

## 61A Lecture 15

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## Announcements

Attributes

## Terminology: Attributes, Functions, and Methods

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All objects have attributes, which are name-value pairs

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Classes are objects too, so they have attributes

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### **Terminology:**

## Terminology: Attributes, Functions, and Methods

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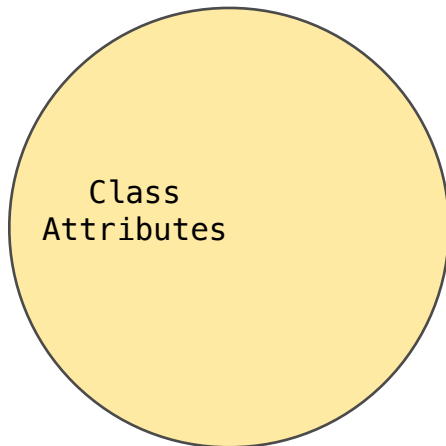
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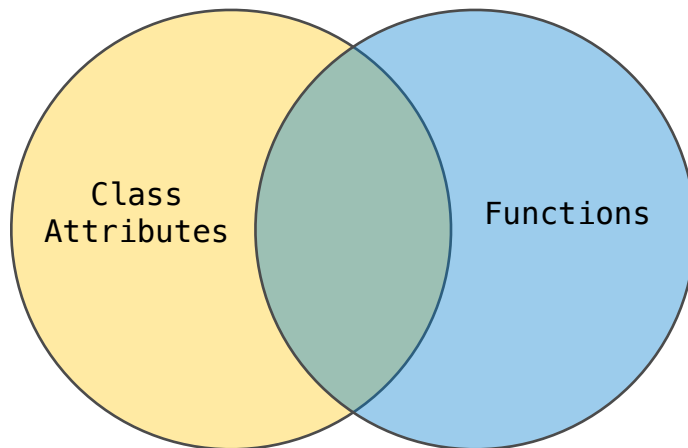
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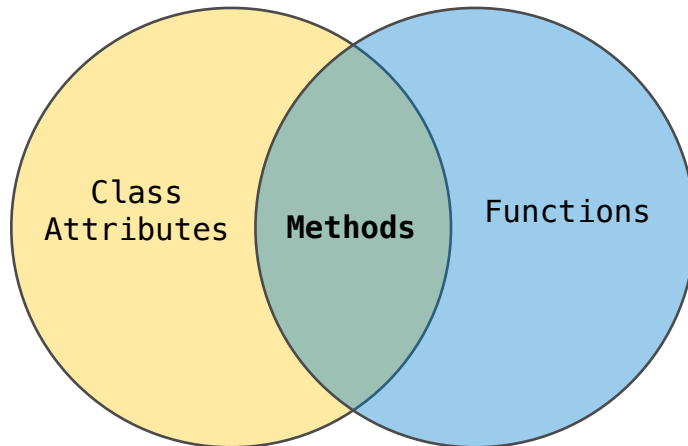
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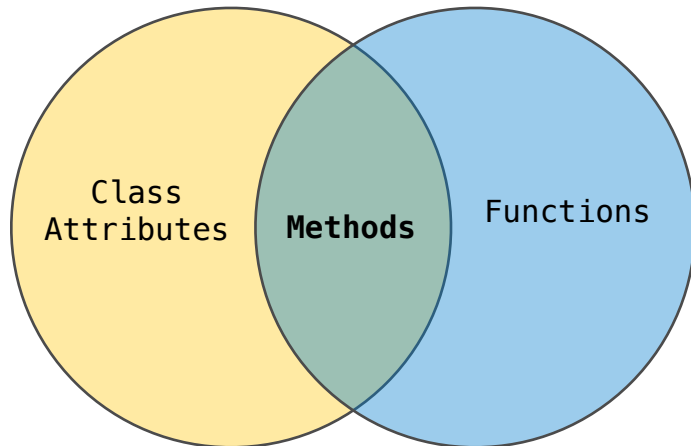
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**Terminology:**

**Python object system:**



## Terminology: Attributes, Functions, and Methods

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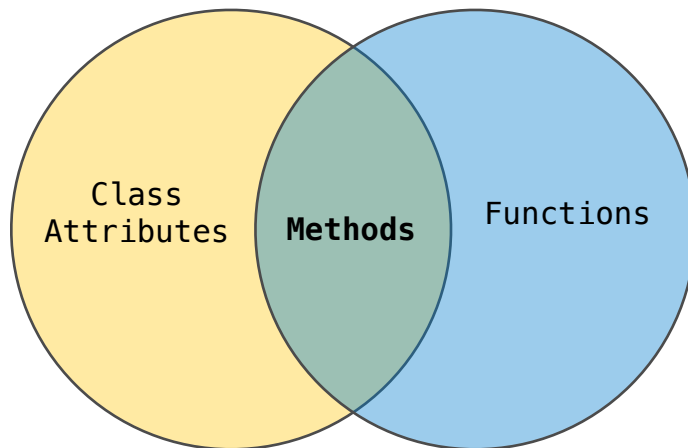
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Functions are objects

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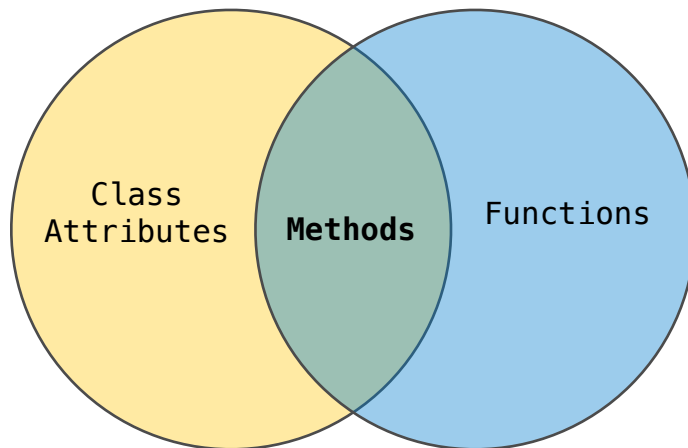
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### Python object system:

Functions are objects

Bound methods are also objects: a function that has its first parameter "self" already bound to an instance

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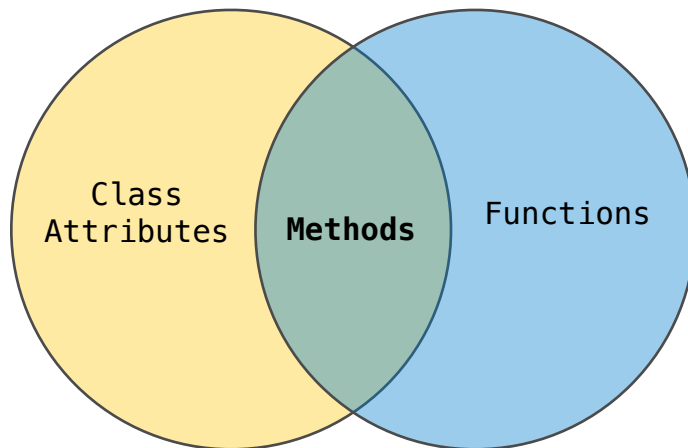
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Dot expressions evaluate to bound methods for class attributes that are functions



## Terminology: Attributes, Functions, and Methods

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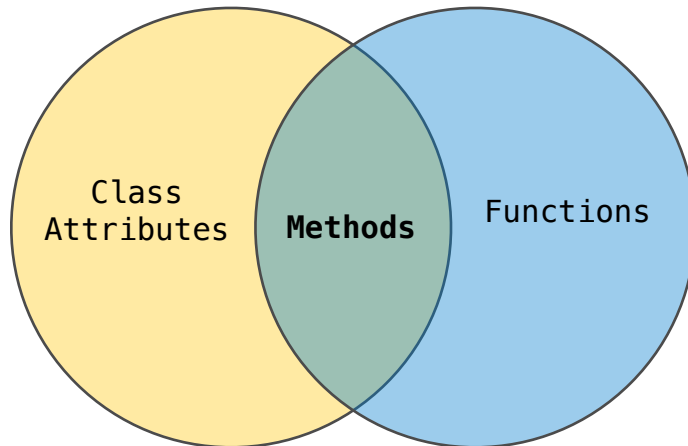
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Dot expressions evaluate to bound methods for class attributes that are functions

`<instance>.<method_name>`

## Reminder: Looking Up Attributes by Name

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`<expression> . <name>`

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To evaluate a dot expression:

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1. Evaluate the `<expression>` to the left of the dot, which yields the object of the dot expression

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1. Evaluate the `<expression>` to the left of the dot, which yields the object of the dot expression
2. `<name>` is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned
3. If not, `<name>` is looked up in the class, which yields a class attribute value
4. That value is returned unless it is a function, in which case a bound method is returned instead

## Attribute Assignment



## Assignment to Attributes

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Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

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```
class Account:
    interest = 0.02
    def __init__(self, holder):
        self.holder = holder
        self.balance = 0
    ...
tom_account = Account('Tom')
```

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```
tom_account.interest = 0.08
```

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This expression  
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tom\_account.interest = 0.08

This expression  
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But the name ("interest")  
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tom\_account.interest = 0.08

This expression evaluates to an object

But the name ("interest") is not looked up

Attribute assignment statement adds or modifies the attribute named "interest" of tom\_account

## Assignment to Attributes

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    ...
tom_account = Account('Tom')
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Instance  
Attribute  
Assignment

tom\_account.interest = 0.08

This expression  
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object

But the name ("interest")  
is not looked up

Attribute  
assignment  
statement adds  
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attribute named  
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tom\_account

## Assignment to Attributes

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    interest = 0.02
    def __init__(self, holder):
        self.holder = holder
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    ...
tom_account = Account('Tom')
```

Instance  
Attribute  
Assignment

tom\_account.interest = 0.08

This expression  
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object

But the name ("interest")  
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Attribute  
assignment  
statement adds  
or modifies the  
attribute named  
"interest" of  
tom\_account

Class  
Attribute  
Assignment

Account.interest = 0.04

## Attribute Assignment Statements

---

Account class  
attributes

```
interest: 0.02  
(withdraw, deposit, __init__)
```

## Attribute Assignment Statements

---

Account class  
attributes

```
interest: 0.02  
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```

```
>>> jim_account = Account('Jim')
```

## Attribute Assignment Statements

---

Account class  
attributes

```
interest: 0.02  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

```
>>> jim_account = Account('Jim')
```

## Attribute Assignment Statements

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Account class  
attributes

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interest: 0.02  
(withdraw, deposit, __init__)
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Instance  
attributes of  
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balance: 0  
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```

```
>>> jim_account = Account('Jim')  
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```

## Attribute Assignment Statements

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Account class  
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```
interest: 0.02  
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```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')
```



## Attribute Assignment Statements

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Account class  
attributes

```
interest: 0.02  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02
```

## Attribute Assignment Statements

---

Account class  
attributes

```
interest: 0.02  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02
```

## Attribute Assignment Statements

---

Account class  
attributes

```
interest: 0.02  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04
```

## Attribute Assignment Statements

---

Account class  
attributes

```
interest: 0.02 0.04  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04
```

## Attribute Assignment Statements

Account class  
attributes

```
interest: 0.02 0.04  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04
```

## Attribute Assignment Statements

Account class  
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interest: 0.02 0.04  
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Instance  
attributes of  
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balance: 0  
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Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

## Attribute Assignment Statements

Account class  
attributes

```
interest: 0.02 0.04  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

```
>>> jim_account.interest = 0.08
```

## Attribute Assignment Statements

Account class  
attributes

```
interest: 0.02 0.04  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'  
interest: 0.08
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

```
>>> jim_account.interest = 0.08
```



## Attribute Assignment Statements

Account class attributes

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interest: 0.02 0.04  
(withdraw, deposit, __init__)
```

Instance attributes of jim\_account

```
balance: 0  
holder: 'Jim'  
interest: 0.08
```

Instance attributes of tom\_account

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balance: 0  
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```

```
>>> jim_account = Account('Jim')  
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>>> tom_account.interest  
0.02  
>>> jim_account.interest  
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>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

```
>>> jim_account.interest = 0.08  
>>> jim_account.interest  
0.08
```

## Attribute Assignment Statements

Account class  
attributes

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interest: 0.02 0.04  
(withdraw, deposit, __init__)
```

Instance  
attributes of  
jim\_account

```
balance: 0  
holder: 'Jim'  
interest: 0.08
```

Instance  
attributes of  
tom\_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
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0.08  
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```
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>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

```
>>> jim_account.interest = 0.08  
>>> jim_account.interest  
0.08  
>>> tom_account.interest  
0.04  
>>> Account.interest = 0.05
```

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Instance  
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balance: 0  
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```
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>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

```
>>> jim_account.interest = 0.08  
>>> jim_account.interest  
0.08  
>>> tom_account.interest  
0.04  
>>> Account.interest = 0.05
```

## Attribute Assignment Statements

Account class attributes

```
interest: 0.02 0.04 0.05  
(withdraw, deposit, __init__)
```

Instance attributes of jim\_account

```
balance: 0  
holder: 'Jim'  
interest: 0.08
```

Instance attributes of tom\_account

```
balance: 0  
holder: 'Tom'
```

```
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>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

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```

```
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>>> jim_account.interest  
0.08  
>>> tom_account.interest  
0.04  
>>> Account.interest = 0.05  
>>> tom_account.interest  
0.05  
>>> jim_account.interest  
0.08
```

# Inheritance

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---



## Inheritance

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Inheritance is a technique for relating classes together

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A common use: Two similar classes differ in their degree of specialization

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The specialized class may have the same attributes as the general class, along with some special-case behavior

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A common use: Two similar classes differ in their degree of specialization

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```
class <Name>(<Base Class>):  
    <suite>
```

## Inheritance

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Inheritance is a technique for relating classes together

A common use: Two similar classes differ in their degree of specialization

The specialized class may have the same attributes as the general class, along with some special-case behavior

```
class <Name>(<Base Class>):  
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```

Conceptually, the new subclass inherits attributes of its base class

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The subclass may override certain inherited attributes

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A common use: Two similar classes differ in their degree of specialization

The specialized class may have the same attributes as the general class, along with some special-case behavior

```
class <Name>(<Base Class>):  
    <suite>
```

Conceptually, the new subclass inherits attributes of its base class

The subclass may override certain inherited attributes

Using inheritance, we implement a subclass by specifying its differences from the the base class

## Inheritance Example

---

A `CheckingAccount` is a specialized type of `Account`



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A `CheckingAccount` is a specialized type of `Account`

```
>>> ch = CheckingAccount('Tom')
```

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A `CheckingAccount` is a specialized type of `Account`

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest      # Lower interest rate for checking accounts
0.01
```

## Inheritance Example

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A `CheckingAccount` is a specialized type of `Account`

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest      # Lower interest rate for checking accounts
0.01
>>> ch.deposit(20)   # Deposits are the same
20
```

## Inheritance Example

---

A `CheckingAccount` is a specialized type of `Account`

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest      # Lower interest rate for checking accounts
0.01
>>> ch.deposit(20)  # Deposits are the same
20
>>> ch.withdraw(5)  # Withdrawals incur a $1 fee
14
```

## Inheritance Example

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A `CheckingAccount` is a specialized type of `Account`

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest      # Lower interest rate for checking accounts
0.01
>>> ch.deposit(20)   # Deposits are the same
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Most behavior is shared with the base class `Account`

## Inheritance Example

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## Inheritance Example

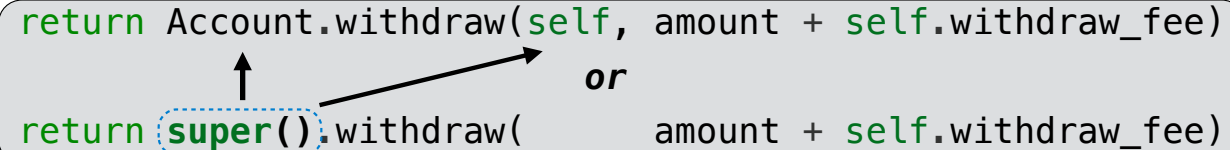
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(Demo)

# Object-Oriented Design



## Designing for Inheritance

---

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Attributes that have been overridden are still accessible via class objects

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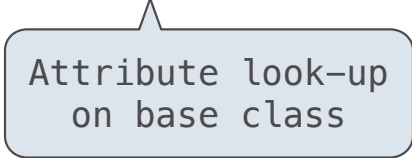
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Attribute look-up  
on base class

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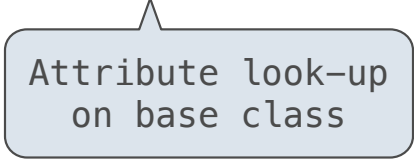
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Look up attributes on instances whenever possible

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```

Attribute look-up  
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Preferred to `CheckingAccount.withdraw_fee`  
to allow for specialized accounts

## Inheritance and Composition

---



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Composition is best for representing has-a relationships

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(Demo)



## Multiple Inheritance

## Multiple Inheritance

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```
class SavingsAccount(Account):  
    deposit_fee = 2  
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```
class AsSeenOnTVAccount(CheckingAccount, SavingsAccount):
    def __init__(self, account_holder):
        self.holder = account_holder
        self.balance = 1           # A free dollar!
```

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## Resolving Ambiguous Class Attribute Names

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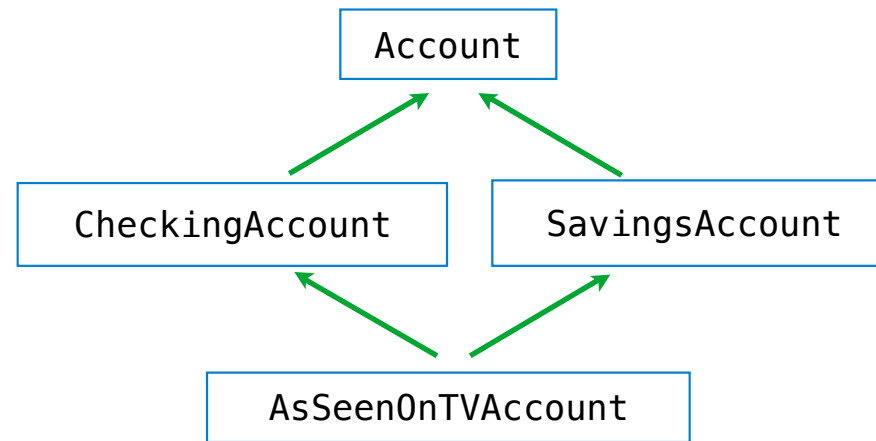
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## Complicated Inheritance

## Biological Inheritance

---

## Biological Inheritance

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Grandma

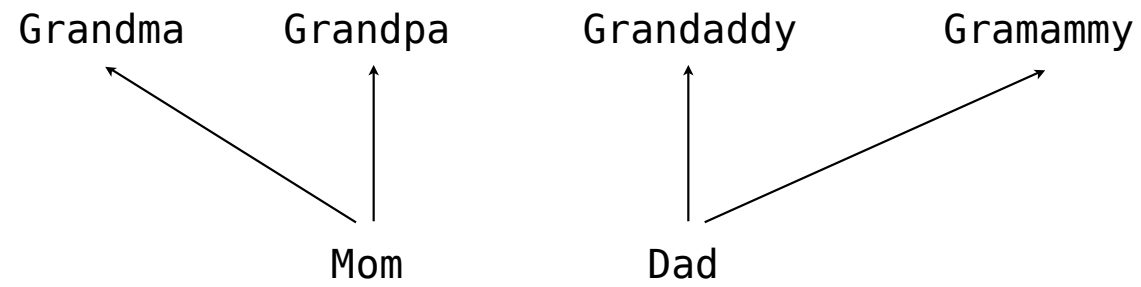
Grandpa

Granddaddy

Gramammy

## Biological Inheritance

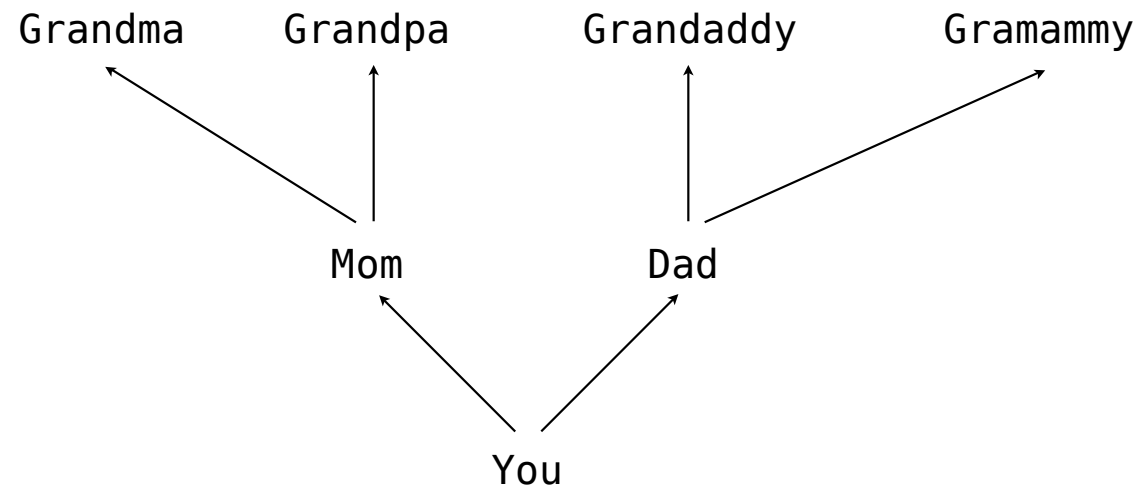
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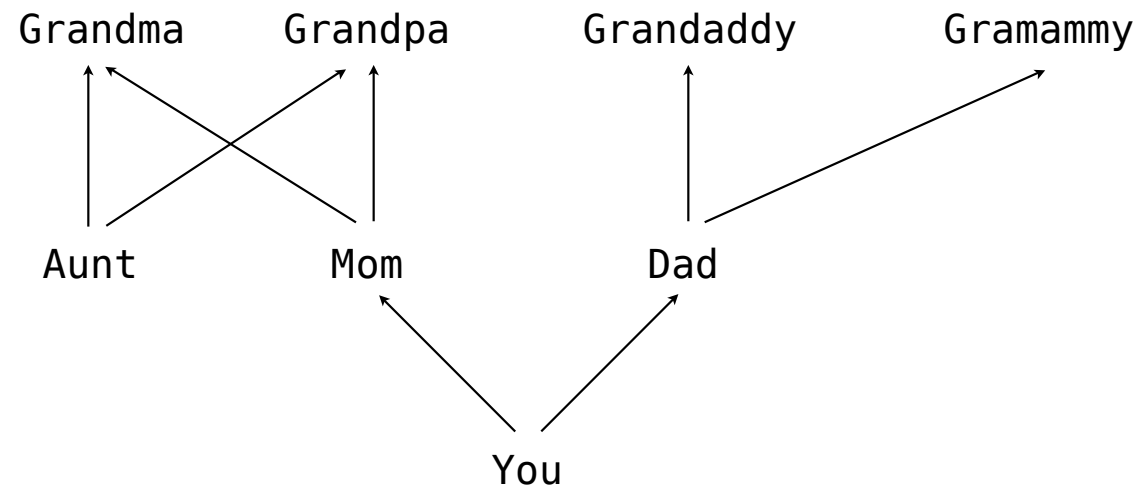
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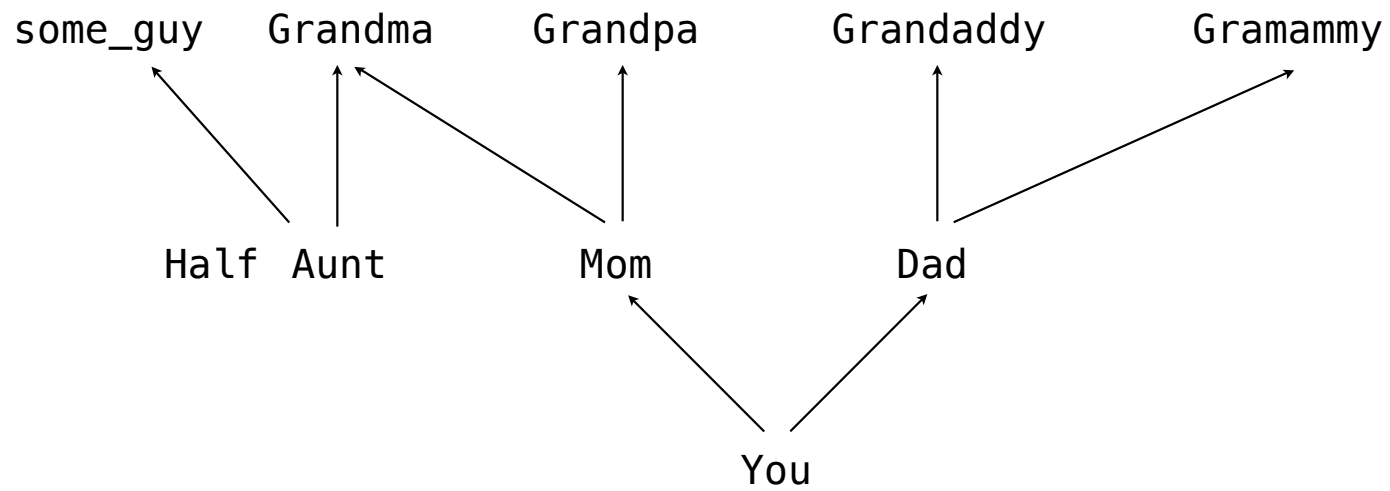
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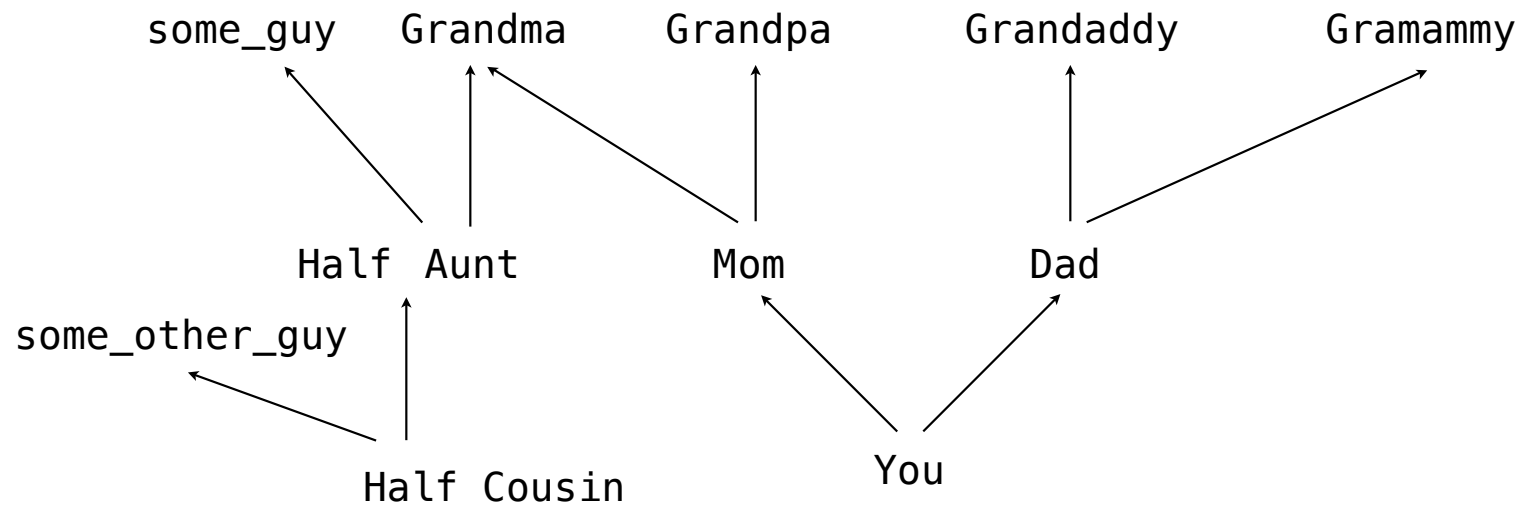
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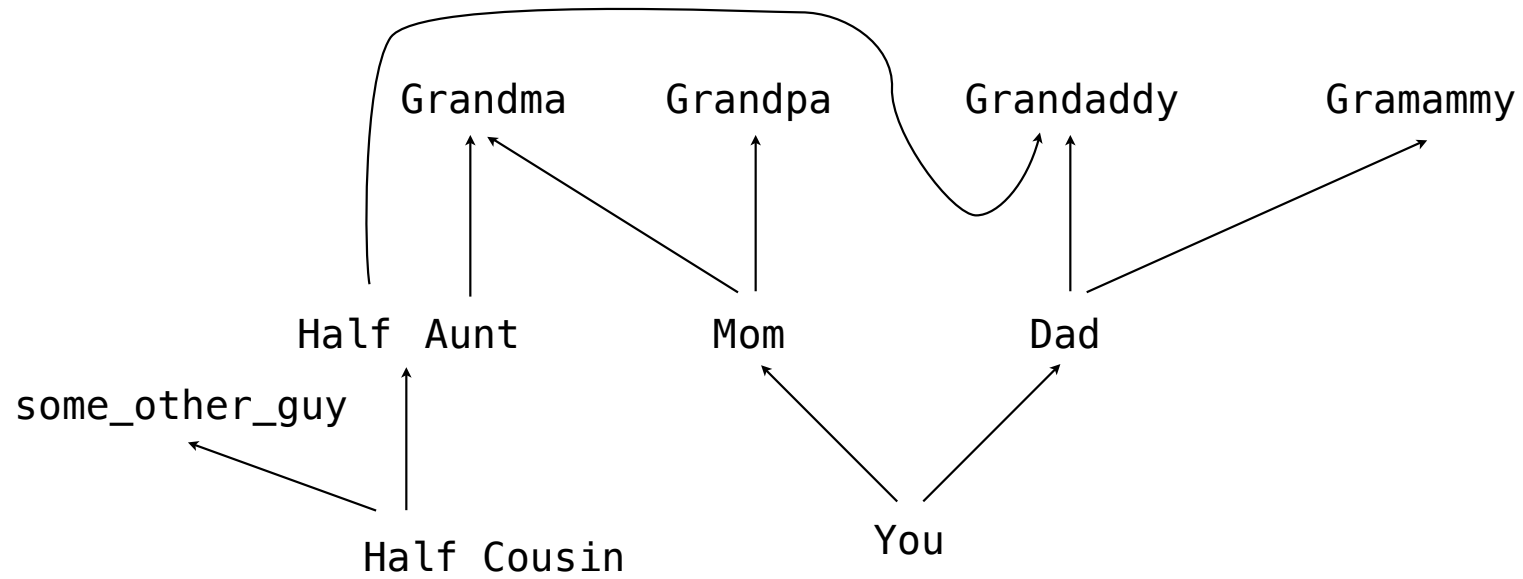
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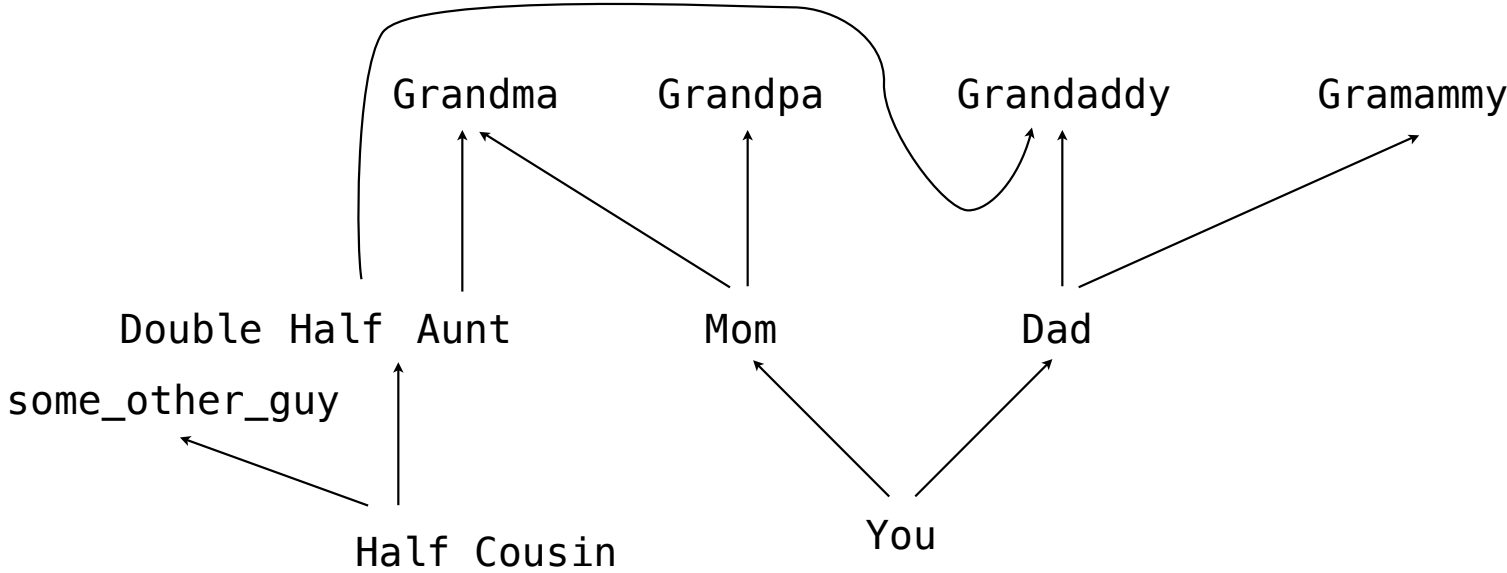
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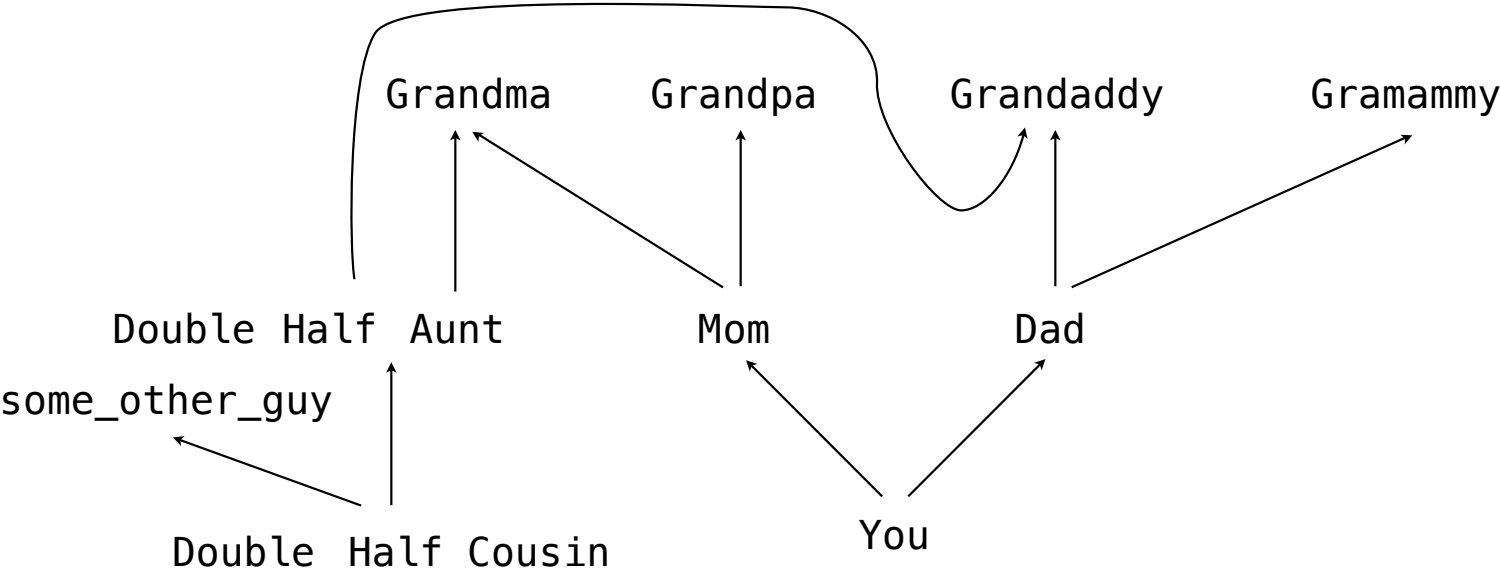
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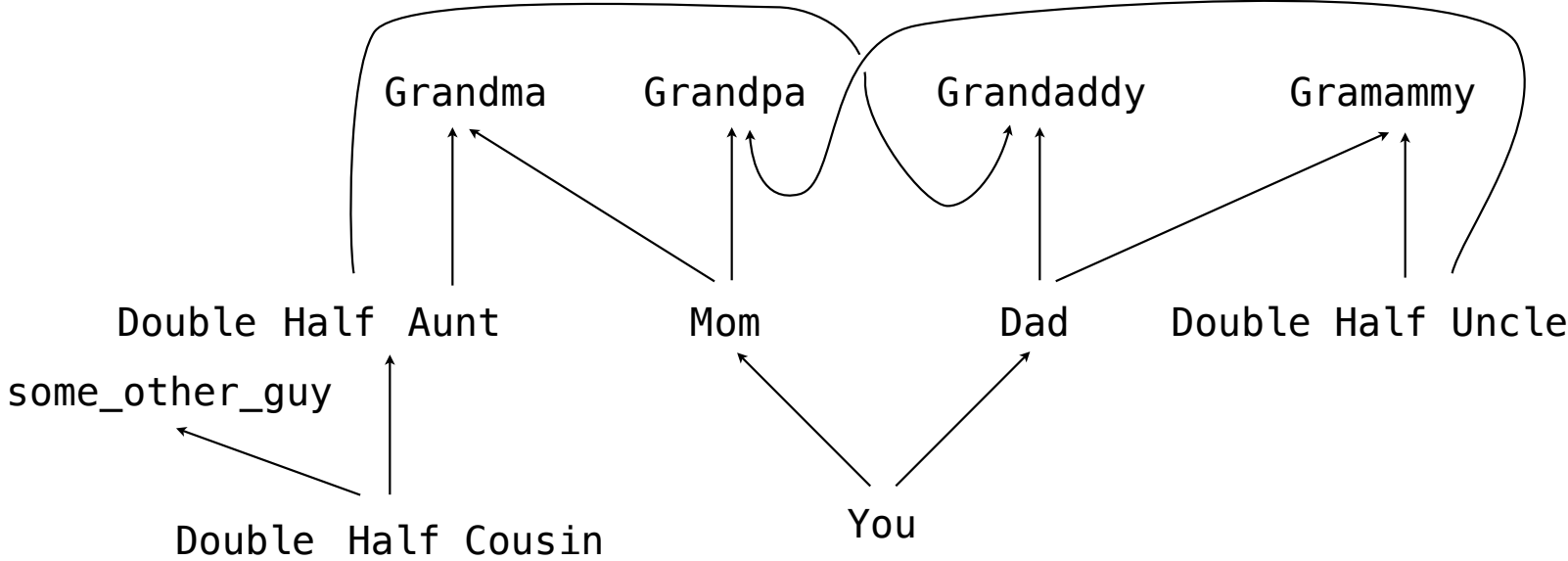
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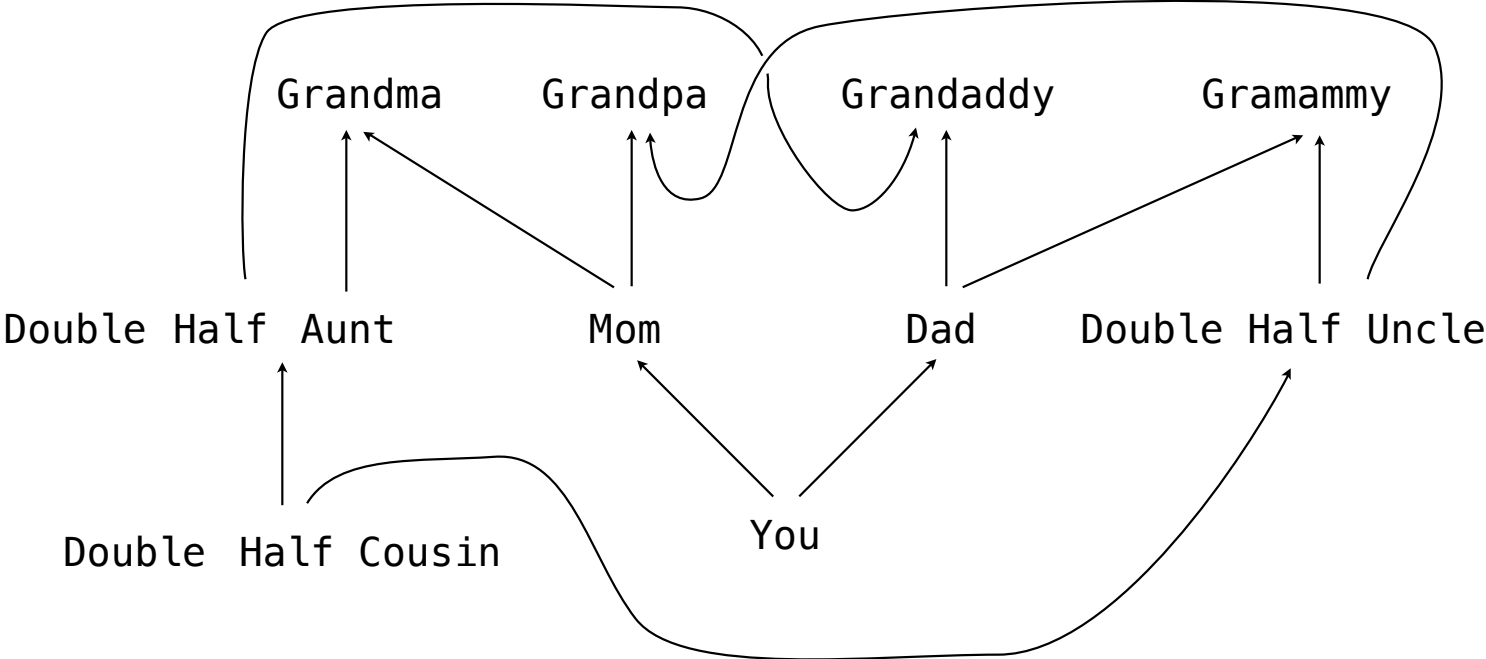
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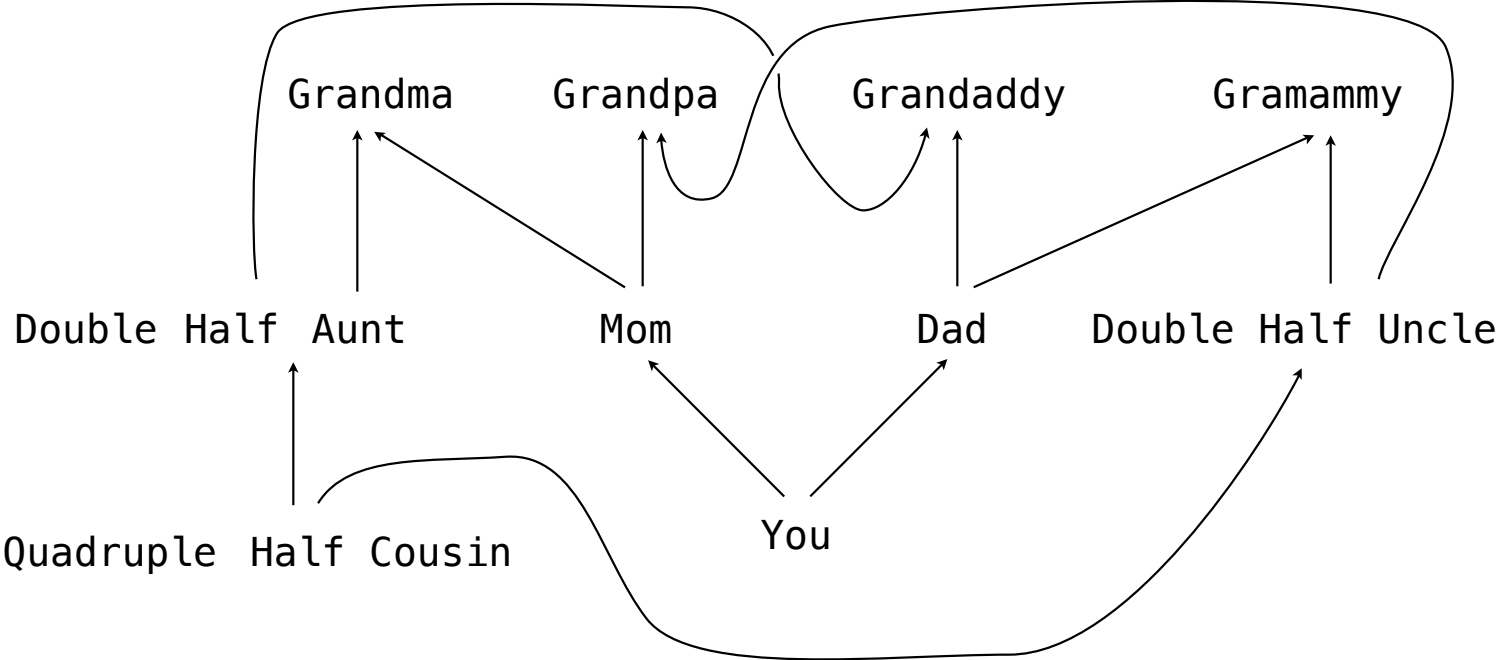




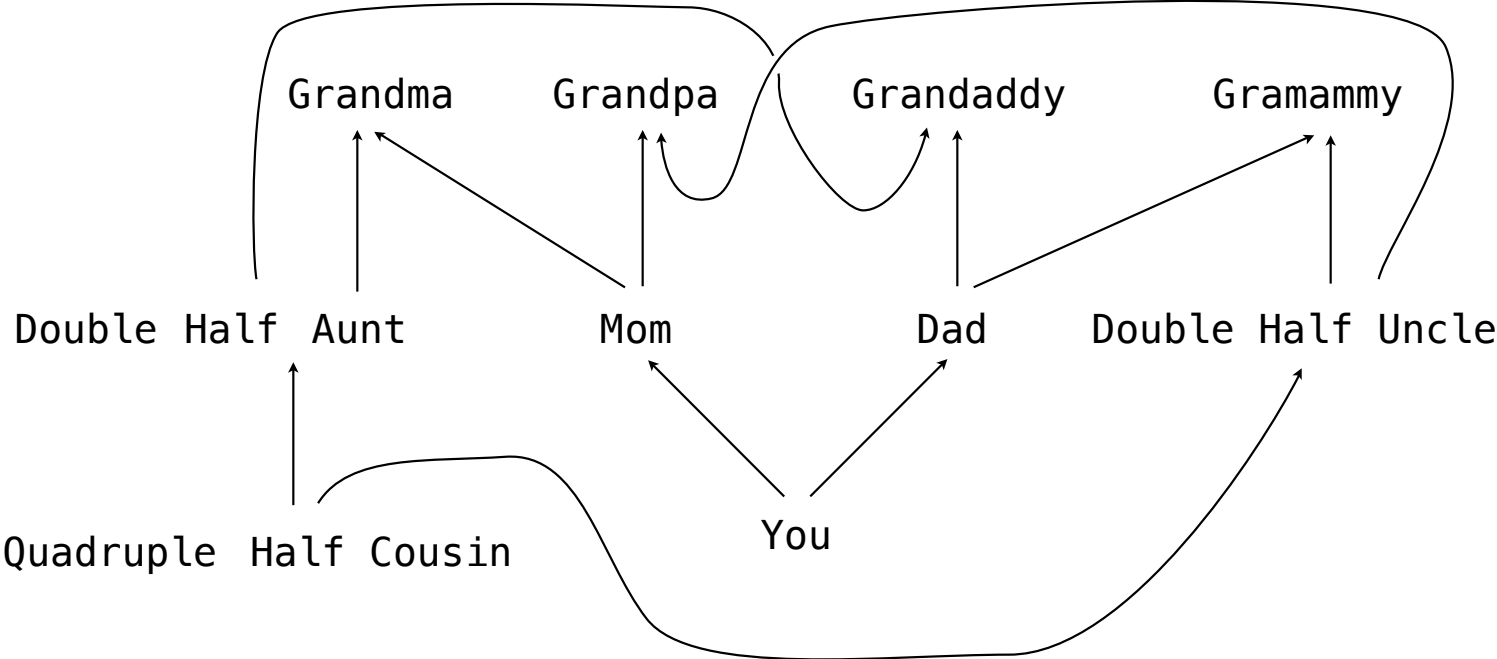
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Moral of the story: Inheritance can be complicated, so don't overuse it!