Python for Astronomers

Functions and modules

Exercise

- The files HD152200.uvspec and HD152234.uvspec in /home/mmetz contain FUSE spectra (thanks to Ole !) of the star HD* as ASCII data (wavelength, count rate).

  i) Read the data, normalise the count rates, and plot both spectra into one subplot.

  ii) Create a subplot below the first one and plot binned spectra (use numpy to bin the data)

Defining functions

```
>>> def fib(n):
...     """Print Fibonacci numbers up to n"""
...     a, b = 0, 1
...     print a,
...     while b <= n:
...       print b,
...       a, b = b, a + b

>>> fib(2000)     # Execute function for integer
>>> fib(1000.)    # for float
>>> fib("abc")    # and for string
```

return statement

```
>>> def fib2(n):
...     fibs, newfib = [0, 1], 1
...     while newfib <= n:
...         fibs.append(newfib)
...         newfib = fibs[-1] + fibs[-2]
...     return fibs

>>> f2000 = fib2(2000)
>>> print f2000

>>> f1000 = fib(1000)    # Function fib has no return!
>>> print f1000          # None returned
```

Recursive functions

```
>>> def fact(n):
...    if n > 0:
...      return n * fact(n-1) # Recursive call
...    return 1  # exits function returning 1

>>> print fact(100)
>>> print fact(1000)
```

Excercise: Determine the maximum recursion depth

Solution

```
>>> n = 0
>>> while fact(n):
...     print n
...     n += 1
```

Calling functions

```
>>> def f(x, y, z):
...     print x, y, z

>>> # Using positional arguments:
>>> f("Ham", 17+4, [1,2,3])
>>> f(17+4, [1,2,3], "Ham")

>>> # Using keyword arguments:
>>> f(x="Spam", y=13, z=range(3))
>>> f(y=13, z=range(3), x="Spam")

>>> # Using positional and keyword arguments:
>>> f(1, z="last", y=[2])
```

Default arguments

```
>>> def f(x=1, y=2, z=3):
...     print x, y, z

>>> f()
>>> f(42, 13)
>>> f(z="Three")

>>> def f(x, y, z=None):
...     if z is None:
...         doSomething(x, y)
...     else:
...         doSomethingElse(x, y, z)
```

Excersices: Function calls

```
>>> def f(x, y, z):
...     print x, y, z

>>> # Test the following function calls:
>>> f(1, 2)
>>> f(1, 2, 3, 4)
>>> f(x=1, y=2, bla=3)
>>> f(1, x=2, y=3, z=4)
>>> f(x=1, 2, 3)

>>> # Repeat with
>>> def f(x="a", y="b", z="c"):
...     print x, y, z
```

Local variables

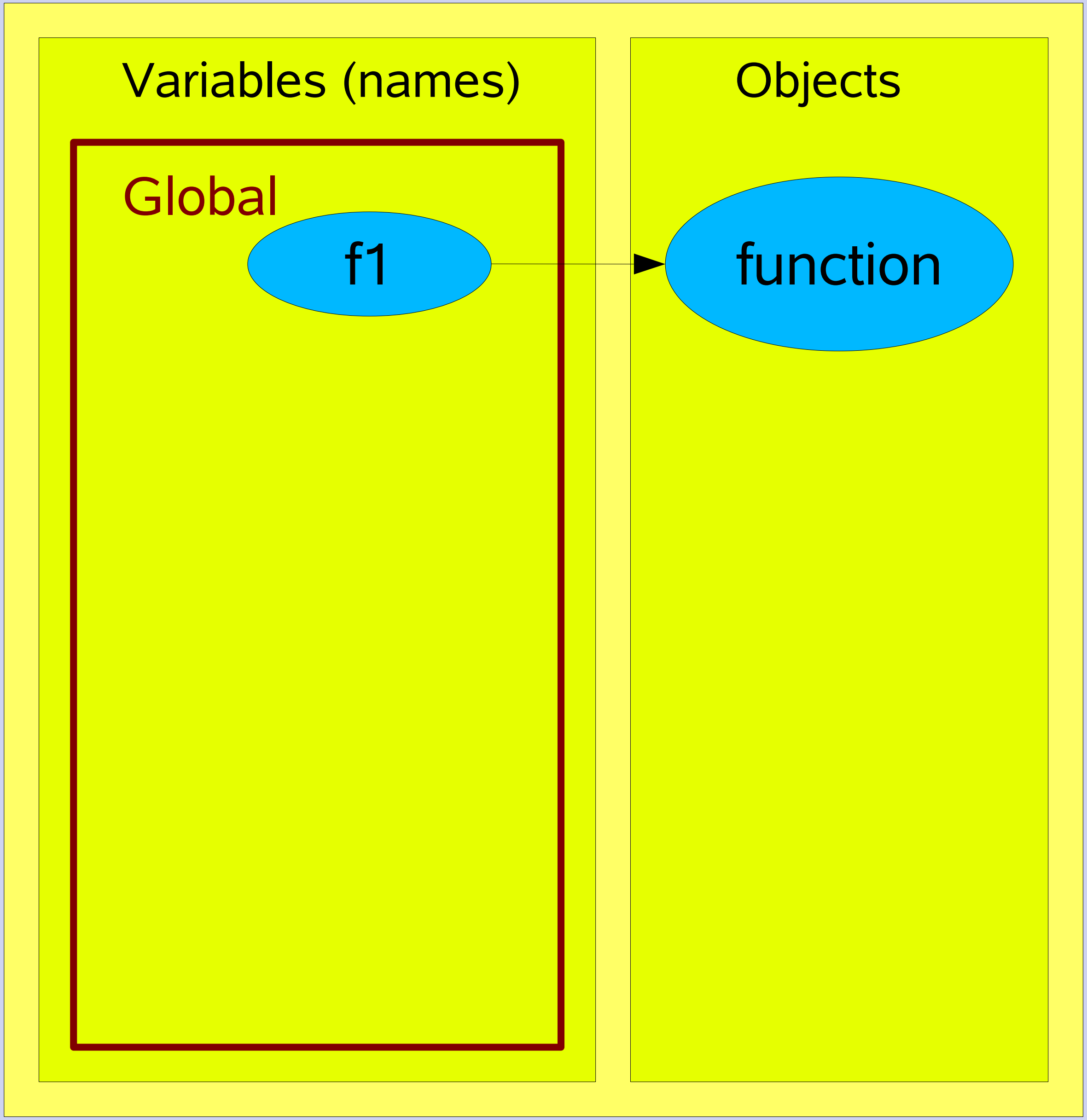
```
>>> import math

>>> def area(r):
...     """Area of circle with radius r"""
...     return math.pi * r**2    # Name math is known!

>>> def volume(r, h):
...      """Vol. of cylinder with radius r, height h"""
...      return area(r) * h      # Name area is known!


>>> volume(1., 2.)
```

Local variables

```
>>> def f1():
...     print x            # Use variable x

>>> def f2():
...     x = "local x"  # Assign variable x
...     print x

>>> x = "global x"     # Same name x as in functions
>>> f1()               # "global x"
>>> print x            # "global x"

>>> f2()               # "local x"
>>> print x            # still "global x"
```

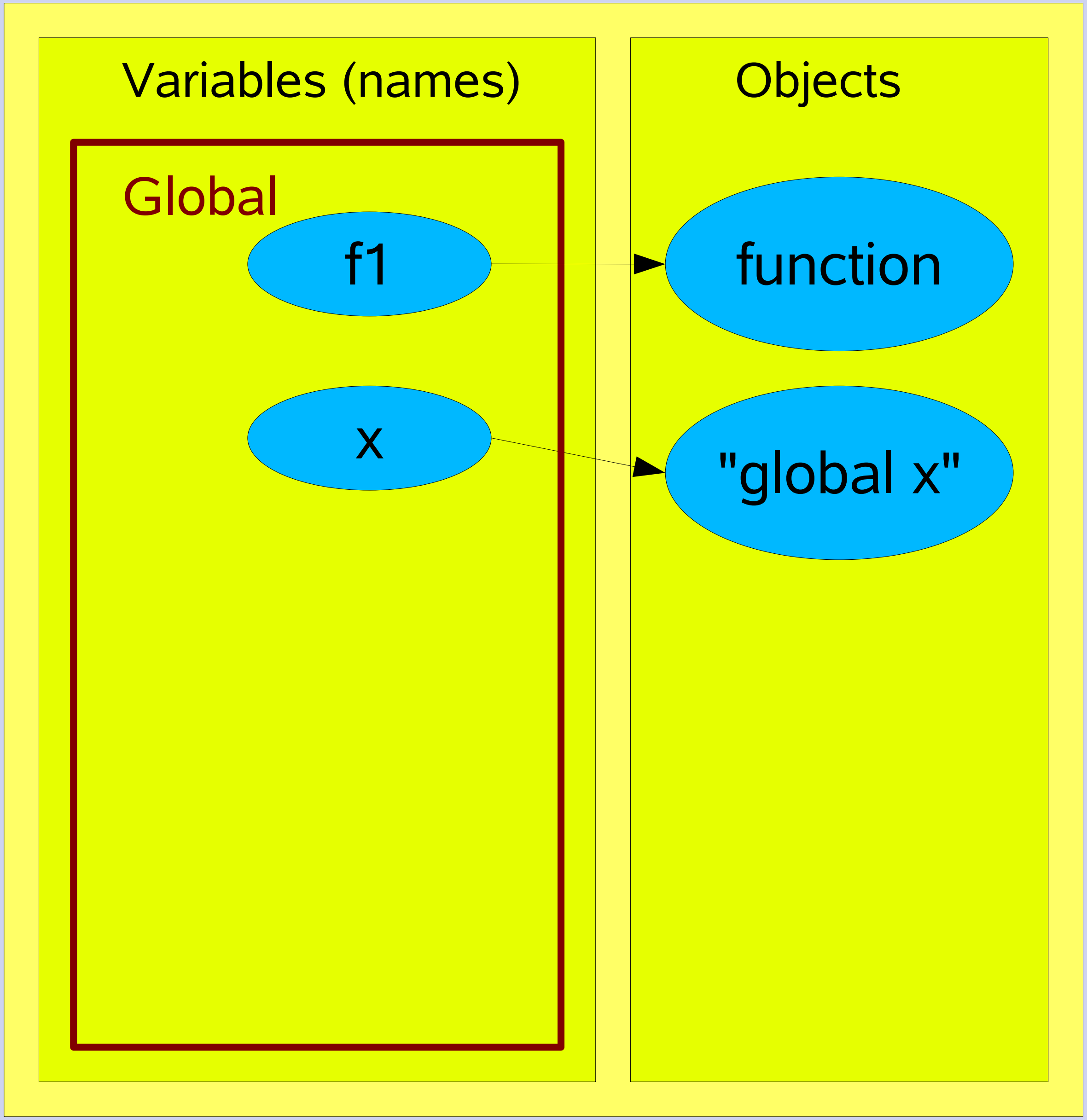
Function namespace

```
>>> def f1():
...     print x
```



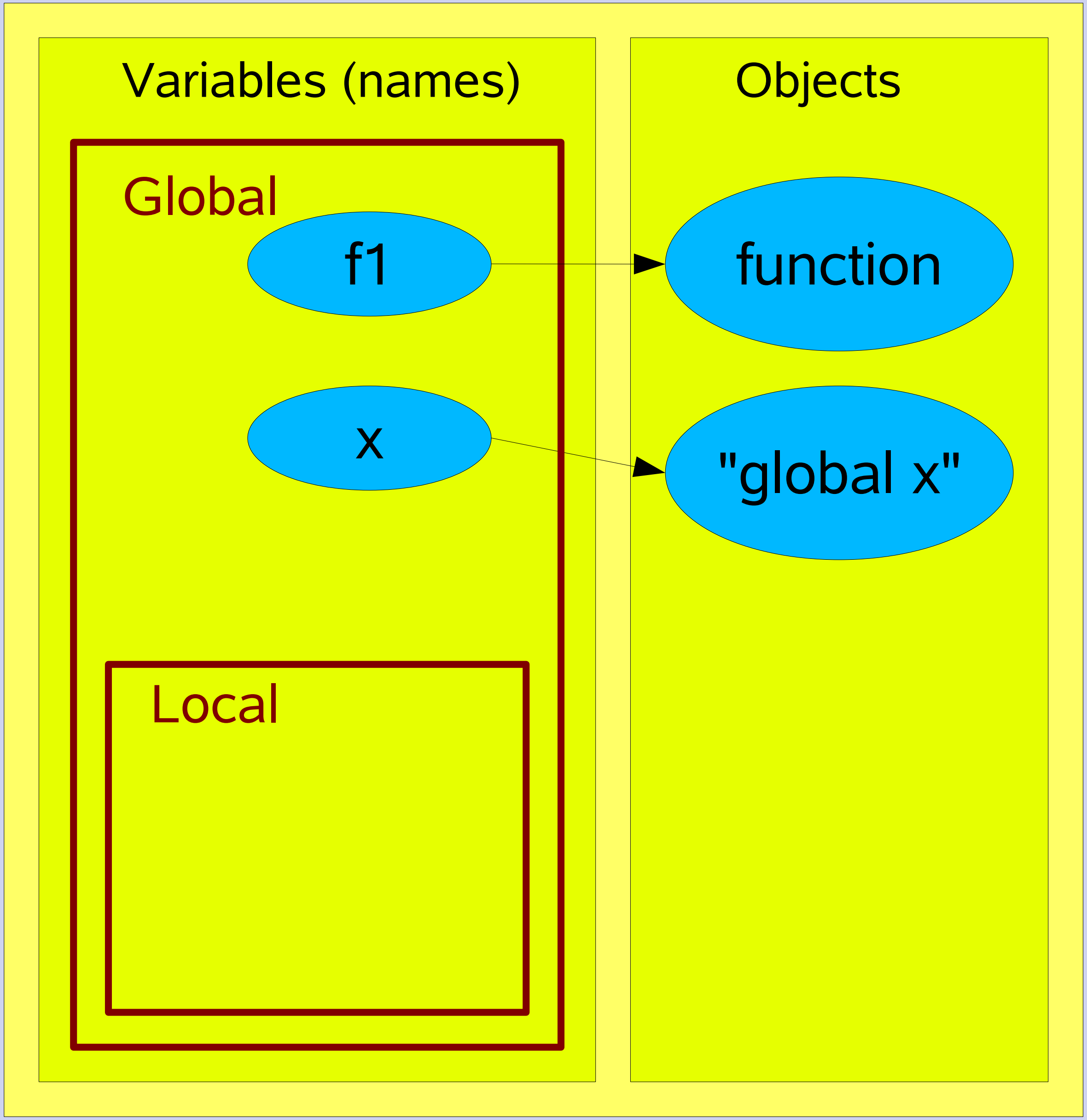
Function namespace

```
>>> def f1():
...   print x

>>> x = "global x"
```



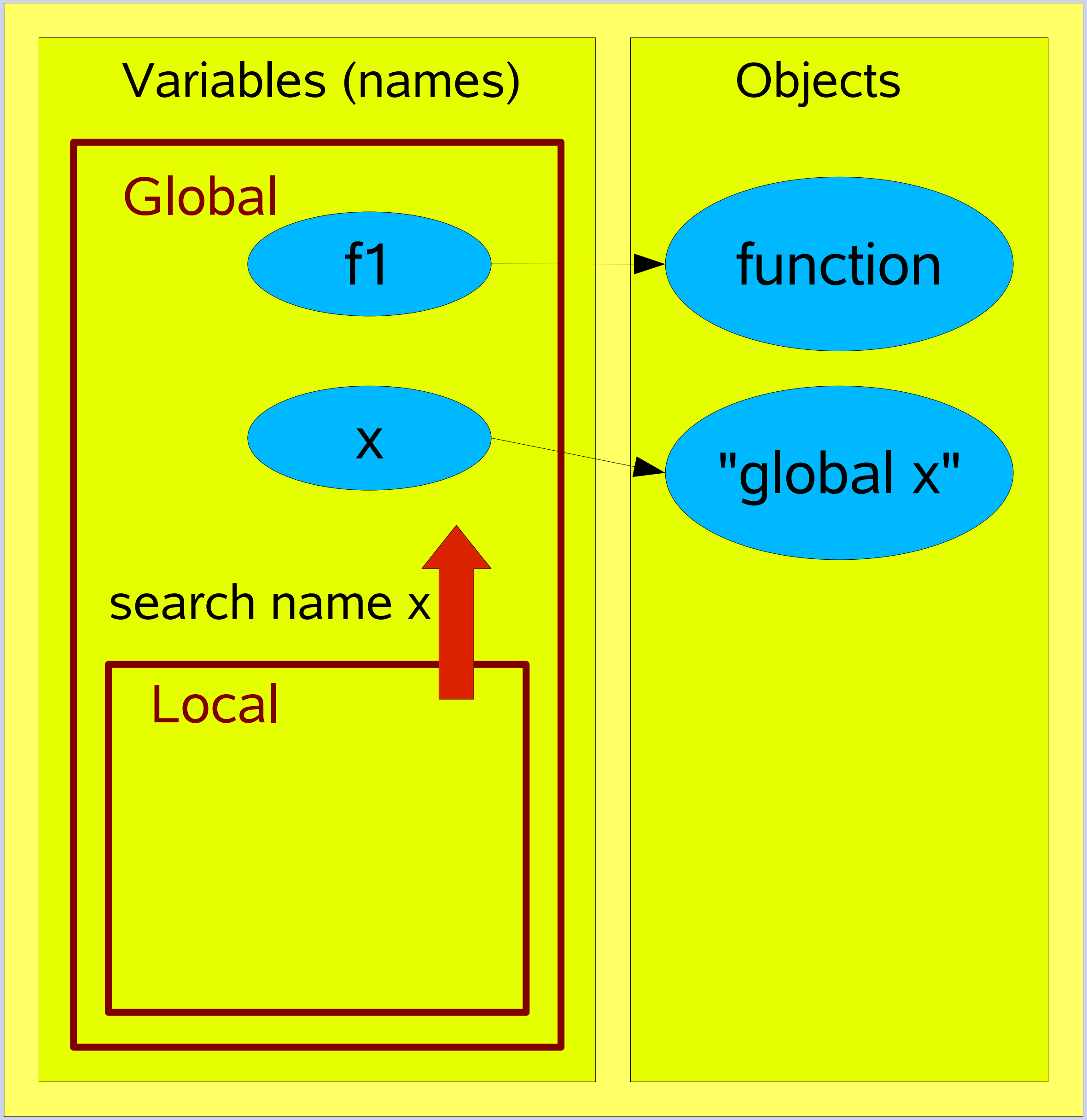
Function namespace

```
>>> def f1():
...   print x

>>> x = "global x"

>>> f1()
```



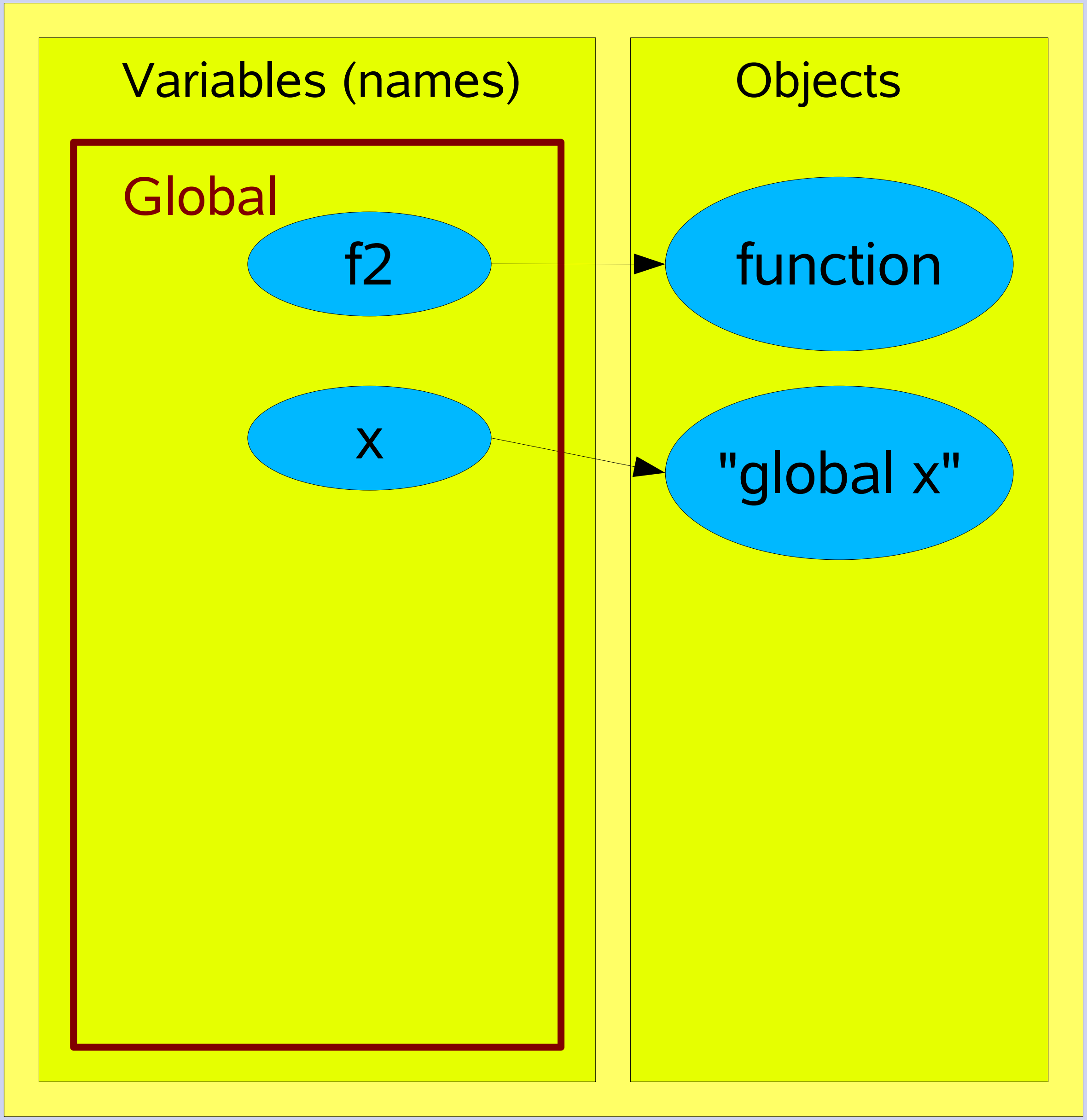
Function namespace

```
>>> def f1():
...     print x

>>> x = "global x"

>>> f1()
```



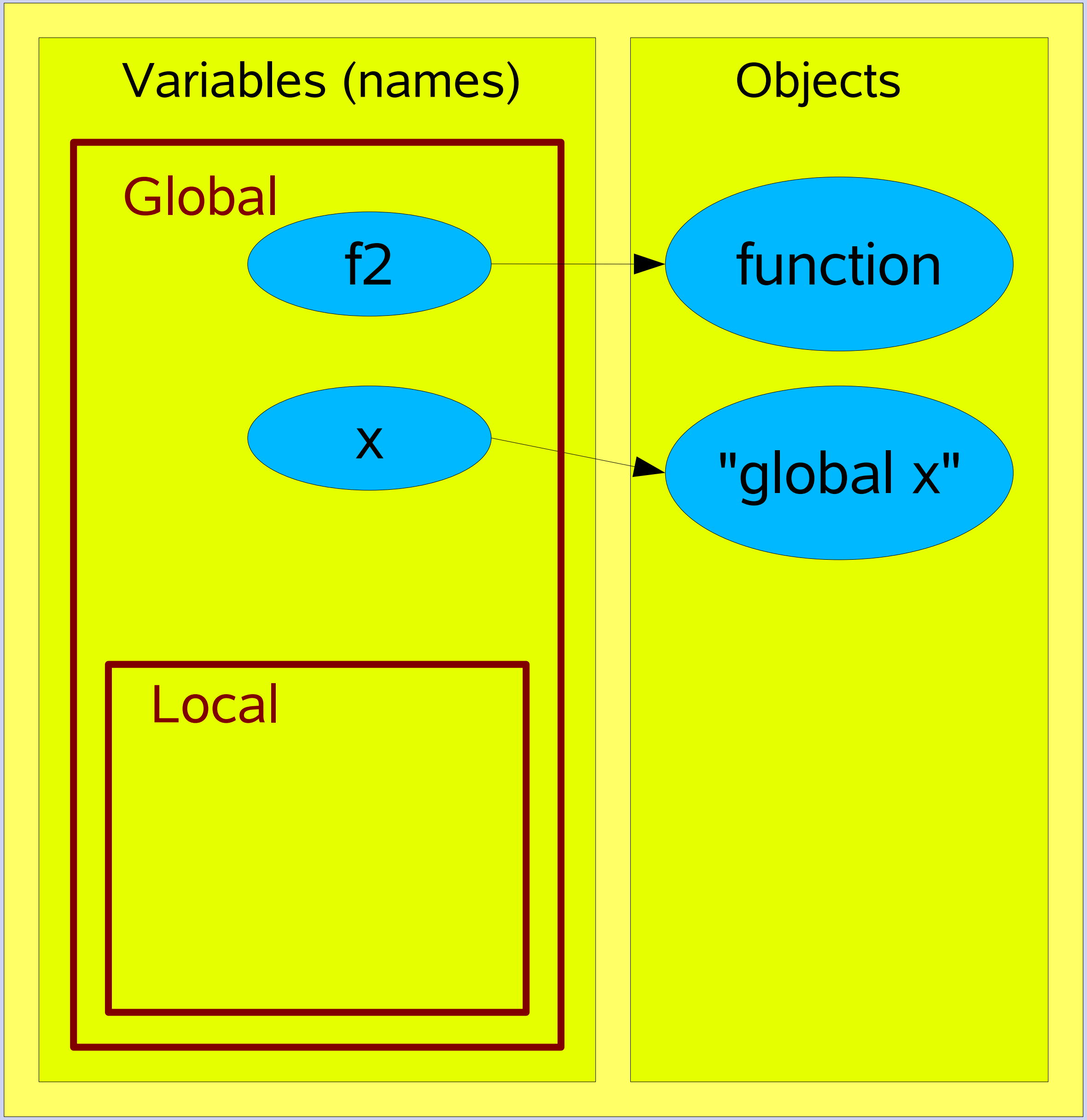
Function namespace

```
>>> def f2():
...     x = "local x"
...     print x

>>> x = "global x"
```



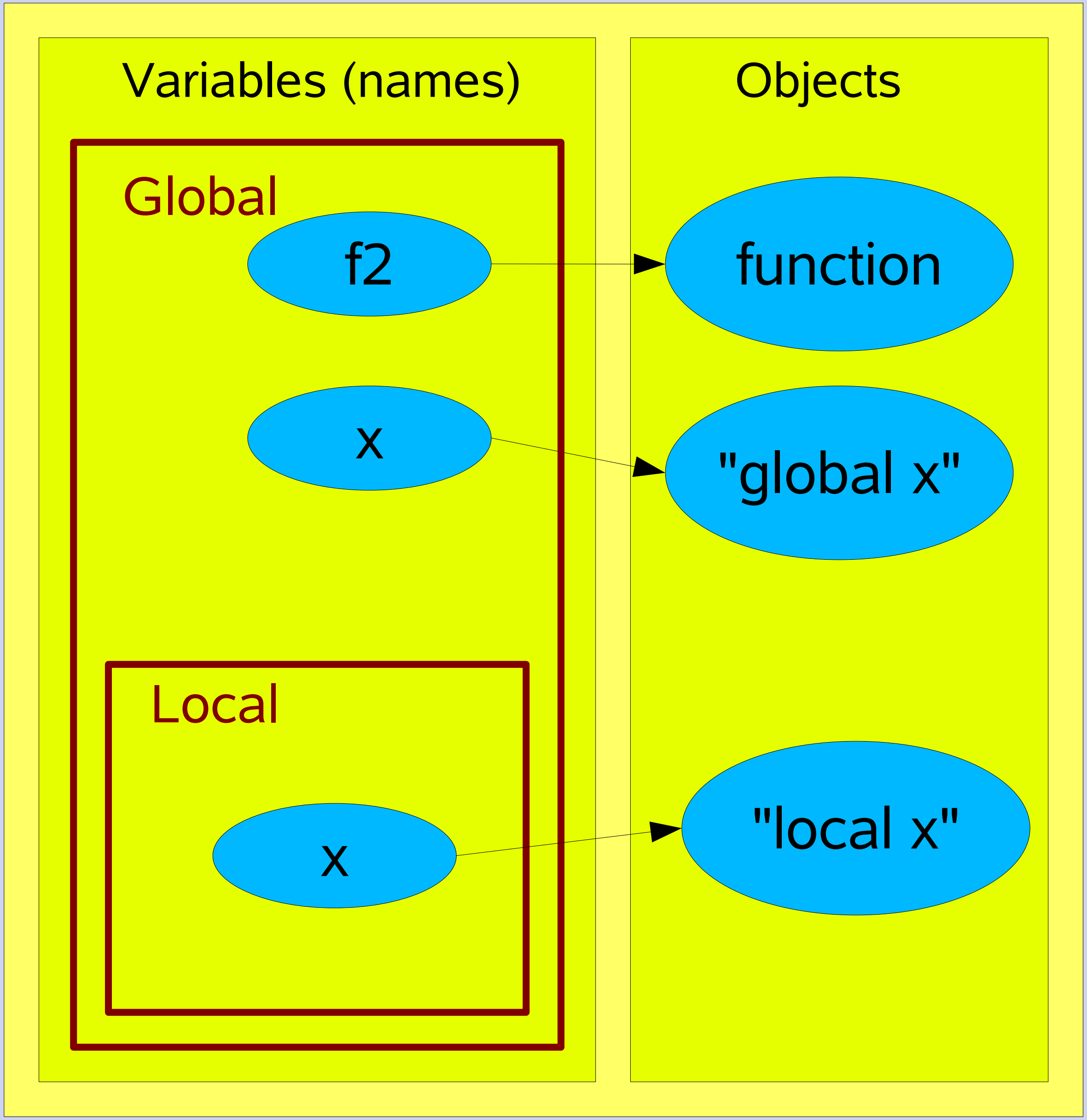
Function namespace

```
>>> def f2():
...   x = "local x"
...   print x

>>> x = "global x"

>>> f2()
```



Function namespace

```
>>> def f2():
...     x = "local x"
...     print x

>>> x = "global x"

>>> f2()
```



Scope rules

Functions provide a nested namespace (scope)

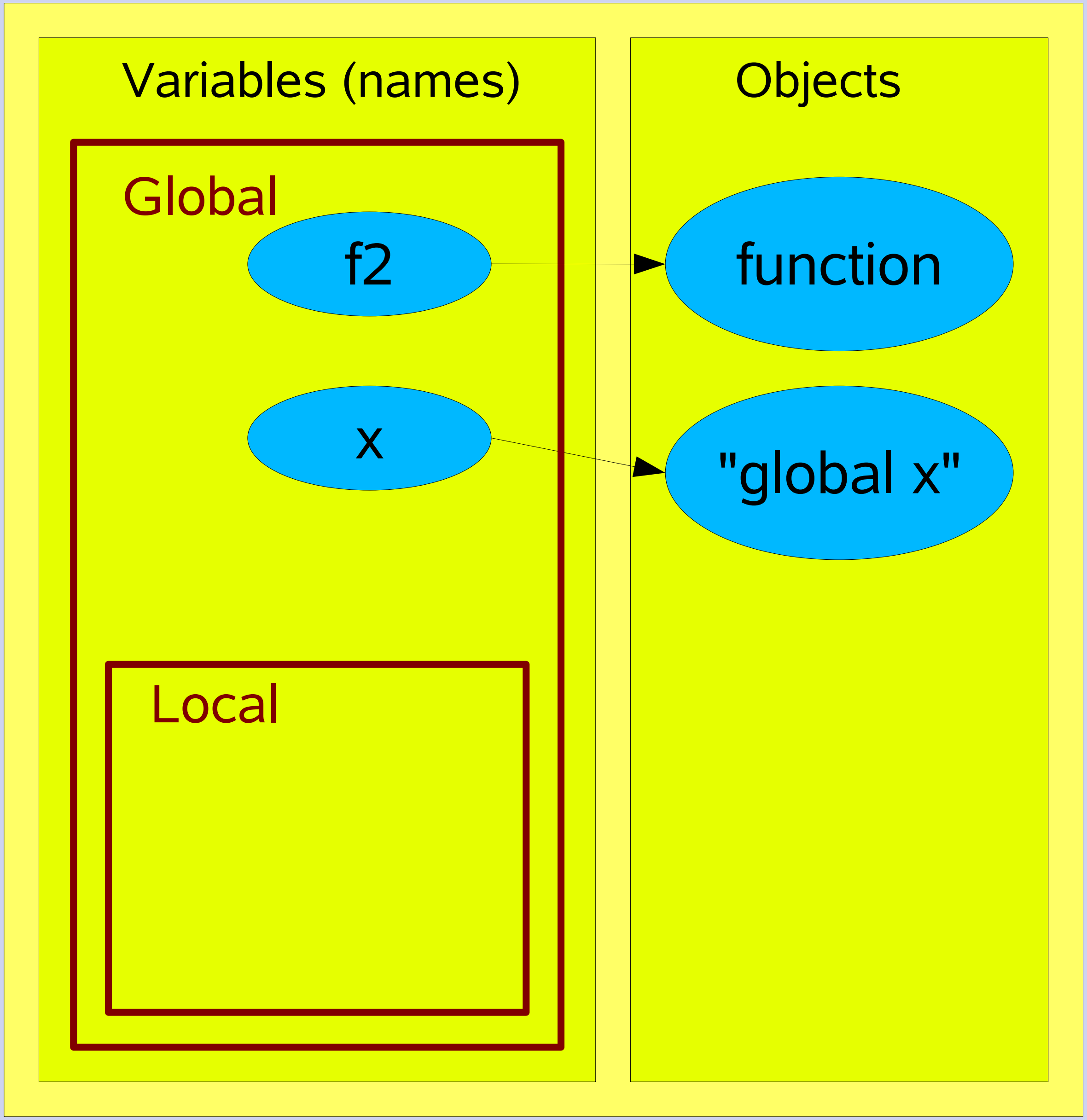
- Name ***references*** search four scopes:
  - ***L***: the function's local scope
  - ***E***: the scope of enclosing functions
  - ***G***: the (module's) global scope
  - ***B***: the built-in scope (e.g. range function)
- Name ***assignments*** create local names

The global statement

```
>>> def f3():
...     global x
...     x = "local x"
...     print x

>>> x = "global x"

>>> print x          # "global x"
>>> f3()             # "local x"
>>> print x          # now "local x"
```

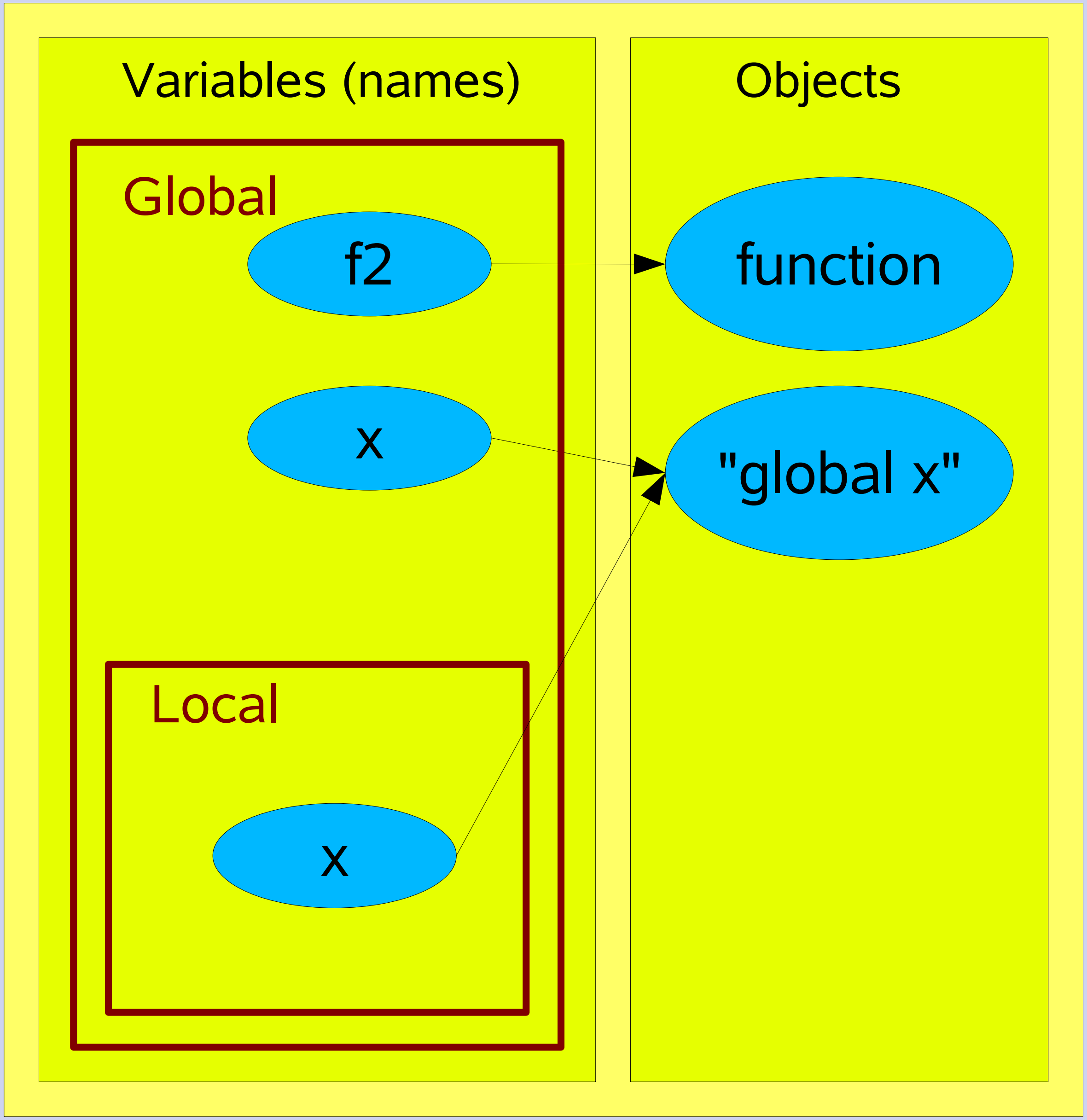
Function namespace

```
>>> def f3():
...     global x
...     x = "local x"
...     print x

>>> x = "global x"


>>> f3()
```



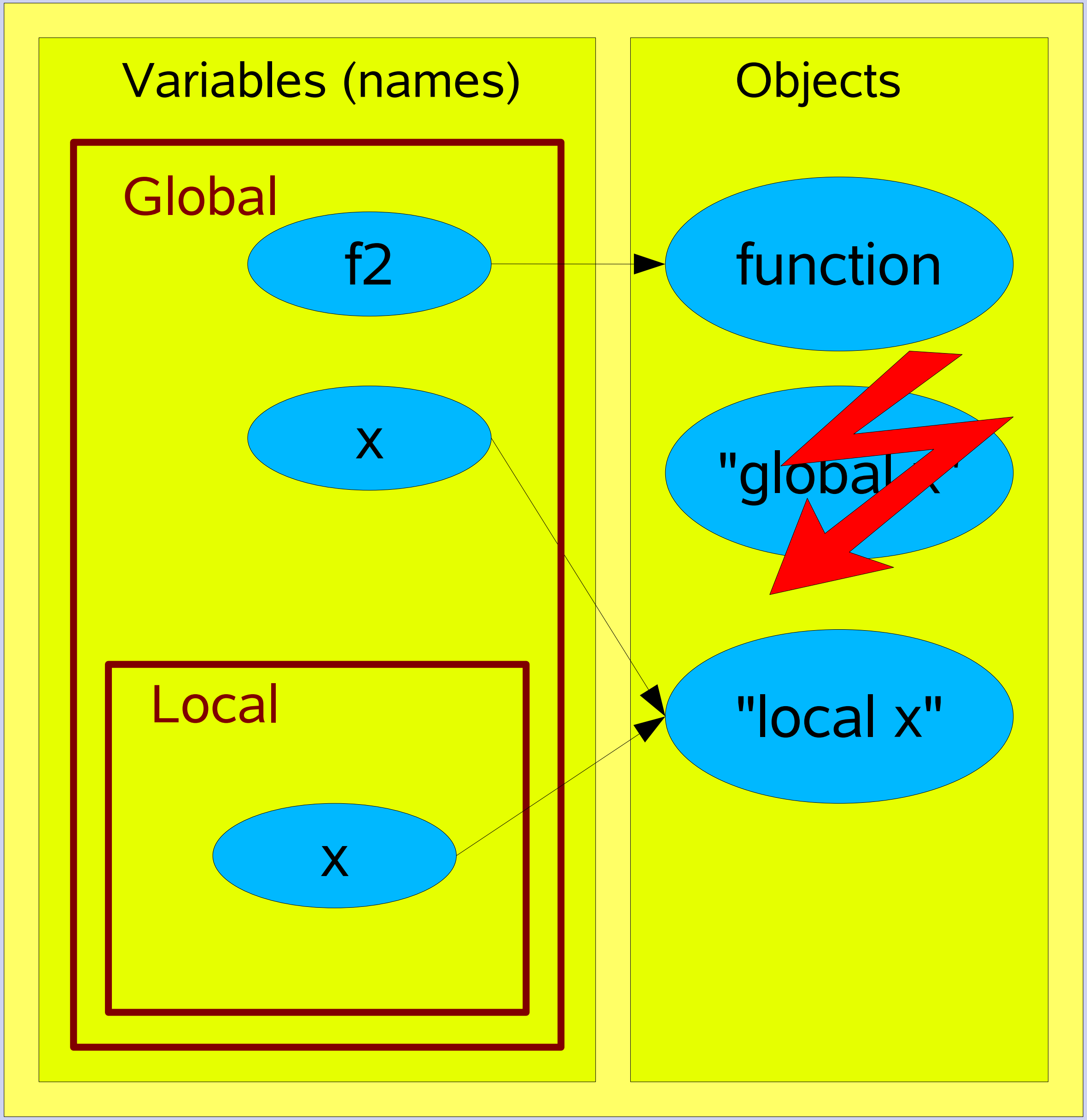
Function namespace

```
>>> def f3():
...     global x
...     x = "local x"
...     print x

>>> x = "global x"



>>> f3()
```



Function namespace

```
>>> def f3():
...     global x
...     x = "local x"
...     print x

>>> x = "global x"

>>> f3()
```



Argument passing - Experiments

```
>>> def twice1(a):
...     a = 2 * a

>>> x = 42
>>> twice1(x)
>>> print x                # x changed or not?

>>> # Repeat the test with:
>>> x = "fortytwo"
>>> x = [4, 2]
>>> x = numpy.array([4, 2])
```

Argument passing - Experiments

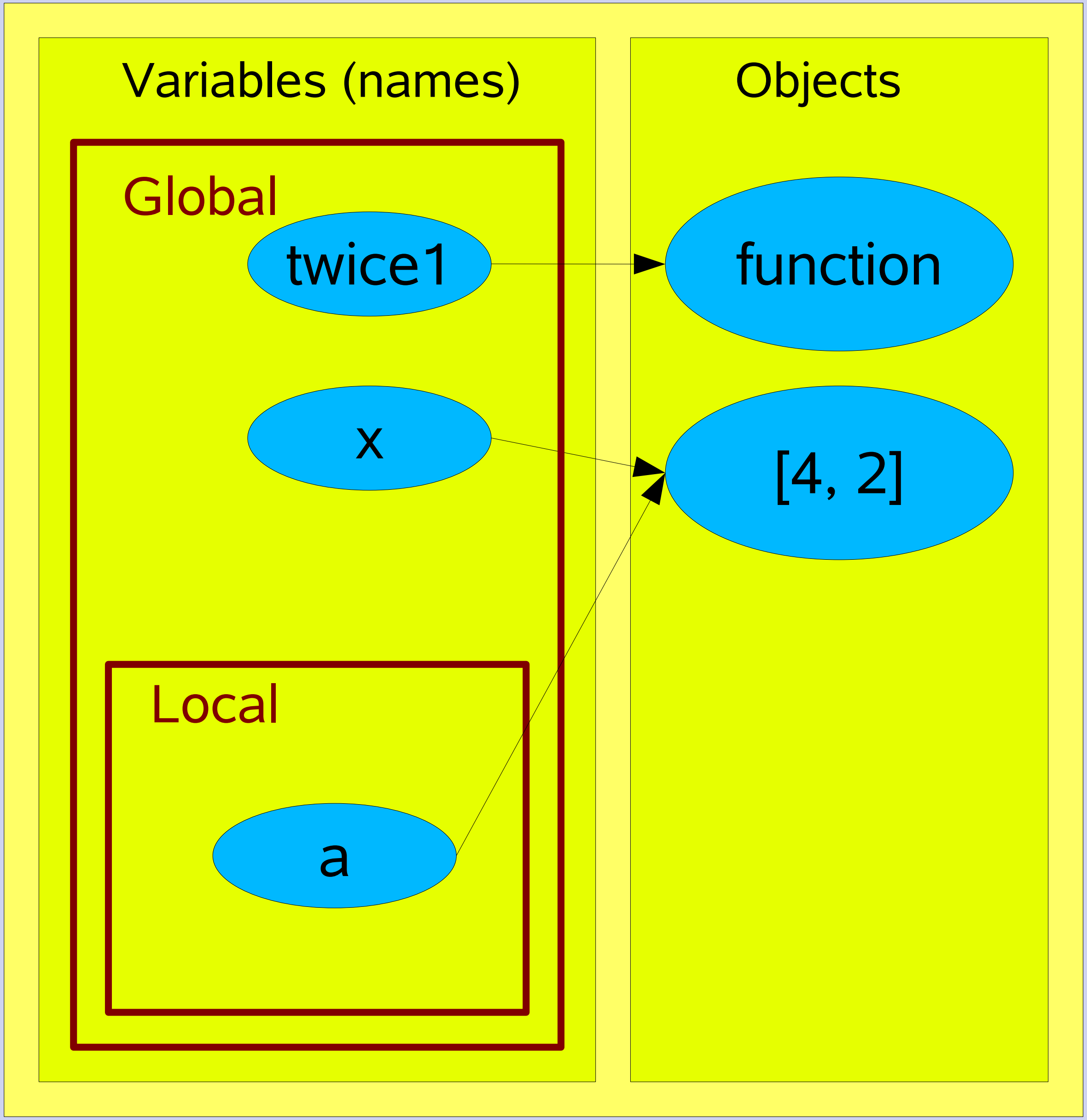
```
>>> def twice2(a):
...     a *= 2

>>> x = 42
>>> twice2(x)
>>> print x                 # x changed or not?

>>> # Repeat the test with:
>>> x = "fortytwo"
>>> x = [4, 2]
>>> x = numpy.array([4, 2])
```

Argument passing - Experiments

```
>>> def twice1(a):
...     a = 2 * a

>>> def twice2(a):
...     a *= 2

>>> x = [4, 2]
>>> print id(x)
>>> x *= 2
>>> print id(x)    # Changed in-place!
>>> x = 2 * x
>>> print id(x)    # New object!
```

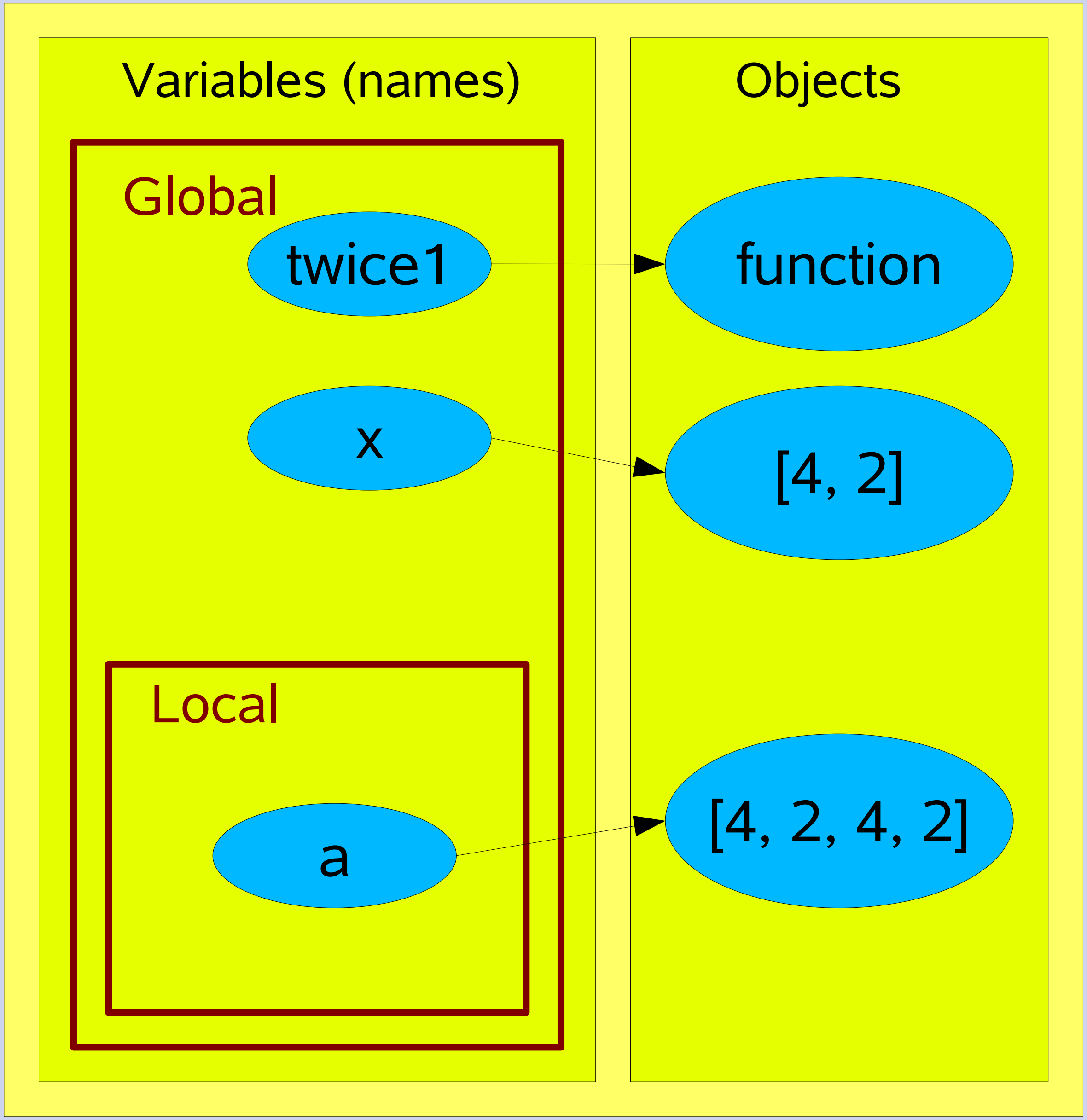
Argument passing

```
>>> def twice1(a):
...     a = 2 * a

>>> x = [4, 2]

>>> twice1(x)
```



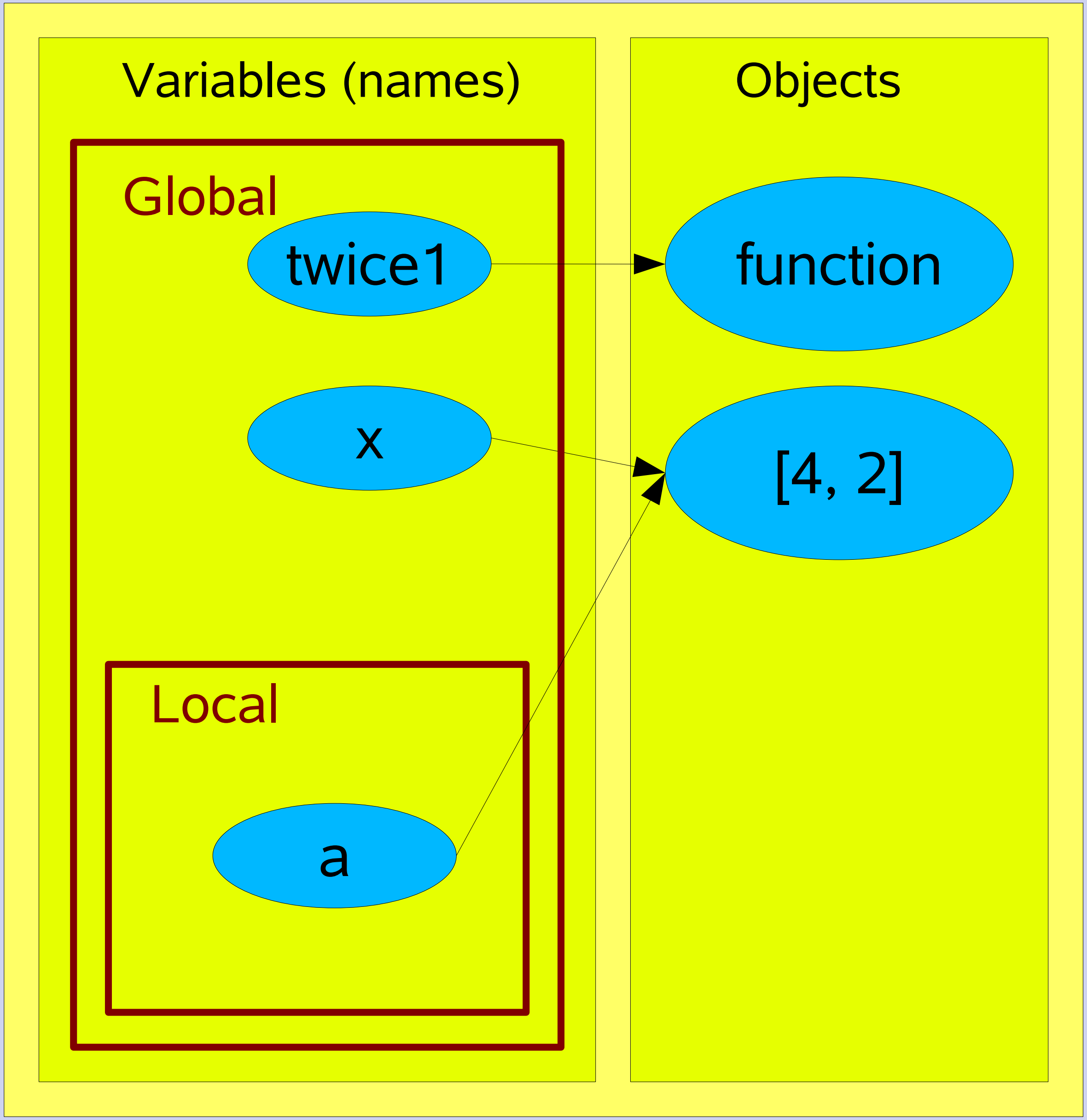
Argument passing

```
>>> def twice1(a):
...     a = 2 * a

>>> x = [4, 2]

>>> twice1(x)
```



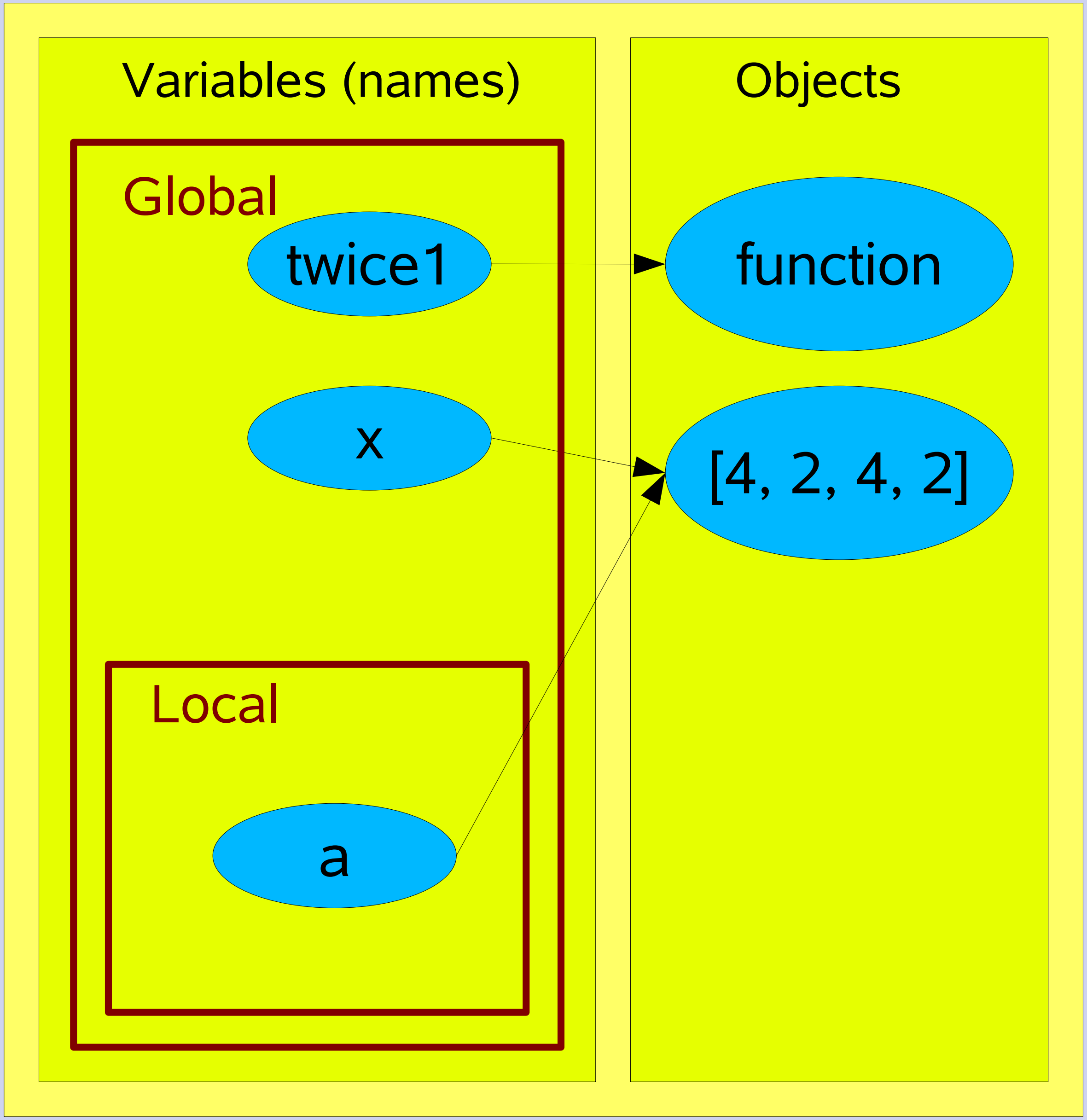
Argument passing

```
>>> def twice2(a):
...     a *= 2

>>> x = [4, 2]

>>> twice2(x)
```



Argument passing

```
>>> def twice2(a):
...     a *= 2

>>> x = [4, 2]

>>> twice2(x)
```



Passing argument rules

- ***Immutable*** arguments act as if passed by value
- When changing ***mutable*** arguments ***in place*** inside the function, the object is changed outside the function too!

Reminder:

- Numbers, strings, tuples are immutable
- Lists, dictionaries, numpy.arrays are mutable

Safety measures

```
>>> def twice2(a):
...     a *= 2                # a changed in place

>>> # Pass copies:
>>> x = [4, 2]
>>> twice2(x[:])
>>> print x                   # x unchanged
```

Functions as objects

```
>>> def f(x="Hello world"):
...     """Prints something"""
...     print x

>>> f()# Function call
>>> f  # Function object, created by def statement

>>> f.<TAB>  # Explore methods and attributes

>>> print f.__doc__
```

Functions as objects - Consequences

```
>>> def f(x="Hello world"):
...   print x

>>> g = f # Assign new variable to function object
>>> f("Printed from f")
>>> g("Printed from g")

>>> # Redefine function:
>>> def f():
...    print "f reloaded"

>>> f()   # Redefined
>>> g()   # Original
```

Functions as objects - Consequences

```
>>> # Conditional definition:

>>> x = True

>>> if x:
...     def f():
...         print "True f"
... else:
...     def f():
...         print "False f"

>>> f()
```

Functions as objects - Consequences

```
>>> # Dispatch dictionaries:

>>> def f():
...     print "f"

>>> def g():
...     print "g"

>>> disp = {"F": f, "G": g}

>>> disp["F"]()
```

Functions as objects - Consequences

```
>>> # Passing functions as arguments:

>>> def f():
...     print "f"

>>> def g(func):
...     print "g"
...     func()

>>> g(f)
```

Bonus 1: Nested functions

```
>>> import math
>>> def poisson(k, l):
...     """Poisson distribution"""
...     def nestFact(n):
...       # Used fact already earlier!
...       if n > 0:
...         return n * nestFact(n-1)
...       return 1
...     return (l**k * math.exp(-l)) / nestFact(k)

>>> poisson(2, 3)
>>> nestFact(2)         # Local to poisson!
```

Bonus 2: Arbitrary arguments

```
>>> # Arbitrary positional arguments:
>>> def f(*pargs):
...     print pargs     # tuple

>>> f("Spam", 42, [17, 4])

>>> # Arbitrary keyword arguments:
>>> def f(**kargs):
...     print kargs     # dictionary

>>> f(a="Spam", b=42, c=[17, 4])
```

Bonus 2: Arbitrary arguments

```
>>> # Combination:
>>> def f(x, *pargs, **kargs):
...     print x, pargs, kargs

>>> f("X", "P0", "P1", karg0="K0", karg1="K1")
```

Bonus 2: Arbitrary arguments

```
>>> # Two simple examples:

>>> def minmax(*args):
...     l = list(args)
...     l.sort()
...     return l[0], l[-1]

>>> def fprintf(file, format, *args):
...     file.write(format % args)
```

Bonus 3: Argument unpacking

```
>>> # Complementary to arbitrary arguments:
>>> limits = (1, 5)
>>> range(*limits)
```

Modules

```
> # Get the example module file:
> cp ~rschaaf/lecture7.py .

>>> import lecture7    # Runs code in lecture7.py
>>>                    # and provides objects in
>>>                    # namespace lecture7:

>>> print lecture7.x         # Module attribute
>>> print lecture7.fact(10) # Module function
>>> print lecture.math.pi   # Nested module

>>> import lecture7    # Only run during first import
>>> reload(lecture7)   # But some tricky details
```

Modules as objects

```
>>> import lecture7    # Creates module object

>>> print lecture7

>>> lecture7.<TAB>  # Explore methods and attributes

>>> print lecture7.__doc__   # Doc string
>>> print lecture7.__name__  # "lecture7"
>>> print lecture7.__file__  # "lecture7.py" or
>>>                          # "lecture7.pyc"
```

Modules as objects - Consequences

```
>>> # Conditional imports:
>>> useLect7 = True
>>> if useLect7:
...     import lecture7
---------------------------------------------- (Restart Python)
>>> # Local imports:
>>> def f():
...     import lecture7
...     print lecture7.poisson(2, 3)
---------------------------------------------- (Restart Python)
>>> # Module name must make valid variable name:
>>> import if          # Fails even if if.py present
```

Module files as scripts

```
>>> # Imported from within Python:
>>> import lecture7     # __name__ = "lecture7"
>>>                     # Main program skipped


> # Run as script from shell:
> python lecture7.py    # __name__ = "__main__"
>                       # Main program executed
```

from statement

```
>>> x = "spam"

>>> from lecture7 import *

>>> # All attributes copied to global namespace:
>>> print x
>>> print poisson(2, 3)
----------------------------------------------- (Restart Python)
>>> from lecture7 import poisson

>>> print x                     # Not imported
>>> print poisson(2, 3)         # Ok
>>> print fact(10)              # Not imported
----------------------------------------------- (Restart Python)
```

import ... as ...

```
>>> import lecture7 as l7

>>> print l7.x
```

As word about code clearness

Use `from...import` and `import...as` with care. Both make your code harder to understand.

Do not sacrifice code clearness for some keystrokes!

In some cases, the use is acceptable:

- In interactive work (`import numpy as np`)
- If things are absolutely clear (e.g. all functions of an imported module obey a clear naming convention; cfits_xyz)
- `import.. as`: As last resort in case of name clashes between module names

Module search path

Modules are searched for in the following places:

- the current working directory (for interactive sessions)
- the directory of the top-level script file (for script files)
- the directories defined in PYTHONPATH
- Standard library directories
- Directories defined in .pth files

```
>>> # Get the complete module search path:
>>> import sys
>>> print sys.path
```

Using module packages

```
>>> import numpy
>>> numpy.random                      # Submodule
>>> numpy.random.randn()              # Function in submodule
----------------------------------------------- (Restart Python)
>>> import numpy.random               # Import submodule only
>>> numpy.random.randn()
----------------------------------------------- (Restart Python)
>>> from numpy import random          # Alternative form
>>> random.randn()
----------------------------------------------- (Restart Python)
>>> from numpy.random import *        # Provisos from above
>>> randn()                           # apply here as well!
```

Exercise

Create a module textstat that contains the functions

- openfile(filename, readwrite=False): opens the specified file (readonly or readwrite) and returns the open file object
- isopen(file): returns True or False respectively
- closefile(file): closes the file, if open
- wordcount(file): returns the number of words in the file object
- linecount(file): returns the number of lines in the file object
- charcount(file): returns the number of characters in the file object

The module should contain a main program that uses these functions to print some statistics of mobydick.txt

Write a script that imports textstat and prints the same statistics of mobydick.txt