

CSE 130 : Fall 2011

Programming Languages

Lecture 13:
What's in a Name ?

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Next: What's in a name ?

More precisely:

- How should programmer think of data
- What does a variable “x” really mean ?

What's in a name ?

ML (or Functional Languages)

- Name refers to a Value
- Binding maps Names to Values
- Environment list of bindings
- Environment can be extended
- Environment can't be changed

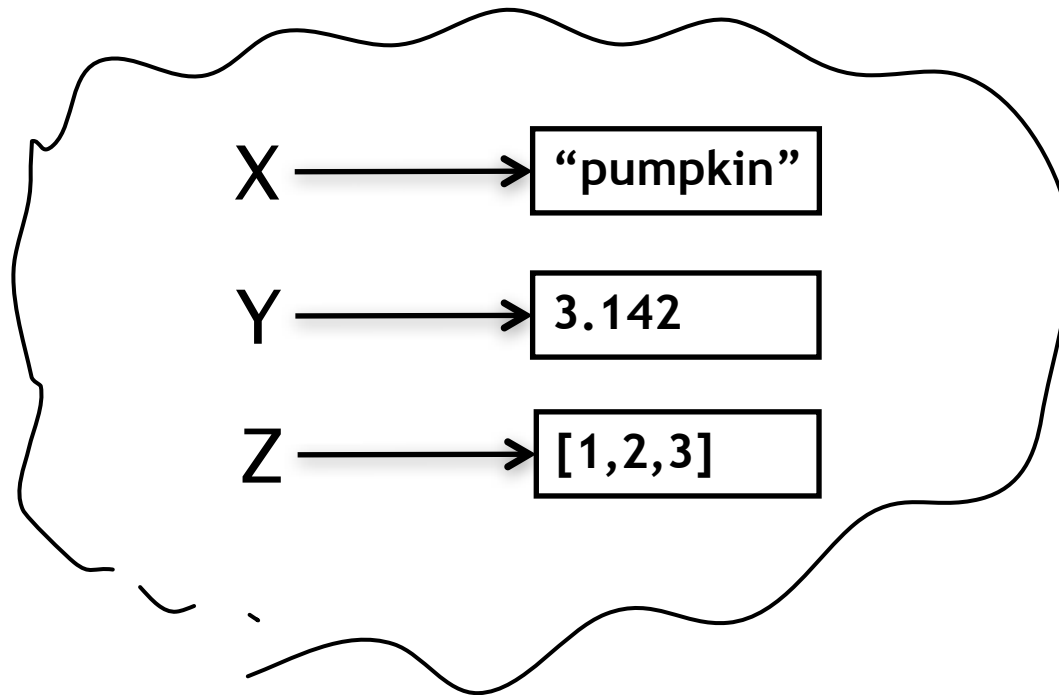
name	value
x	5
y	"a"b
z	2.9
⋮	
x	2.7

Data model in functional PL

- Vars = names in phonebook
- Evaluation = Most recent
- Environment “frozen” in function value
 - behavior of function cannot be changed
 - easier reasoning

Data model in OO languages

- Variables “point to” objects
- Objects = boxes with data inside

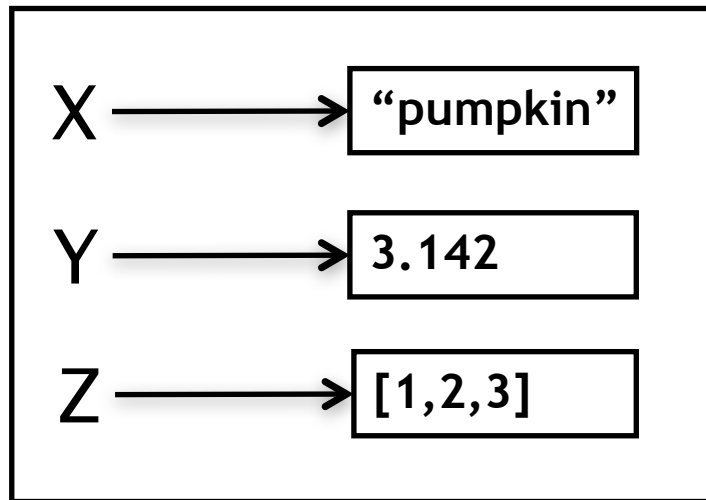


Namespaces

- Manage variable names in Python
- Similar to, but different from Environments
 - Core PL concept, unifies many ideas
- We will see very important differences

Ok, but what IS a namespace ?

A mapping from names to objects



Namespaces vs. Environments

Both are maps from variables to something

Namespace

Environment

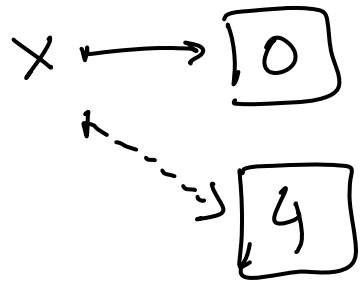
What's the difference ?

1. Assignment

2. Updates/Mutation

1. Assignment

Basic operation in Imperative PL:



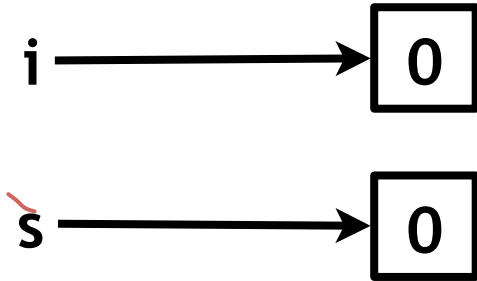
x = e

1. Compute object corresponding to e
2. Change the name “x” to refer to object

Simple example

```
i,s = 0,0  
while (i <= 3):  
    i,s = i+1, s+i
```

Iter 0

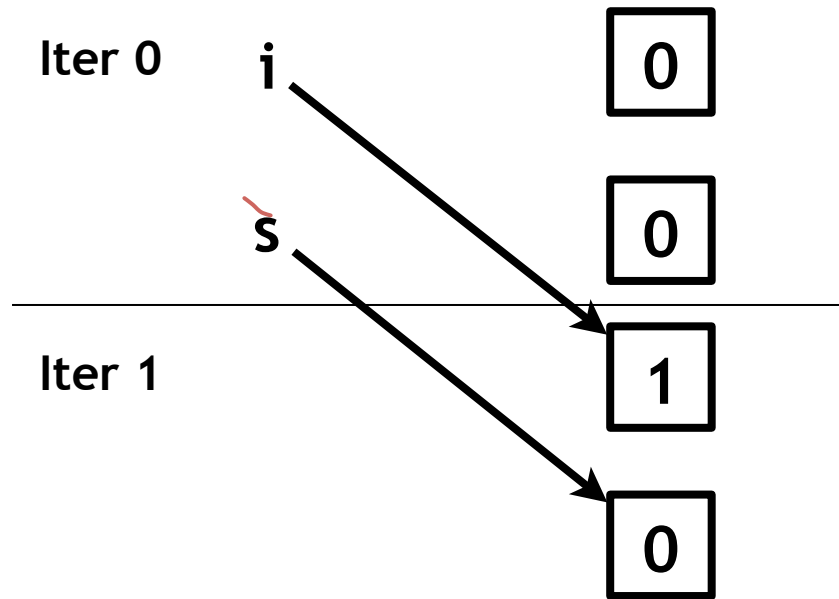


Same name “s”

- points to different objects
- namespace is not extended

Simple example

```
i,s = 0,0  
while (i <= 3):  
    i,s = i+1, s+i
```

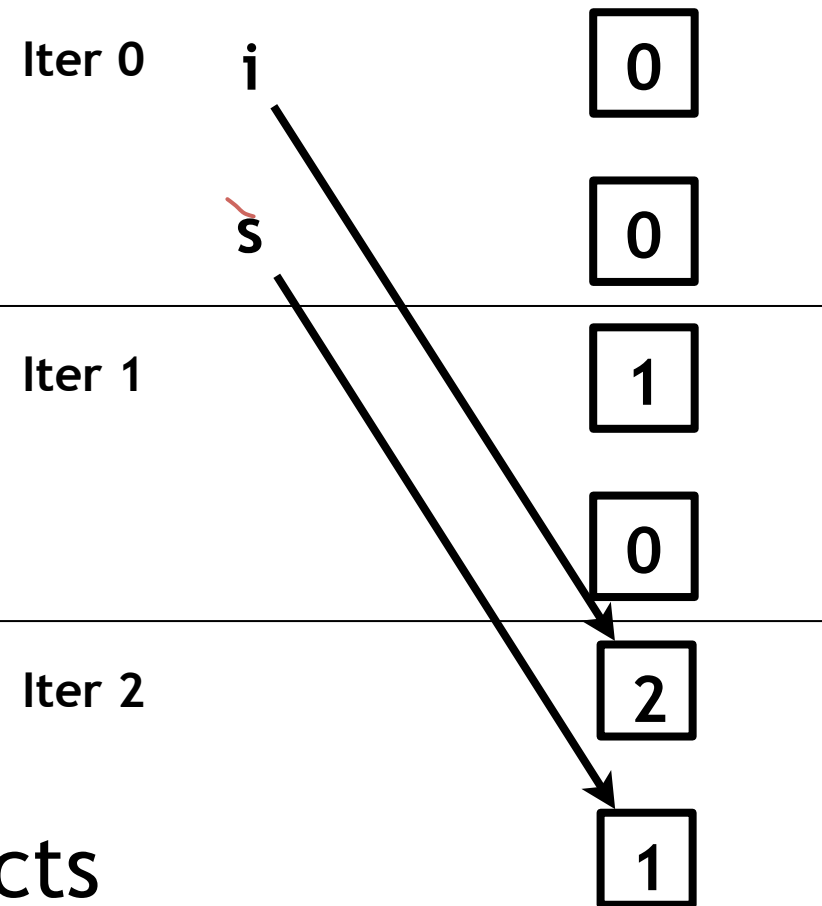


Same name “s”

- points to different objects
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Simple example

```
i,s = 0,0  
while (i <= 3):  
    i,s = i+1, s+i
```



Same name “s”

- points to different objects
- namespace is not extended

1. Assignment

Basic operation in Imperative PL:

$$x = e$$

1. Compute object corresponding to e
2. Change the name “ x ” to refer to object

Assignment: changes box that name refers to

2. Update/Mutation

Change what's inside the box (object)

- Not with **immutable** objects
 - eg. integers
- But with **mutable** objects
 - eg. arrays, lists, dictionaries

```
>>> x = [100,200]
>>> x
[100, 200]
>>> x[0] = "gobble gobble"
>>> x
['gobble gobble', 200]
```

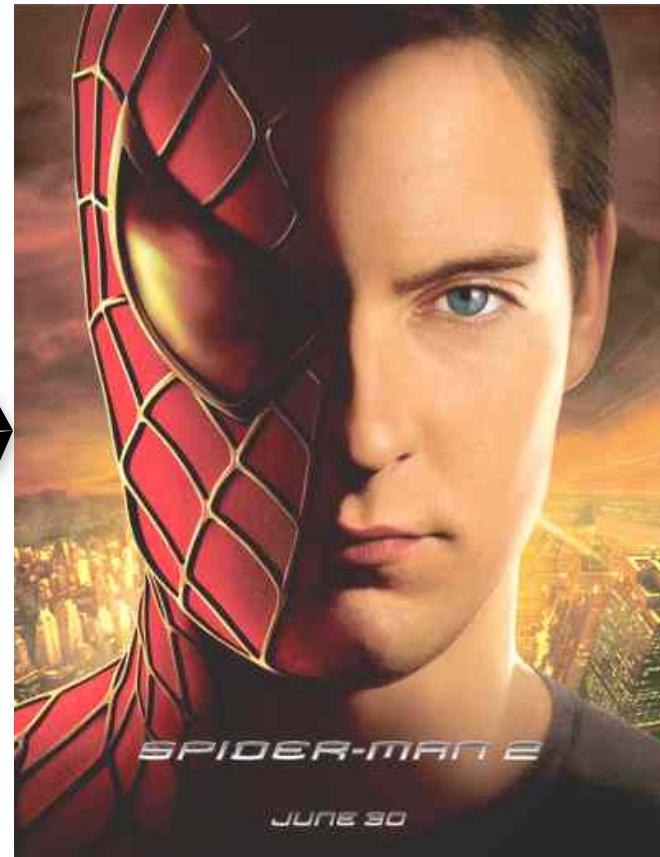
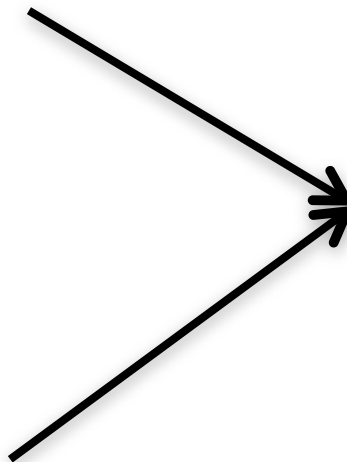
How is it different from
“build a new box with
updated value inside” ?

Aliasing

Two or more names refer to same object

“Peter Parker”

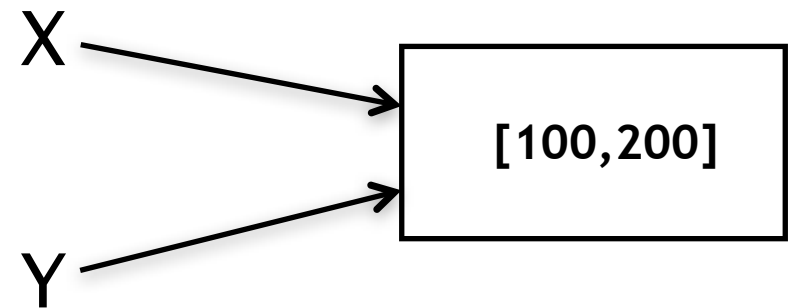
“Spider-Man”



Aliasing

Two or more names refer to same object

```
>> x = [100,200]  
>> y = x
```

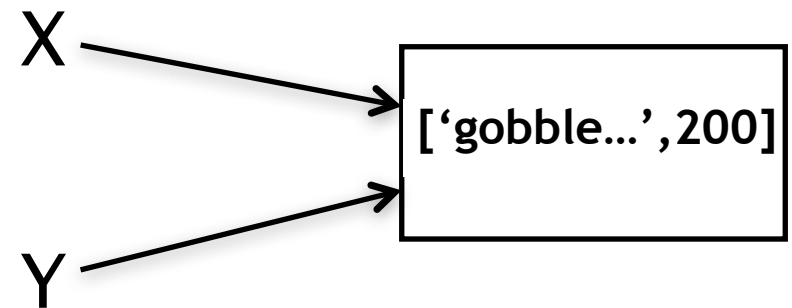


Aliasing and Update

Two or more names refer to same object

```
>> x = [100,200]
>> y = x

>> y[0] = "gobble gobble"
>> x
```

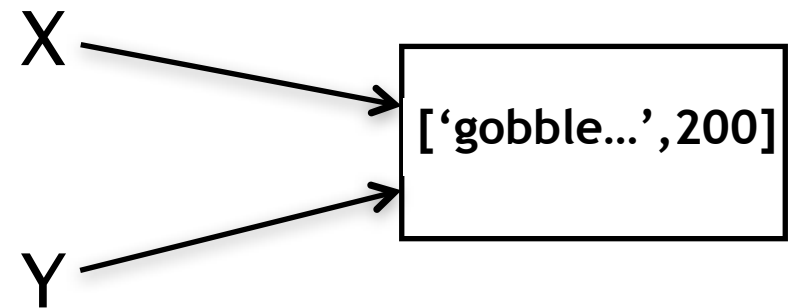


Aliasing

Two or more names refer to same object

```
>> x = [100,200]
>> y = x

>> y[0] = "gobble gobble"
>> x
['gobble gobble',200]
```



If multiple names refer to same object,
update affects values of all names

Aliasing

Does not happen in **Ocaml/Functional PLs**

- actually it does happen (where ?)
- but not exposed to the (130) programmer

Does happen in every **imperative PL**

- Java, Python: **names** point to **objects**
- C: **names** point to **memory cells**

Aliasing

Good because ?

Avoids copying objects

Bad because ?

Sharing

Non-local effects

Memory Leaks

Namespaces everywhere

Namespace = map from names to objects

Notion of namespace pervades Python

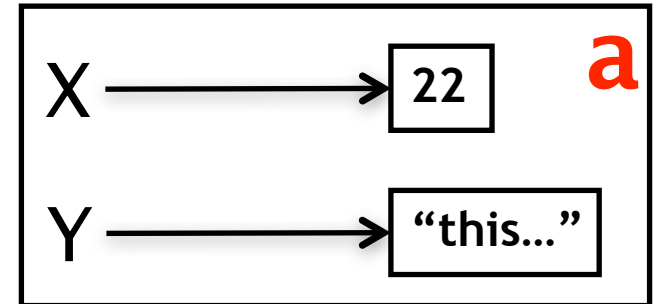
- Can **create** namespace,
- Can **name** a namespace,
- Can **peek inside** a namespace (see whats bound)

Go to code!

Creating Namespaces

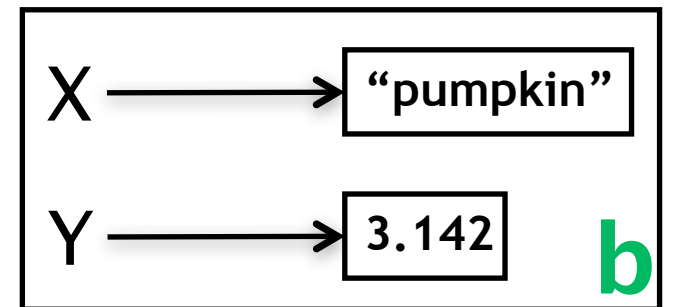
a.py

```
x = 22  
y = "this sentence is false"
```



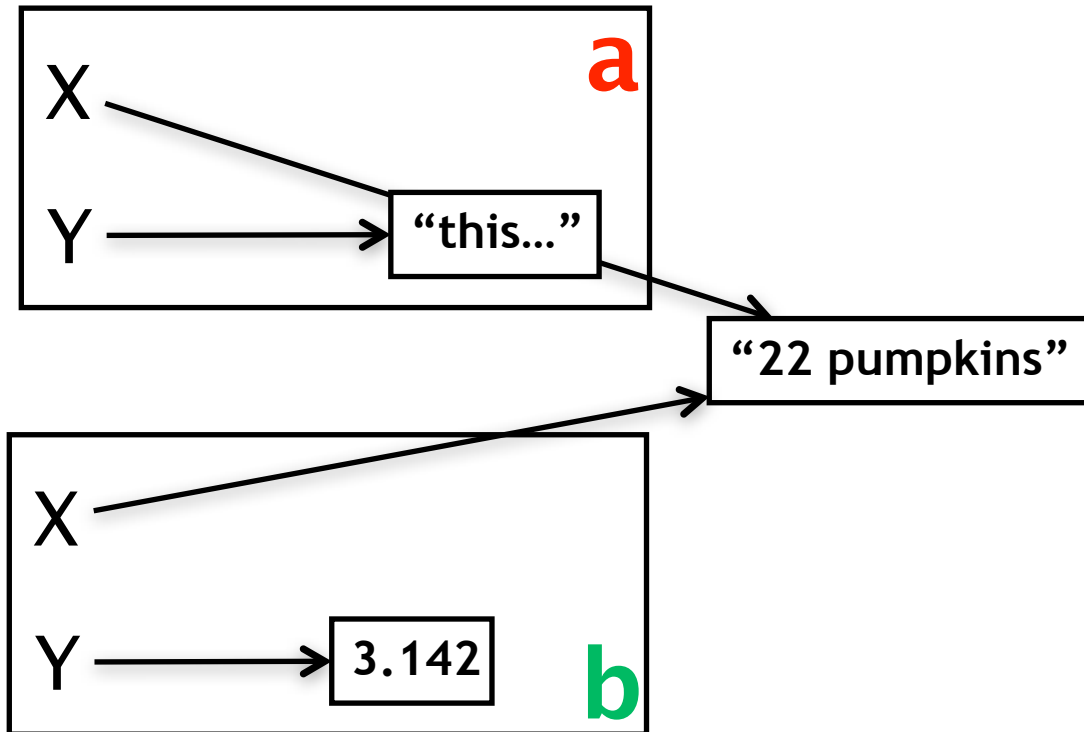
b.py

```
x = "pumpkin"  
y = 3.142
```



```
>>> import a  
>>> a.x  
22
```

Namespaces

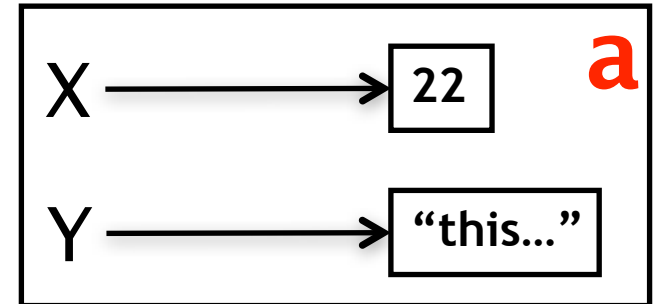


Different names can point to same object!

Namespaces

For two namespaces **a** , **b**:

- names inside unrelated
- names in different spaces

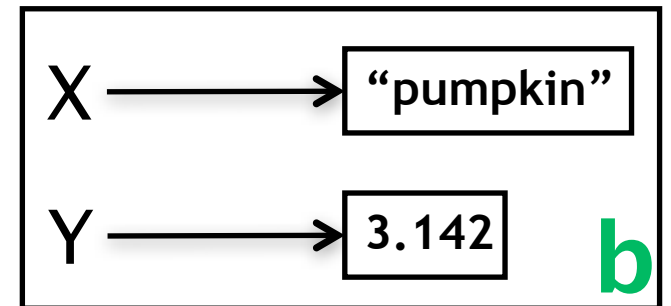


a.x :

attribute/name **"x"** in space **"a"**

b.x :

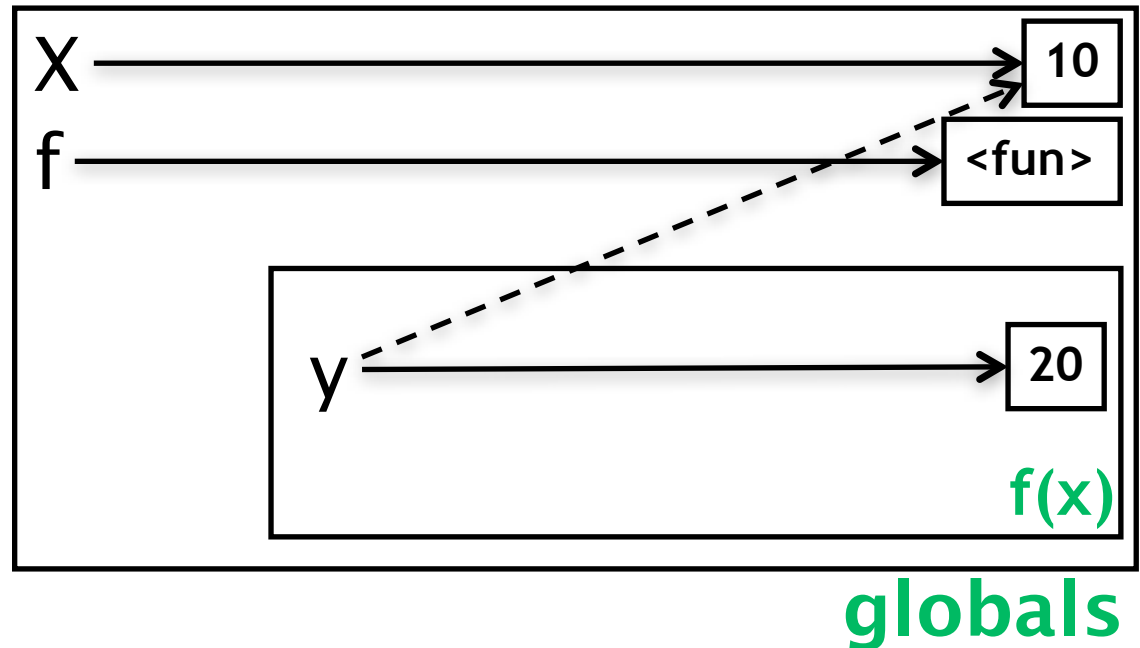
attribute/name **"x"** in space **"a"**



Different names can point to same object!

Creating Namespaces: Fun Calls

```
x = 10  
  
def f(y):  
    y = y + x  
    return y  
  
f(x)
```



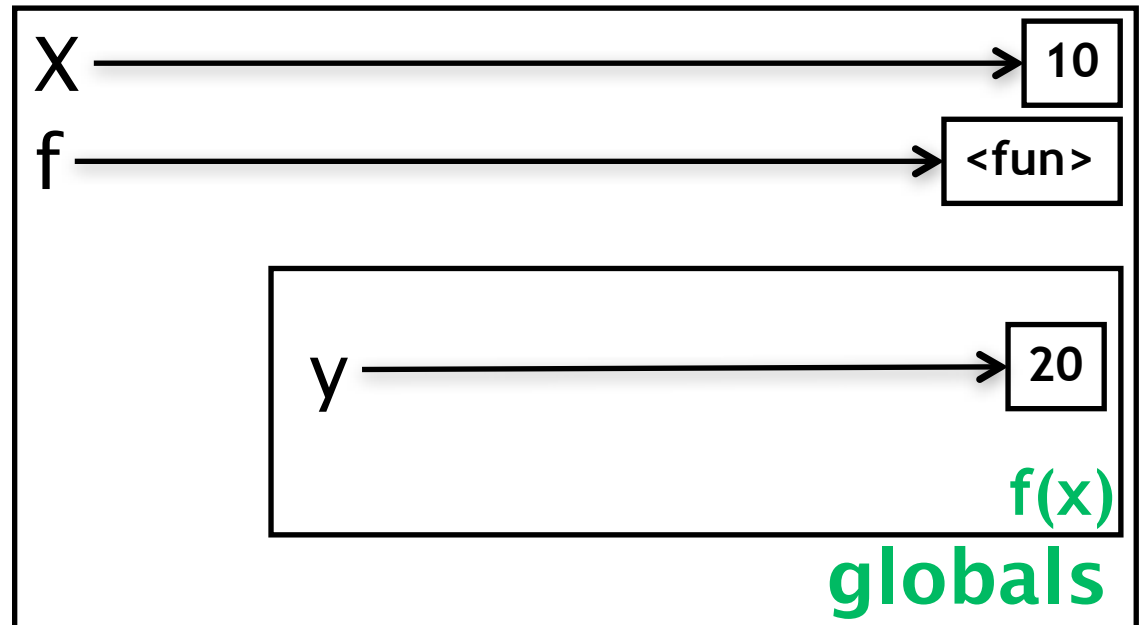
Call-by-Value:

- New local namespace for call
- y bound to same object (value) as arg x
- x binding unchanged by call

In this case, after call, local namespace disappears...

Creating Namespaces: Fun Calls

```
x = 10  
  
def f(y):  
    y = y + x  
    return y  
  
f(x)
```



Questions:

- Why “new local namespace” (not just stack) ?
- What’s the deal with “`x`” not declared/bound in “`f`” ?
- When do we need to freeze a namespace ?

Creating Namespaces: Fun Calls 2

```
y = 0
x = [10]

def f(y):
    z = len(x)+y
    return z

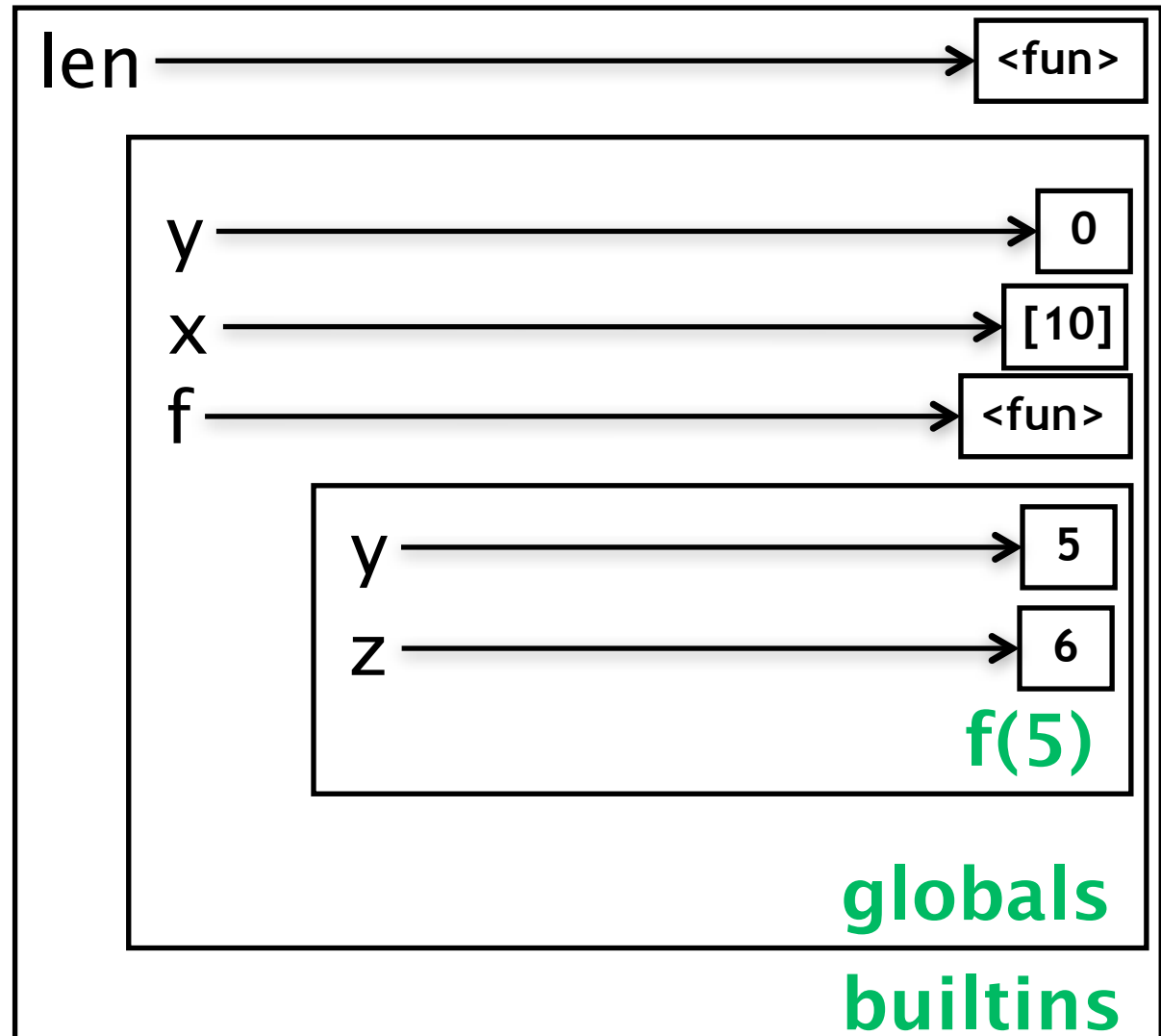
f(5)
```

Static Scoping

Lookup at runtime

Not compile time

Missing z added



Creating Namespaces: Fun Calls 3

```
>>> def g(y):  
>>>     return y + n  
>>> g(5)  
...NameError:  
global name 'n'  
is not defined
```

What happened ?

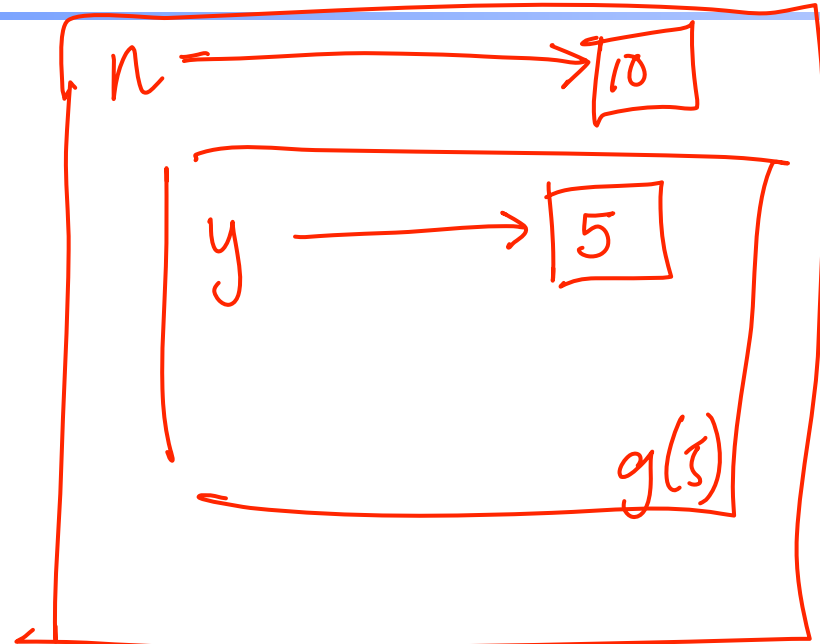
Looks for “n” at **run-time** ,when “g” is called

Can't find “n” in local, global, builtins

Throws run-time error...

Creating Namespaces: Fun Calls 3

```
>>> def g(y):  
>>>     return y + n  
>>> g(5)  
NameError...  
>>> n = 10  
>>> g(5)  
15
```



What happened ?

Looks for “n” at **run-time** ,when “g” is called

Finds “n” in global, returns 15

Here “n” is a “free variable” of “g”

Needs to be “bound” in some enclosing scope

ML : compile time
Pyth : run time !

Aaargh!

```
>>> def g(y):  
>>>     return y + n  
>>> g(5)  
NameError...  
>>> n = 10  
>>> g(5)  
15  
>>> n = 100  
>>> g(5)  
105
```

Changed behavior after definition
whether or not fun works depends
on what we did after func-definition

Change I/O behavior too ...

Unlike ML, no new binding:
Just **change** what “n” is bound to
Be careful with **free variables!**

Python tries to avoid “overwrites”

```
>>> n
100
>>> def f():
>>>     n = “smash”
>>>     print n
>>>
>>> f()
smash
>>> n
100
```

Python tries to ensure you
don't overwrite outer variables

How ?

- unlike C/Java
- assignment different from reads
- no variable “declarations”
- assignment = declaration!

Python tries to avoid “overwrites”

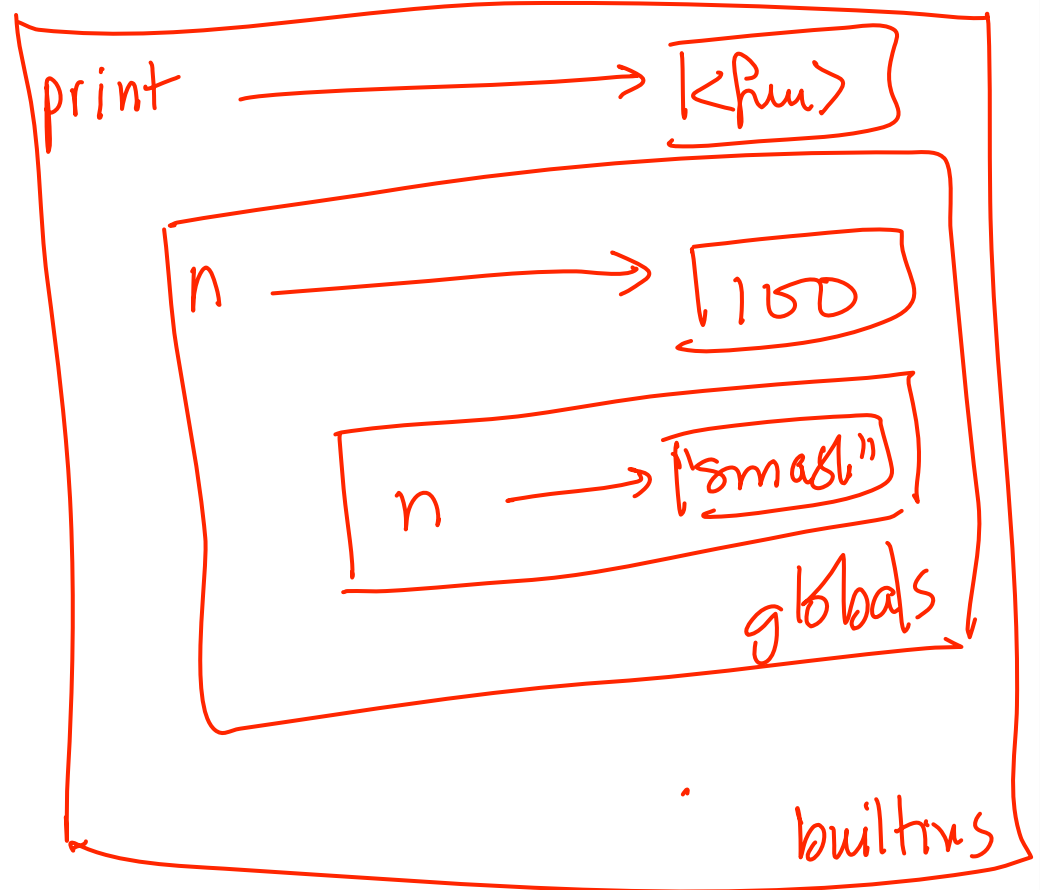
Assignment Revisited

$x = e$

1. Compute object corresponding to e
2. Change the name “ x ” to refer to object in the current namespace (added if missing)

Python tries to avoid “overwrites”

```
>>> n
100
>>> def f():
>>>     n = "smash"
>>>     print n
>>>
>>> f()
smash
>>> n
100
```



hence in global scope $n = 100$.

What happens ?

```
>>> x = 10
>>> def g():
>>>     x = x + 1
>>>     print x
>>>
>>> g()
>>> x
```

What happens ?

```
>>> x = 10
>>> def g():
>>>     global x
>>>     x = x + 1
>>>     print x
>>>
>>> g()
>>> x
```

What happens ?

```
>>> x = [10]
>>> def g():
>>>     x[0] = "abc"
>>>     print x
>>>
>>> g()
>>> x
```

Remember: Assignment v. Mutation!

What happens? (Hint: Closures!)

```
>>> x = [10]
>>> def f(y):
>>>     def h(z):
>>>         return (y+x[0]+z)
>>>     return h
>>>
>>> foo = f(5)
>>> foo
<function object>
>>> foo(100)
>>> 115
>>> foo1 = f(-5)
>>> foo1(100)
105
```

