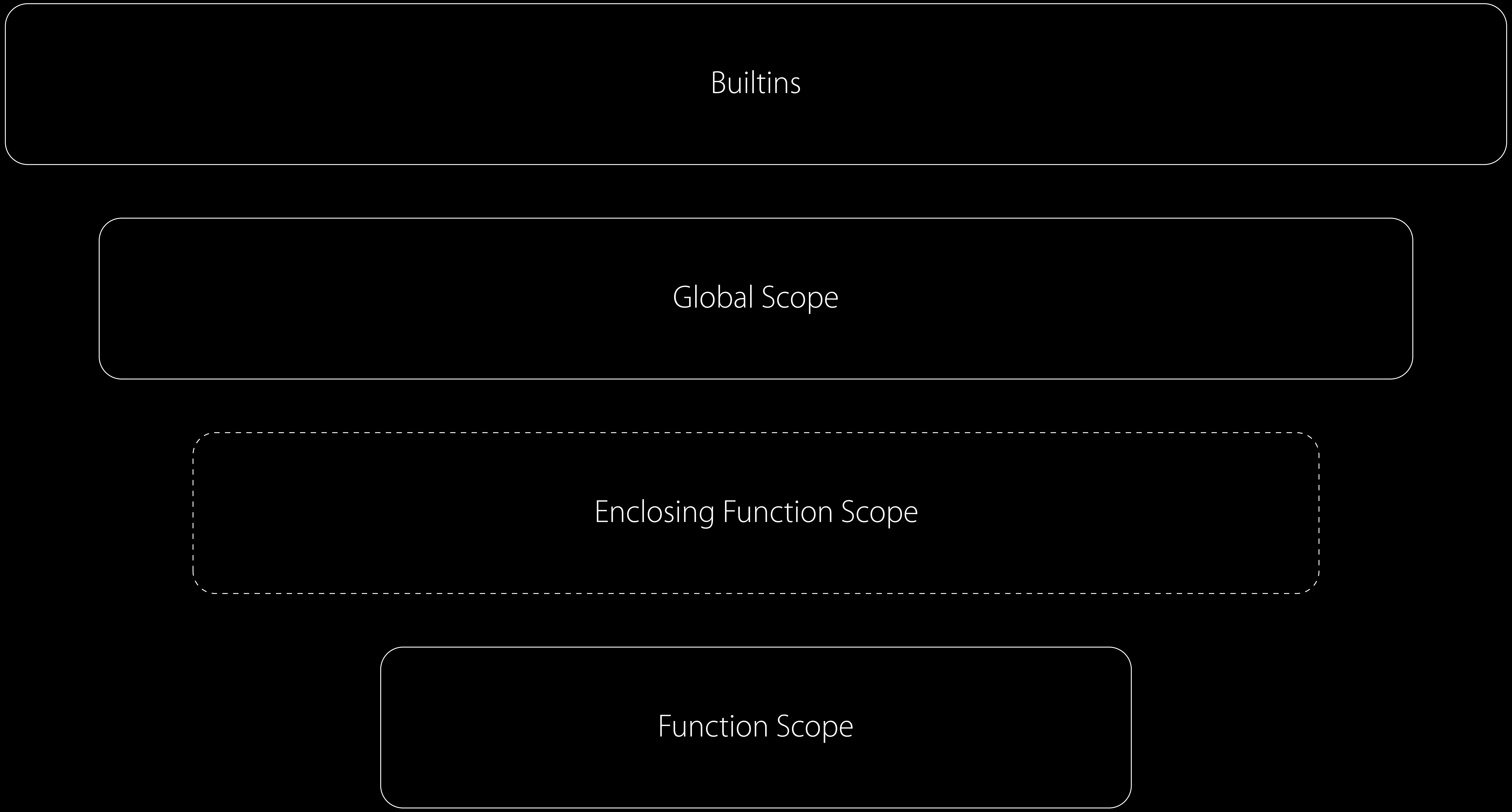
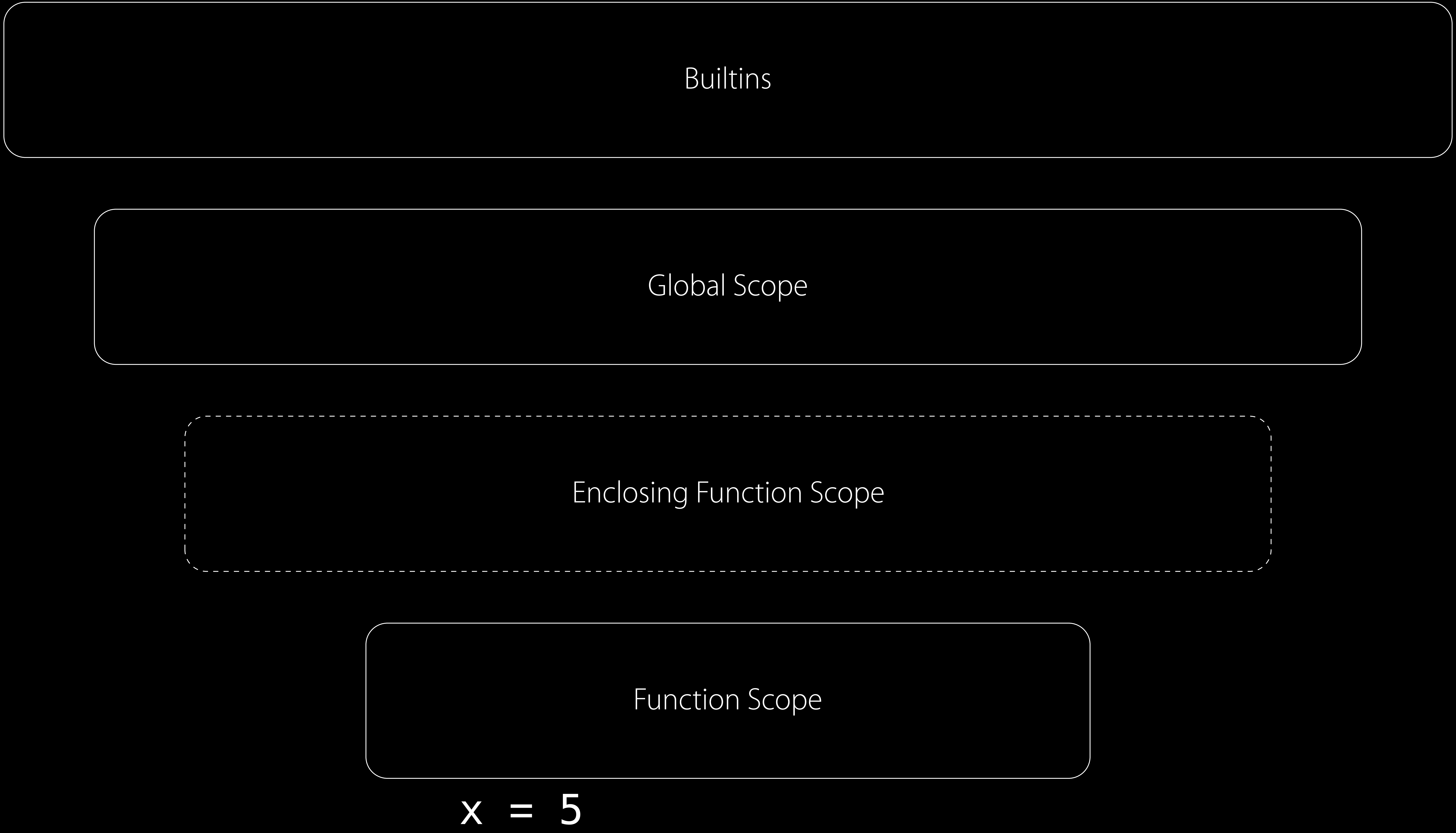
- Function execution introduces a new local symbol table
  - Think baggage tags and suitcases
- Variable assignments (L-values)
  - Add entry to local symbol table
- Variable references (R-values)
  - First, look in local symbol table
  - Next, check symbol tables of enclosing functions (unusual)
  - Then, search global (top-level) symbol table
  - Finally, check builtin symbols (`print`, `input`, etc)


Builtins
Global Scope
Enclosing Function Scope
Function Scope


Builtins
Global Scope
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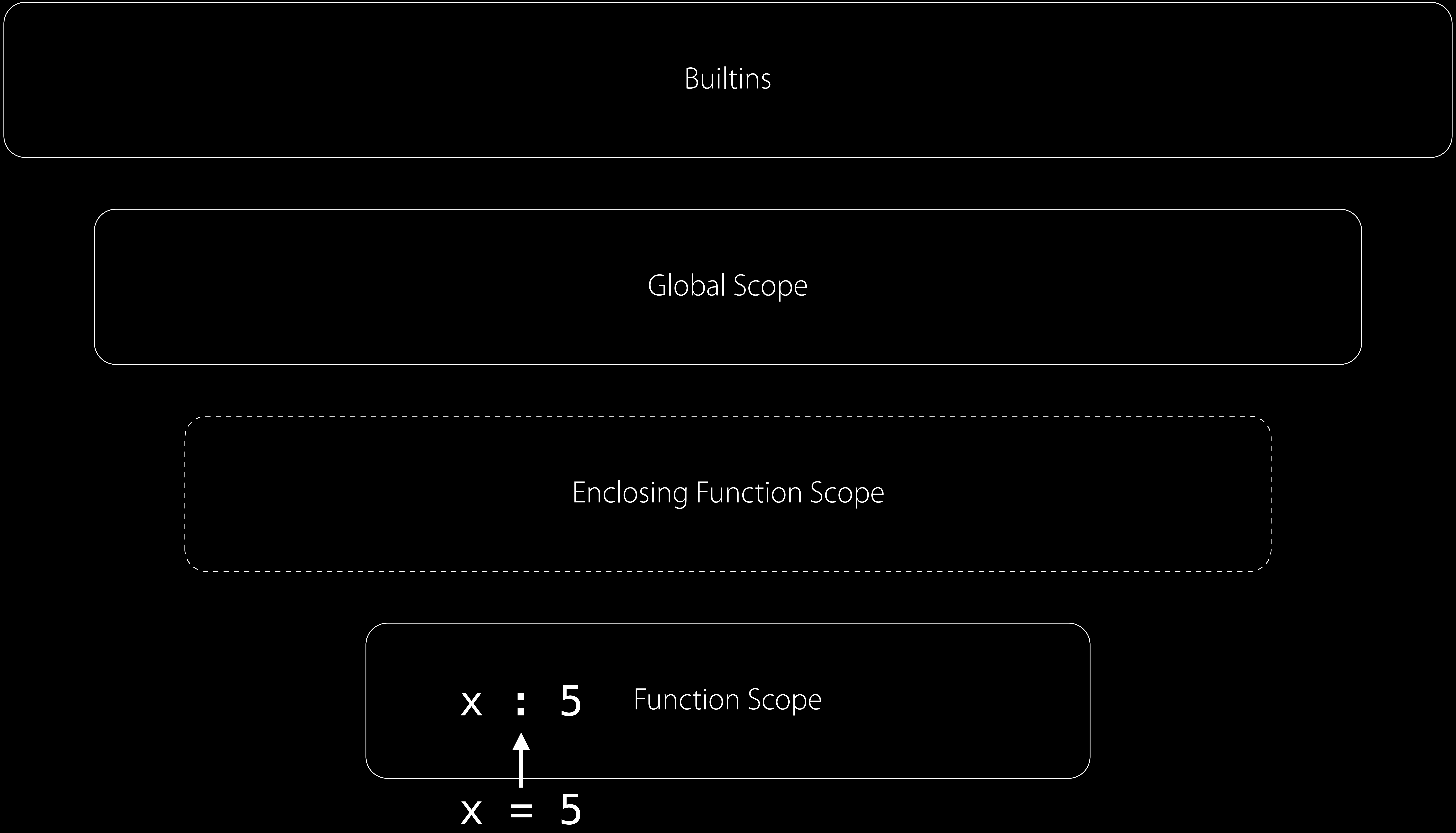
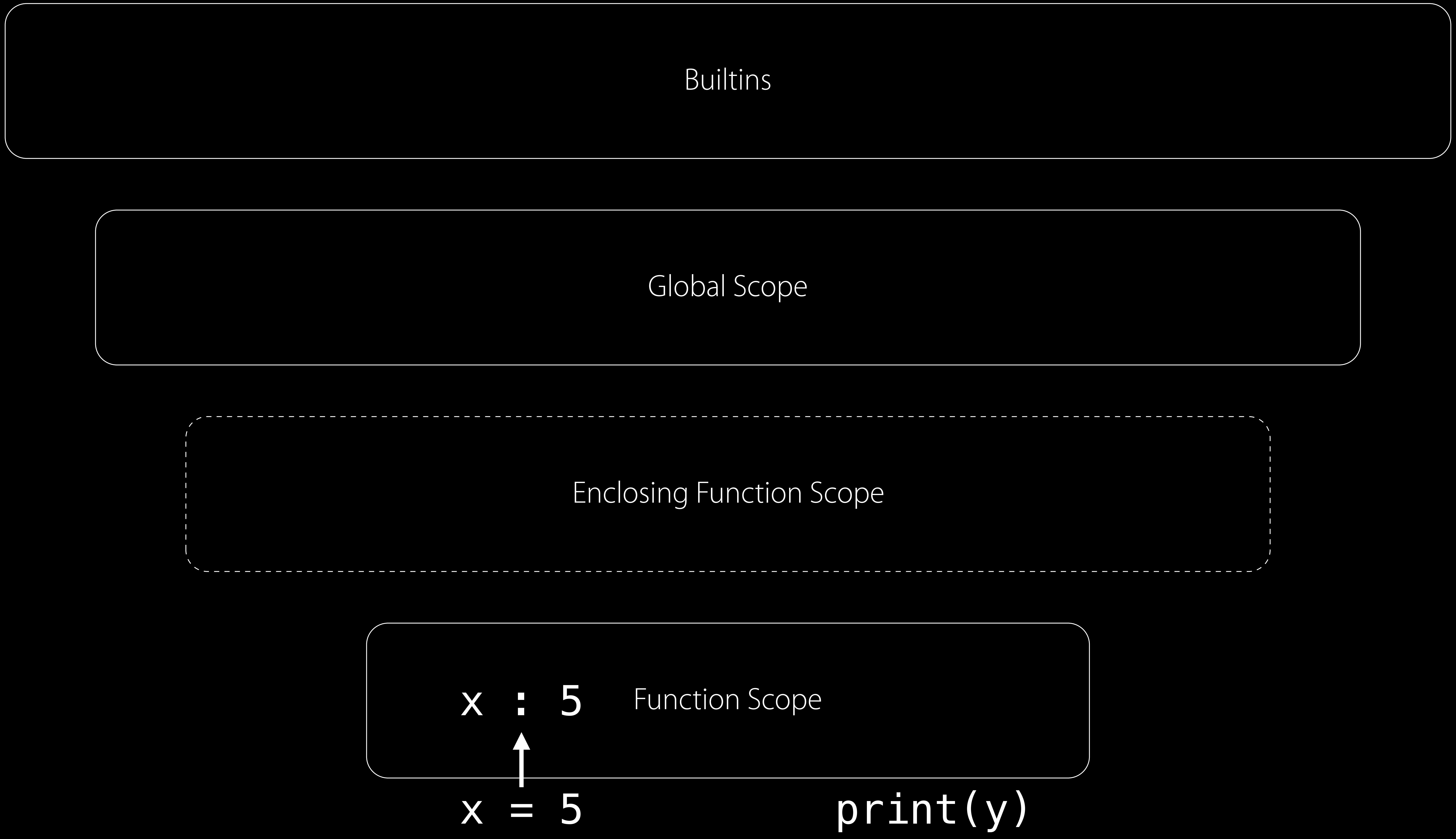
Function Scope

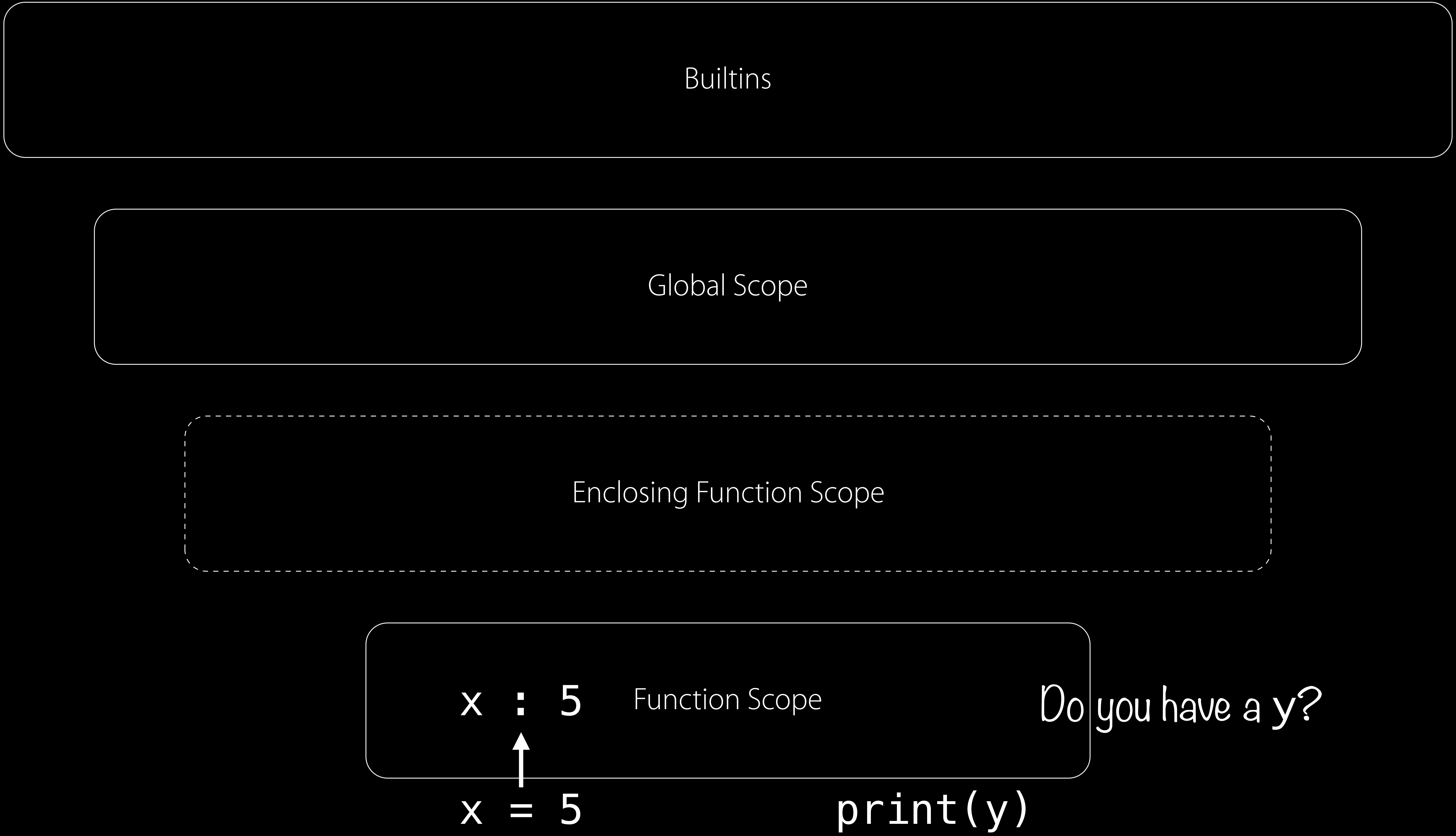
```
x = 5
```

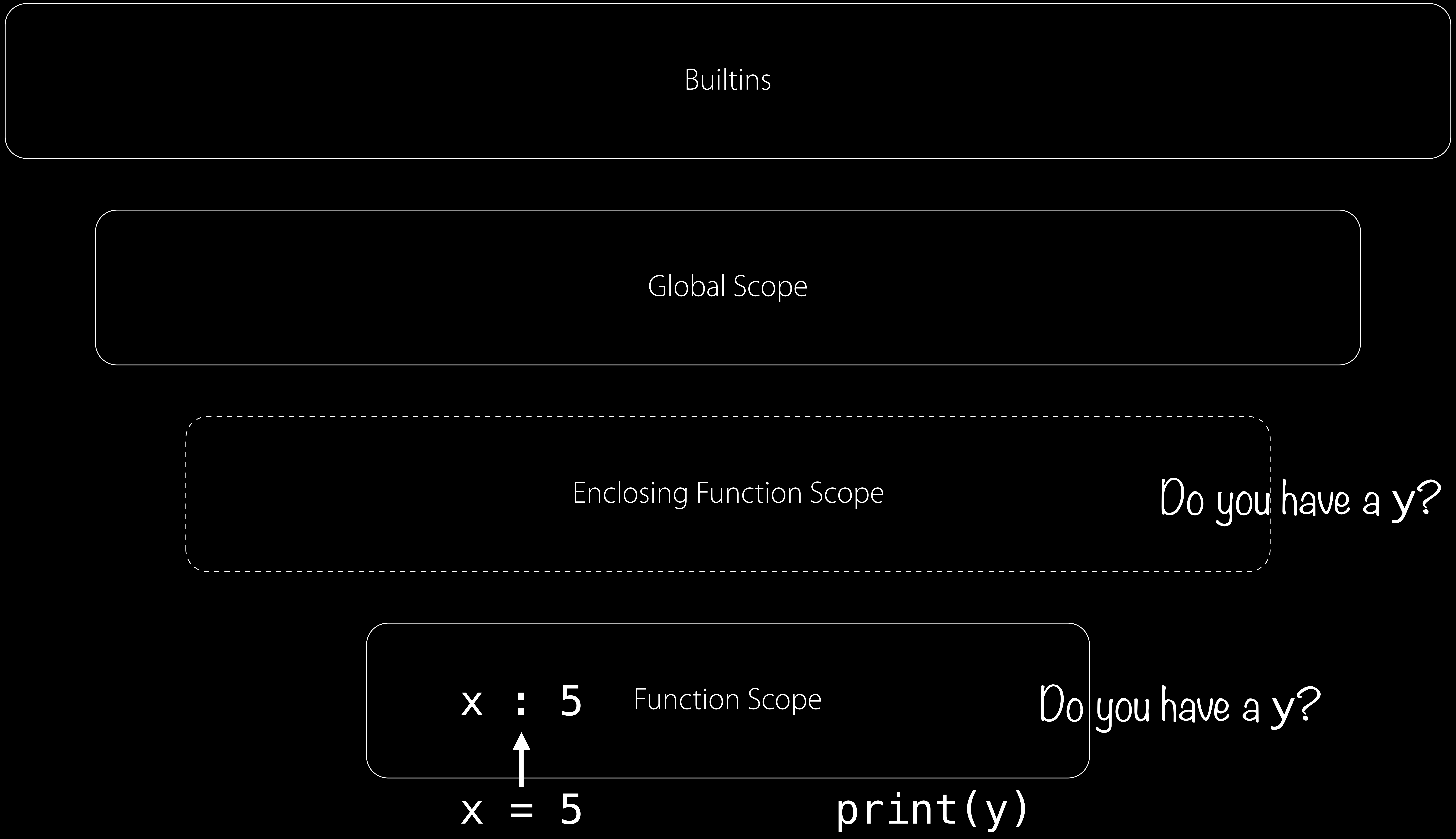

Builtins
Global Scope
Enclosing Function Scope
x : 5
Function Scope
x = 5


Builtins
Global Scope
Enclosing Function Scope
x : 5
Function Scope

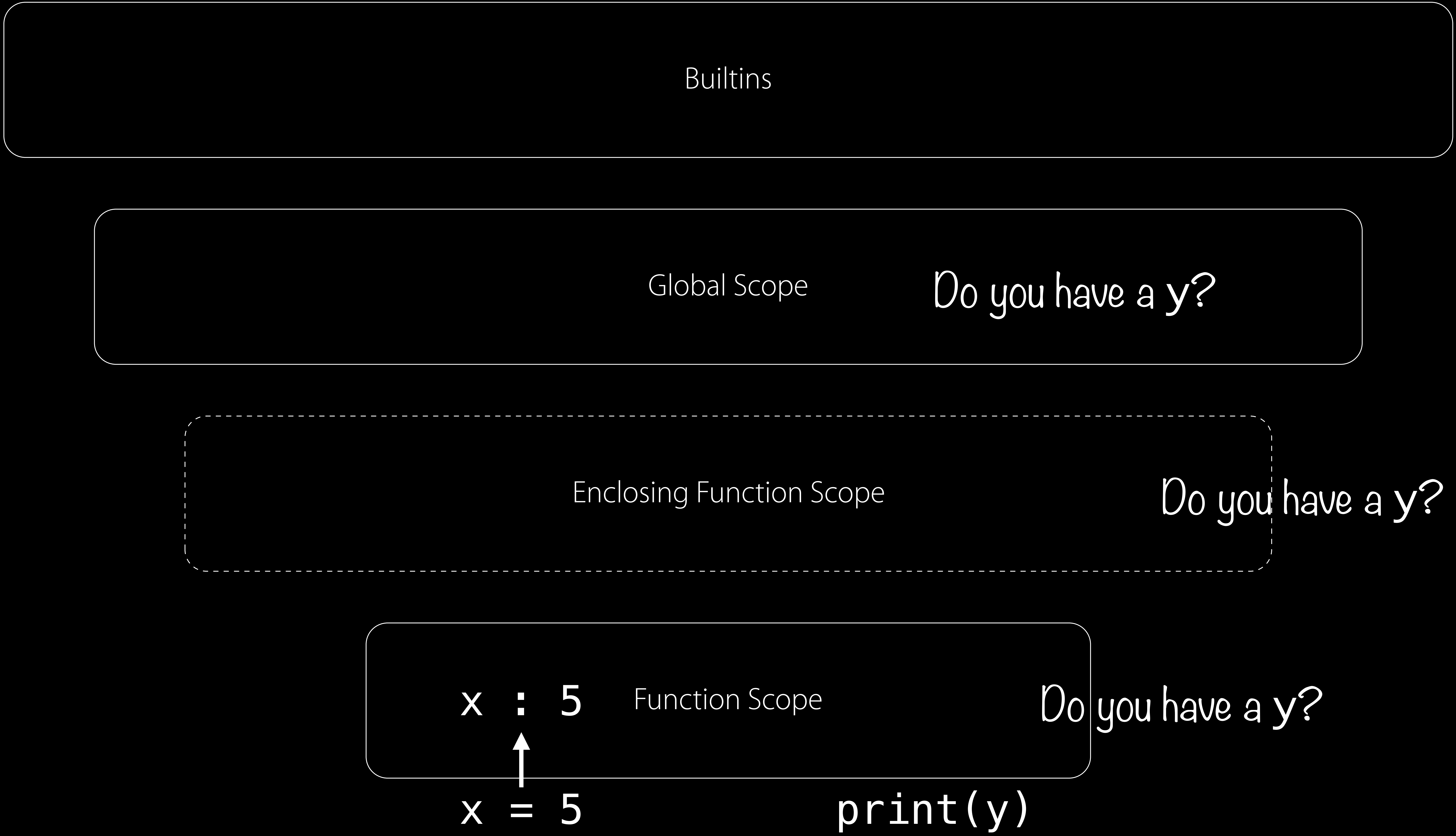
```
x = 5
```

```
print(y)
```


Builtins
Global Scope
Enclosing Function Scope
x : 5
Function Scope
Do you have a y?
x = 5
print(y)


Builtins
Global Scope
Enclosing Function Scope
Do you have a y?
x : 5
Function Scope
Do you have a y?

```
x = 5
print(y)
```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Global Scope
Do you have a y?
Enclosing Function Scope
Do you have a y?
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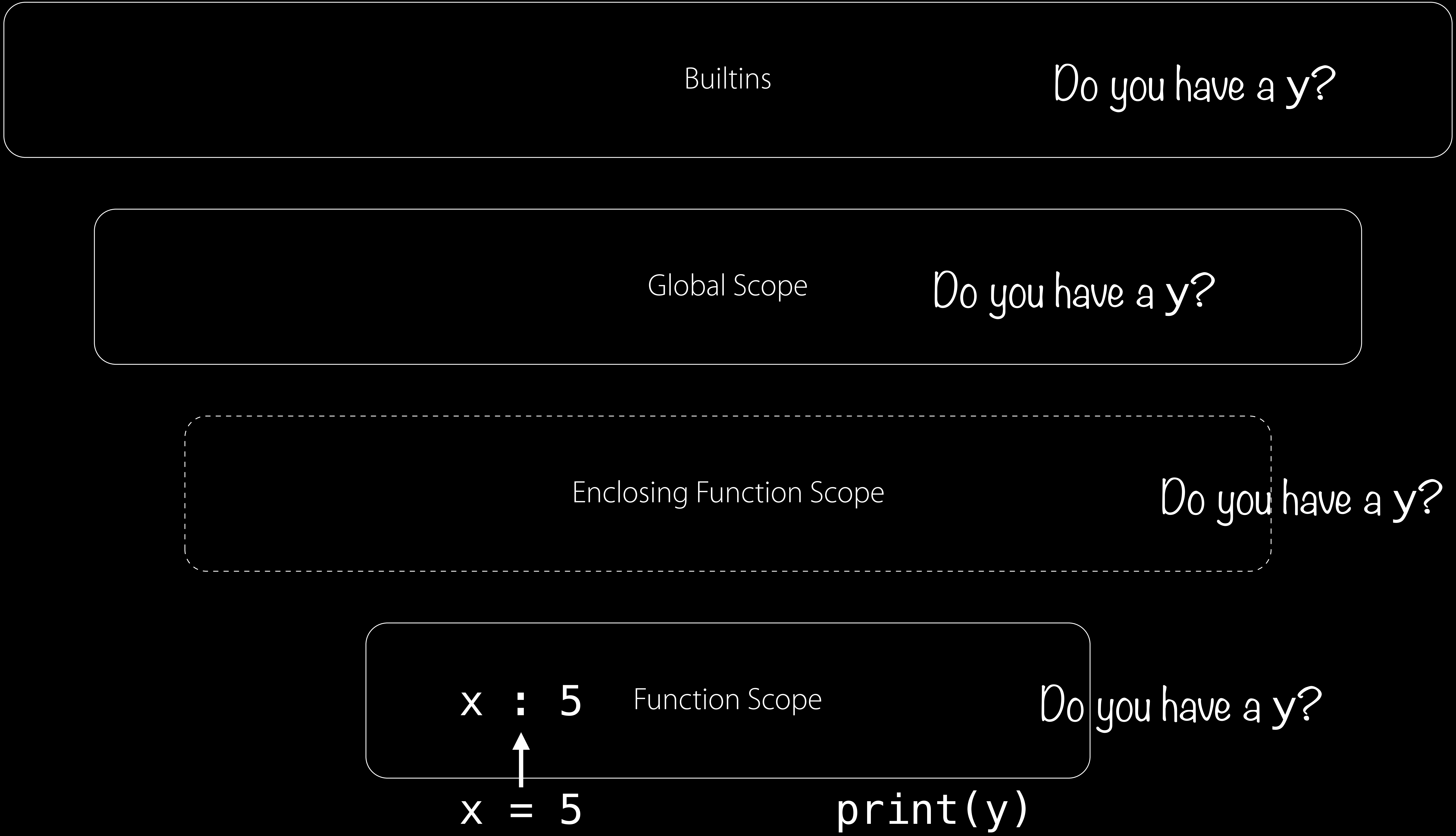
Function Scope
Do you have a y?

```
x = 5                print(y)
```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```
print(y)
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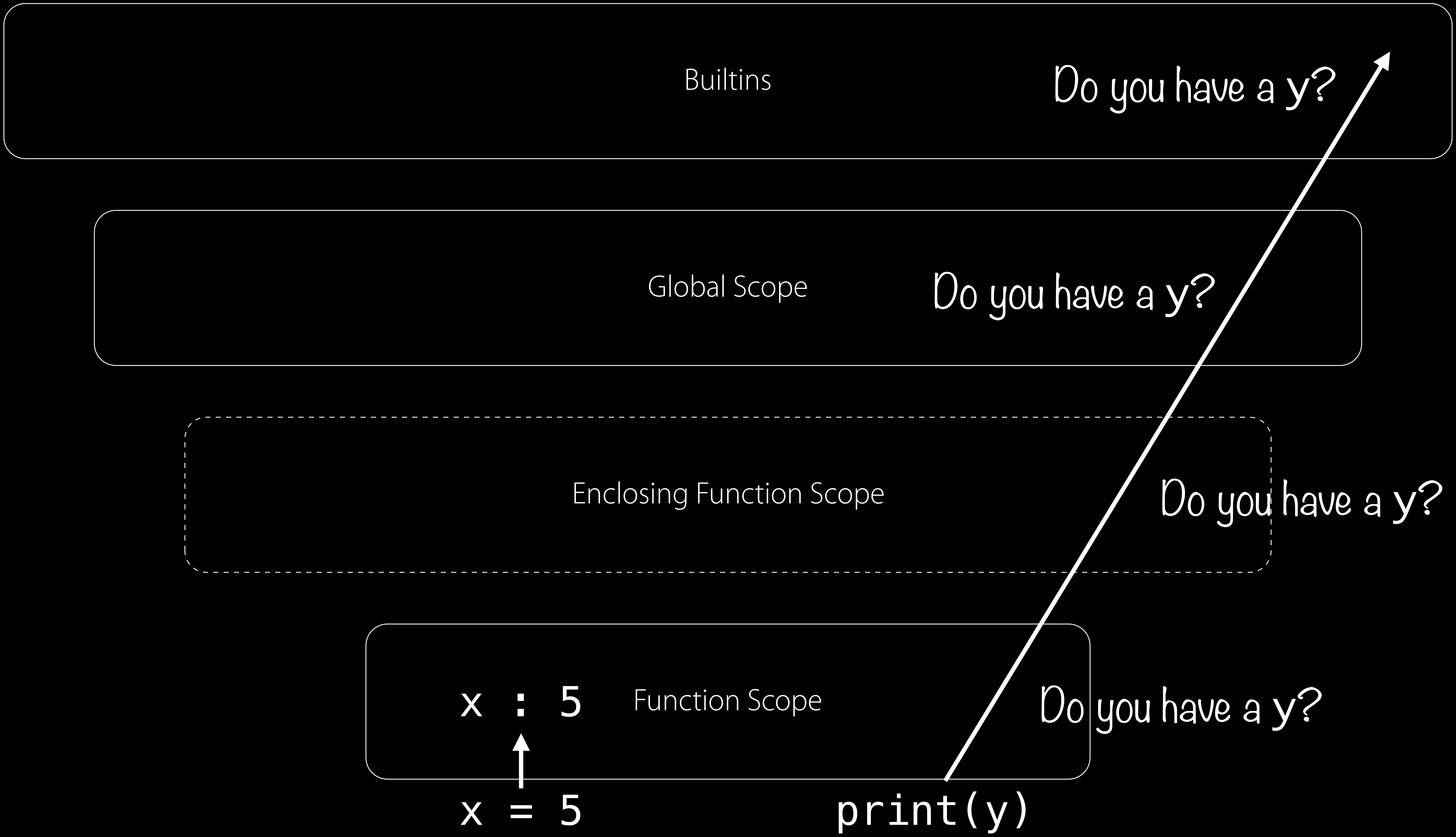
Builtins
Do you have a y?
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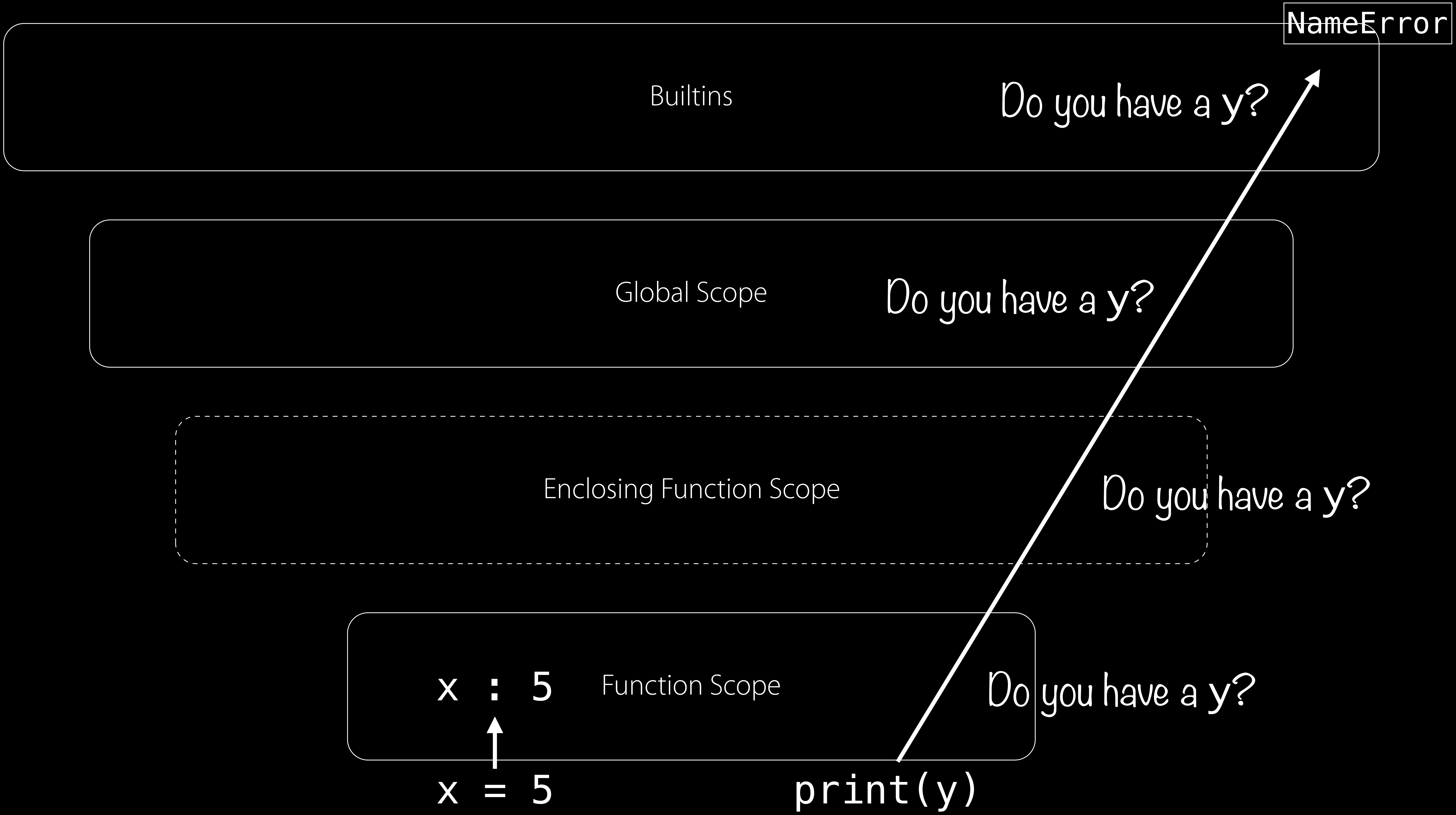
NameError
Builtins
Do you have a y?
Global Scope
Do you have a y?
Enclosing Function Scope
Do you have a y?
x : 5
Function Scope
Do you have a y?
x = 5
print(y)

If / For Scope

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- Notably, only* function definitions define new scopes

*Also classes... kinda (Wk 5)

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- If statements, for loops, while loops, etc do *not* introduce a new scope.

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If / For Scope

- Notably, only* function definitions define new scopes
- If statements, for loops, while loops, etc do *not* introduce a new scope.

```python
if success:
    desc = 'Winner!'
else:
    desc = 'Loser :('
print(desc)
```

*Also classes... kinda (Wk 5)

Pass-By-Value or Pass-By-Reference?

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Pass-By-Value or Pass-By-Reference?

- Variables *are* copied into function's local symbol table
  - But variables are just references to objects!
- Best to think of it as *pass-by-object-reference*
  - If a mutable object is passed, caller will see changes

Default Parameters

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    - Provide reasonable defaults for parameters

Default / Named Parameters

- Specify a default value for one or more parameters
    - Called with fewer arguments than it is defined to allow
- Usually used to provide "settings" for the function.
- Why?
    - Present a simplified interface for a function
    - Provide reasonable defaults for parameters
    - Declare intent to caller that parameters are "extra"

```python
def ask_yn(prompt,
           retries=4,
           complaint='...'):
```

Required argument `prompt`

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Optional argument `retries` defaults to 4

Required argument `prompt`

```
def ask_yn(prompt,
           retries=4,
           complaint='...'):
```

Optional argument `retries` defaults to 4

Optional argument `complaint` defaults to 'Enter Y/N'

Keyword Arguments

Keyword Arguments

```
def ask_yn(prompt, retries=4, complaint='Enter Y/N!'):
    for i in range(retries)
        ok = input(prompt)
        if ok == 'Y':
            return True
        if ok == 'N':
            return False
        print(complaint)
    return False
```

Examples

```
print(…, sep=' ', end='\n', file=sys.stdout, flush=False)
range(start, stop, step=1)
enumerate(iter, start=0)
int(x, base=10)
pow(x, y, z=None)
seq.sort(*, key=None, reverse=None)
```

Examples

```
print(…, sep=' ', end='\n', file=sys.stdout, flush=False)
range(start, stop, step=1)
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subprocess.Popen(args, bufsize=-1, executable=None,
stdin=None, stdout=None, stderr=None, preexec_fn=None,
close_fds=True, shell=False, cwd=None, env=None,
universal_newlines=False, startupinfo=None,
creationflags=0, restore_signals=True,
start_new_session=False, pass_fds=())
```

Examples

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print(…, sep=' ', end='\n', file=sys.stdout, flush=False)
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```

Wow...

```
ask_yn(prompt, retries=4, complaint='...')
```

ask_yn(prompt, retries=4, complaint='...')

```
# Call with only the mandatory argument
ask_yn('Really quit?')
ask_yn(prompt, retries=4, complaint='...')
```

```
# Call with only the mandatory argument
ask_yn('Really quit?')

# Call with one keyword argument
ask_yn('OK to overwrite the file?', retries=2)
```

ask_yn(prompt, retries=4, complaint='...')

```
# Call with only the mandatory argument
ask_yn('Really quit?')

# Call with one keyword argument
ask_yn('OK to overwrite the file?', retries=2)

# Call with one keyword argument - in any order!
ask_yn('Update status?', complaint='Just Y/N')
```

ask_yn(prompt, retries=4, complaint='...')

```
# Call with only the mandatory argument
ask_yn('Really quit?')

# Call with one keyword argument
ask_yn('OK to overwrite the file?', retries=2)

# Call with one keyword argument - in any order!
ask_yn('Update status?', complaint='Just Y/N')

# Call with all of the keyword arguments
ask_yn('Send text?', retries=2, complaint='Y/N please!')
```

Rules about Function Calls

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```python
def fn(a): pass
fn(0, a=0)
# Not allowed! Multiple values for a
```

Variadic Positional Arguments

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        - Used in subclasses, proxies, and decorators

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  - These excess arguments are bundled into an **`args`** tuple
- Why?
  - Call functions with any number of positional arguments
  - Capture all arguments to forward to another handler
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```
print(*objects, sep=' ', end='\n', file=sys.stdout, flush=False)
```

Variadic Positional Arguments

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```
# Suppose we want a product function that works as so:
product(3, 5)  # => 15
product(3, 4, 2)  # => 24
product(3, 5, scale=10)  # => 150
```

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# Suppose we want a product function that works as so:
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# product accepts any number of arguments
def product(*nums, scale=1):
```

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product(3, 5)  # => 15
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product(3, 5, scale=10)  # => 150


# product accepts any number of arguments
def product(*nums, scale=1):
    p = scale
    for n in nums:
        p *= n
    return p
```

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# Suppose we want a product function that works as so:
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# product accepts any number of arguments
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        p *= n
    return p
```

Named parameters after `*args` are 'keyword-only' arguments

Unpacking Variadic Positional Arguments

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```
# Suppose we want to find 2 * 3 * 5 * 7 * … up to 100
def is_prime(n):  pass  # Some implementation
```

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# Suppose we want to find 2 * 3 * 5 * 7 * … up to 100
def is_prime(n):  pass  # Some implementation

# Extract all the primes
primes = [number for number in range(2, 100)
          if is_prime(number)]
```

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# Extract all the primes
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          if is_prime(number)]

print(product(*primes))  # equiv. to product(2, 3, 5, …)
```

The syntax `*seq` unpacks a sequence into its constituent components

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  - Similar: capture all arguments to forward to another handler

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- Why?
  - Allow arbitrary named parameters, usually for configuration
  - Similar: capture all arguments to forward to another handler
    - Used in subclasses, proxies, and decorators

Variadic Keyword Arguments

Variadic Keyword Arguments

```python
def authorize(quote, **speaker_info):
    print(">", quote)
    print("-" * (len(quote) + 2))
    for k, v in speaker_info.items():
        print(k, v, sep=': ')
```

Calling Variadic Keyword Arguments

Calling Variadic Keyword Arguments

```
authorize(
    "If music be the food of love, play on.",
    playwright="Shakespeare",
    act=1,
    scene=1,
    speaker="Duke Orsino"
)
```

Calling Variadic Keyword Arguments

```
authorize(
    "If music be the food of love, play on.",
    playwright="Shakespeare",
    act=1,
    scene=1,
    speaker="Duke Orsino"
)
```

```
speaker_info = {
  'act': 1,
  'scene': 1,
  'speaker': "Duke Orsino",
  'playwright': "Shakespeare"
}
```

Calling Variadic Keyword Arguments

```
authorize(
    "If music be the food of love, play on.",
    playwright="Shakespeare",
    act=1,
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)
```

```
speaker_info = {
  'act': 1,
  'scene': 1,
  'speaker': "Duke Orsino",
  'playwright': "Shakespeare"
}
```

```
# > If music be the food of love, play on.
# ----------------------------------------
# act: 1
# scene: 1
# speaker: Duke Orsino
# playwright: Shakespeare
```

Example: Formatting Strings

```
fstr.format(*args, **kwargs)
```

All positional arguments go into `args`

```
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```
fstr.format(*args, **kwargs)
```

All keyword arguments go into `kwargs`

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```
# {n} refers to the nth positional argument in `args`
"First, thou shalt count to {0}".format(3)
```

fstr.format(*args, **kwargs)

```
# {n} refers to the nth positional argument in `args`
"First, thou shalt count to {0}".format(3)          args = (3, )
```

fstr.format(*args, **kwargs)

```
# {n} refers to the nth positional argument in `args`
"First, thou shalt count to {0}".format(3)          args = (3, )
"{0} shalt thou not count, neither count thou {1},
excepting that thou then proceed to {2}".format(4, 2, 3)
```

fstr.format(*args, **kwargs)

```
# {n} refers to the nth positional argument in `args`
"First, thou shalt count to {0}".format(3)        args = (3, )
"{0} shalt thou not count, neither count thou {1},
excepting that thou then proceed to {2}".format(4, 2, 3)
                                                args = (4, 2, 3)
```

fstr.format(*args, **kwargs)

```
# {n} refers to the nth positional argument in `args`
"First, thou shalt count to {0}".format(3)          args = (3, )
"{0} shalt thou not count, neither count thou {1},
excepting that thou then proceed to {2}".format(4, 2, 3)
                                                  args = (4, 2, 3)

# {key} refers to the optional argument bound by key
"lobbest thou thy {weapon} towards thy foe".format(
    weapon="Holy Hand Grenade of Antioch"
)
```

fstr.format(*args, **kwargs)

```python
# {n} refers to the nth positional argument in `args`
"First, thou shalt count to {0}".format(3)        args = (3, )
"{0} shalt thou not count, neither count thou {1},
excepting that thou then proceed to {2}".format(4, 2, 3)
                                               args = (4, 2, 3)

# {key} refers to the optional argument bound by key
"lobbest thou thy {weapon} towards thy foe".format(
    weapon="Holy Hand Grenade of Antioch"
)
        kwargs = {"weapon": "Holy Hand Grenade of Antioch"}
```

Complicated Example

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```
"{0}{b}{1}{a}{0}{2}".format(
    5, 8, 9, a='z', b='x'
)
```

Complicated Example

```
"{0}{b}{1}{a}{0}{2}".format(
    5, 8, 9, a='z', b='x'
)
```

```
args = (5, 8, 9)
kwargs = {'a':'z', 'b':'x'}
```

Complicated Example

```
"{0}{b}{1}{a}{0}{2}".format(
    5, 8, 9, a='z', b='x'
)
# => 5x8z59
```

```
args = (5, 8, 9)
kwargs = {'a':'z', 'b':'x'}
```

Cute Trick: Unpacking Variadic Keyword Arguments

```
x = 3
foo = 'fighter'
y = 4
bar = 'bell'
z = 5
```

Cute Trick: Unpacking Variadic Keyword Arguments

```
x = 3

foo = 'fighter'

y = 4

bar = 'bell'

z = 5
```

local symbol table

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    'x': 3,
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Cute Trick: Unpacking Variadic Keyword Arguments

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Usually slow... and bad style, but can be useful for debugging!

Putting it All Together

A Valid Python Function Definition

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def foo(a, b, c=1, *d, e=1, **f)
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A Valid Python Function Definition

Mandatory positional arguments

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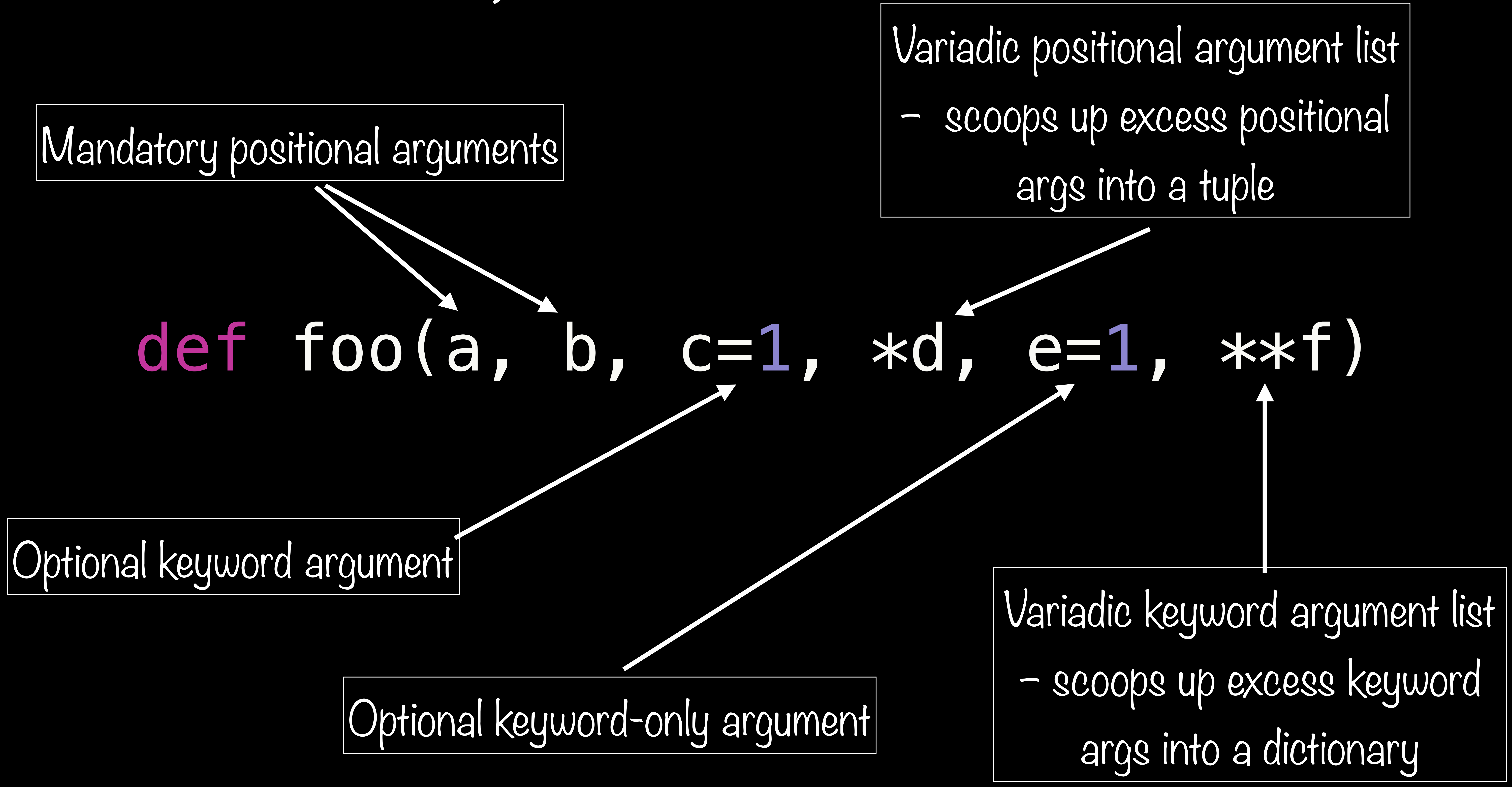

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Mandatory positional arguments
Variadic positional argument list – scoops up excess positional args into a tuple
Optional keyword argument
Optional keyword-only argument
Variadic keyword argument list – scoops up excess keyword args into a dictionary

Aside: Code Style

Function Comments

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- The usual rules apply too! List pre-/post-conditions, if any.

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Decomposition and Logic Same as in 106s

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print(echo)  # <function echo at 0x1003c2bf8>

foo = echo
hex(id(foo))  # '0x1003c2bf8'
print(foo)  # <function echo at 0x1003c2bf8>

isinstance(echo, object)  # => True
```

Functions are Objects

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WE MUST GO DEEPER

Summary

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Use docstrings and good style

Functions are objects too (?!)