Inheritance

Class outline:

- Motivation
- Inheritance
- Multiple Inheritance
- Identity
- Class methods

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:

```
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}")
```

How would we use that class?

```
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}")
```

How would we use that class?

```
rabbit1 = Rabbit("Mister Wabbit", 3)
rabbit2 = Rabbit("Bugs Bunny", 2)
rabbit1.eat(broccoli)
rabbit2.interact_with(rabbit1)
```

Notice similarities?

Elephant

```
# Class variables
species_name
scientific_name
calories_needed

# Instance variables
name
age
happiness

# Methods
eat(food)
play()
interact_with(other)
```

Rabbit

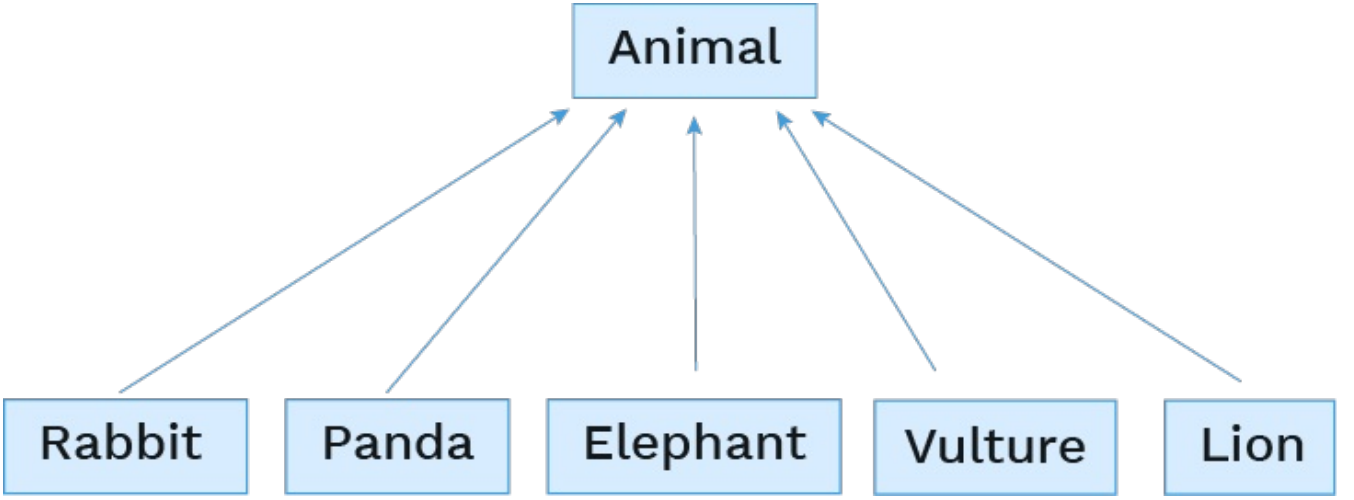
```
# Class variables
species_name
scientific_name
calories_needed

# Instance variables
name
age
happiness

# Methods
eat(food)
play()
interact_with(other)
```

`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}")
```

The subclasses

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

```
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:

```
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
```

Exercise: LearnableContent

```
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)

```
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: Clothing

```
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()
    >>> 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!
```

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):
    """
```

```
    >>> 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()`:

```
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.

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

...is the same as:

```
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.

```
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        # 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}")
```

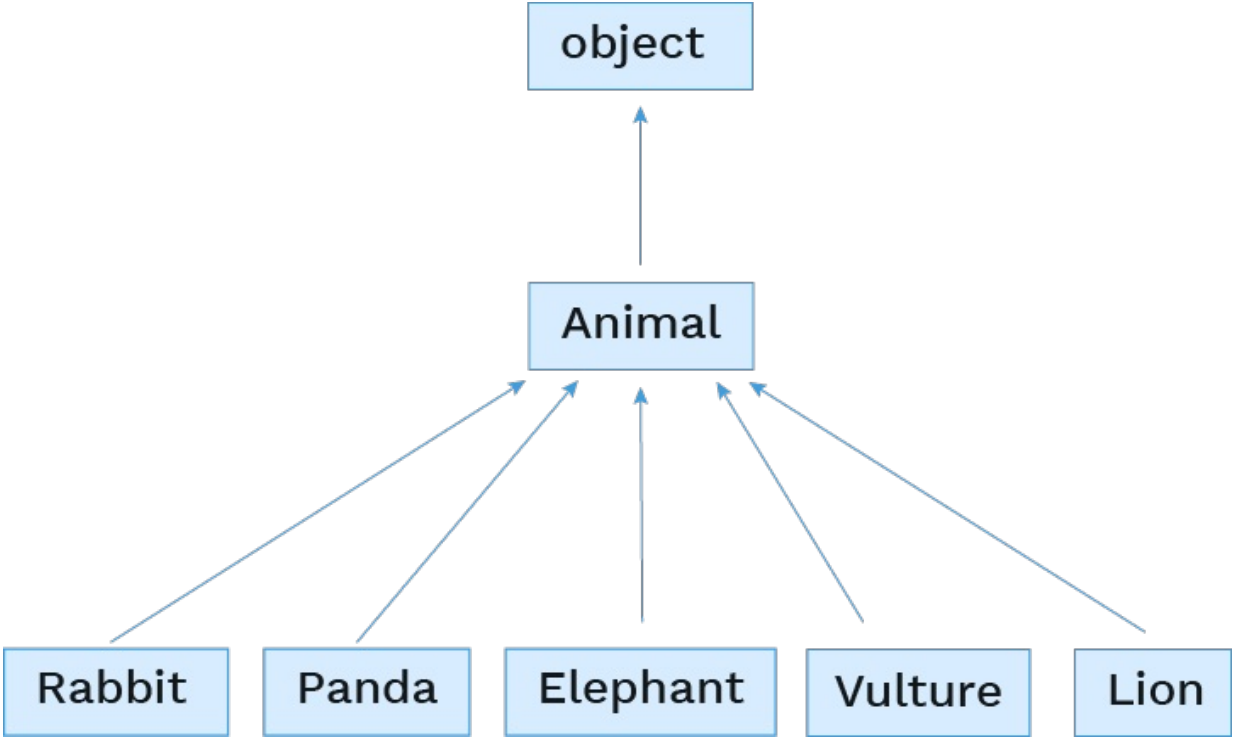
```
class Cat(Animal):
    """
```

```
    >>> 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
```

Layers of inheritance

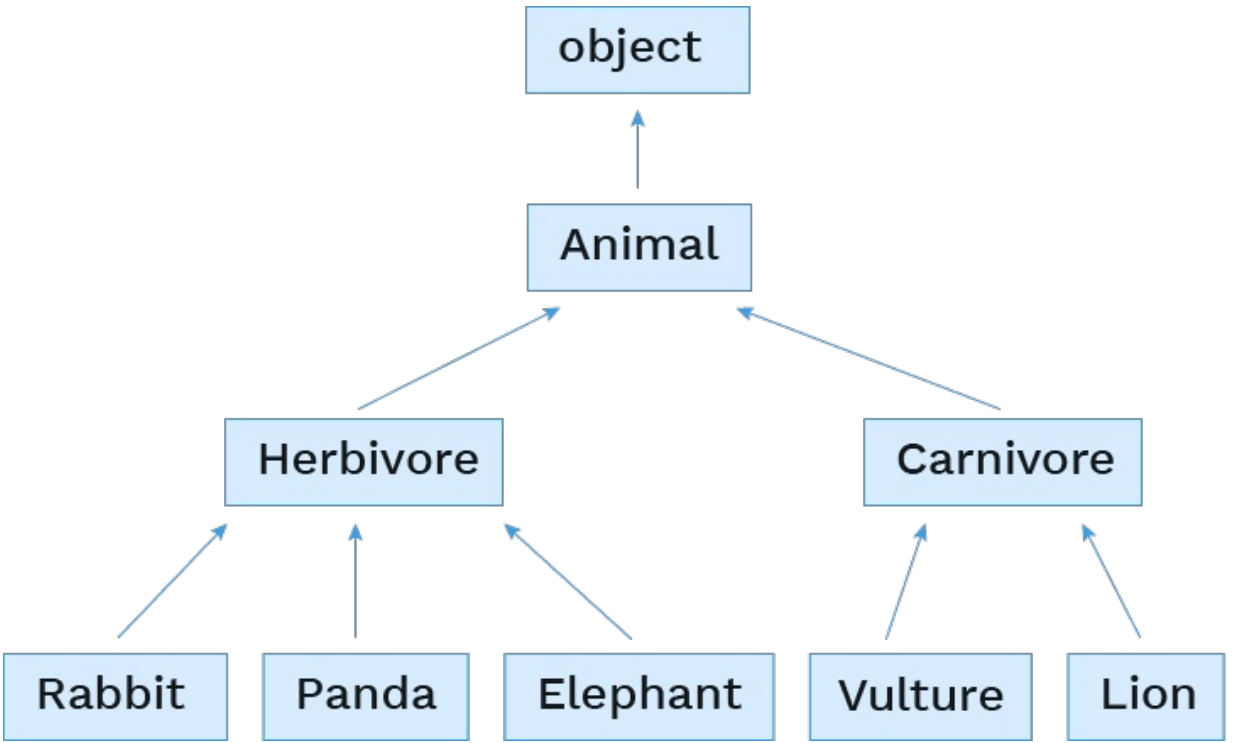
Object base class

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:

```
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)
```

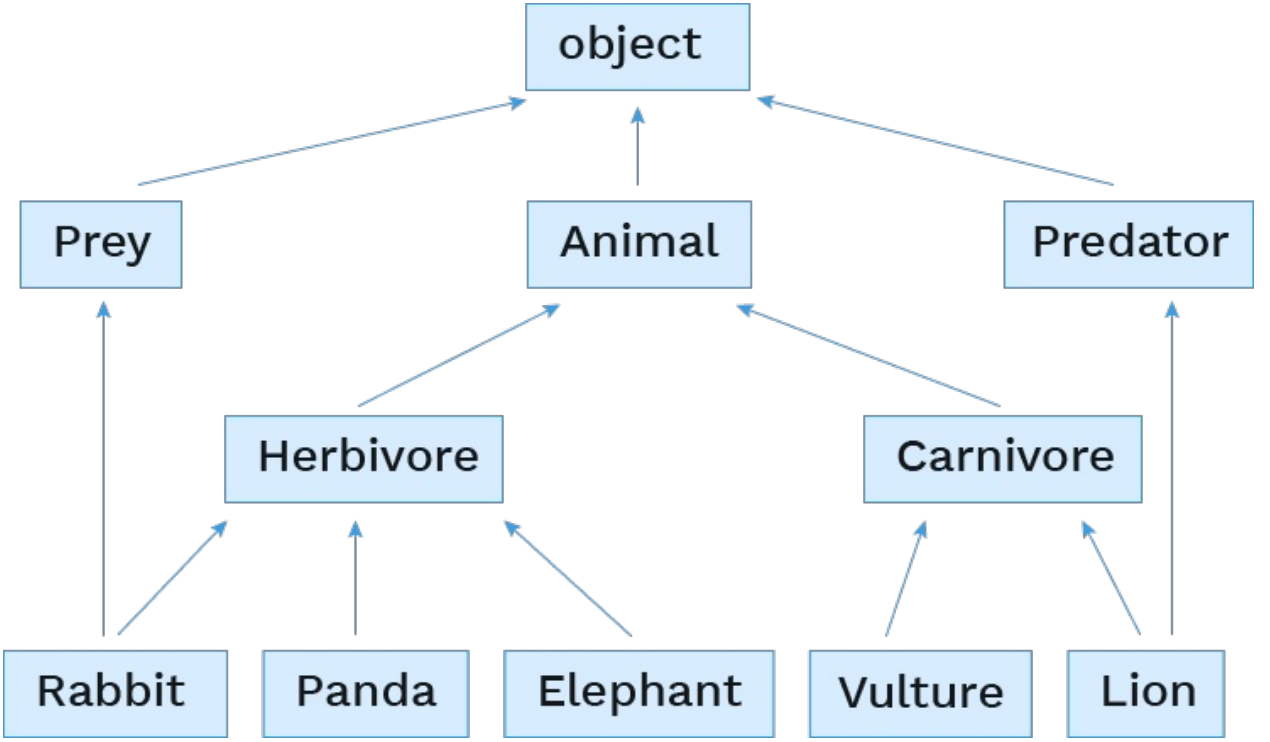
Then we change the base classes for the subclasses:

```
class Rabbit(Herbivore):
class Panda(Herbivore):
class Elephant(Herbivore):

class Vulture(Carnivore):
class Lion(Carnivore):
```

Multiple inheritance

Multiple inhteritance

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:

```
>>> 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

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:

```
>>> 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

```
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
```

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()
```

Find out in PythonTutor

Class Methods

The @classmethod decorator

By default, a function definition inside a class is a bound method that receives an instance of that class.

To instead make a function that receives the class itself, use the `@classmethod` decorator.

```
class Rabbit(Animal):
    species_name = "European rabbit"
    scientific_name = "Oryctolagus cuniculus"
    calories_needed = 200
    play_multiplier = 8

    @classmethod
    def rabbit_twins(cls, name1, name2):
        rabbit1 = cls(name1)
        rabbit2 = cls(name2)
        rabbit1.interact_with(rabbit2)
        return [rabbit1, rabbit2]
```

```
twinsies = Rabbit.rabbit_twins("Fluffy", "Hoppy")
```