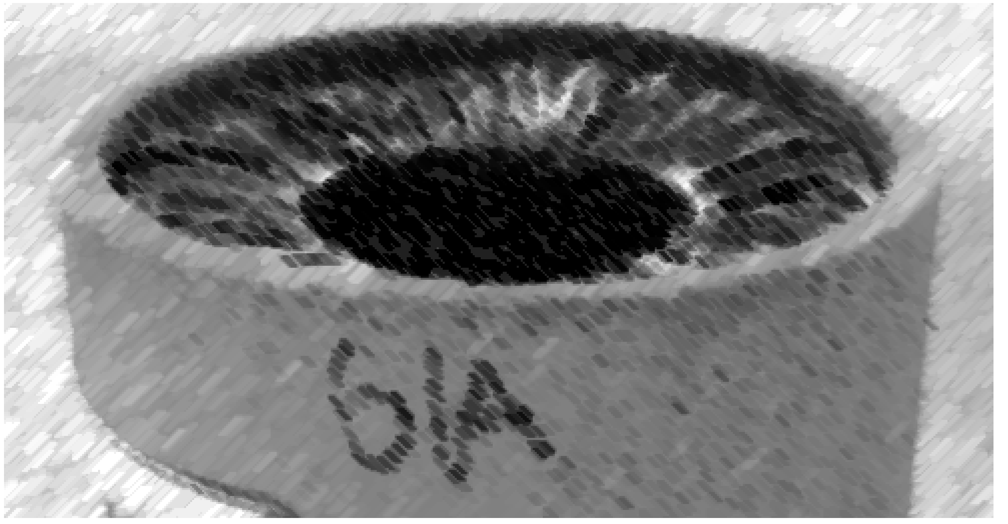


# CS61A Lecture 16

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# Announcements

- HW5 due tonight

- Trends project due on Tuesday
  - Partners are required; find one in lab or on Piazza
  - Will not work in IDLE
  - New bug submission policy; see Piazza

# Iterables

Iterables provide access to some elements in order but do not provide length or element selection

Python-specific construct; more general than a sequence

Many built-in functions take iterables as argument

| | |
|---|---|
| **`tuple`** | Construct a tuple containing the elements |
| **`map`** | Construct a map that results from applying the given function to each element |
| **`filter`** | Construct a filter with elements that satisfy the given condition |
| **`sum`** | Return the sum of the elements |
| **`min`** | Return the minimum of the elements |
| **`max`** | Return the maximum of the elements |

For statements also operate on iterable values.

# Generator Expressions

One large expression that combines mapping and filtering to produce an iterable

```
(<map exp> for <name> in <iter exp> if <filter exp>)
```

- Evaluates to an iterable.
- <iter exp> is evaluated when the generator expression is evaluated.
- Remaining expressions are evaluated when elements are accessed.

No-filter version: `(<map exp> for <name> in <iter exp>)`

Precise evaluation rule introduced in Chapter 4.

# Reducing a Sequence

Reduce is a higher-order generalization of max, min, and sum.

```
>>> from operator import mul
>>> from functools import reduce
>>> reduce(mul, (1, 2, 3, 4, 5), 1)
120
```

First argument: A two-argument function

Second argument: an iterable object

Optional initial value as third argument

Like accumulate from Homework 2, but with iterables

```
def accumulate(combiner, start, n, term):
    return reduce(combiner,
                  map(term, range(1, n + 1)),
                  start)
```

# More Functions on Iterables (Bonus)

Create an iterable of fixed-length sequences

```
>>> a, b = (1, 2, 3), (4, 5, 6, 7)
>>> for x, y in zip(a, b):
...     print(x + y)
...
5
7
9
```

Produces tuples with one element from each argument, up to length of smallest argument

The **`itertools`** module contains many useful functions for working with iterables

```
>>> from itertools import product, combinations
>>> tuple(product(a, b[:2]))
((1, 4), (1, 5), (2, 4), (2, 5), (3, 4), (3, 5))
>>> tuple(combinations(a, 2))
((1, 2), (1, 3), (2, 3))
```

# Lists

```
>>> a = [3, 1, 2]
>>> a
[3, 1, 2]
>>> len(a)
3
>>> a[1]
1
>>> c, d = a, a[:]
>>> a, c, d
([3, 1, 2], [3, 1, 2], [3, 1, 2])
>>> c[0] = 4
>>> a, c, d
([4, 1, 2], [4, 1, 2], [3, 1, 2])
>>> d[0] = 5
>>> a, c, d
([4, 1, 2], [4, 1, 2], [5, 1, 2])
>>> a[1:2] = [7, 8, 9]
>>> a, c, d
([4, 7, 8, 9, 2], [4, 7, 8, 9, 2], [5, 1, 2])
```

Create a list using square brackets

Lists are sequences

Bind another name to a list or a slice of a list

Modify contents of a list

**wut()**?

# Objects

An *object* is a representation of information

All data in Python are objects

But an object is not just data; it also bundles behavior together with that data

An object's *type* determines what data it stores and what behavior it provides

```
>>> type(4)
<class 'int'>

>>> type([4])
<class 'list'>
```

# Object Attributes

All objects have attributes

We use dot notation to access an attribute

```
>>> (4).real, (4).imag
(4, 0)
```

An attribute may be a *method*, which is a type of function, so it may be called

```
>>> [1, 2, 1, 4].count(1)
2
```

Notice that we did not have to pass in the list as an argument; the method already knows the object on which it is operating

# Creating and Distinguishing Objects

Calling the constructor of a built-in type creates a new object of that type

Objects can be distinct even if they hold the same data

The is and not is operators check if two objects are the same

```
>>> [1, 2, 1, 4] is [1, 2, 1, 4]
False
```

Compare to ==, which checks for equality, not sameness

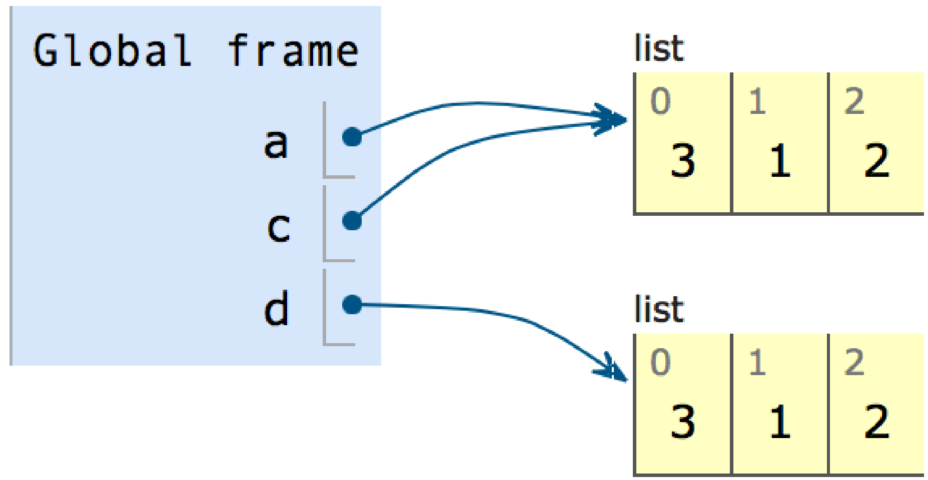
```
>>> [1, 2, 1, 4] == [1, 2, 1, 4]
True
```

# Objects and Assignment

Assignment does not create a new object

```
a = [3, 1, 2]
c, d = a, a[:]
```

But slicing does!




In our environment diagrams, assignment copies the arrow

The “arrow” is called a *pointer* or *reference*

Multiple names can *point to* or *reference* the same object

Example: [http://goo.gl/Xrm4k](http://goo.gl/Xrm4k)

# Immutable Types

An object may be *immutable*, which means that its data cannot be changed

Most of the types we have seen so far are immutable

- ints, floats, booleans, tuples, ranges, strings

For an immutable type, it doesn't matter whether or not two equal objects are the same

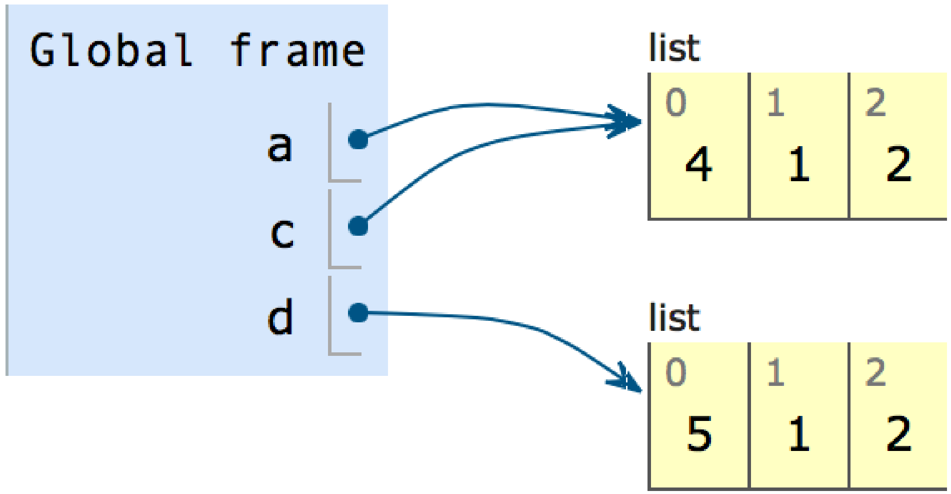
Neither can change, so one is as good as the other

```
>>> e, f = 1e12, 1e12
>>> e is f
True
>>> e = 1e12
>>> f = 1e12
>>> e is f
False
```

# Mutable Types

Mutable objects, on the other hand, can change, and any change affects all references to that object

```
a = [3, 1, 2]
c, d = a, a[:]
c[0] = 4
d[0] = 5
```




So we need to be careful with mutation

Example: [http://goo.gl/ornZ8](http://goo.gl/ornZ8)

# List Methods

Lists have many useful methods

- **`append`**: add an element to the end of a list
- **`extend`**: add all elements from an iterable to the end of the list
- **`count`**: count the number of occurrences of a value
- **`pop`**: remove an element from the end of a list
- **`sort`**: sort the elements of a list

These methods (except **`count`**) mutate the list

Compare to **`sorted(x)`**, which returns a new list

Call **`dir(list)`** to see a full list of attributes

# List Comprehensions

We can construct a list using a *list comprehension*, which is similar to a generator expression

```
[<map exp> for <name> in <iter exp> if <filter exp>]
```

- Evaluates to a list.
- <iter exp> is evaluated once.
- <name> is bound to an element, and <filter exp> is evaluated. If it evaluates to a true value, then <map exp> is evaluated, and its value is added to the resulting list.

```
>>> [3 / x for x in range(4) if x != 0]
[3.0, 1.5, 1.0]
```

# Dictionaries

Sequences map integers to values

```
>>> a = [3, 1, 2]
```

```
-3 -> 3      0 -> 3
-2 -> 1      1 -> 1
-1 -> 2      2 -> 2
```

What if we wanted arbitrary values in the domain?

We use a dictionary

```
>>> eras = {'cain':       2.79,
            'bumgarner':  3.37,
            'vogelsong':  3.37,
            'lincecum':   5.18,
            'zito':       4.15}
>>> eras['cain']
2.79
```

```
'cain'      -> 2.79
'bumgarner' -> 3.37
'vogelsong' -> 3.37
'lincecum'  -> 5.18
'zito'      -> 4.15
```

# Dictionary Features

Dictionaries are not sequences, but they do have a length and are iterable

- Iterating provides each of the keys in some arbitrary order

```
>>> total_era = 0
>>> for pitcher in eras:
...     total_era += eras[pitcher]
...
>>> total_era / len(eras)
3.772
```

Dictionaries are mutable

```
>>> eras['lincecum'] = 3.0
```

There are dictionary comprehensions, which are similar to list comprehensions

```
>>> {p: round(eras[p]-1, 3) for p in eras}
{'zito': 3.15, 'cain': 1.79, 'bumgarner': 2.37,
'lincecum': 2.0, 'vogelsong': 2.37}
```

# Limitations on Dictionaries

Dictionaries are unordered collections of key-value pairs.

Dictionary keys do have two restrictions:

- A key of a dictionary cannot be an object of a mutable built-in type.
- Two keys cannot be equal. There can be at most one value for a given key.

This first restriction is tied to Python's underlying implementation of dictionaries.

The second restriction is an intentional consequence of the dictionary abstraction.