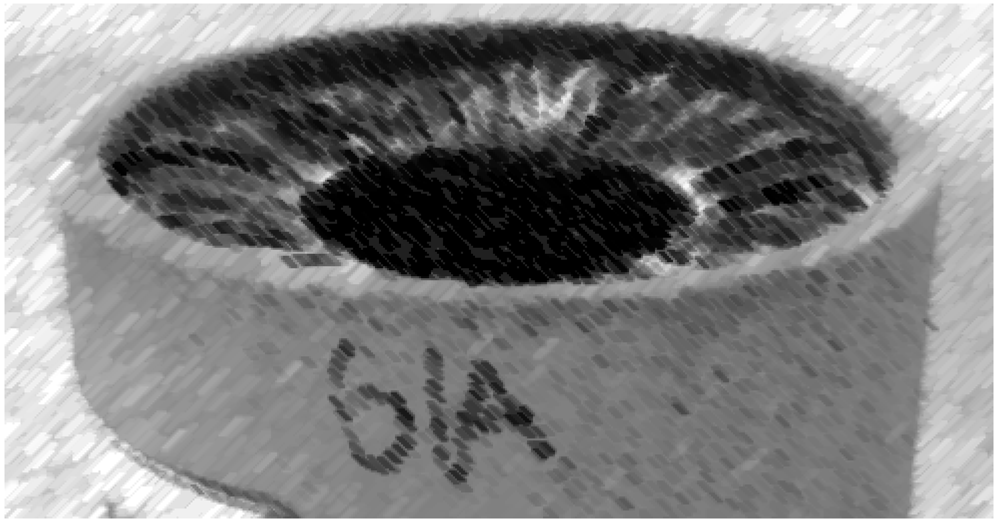

CS61A Lecture 19

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Announcements

- HW6 due tomorrow
- Ants project out

Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
            return getitem_rlist(contents, value)
        elif message == 'push':
            contents = make_rlist(value, contents)
        elif message == 'pop':
            item = first(contents)
            contents = rest(contents)
            return item
        elif message == 'str':
            return str_rlist(contents)
    return dispatch
```

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

We store key-value pairs as 2-element lists inside another list

```
records = [['cain',      2.79],
           ['bumgarner', 3.37],
           ['vogelsong', 3.37],
           ['lincecum',  5.18],
           ['zito',      4.15]]
```

Dictionary operations:

- **`getitem(key)`**: Look at each record until we find a stored key that matches **`key`**
- **`setitem(key, value)`**: Check if there is a record with the given key. If so, change the stored value to **`value`**. If not, add a new record that stores **`key`** and **`value`**.

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []

    def getitem(key):
        for k, v in records:
            if k == key:
                return v

    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])

    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
        elif message == 'values':
            return tuple(v for _, v in records)

    return dispatch
```

Question: Do we need a nonlocal statement here?

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive
- We can't add new messages without writing new code

A dispatch dictionary has messages as keys and functions (or data objects) as values.

Dictionaries handle the message look-up logic; we concentrate on implementing useful behavior.

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
    dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
        dispatch['balance'] += amount
        return dispatch['balance']

    dispatch = {'balance': balance, 'withdraw': withdraw,
                'deposit': deposit}

    return dispatch
```

Question: Why `dispatch['balance']` and not `balance`?

The Story So Far About Data

Data abstraction: Enforce a separation between how data values are represented and how they are used.

Abstract data types: A representation of a data type is valid if it satisfies certain behavior conditions.

Message passing: We can organize large programs by building components that relate to each other by passing messages.

Dispatch functions/dictionaries: A single object can include many different (but related) behaviors that all manipulate the same local state.

(All of these techniques can be implemented using only functions and assignment.)

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each *object* has its own local state.
- Each object also knows how to manage its own local state, based on the messages it receives.
- Several objects may all be instances of a common type.
- Different types may relate to each other as well.

Specialized syntax & vocabulary to support this metaphor

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

Better idea: All bank accounts share a "withdraw" method.

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created:
2. The constructor `__init__` of the class is called with the new object as its first argument (called `self`), along with additional arguments provided in the call expression.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

Identity testing is performed by "is" and "is not" operators:

```
>>> a is a
True
>>> a is not b
True
```

Binding an object to a new name using assignment **does not** create a new object:

```
>>> c = a
>>> c is a
True
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance

    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance
```

These def statements create function objects as always, but their names are bound as attributes of the class.

Invoking Methods

All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

```
class Account(object):
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Called with two arguments

Dot notation automatically supplies the first argument to a method.

```
>>> tom_account = Account('Tom')
>>> tom_account.deposit(100)
100
```

Invoked with one argument

Dot Expressions

Objects receive messages via dot notation

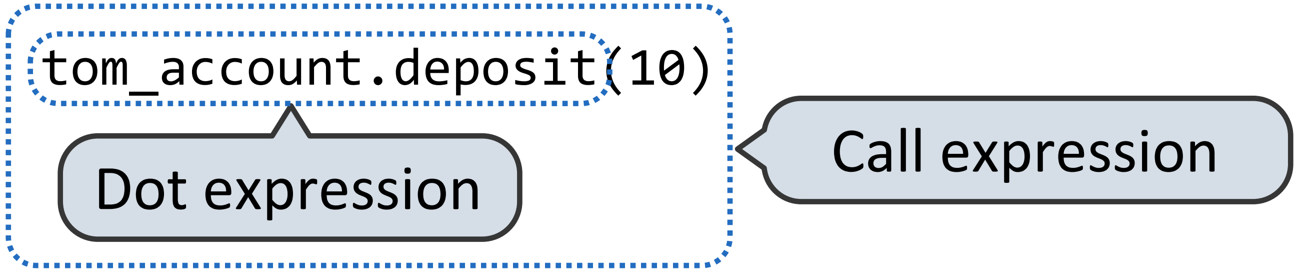
Dot notation accesses attributes of the instance or its class

`<expression> . <name>`

The **`<expression>`** can be any valid Python expression

The **`<name>`** must be a simple name

Evaluates to the value of the attribute **looked up** by **`<name>`** in the object that is the value of the **`<expression>`**



```
tom_account.deposit(10)
```

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

`getattr` and dot expressions look up a name in the same way

Looking up an attribute name in an object may return:

- One of its instance attributes, **or**
- One of the attributes of its class

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object  +  Function  =  Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
1011
>>> tom_account.deposit(1000)
2011
```

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

The same procedure can be used to create a bound method from a function

```
def curry(f):
    def outer(x):
        def inner(*args):
            return f(x, *args)
        return inner
    return outer
```

```
>>> add2 = curry(add)(2)
>>> add2(3)
5

>>> tom_deposit = curry(Account.deposit)(tom_account)
>>> tom_deposit(1000)
3011
```