Inheritance
Class outline:

- Motivation
- Inheritance
- Multiple Inheritance
- Composition
- Identity
Motivation
Building "Animal Conserving"

A game where we take care of cute furry/ferocious animals:
What should be the classes?
What should be the classes?

Panda()
Lion()
Rabbit()
Vulture()
Elephant()
Food()
A Food class

Let's start simple:

```python
class Food:
    def __init__(self, name, type, calories):
        self.name = name
        self.type = type
        self.calories = calories
```

How would we use that class?
A Food class

Let's start simple:

class Food:

    def __init__(self, name, type, calories):
        self.name = name
        self.type = type
        self.calories = calories

How would we use that class?

broccoli = Food("Broccoli Rabe", "veggies", 20)
bone_marrow = Food("Bone Marrow", "meat", 100)
An Elephant class

class Elephant:
    species_name = "African Savanna Elephant"
    scientific_name = "Loxodonta africana"
    calories_needed = 8000

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * 4)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += 1
        print(f"Yay happy fun time with {animal2.name}")

How would we use that class?
An Elephant class

class Elephant:
    species_name = "African Savanna Elephant"
scientific_name = "Loxodonta africana"
calories_needed = 8000

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * 4)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += 1
        print(f"Yay happy fun time with {animal2.name}")

el1 = Elephant("Willaby", 5)
el2 = Elephant("Wallaby", 3)
el1.play(2)
el1.interact_with(el2)
A Rabbit class

class Rabbit:
    species_name = "European rabbit"
    scientific_name = "Oryctolagus cuniculus"
    calories_needed = 200

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * 10)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += 4
        print(f"Yay happy fun time with {animal2.name}"

How would we use that class?
A Rabbit class

class Rabbit:
    species_name = "European rabbit"
    scientific_name = "Oryctolagus cuniculus"
    calories_needed = 200

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * 10)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += 4
        print(f"Yay happy fun time with {animal2.name}")

rabbit1 = Rabbit("Mister Wabbit", 3)
rabbit2 = Rabbit("Bugs Bunny", 2)
rabbit1.eat(broccoli)
rabbit2.interact_with(rabbit1)
**Notice similarities?**

<table>
<thead>
<tr>
<th></th>
<th><strong>Elephant</strong></th>
<th><strong>Rabbit</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># Class variables</strong></td>
<td><code>species_name</code></td>
<td><code>species_name</code></td>
</tr>
<tr>
<td></td>
<td><code>scientific_name</code></td>
<td><code>scientific_name</code></td>
</tr>
<tr>
<td></td>
<td><code>calories_needed</code></td>
<td><code>calories_needed</code></td>
</tr>
<tr>
<td><strong># Instance variables</strong></td>
<td><code>name</code></td>
<td><code>name</code></td>
</tr>
<tr>
<td></td>
<td><code>age</code></td>
<td><code>age</code></td>
</tr>
<tr>
<td></td>
<td><code>happiness</code></td>
<td><code>happiness</code></td>
</tr>
<tr>
<td><strong># Methods</strong></td>
<td><code>eat(food)</code></td>
<td><code>eat(food)</code></td>
</tr>
<tr>
<td></td>
<td><code>play()</code></td>
<td><code>play()</code></td>
</tr>
<tr>
<td></td>
<td><code>interact_with(other)</code></td>
<td><code>interact_with(other)</code></td>
</tr>
</tbody>
</table>

**Elephant** and **Rabbit** are both animals, so they have similar attributes. Instead of repeating code, we can inherit the code.
Inheritance
Base classes and subclasses

When multiple classes share similar attributes, you can reduce redundant code by defining a base class and then subclasses can inherit from the base class.

Tip: The base class is also known as the superclass.
The base class

The base class contains method headers common to the subclasses, and code that is used by multiple subclasses.

class Animal:
    species_name = "Animal"
    scientific_name = "Animalia"
    play_multiplier = 2
    interact_increment = 1

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * self.play_multiplier)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}"
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += self.interact_increment
        print(f"Yay happy fun time with {animal2.name}"

    def
The subclasses

To declare a subclass, put parentheses after the class name and specify the base class in the parentheses:

```python
class Panda(Animal):
```

Then the subclasses only need the code that's unique to them. They can redefine any aspect: class variables, method definitions, or constructor. A redefinition is called **overriding**.

The simplest subclass overrides nothing:

```python
class AmorphousBlob(Animal):
    pass
```
Overriding class variables

Subclasses can override existing class variables and assign new class variables:

class Rabbit(Animal):
    species_name = "European rabbit"
    scientific_name = "Oryctolagus cuniculus"
    calories_needed = 200
    play_multiplier = 8
    interact_increment = 4
    num_in_litter = 12

class Elephant(Animal):
    species_name = "African Savanna Elephant"
    scientific_name = "Loxodonta africana"
    calories_needed = 8000
    play_multiplier = 4
    interact_increment = 2
    num_tusks = 2
class LearnableContent:

    """A base class for specific kinds of learnable content. All kinds have title and author attributes, but each kind may have additional attributes. """

    license = "Creative Commons"

    def __init__(self, title, author):
        self.title = title
        self.author = author

# Create a Video subclass with
# license of "YouTube Standard License"

# Create an Article subclass with
# license of "CC-BY-NC-SA"

# Create a new Video instance with a title of "DNA" and an author of "Megan"
# Create a new Article instance with a title of "Water phases" and an author of
Exercise: LearnableContent (solution)

```python
class LearnableContent:
    """A base class for specific kinds of learnable content.
    All kinds have title and author attributes,
    but each kind may have additional attributes.
    """
    license = "Creative Commons"

    def __init__(self, title, author):
        self.title = title
        self.author = author

# Create a Video subclass with license of "YouTube Standard License"
class Video(LearnableContent):
    license = "YouTube Standard License"

# Create an Article subclass with license of "CC-BY-NC-SA"
class Article(LearnableContent):
    license = "CC-BY-NC-SA"

# Create a new Video instance with a title of "DNA" and an author of "Megan"
dna_video = Video("DNA", "Megan")

# Create a new Article instance with a title of "Water phases" and an author of "Lauren"
water_article = Article("Water phases", "Lauren")```

Overriding methods

If a subclass overrides a method, Python will use that definition instead of the superclass definition.

class Panda(Animal):
    species_name = "Giant Panda"
    scientific_name = "Ailuropoda melanoleuca"
    calories_needed = 6000

    def interact_with(self, other):
        print(f"I'm a Panda, I'm solitary, go away {other.name}!")

How would we call that method?
Overriding methods

If a subclass overrides a method, Python will use that definition instead of the superclass definition.

class Panda(Animal):
    species_name = "Giant Panda"
    scientific_name = "Ailuropoda melanoleuca"
    calories_needed = 6000

    def interact_with(self, other):
        print(f"I'm a Panda, I'm solitary, go away {other.name}!")

How would we call that method?

panda1 = Panda("Pandeybear", 6)
panda2 = Panda("Spot", 3)
panda1.interact_with(panda2)
Exercise: Character methods

class Character:
    ""
    >>> player = Character("Mario")
    >>> player.name
    'Mario'
    >>> player.health
    100
    >>> player.damage(10)
    >>> player.health
    90
    >>> player.boost(5)
    >>> player.health
    95
    ""

    def __init__(self, name):
        self.name = name
        self.health = 100

    def damage(self, amount):
        self.health -= amount

    def boost(self, amount):
        self.health += amount

class Boss(Character):
    """
>>> mx_boss = Boss("Mx Boss Person")
>>> mx_boss.damage(100)
>>> mx_boss.health
99
>>> mx_boss.damage(10)
>>> mx_boss.health
98
>>> mx_boss.boost(1)
>>> mx_boss.health
100
""

def damage(self, amount):
    # Bosses ignore the amount and instead
    # always receive 1 unit of damage to their health

def boost(self, amount):
    # Bosses always receive twice the amount
    # of boost to their health
Exercise: Character methods (solution)

class Character:
    """
    >>> player = Character("Mario")
    >>> player.name
    'Mario'
    >>> player.health
    100
    >>> player.damage(10)
    >>> player.health
    90
    >>> player.boost(5)
    >>> player.health
    95
    """
    def __init__(self, name):
        self.name = name
        self.health = 100

    def damage(self, amount):
        self.health -= amount

    def boost(self, amount):
        self.health += amount

class Boss(Character):
    """
>>> mx_boss = Boss("Mx Boss Person")
>>> mx_boss.damage(100)
>>> mx_boss.health
99
>>> mx_boss.damage(10)
>>> mx_boss.health
98
>>> mx_boss.boost(1)
>>> mx_boss.health
100

```python
""

def damage(self, amount):
    # Bosses ignore the amount and instead
    # always receive 1 unit of damage to their health
    self.health -= 1

def boost(self, amount):
    # Bosses always receive twice the
    # amount of boost to their health
    self.health += amount * 2
```
class Clothing:
    
    >>> blue_shirt = Clothing("shirt", "blue")
    >>> blue_shirt.category
    'shirt'
    >>> blue_shirt.color
    'blue'
    >>> blue_shirt.is_clean
    True
    >>> blue_shirt.wear()
    >>> blue_shirt.is_clean
    False
    >>> blue_shirt.clean()
    >>> blue_shirt.is_clean
    True
    

    def __init__(self, category, color):
        self.category = category
        self.color = color
        self.is_clean = True

    def wear(self):
        self.is_clean = False

    def clean(self):
        self.is_clean = True

class KidsClothing(Clothing):
    
    """
>>> onesie = KidsClothing("onesie", "polka dots")
>>> onesie.wear()
False
>>> onesie.clean()
>>> onesie.is_clean
False
>>> dress = KidsClothing("dress", "rainbow")
>>> dress.clean()
>>> dress.is_clean
True
>>> dress.wear()
>>> dress.is_clean
False
>>> dress.clean()
>>> dress.is_clean
False

# Override the clean() method
# so that kids clothing always stays dirty!
Exercise: Clothing (solution)

class Clothing:
    
    >>> blue_shirt = Clothing("shirt", "blue")
    >>> blue_shirt.category
    'shirt'
    >>> blue_shirt.color
    'blue'
    >>> blue_shirt.is_clean
    True
    >>> blue_shirt.wear()
    >>> blue_shirt.is_clean
    False
    >>> blue_shirt.clean()
    >>> blue_shirt.is_clean
    True
    
    def __init__(self, category, color):
        self.category = category
        self.color = color
        self.is_clean = True

    def wear(self):
        self.is_clean = False

    def clean(self):
        self.is_clean = True

class KidsClothing(Clothing):
    
    

```python
>>> onesie = KidsClothing("onesie", "polka dots")
>>> onesie.wear()
>>> onesie.is_clean
False
>>> onesie.clean()
>>> onesie.is_clean
False

>>> dress = KidsClothing("dress", "rainbow")
>>> dress.clean()
>>> dress.is_clean
True
>>> dress.wear()
>>> dress.is_clean
False
>>> dress.clean()
>>> dress.is_clean
False

""

# Override the clean() method
# so that kids clothing always stays dirty!
def clean(self):
    self.is_clean = self.is_clean
```
Using methods from the base class

To refer to a superclass method, we can use `super()`:  

```python
class Lion(Animal):
    species_name = "Lion"
    scientific_name = "Panthera"
    calories_needed = 3000

    def eat(self, food):
        if food.type == "meat":
            super().eat(food)
```

How would we call that method?
Using methods from the base class

To refer to a superclass method, we can use `super()`:

class Lion(Animal):
    species_name = "Lion"
    scientific_name = "Panthera"
    calories_needed = 3000

    def eat(self, food):
        if food.type == "meat":
            super().eat(food)

How would we call that method?

bones = Food("Bones", "meat")
mufasa = Lion("Mufasa", 10)
mufasa.eat(bones)
More on super()

`super().attribute` refers to the definition of `attribute` in the superclass of the first parameter to the method.

```python
def eat(self, food):
    if food.type == "meat":
        super().eat(food)
```

...is the same as:

```python
def eat(self, food):
    if food.type == "meat":
        Animal.eat(self, food)
```

`super()` is better style than `BaseClassName`, though slightly slower.
Overriding __init__

Similarly, we need to explicitly call `super().__init__()` if we want to call the `__init__` functionality of the base class.

class Elephant(Animal):
    species_name = "Elephant"
    scientific_name = "Loxodonta"
    calories_needed = 8000

    def __init__(self, name, age=0):
        super().__init__(name, age)
        if age < 1:
            self.calories_needed = 1000
        elif age < 5:
            self.calories_needed = 3000

What would this display?

elly = Elephant("Ellie", 3)
elly.calories_needed
Overriding `__init__`

Similarly, we need to explicitly call `super().__init__()` if we want to call the `__init__` functionality of the base class.

```python
class Elephant(Animal):
    species_name = "Elephant"
    scientific_name = "Loxodonta"
    calories_needed = 8000

    def __init__(self, name, age=0):
        super().__init__(name, age)
        if age < 1:
            self.calories_needed = 1000
        elif age < 5:
            self.calories_needed = 3000

elly = Elephant("Ellie", 3)
elly.calories_needed  # 3000
```

What would this display?

```
enny = Elephant("Ellie", 3)
elly.calories_needed  # 3000
```
Exercise: Catplay

class Animal:
    species_name = "Animal"
    scientific_name = "Animalia"
    play_multiplier = 2
    interact_increment = 1

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * self.play_multiplier)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += self.interact_increment
        print(f"Yay happy fun time with {animal2.name}")

class Cat(Animal):
>>> adult = Cat("Winston", 12)
>>> adult.name
'Winston'
>>> adult.age
12
>>> adult.play_multiplier
3
>>> kitty = Cat("Kurty", 0.5)
>>> kitty.name
'Kurty'
>>> kitty.age
0.5
>>> kitty.play_multiplier
6

"""
species_name = "Domestic cat"
scientific_name = "Felis silvestris catus"
calories_needed = 200
play_multiplier = 3

def __init__(self, name, age):
    # Call the super class to set name and age
    # If age is less than 1, set play multiplier to 6
Exercise: Catplay (solution)

class Animal:
    species_name = "Animal"
    scientific_name = "Animalia"
    play_multiplier = 2
    interact_increment = 1

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * self.play_multiplier)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += self.interact_increment
        print(f"Yay happy fun time with {animal2.name}")

class Cat(Animal):
```python
def __init__(self, name, age):
    super().__init__(name, age)
    if self.age < 1:
        self.playMultiplier = 6

>>> adult = Cat("Winston", 12)
>>> adult.name
'Winston'
>>> adult.age
12
>>> adult.playMultiplier
3
>>> kitty = Cat("Kurty", 0.5)
>>> kitty.name
'Kurty'
>>> kitty.age
0.5
>>> kitty.playMultiplier
6

species_name = "Domestic cat"
scientific_name = "Felis silvestris catus"
calories_needed = 200
playMultiplier = 3
```
class Animal:
    species_name = "Animal"
    scientific_name = "Animalia"
    play_multiplier = 2
    interact_increment = 1

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * self.play_multiplier)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += self.interact_increment
        print(f"Yay happy fun time with {animal2.name}")

class Cat(Animal):
>>> adult = Cat("Winston", 12)
>>> adult.name
'Winston'
>>> adult.age
12
>>> adult.play_multiplier
3

>>> kitty = Cat("Kurty", 0.5)
>>> kitty.name
'Kurty'
>>> kitty.age
0.5
>>> kitty.play_multiplier
6

""

species_name = "Domestic cat"
scientific_name = "Felis silvestris catus"
calories_needed = 200
play_multiplier = 3

def __init__(self, name, age):
    super().__init__(name, age)
    if self.age < 1:
        self.play_multiplier = 6
class Animal:
    species_name = "Animal"
    scientific_name = "Animalia"
    play_multiplier = 2
    interact_increment = 1

    def __init__(self, name, age=0):
        self.name = name
        self.age = age
        self.calories_eaten = 0
        self.happiness = 0

    def play(self, num_hours):
        self.happiness += (num_hours * self.play_multiplier)
        print("WHEEE PLAY TIME!")

    def eat(self, food):
        self.calories_eaten += food.calories
        print(f"Om nom nom yummy {food.name}")
        if self.calories_eaten > self.calories_needed:
            self.happiness -= 1
            print("Ugh so full")

    def interact_with(self, animal2):
        self.happiness += self.interact_increment
        print(f"Yay happy fun time with {animal2.name}")

class Dog(Animal):
    """
>>> spot = Dog("Spot", 5, 20)
>>> spot.name
'Spot'
>>> spot.age
5
>>> spot.weight
20
>>> spot.calories_needed
400
>>> puppy = Dog("Poppy", 1, 7)
>>> puppy.name
'Poppy'
>>> puppy.age
1
>>> puppy.weight
7
>>> puppy.calories_needed
140

""
""
species_name = "Domestic dog"
scientific_name = "Canis lupus familiaris"
calories_needed = 200

def __init__(self, name, age, weight):
    # Call the super class to set name and age
Exercise: Dog weight (solution)

class Animal:
    species_name = "Animal"
    scientific_name = "Animalia"
    play_multiplier = 2
    interact_increment = 1

def __init__(self, name, age=0):
    self.name = name
    self.age = age
    self.calories_eaten = 0
    self.happiness = 0

def play(self, num_hours):
    self.happiness += (num_hours * self.play_multiplier)
    print("WHEEE PLAY TIME!")

def eat(self, food):
    self.calories_eaten += food.calories
    print(f"Om nom nom yummy {food.name}"
    if self.calories_eaten > self.calories_needed:
        self.happiness -= 1
        print("Ugh so full")

def interact_with(self, animal2):
    self.happiness += self.interact_increment
    print(f"Yay happy fun time with {animal2.name}"

class Dog(Animal):
    pass
>>> spot = Dog("Spot", 5, 20)
>>> spot.name
'Spot'
>>> spot.age
5
>>> spot.weight
20
>>> spot.calories_needed
400

>>> puppy = Dog("Poppy", 1, 7)
>>> puppy.name
'Poppy'
>>> puppy.age
1
>>> puppy.weight
7
>>> puppy.calories_needed
140

""

species_name = "Domestic dog"
scientific_name = "Canis lupus familiaris"
calories_needed = 200

```
def __init__(self, name, age, weight):
    super().__init__(name, age)
```
Layers of inheritance
Object base class

Every Python 3 class implicitly extends the `object` class.
Adding layers of inheritance

But we can also add in more levels ourselves.
Adding layers of inheritance

First we define the new classes:

```python
class Herbivore(Animal):
    def eat(self, food):
        if food.type == "meat":
            self.happiness -= 5
        else:
            super().eat(food)

class Carnivore(Animal):
    def eat(self, food):
        if food.type == "meat":
            super().eat(food)
```

Then we change the base classes for the subclasses:

```python
class Rabbit(Herbivore):
class Panda(Herbivore):
class Elephant(Herbivore):
class Vulture(Carnivore):
class Lion(Carnivore):
```
Multiple inheritance
Multiple inheritance

A class may inherit from multiple base classes in Python.
The new base classes

First we define the new base classes:

class Predator(Animal):

    def interact_with(self, other):
        if other.type == "meat":
            self.eat(other)
            print("om nom nom, I'm a predator")
        else:
            super().interact_with(other)

class Prey(Animal):
    type = "meat"
    calories = 200
Inheriting from multiple base classes

Then we inherit from them by putting both names in the parentheses:

class Rabbit(Prey, Herbivore):
class Lion(Predator, Carnivore):

Python can find the attributes in any of the base classes:

```python
globals()['r'] = Rabbit("Peter", 4)
r.play()
r.type
r.eat(Food("carrot", "veggies"))
>>> l = Lion("Scar", 12)
l.eat(Food("zazu", "meat"))
l.encounter(r)
```
Inheriting from multiple base classes

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```python
class Rabbit(Prey, Herbivore):
class Lion(Predator, Carnivore):
```

Python can find the attributes in any of the base classes:

```python
>>> r = Rabbit("Peter", 4)  # Animal __init__
>>> r.play()  # Animal method
>>> r.type  # Prey class variable
>>> r.eat(Food("carrot", "veggies"))  # Herbivore method
>>> l = Lion("Scar", 12)  # Animal __init__
>>> l.eat(Food("zazu", "meat"))  # Carnivore method
>>> l.encounter(r)  # Predator method
```
Identity
Checking identity

`exp0 is exp1` evaluates to `True` if both `exp0` and `exp1` evaluate to the same object

```python
mufasa = Lion("Mufasa", 15)
nala = Lion("Nala", 16)

mufasa is mufasa
mufasa is Nala
mufasa is not Nala
nala is not None
```
Checking identity

exp0 is exp1 evaluates to True if both exp0 and exp1 evaluate to the same object

mufasa = Lion("Mufasa", 15)
nala = Lion("Nala", 16)

mufasa is mufasa       # True
mufasa is Nala         # False
mufasa is not Nala     # True
nala is not None       # True
Composition
Composition

An object can contain references to objects of other classes.

What examples of composition are in an animal conservatory?

- An animal has a mate.
- An animal has a mother.
- An animal has children.
- A conservatory has animals.
Referencing other instances

An instance variable can refer to another instance:

class Animal:
    def mate_with(self, other):
        if other is not self and other.species_name == self.species_name:
            self.mate = other
            other.mate = self

How would we call that method?
Referencing other instances

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class Animal:
    def mate_with(self, other):
        if other is not self and other.species_name == self.species_name:
            self.mate = other
            other.mate = self

How would we call that method?

mr_wabbit = Rabbit("Mister Wabbit", 3)
jane_doe = Rabbit("Jane Doe", 2)
mr_wabbit.mate_with(jane_doe)
Referencing a list of instances

An instance variable can also refer to a list of instances:

class Rabbit(Animal):

    def reproduce_like_rabbits(self):
        if self.mate is None:
            print("oh no! better go on ZoOkCupid")
        return
        self.babies = []
        for _ in range(0, self.num_in_litter):
            self.babies.append(Rabbit("bunny", 0))

How would we call that function?
Referencing a list of instances

An instance variable can also refer to a list of instances:

```python
class Rabbit(Animal):
    def reproduce_like_rabbits(self):
        if self.mate is None:
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            return
        self.babies = []
        for _ in range(0, self.num_in_litter):
            self.babies.append(Rabbit("bunny", 0))

mr_wabbit = Rabbit("Mister Wabbit", 3)
jane_doe = Rabbit("Jane Doe", 2)
mr_wabbit.mate_with(jane_doe)
jane_doe.reproduce_like_rabbits()
```

How would we call that function?
Relying on a common interface

If all instances implement a method with the same function signature, a program can rely on that method across instances of different subclasses.

```python
def partytime(animals):
    """Assuming ANIMALS is a list of Animals, cause each
to interact with all the others exactly once."""
    for i in range(len(animals)):
        for j in range(i + 1, len(animals)):
            animals[i].interact_with(animals[j])
```

How would we call that function?
Relying on a common interface

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def partytime(animals):
    """Assuming ANIMALS is a list of Animals, cause each
to interact with all the others exactly once.""
    for i in range(len(animals)):
        for j in range(i + 1, len(animals)):
            animals[i].interact_with(animals[j])
```

How would we call that function?

```python
jane_doe = Rabbit("Jane Doe", 2)
scar = Lion("Scar", 12)
elly = Elephant("Elly", 5)
pandy = Panda("PandeyBear", 4)
partytime([jane_doe, scar, elly, pandy])
```
Composition vs. Inheritance

Inheritance is best for representing "is-a" relationships

- Rabbit is a specific type of Animal
- So, Rabbit inherits from Animal

Composition is best for representing "has-a" relationships

- A conservatory has a collection of animals it cares for
- So, a conservatory has a list of animals as an instance variable
Quiz
What would Python print?

class Parent:
    def f(s):
        print("Parent.f")

    def g(s):
        s.f()

class Child(Parent):
    def f(me):
        print("Child.f")

a_child = Child()
a_child.g()