[220] Advanced Functions

Meena Syamkumar
Mike Doescher

1 Functions as Objects

2 Iterators/Generators

Iterators/Generators (Part 2)

Outline

- when normal functions aren't good enough
- yield keyword by example
- the scary vocabulary of iteration
- the open function
- demos

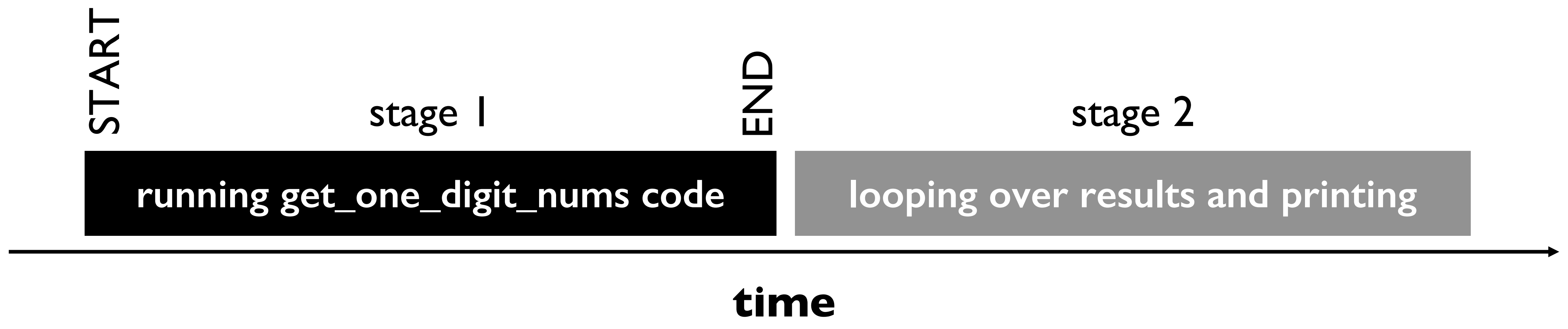
```python
def get_one_digit_nums():
    print("START")
    nums = []
    i = 0
    while i < 10:
        nums.append(i)
        i += 1
    print("END")
    return nums

for x in get_one_digit_nums():
    print(x)
```

how many times is the word "START" printed?

```
def get_one_digit_nums():
    print("START")
    nums = []
    i = 0
    while i < 10:
        nums.append(i)
        i += 1
    print("END")
    return nums

for x in ~~get_one_digit_nums()~~ [0,1,2,3,4,5,6,7,8,9]:
    print(x)
```

how many times is the word "START" printed?

```
def get_one_digit_nums():
    print("START")
    nums = []
    i = 0
    while i < 10:
        nums.append(i)
        i += 1
    print("END")
    return nums

for x in get_one_digit_nums():
    print(x)
```



START
stage 1
END
stage 2
running get_one_digit_nums code
looping over results and printing
time

```
def get_primes():
    print("START")
    nums = []
    i = 0
    while True:
        if is_prime(i):
            nums.append(i)
        i += 1
    print("END")
    return nums

for x in get_primes():
    print(x)
```

what does this code do?

assume there is an earlier

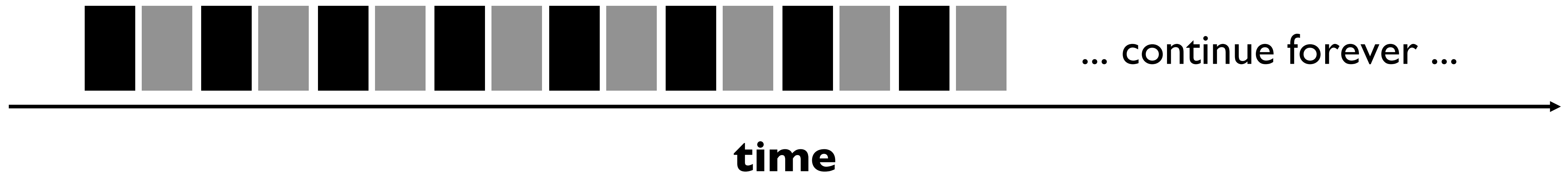
`is_prime` function

```
def get_primes():
    print("START")
    nums = []
    i = 0
    while True:
        if is_prime(i):
            nums.append(i)
        i += 1
    print("END")
    return nums

for x in get_primes():
    print(x)
```

to make this work, we'll need to learn a completely new kind of function, the **generator**

```
def get_primes():
    ... ■

for x in get_primes():
    print(x) ▨
```

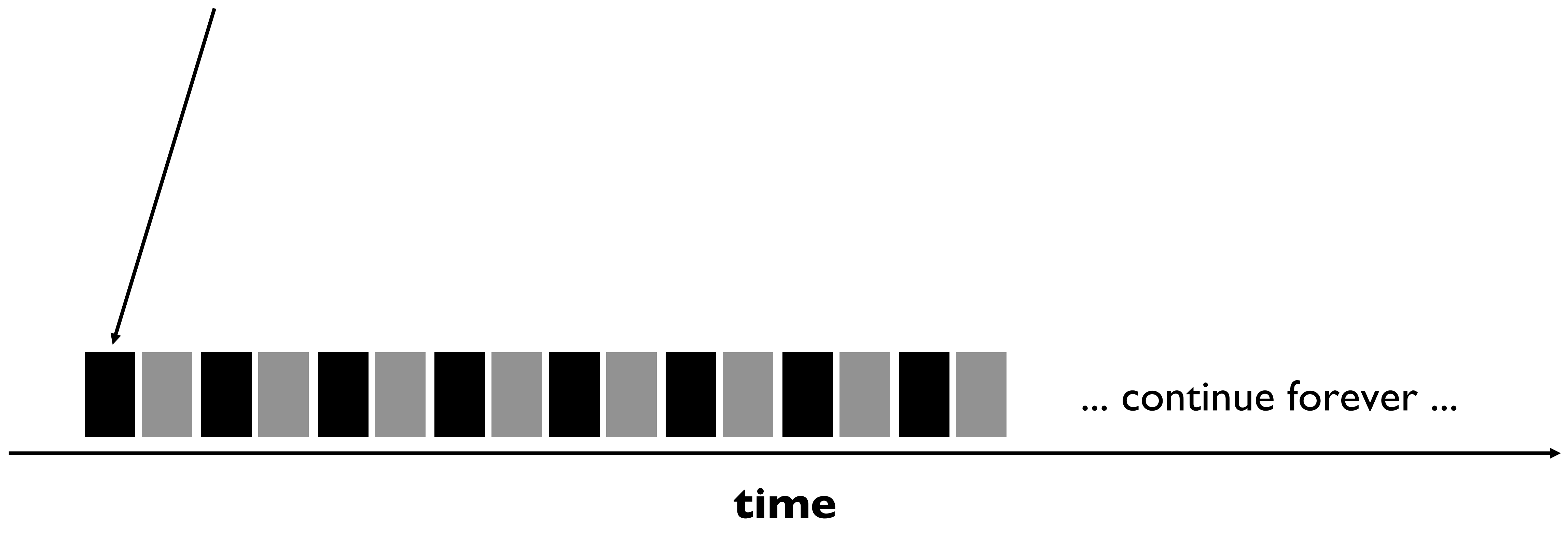
what we want:



```
def get_primes():
    ... ■

for x in get_primes():
    print(x) ▨
```

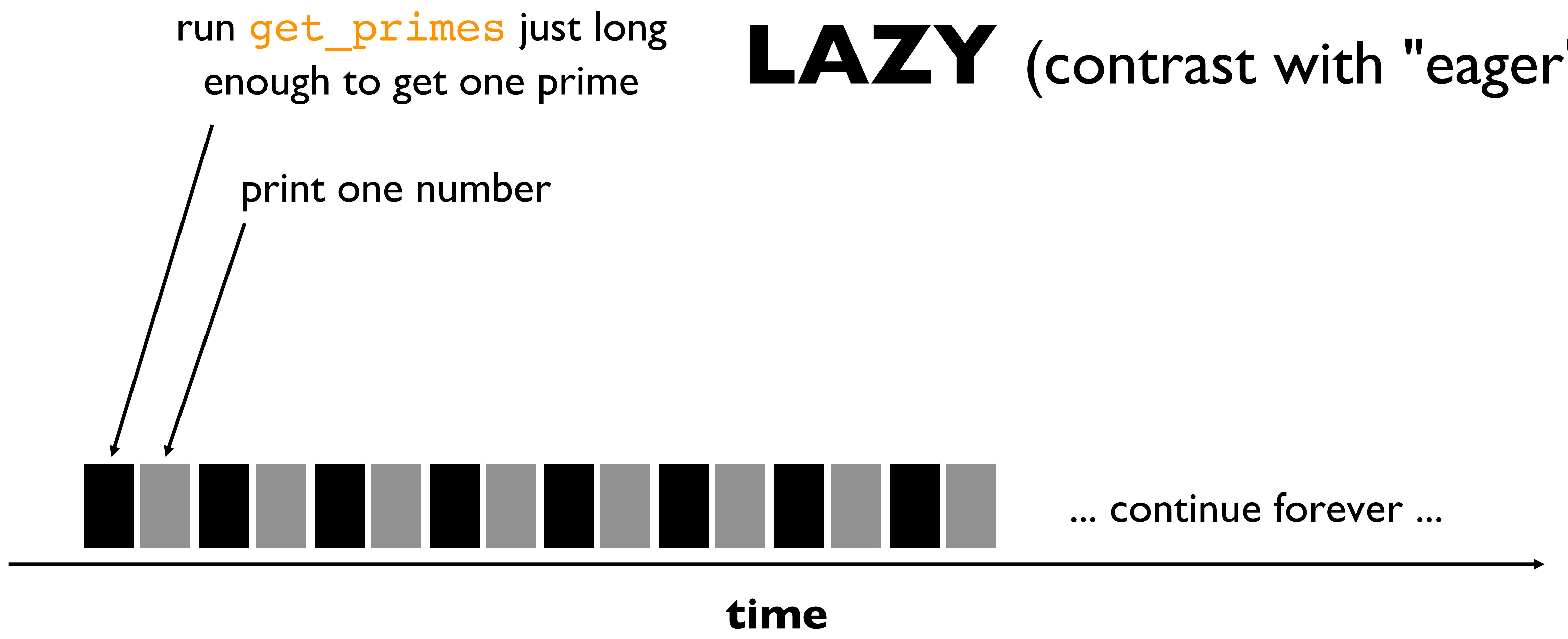
LAZY (contrast with "eager")

run get_primes just long enough to get one prime



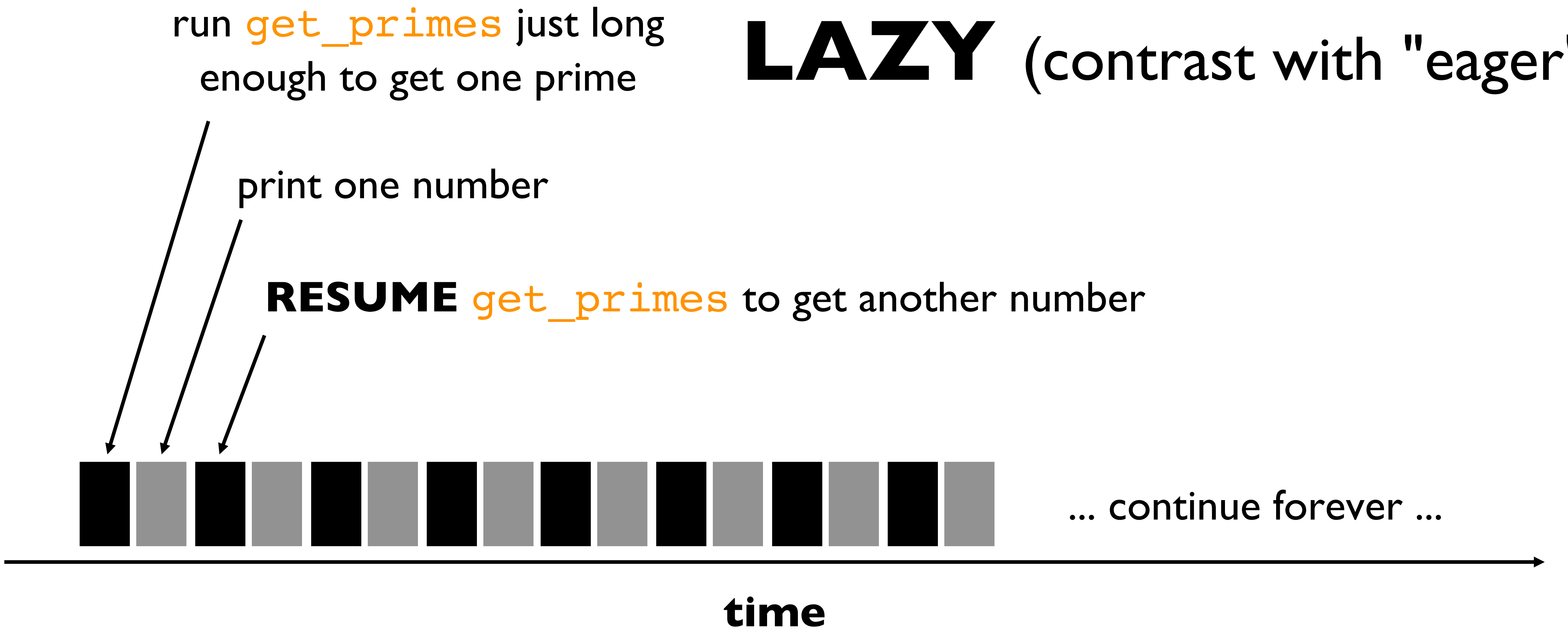
```
def get_primes():
    ... ■

for x in get_primes():
    print(x) ▨
```

LAZY (contrast with "eager")



```
def get_primes():
    ... ■

for x in get_primes():
    print(x) ▨
```

LAZY (contrast with "eager")


run get_primes just long enough to get one prime
print one number
RESUME get_primes to get another number
... continue forever ...
time

```
def get_primes():
    ... ■

for x in get_primes():
    print(x) ▨
```

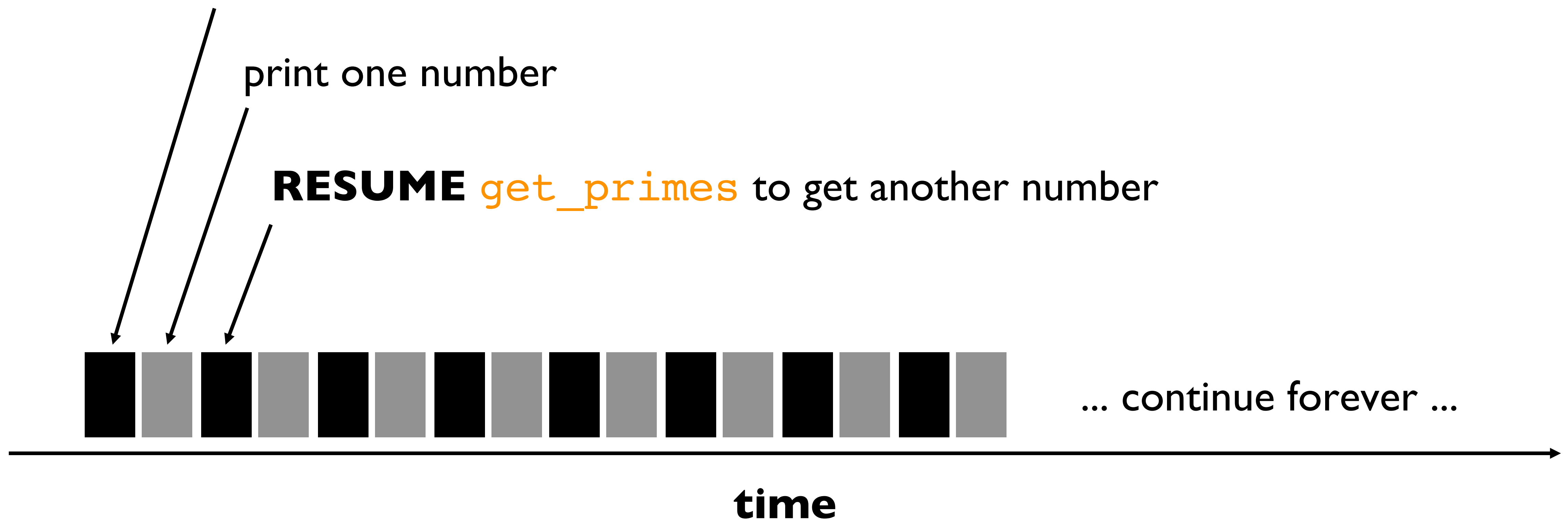
we will stop and resume running get_primes many times, even though we only call it once

run get_primes just long enough to get one prime

LAZY (contrast with "eager")

print one number

RESUME get_primes to get another number



```
def get_primes():
    ...

for x in get_primes():
    print(x)
```

we will stop and resume running get_primes many times, even though we only call it once

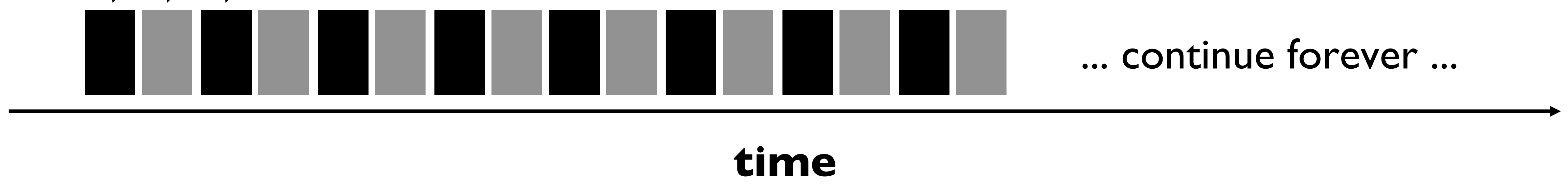
functions with this stop/resume behavior are called generators

run get_primes just long enough to get one prime

LAZY (contrast with "eager")

print one number

RESUME get_primes to get another number



```
def get_primes():
    ... some code ...

    yield VALUE

    ... more code ...
```

any function containing the yield keyword anywhere is a generator

if you see this, all bets are off regarding how you currently understand functions to behave

?

```
gen ~~def~~ get_primes():
    ... some code ...

    yield VALUE

    ... more code ...
```

any function containing the yield keyword anywhere is a generator

if you see this, all bets are off regarding how you currently understand functions to behave

should we even consider it a function?

?

```
gen ~~def~~ get_primes():
    ... some code ...

    yield VALUE

    ... more code ...
```

any function containing the yield keyword anywhere is a generator

if you see this, all bets are off regarding how you currently understand functions to behave

should we even consider it a function?

Should we "*introduce another new keyword (say, gen or generator) in place of def*"?

Guido van Rossum
Python's Benevolent Dictator for Life
(until recently)

https://www.python.org/dev/peps/pep-0255/#bdfl-pronouncements

?

```
gen ~~def~~ get_primes():
    ... some code ...

    yield VALUE

    ... more code ...
```

any function containing the yield keyword anywhere is a generator

if you see this, all bets are off regarding how you currently understand functions to behave

should we even consider it a function?

Argument for `gen`: "*a yield statement buried in the body is not enough warning that the semantics are so different*"

Argument for `def`: "*generators are functions, but with the twist that they're resumable*"

Guido van Rossum
Python's Benevolent Dictator for Life
(until recently)

https://www.python.org/dev/peps/pep-0255/#bdfl-pronouncements

```
def get_primes():
    ... some code ...

    yield VALUE

    ... more code ...
```

always scan a function for yields when trying to understand it

Guido van Rossum
Python's Benevolent Dictator for Life
(until recently)

Argument for `gen`: "*a yield statement buried in the body is not enough warning that the semantics are so different*" 👎

Argument for `def`: "*generators are functions, but with the twist that they're resumable*" 👍

https://www.python.org/dev/peps/pep-0255/#bdfl-pronouncements

Iterators/Generators (Part 2)

Outline

- when normal functions aren't good enough
- yield keyword by example
- the scary vocabulary of iteration
- the open function
- demos

yield by example (note, PyTutor does a bad job showing generators)

```
def f():
    yield 1
    yield 2
    yield 3

for x in f():
    print(x)
```

```
def f():
    print("A")
    yield 1
    print("B")
    yield 2
    print("C")
    yield 3

for x in f():
    print(x)
```

```
def f():
    yield 1
    yield 2
    yield 3

for x in f():
    print(x)

for x in f():
    print(x)
```

```
def f():
    yield 1
    yield 2
    yield 3

for x in f():
    for y in f():
        print(x, y)
```

```
def f():
    yield 1
    yield 2
    yield 3

gen = f()
print(next(gen))
print(next(gen))
```

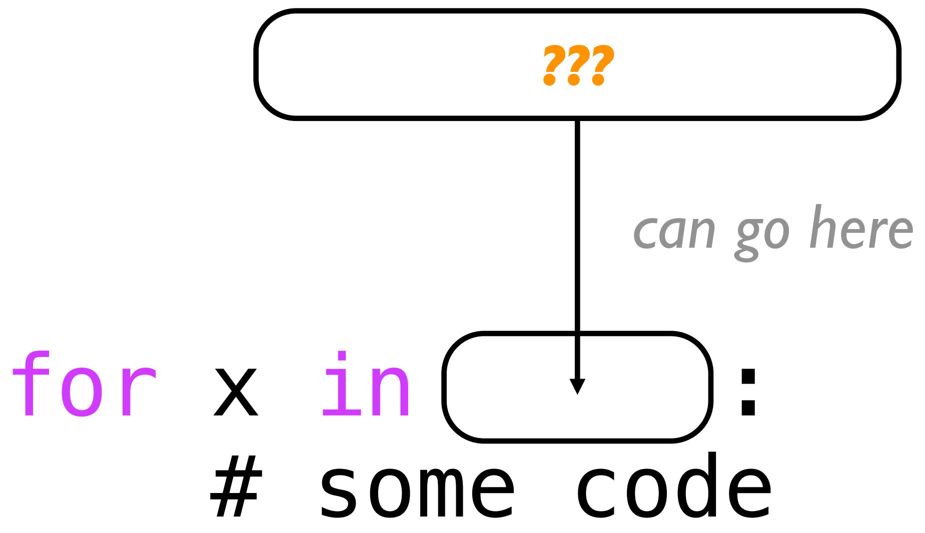
```
def f():
    yield 1
    yield 2
    yield 3

gen = f()
for x in gen:
    print(x)
```

Iterators/Generators (Part 2)

Outline

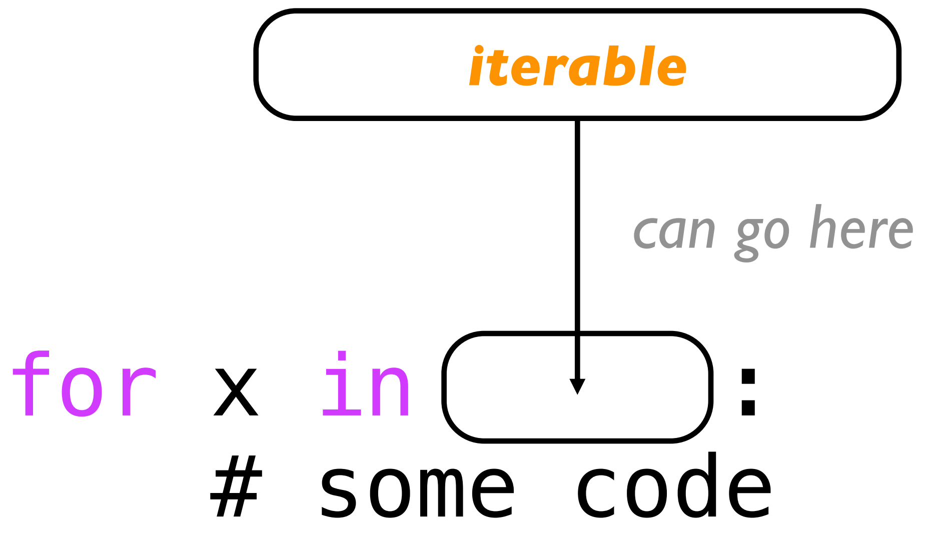
- when normal functions aren't good enough
- yield keyword by example
- the scary vocabulary of iteration
- the open function
- demos

The Vocabulary of Iteration



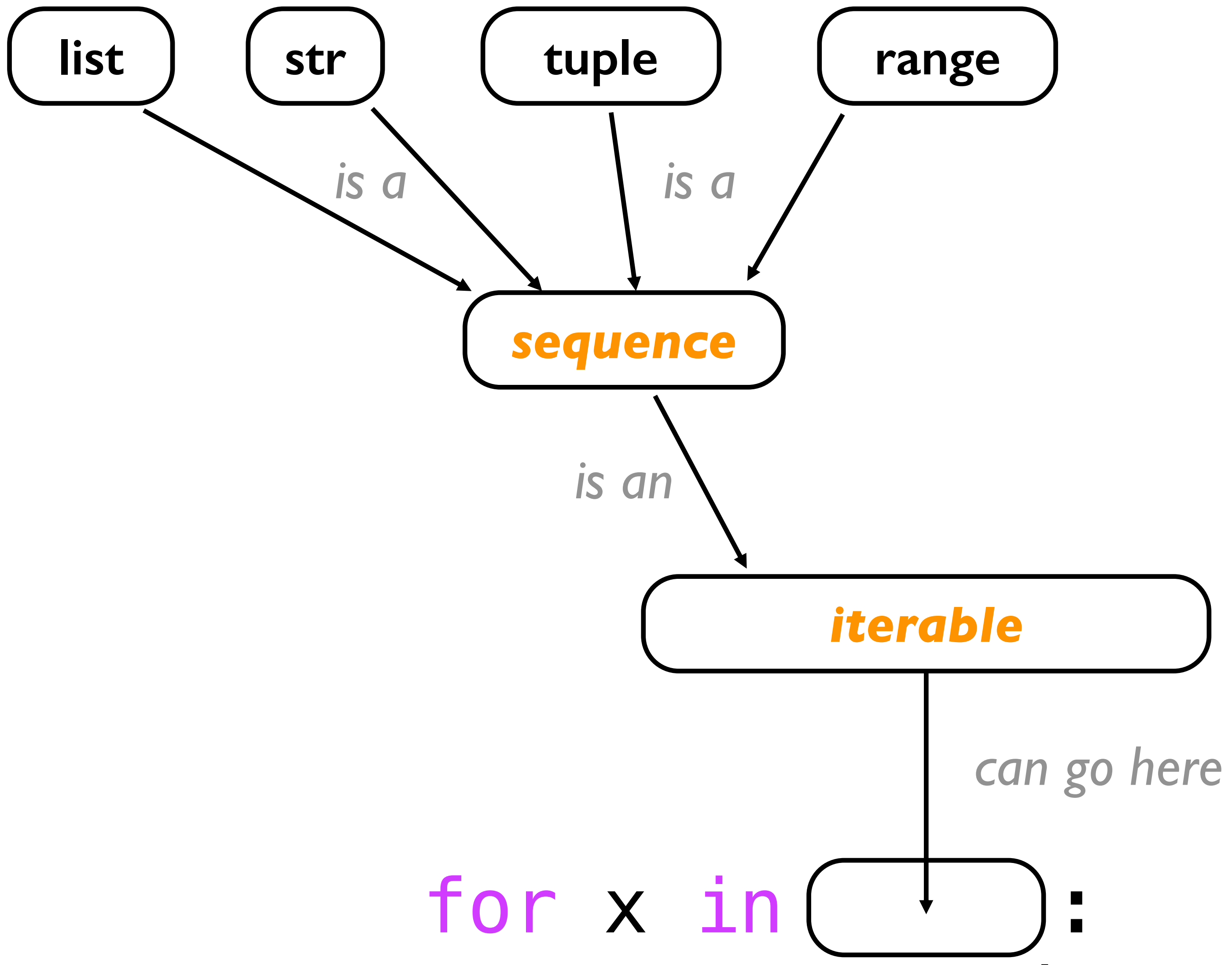
```
for x in [    ]:
    # some code
```

The Vocabulary of Iteration



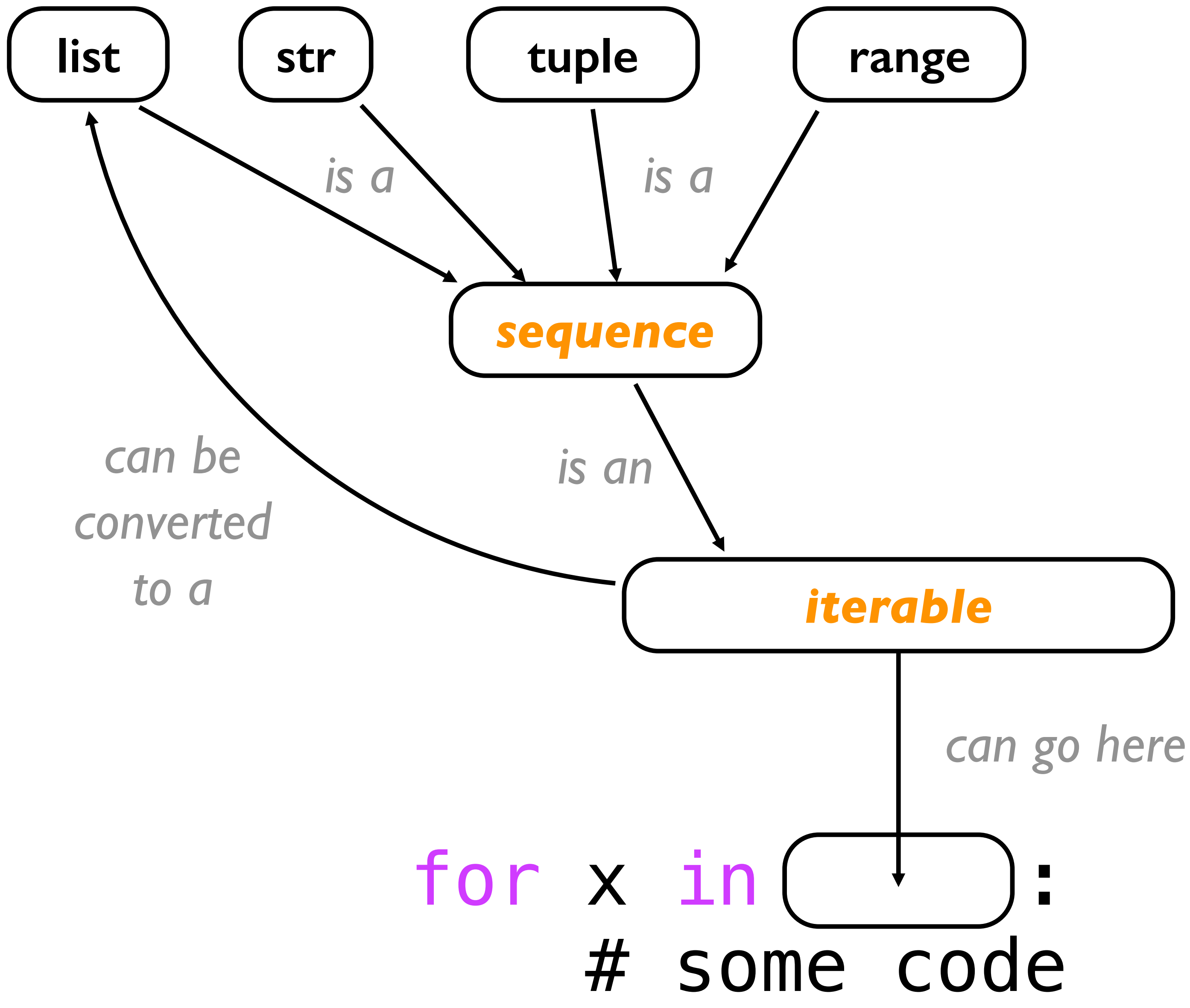
```
for x in [    ]:
    # some code
```

The Vocabulary of Iteration



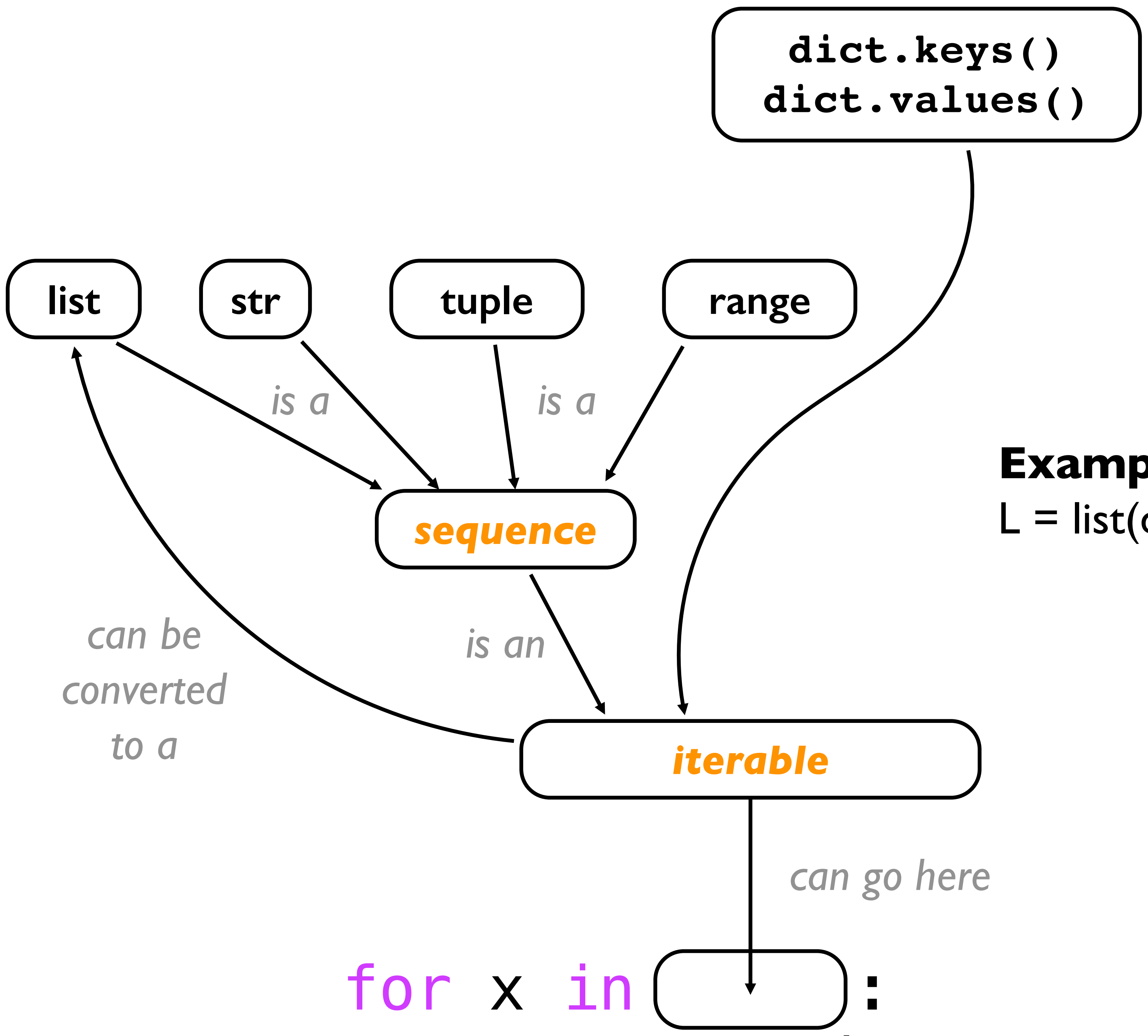
```
for x in      :
    # some code
```

The Vocabulary of Iteration



Example:
L = list("ABC")

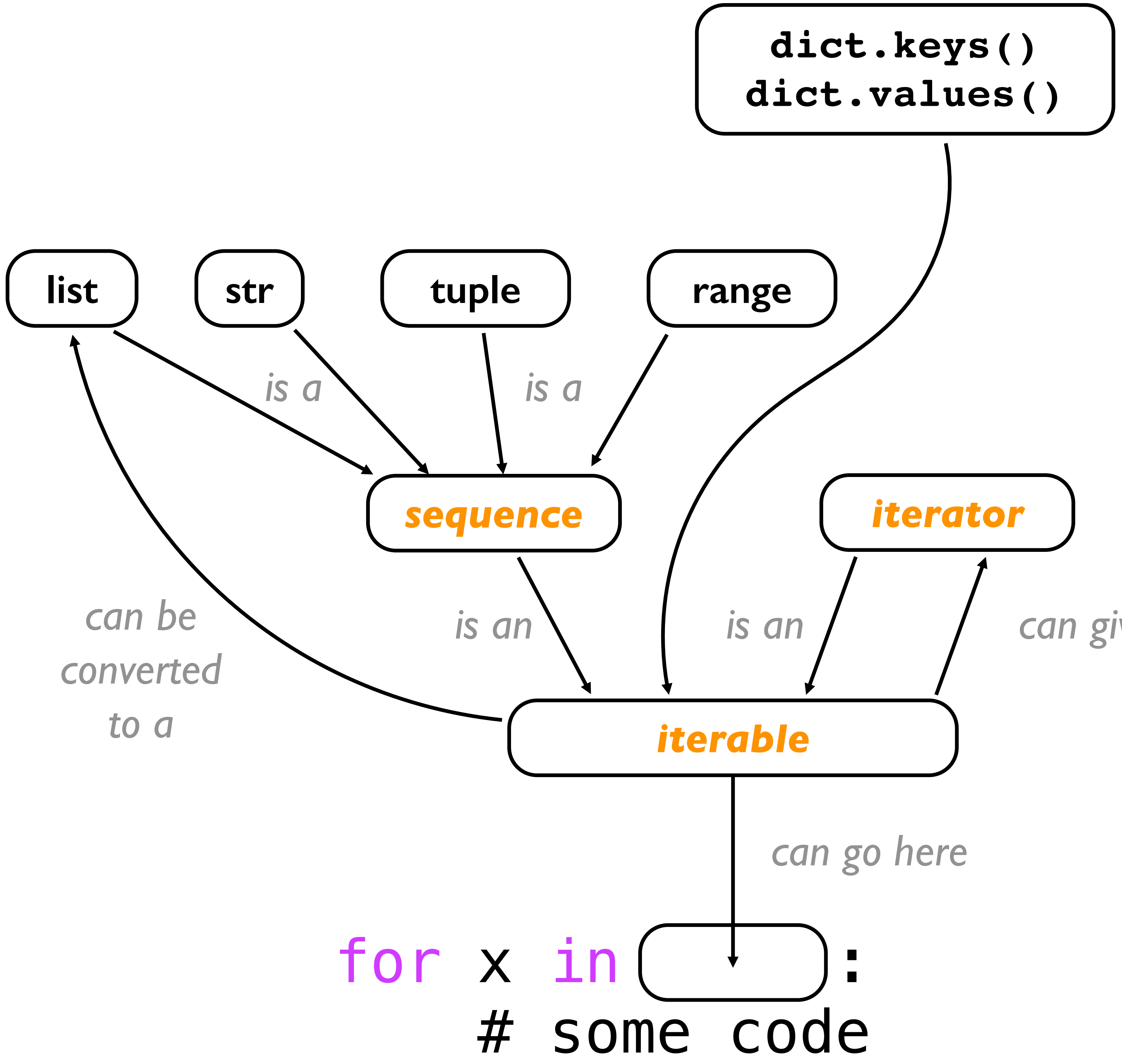
The Vocabulary of Iteration



Example:
L = list(d.keys())

```
for x in [ ]:
    # some code
```

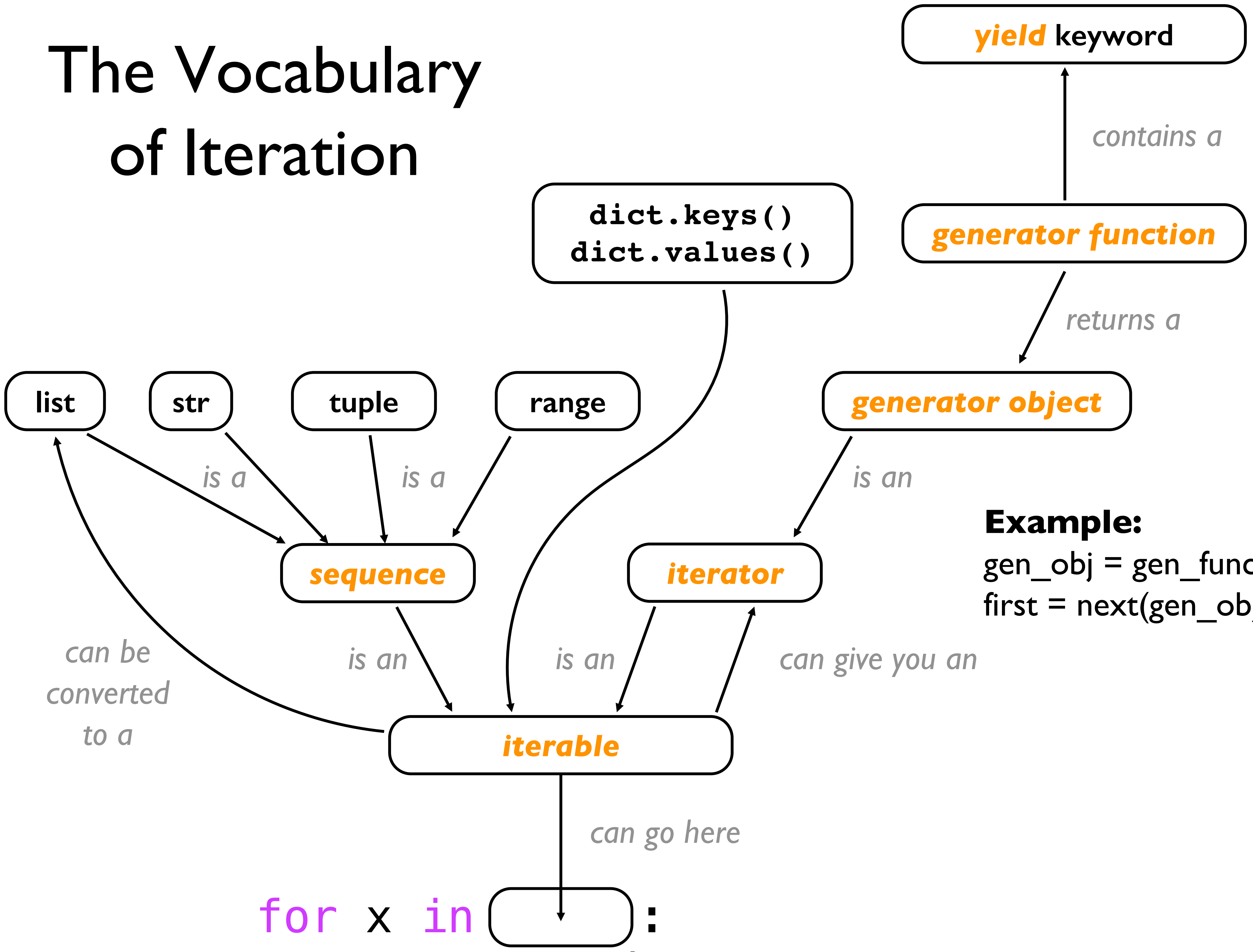
The Vocabulary of Iteration



```
for x in      :
    # some code
```

Example:
it = iter("ABC")
first = next(it)

The Vocabulary of Iteration

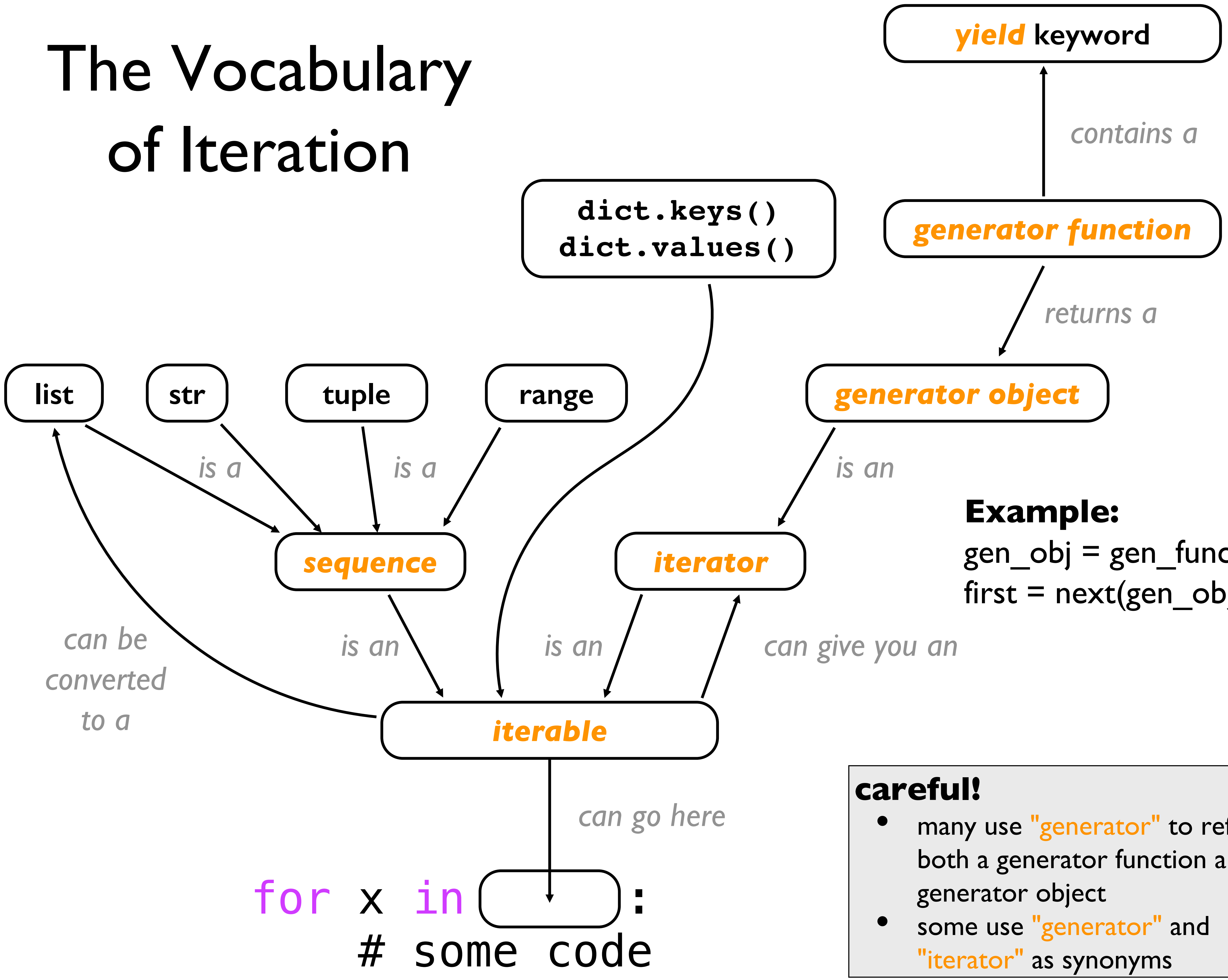


Example:

```
gen_obj = gen_function(...)
first = next(gen_obj)
```

```
for x in      :
    # some code
```

The Vocabulary of Iteration

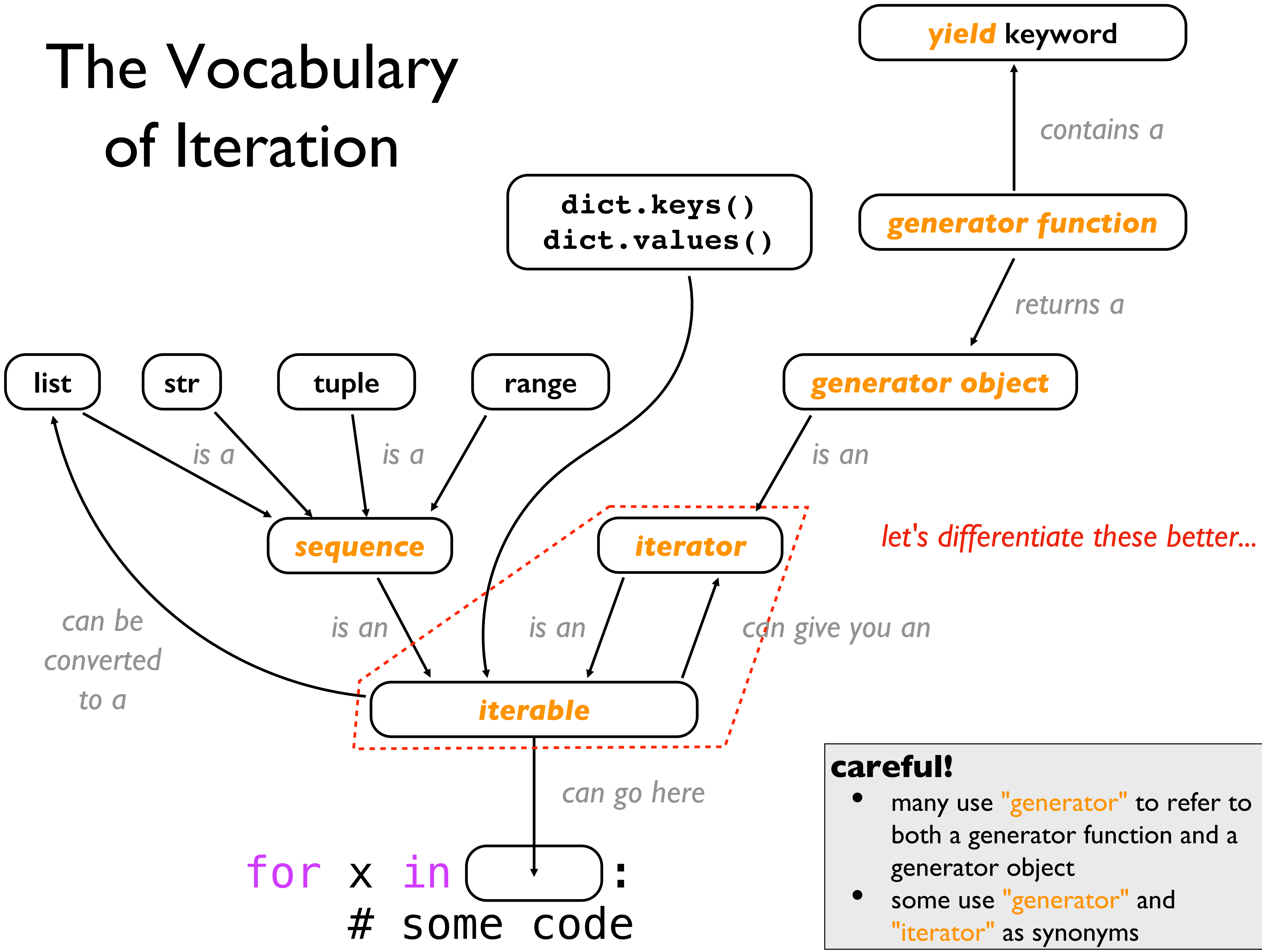


Example:
gen_obj = gen_function(...)
first = next(gen_obj)

careful!

- many use "generator" to refer to both a generator function and a generator object
- some use "generator" and "iterator" as synonyms

The Vocabulary of Iteration



careful!

- many use "generator" to refer to both a generator function and a generator object
- some use "generator" and "iterator" as synonyms

is `x` iterable?

if this works, then yes:

`iter(x)` returns an iterator over x

is `y` an iterator?

if this works, then yes:

`next(y)` returns next value from y

is `x` iterable?

if this works, then yes:

`y = iter(x)` **returns an iterator over x**

is `y` an iterator?

if this works, then yes:

`next(y)` **returns next value from y**

Can you classify x, y, and z?

```
x = [1,2,3]
y = enumerate([1,2,3])
z = 3
```

Things to try:

```
iter(x)
next(x)
```

etc.

Iterators/Generators (Part 2)

Outline

- when normal functions aren't good enough
- yield keyword by example
- the scary vocabulary of iteration
- the open function
- demos

Reading Files

```
path = “file.txt”
f = open(path)
```

open(…) function is built in

Reading Files

```
path = "file.txt"
f = open(path)
```

it takes a string argument,
which contains path to a file

file.txt

```
This is a test!
3
2
1
Go!
```

c:\users\meena\my-doc.txt

/var/log/events.log

../data/input.csv

Reading Files

```
path = “file.txt”
f = open(path)
```

it returns a file object

file objects are iterators!

file.txt

```
This is a test!
3
2
1
Go!
```

Reading Files

```
path = “file.txt”
f = open(path)

for line in f:
    print(line)
```

Output

```
This is a test!

3

2

1

Go!
```

file.txt

```
This is a test!
3
2
1
Go!
```

Iterators/Generators (Part 2)

Outline

- when normal functions aren't good enough
- yield keyword by example
- the scary vocabulary of iteration
- the open function
- demos

Demo 1: add numbers in a file

Goal: read all lines from a file as integers and add them

Input:

- file containing **50 million numbers** between 0 and 100

Output:

- The sum of the numbers

Example:

```
prompt> python sum.py
2499463617
```

Two ways:

- Put all lines in a list first
- Directly use iterable file

Bonus: create generator function that does the str => int conversion

Demo 2: handy functions

Learn these:

- enumerate
- zip

Bonus: tuple packing/unpacking

Demo 3: sorting files by line length

Goal: output file contents, with shortest line first

Input:

- a text file

Output:

- print lines sorted

Demo 4: matrix load

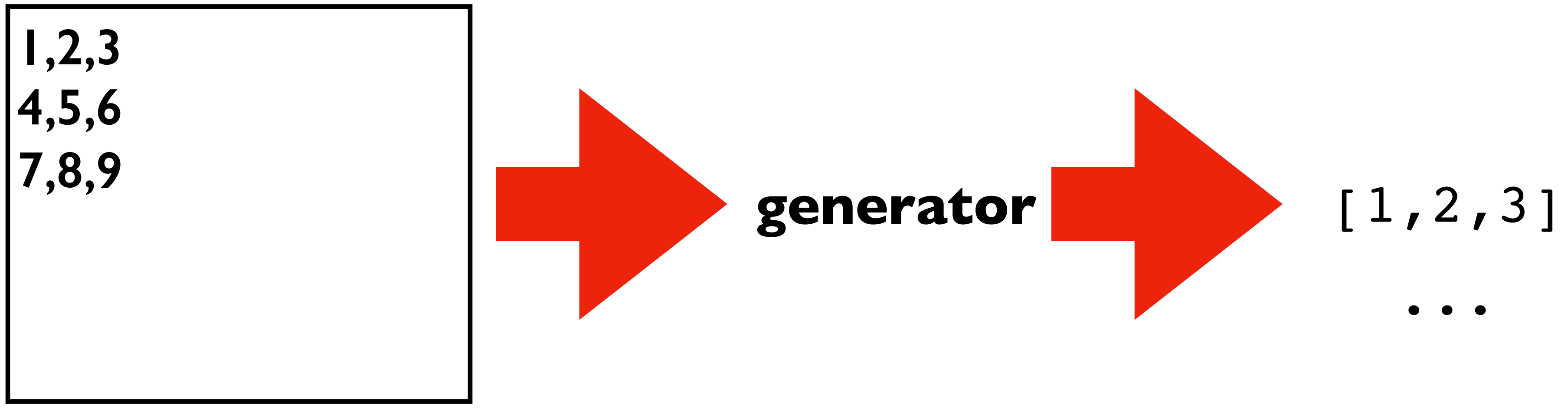
Goal: load a matrix of integers from a file

Input:

- file name

Output:

- generator that yields lists of ints


1,2,3
4,5,6
7,8,9
generator
[1,2,3]
...