19. Lists of Objects

Topics:

Example: The class **`Disk`** Boolean-Valued Methods

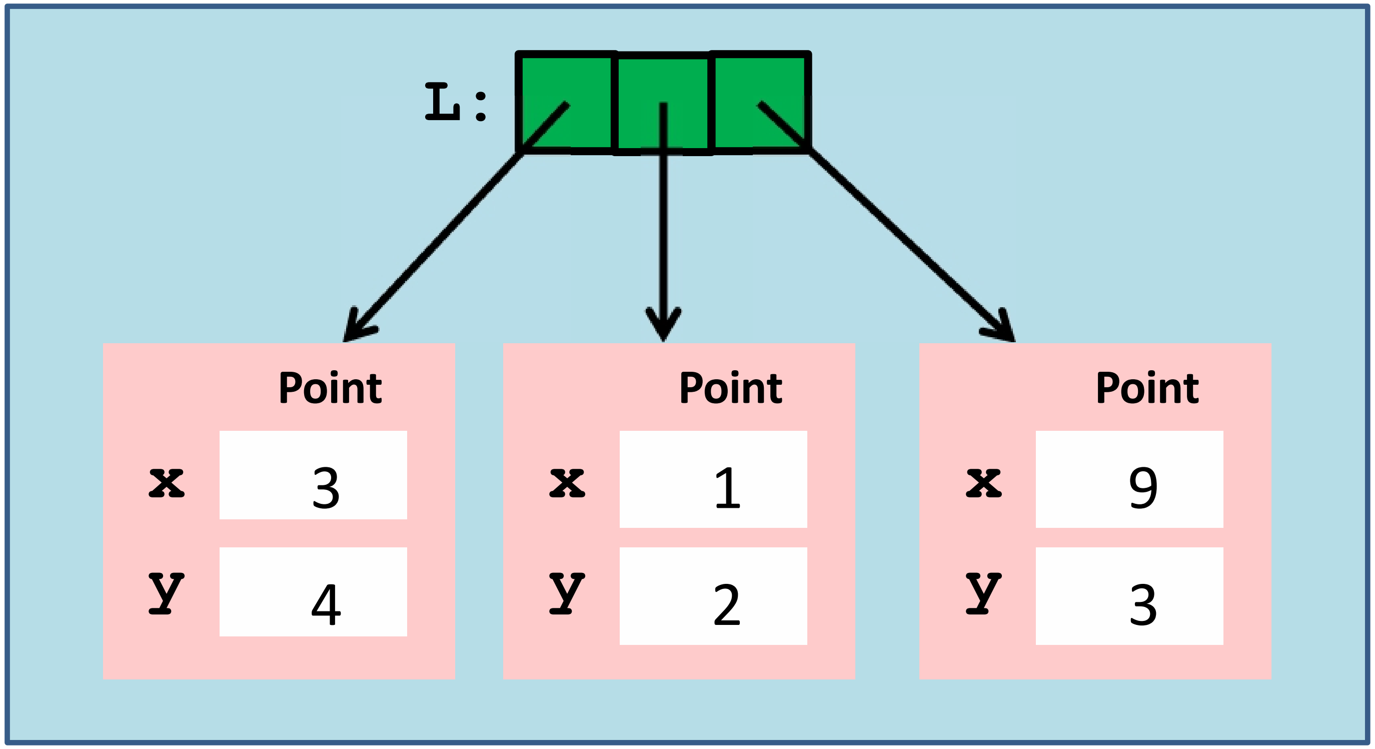
A Disk Intersection Problem

Example: The class **`CountyPop`**

Representing census-related data

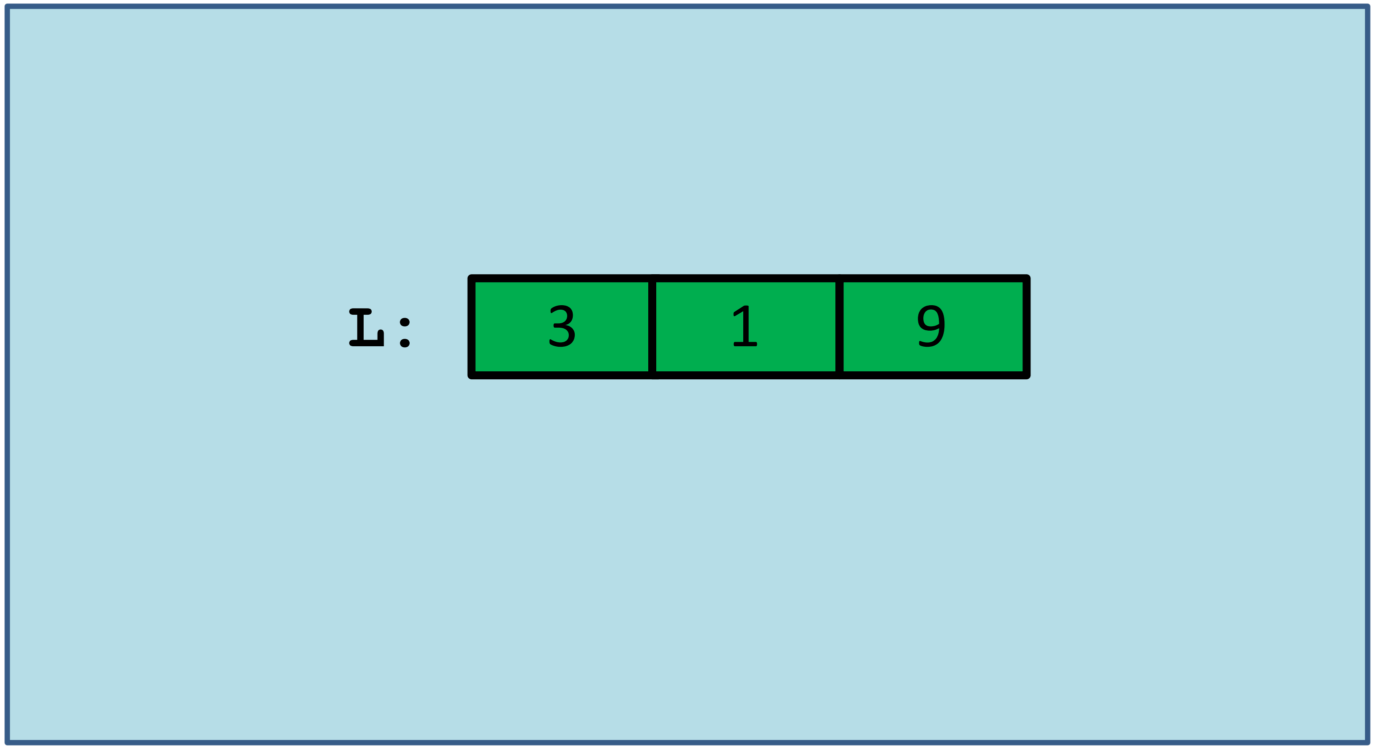
Sorting a list of **`CountyPop`** objects

Visualizing a List of Points



```
>>> P = Point(3,4);Q = Point(1,2);R = Point(9,3)
>>> L = [P,Q,R]
```

Visualizing a List of ints



```
>>> L = [3,1,9]
```

A List of Objects

We would like to assemble a list whose elements are not numbers or strings, but references to objects.

For example, we have a hundred points in the plane and a length-100 list of points called `ListOfPoints`.

Let's compute the average distance to (0,0).

Working with a List of Point Objects

```
Origin = Point(0,0)
d = 0
for P in ListOfPoints:
   d += P.Dist(Origin)
N = len(ListOfPoints)
AveDist = d/N
```

A lot of familiar stuff: Running sums. A for-loop based on "in". The len function, Etc

A List of Random Points

```
def RandomCloud(Lx,Rx,Ly,Ry,n):
    """ Returns a length-n list of points,
    each chosen randomly from the rectangle
    Lx<=x<=Rx, Ly<=y<=Ry.
    PreC: Lx and Rx are floats with Lx<Rx,
    Ly and Ry are floats with Ly<Ry, and
    n is a positive int.
    """
    A = []
    for k in range(n):
        P = RandomPoint(Lx,Rx,Ly,Ry)
        A.append(P)
    return A
```

The append method for lists works for lists of objects.

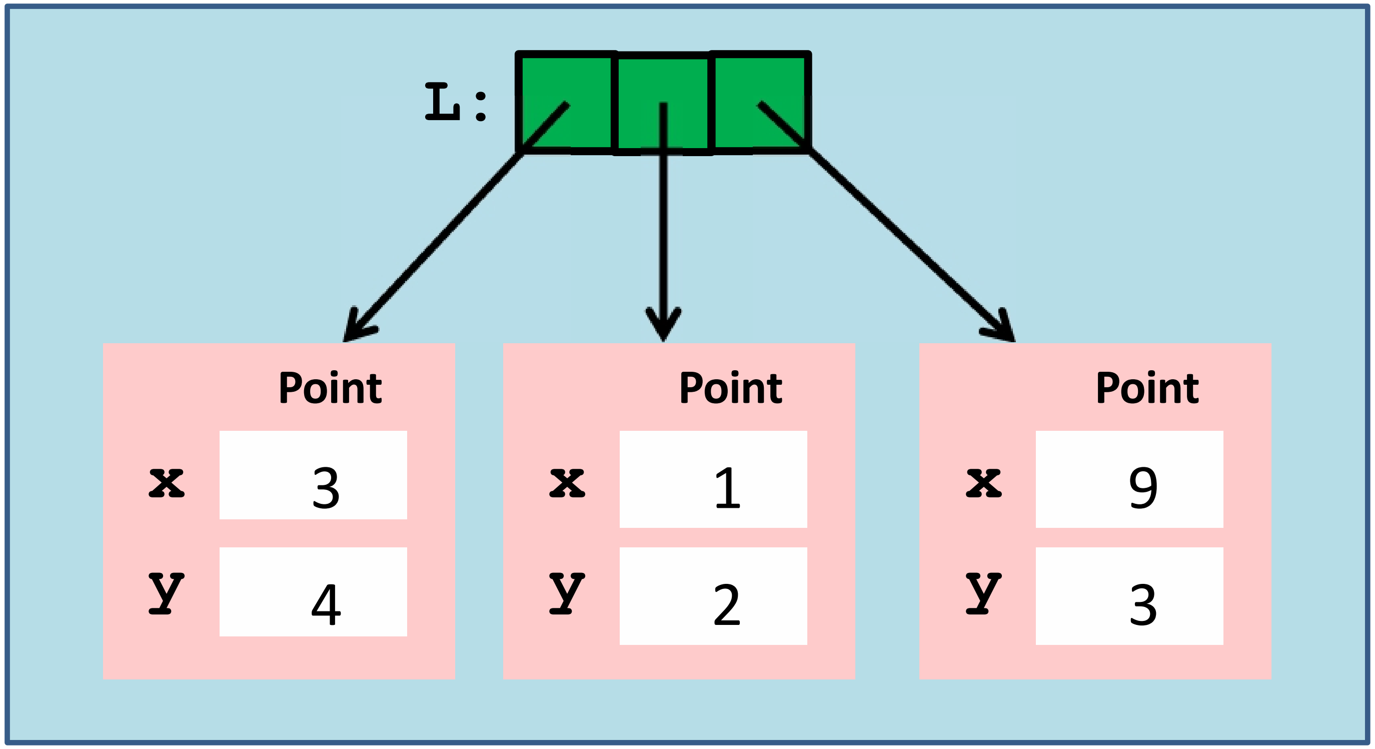
Recall: Random Point

```
def RandomPoint(Lx,Rx,Ly,Ry):
    """ Returns a point that is randomly chosen
    from the square Lx<=x<=Rx, Ly<=y<=Ry.

    PreC: Lx and Rx are floats with Lx<Rx
    Ly and Ry are floats with Ly<Ry
    """
    x = randu(Lx,Rx)
    y = randu(Ly,Ry)
    P = Point(x,y)
    return P
```

Use import to get access to classes defined in other modules

Visualizing a List of Points



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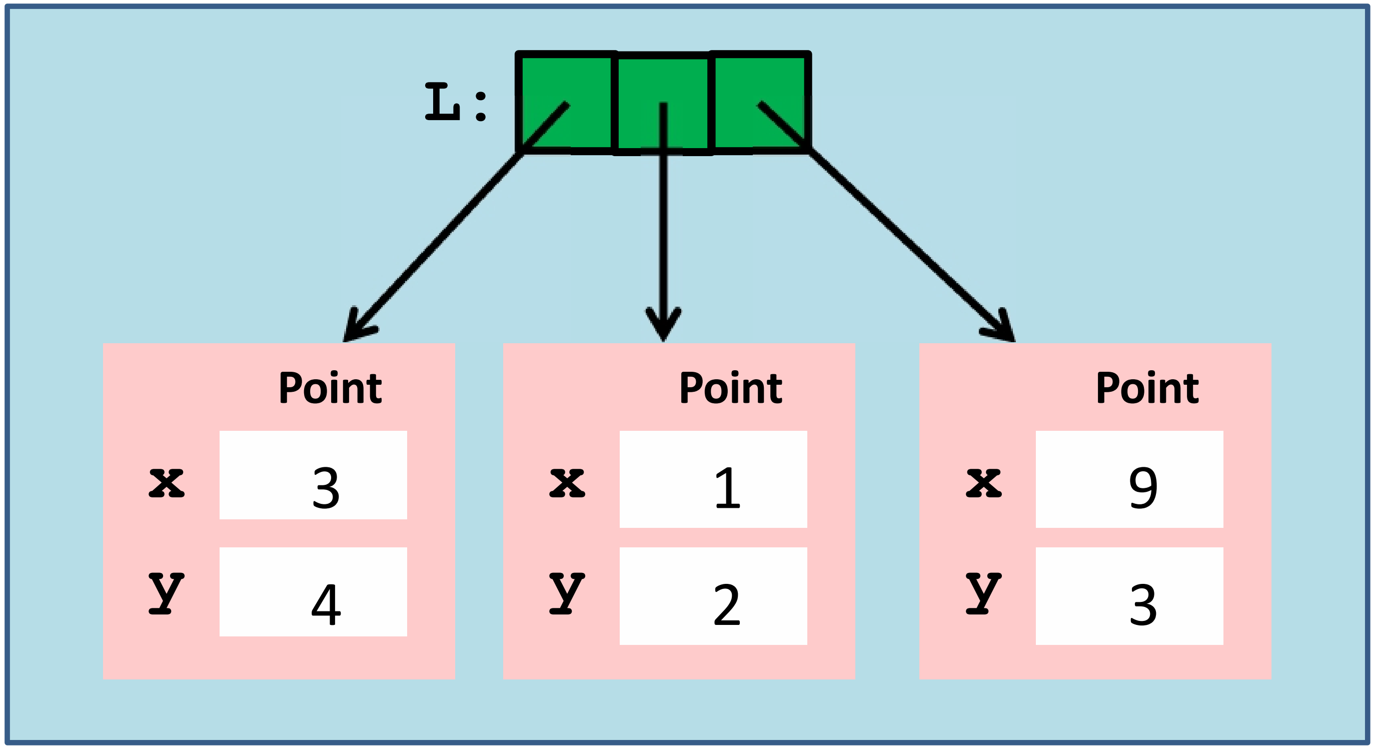
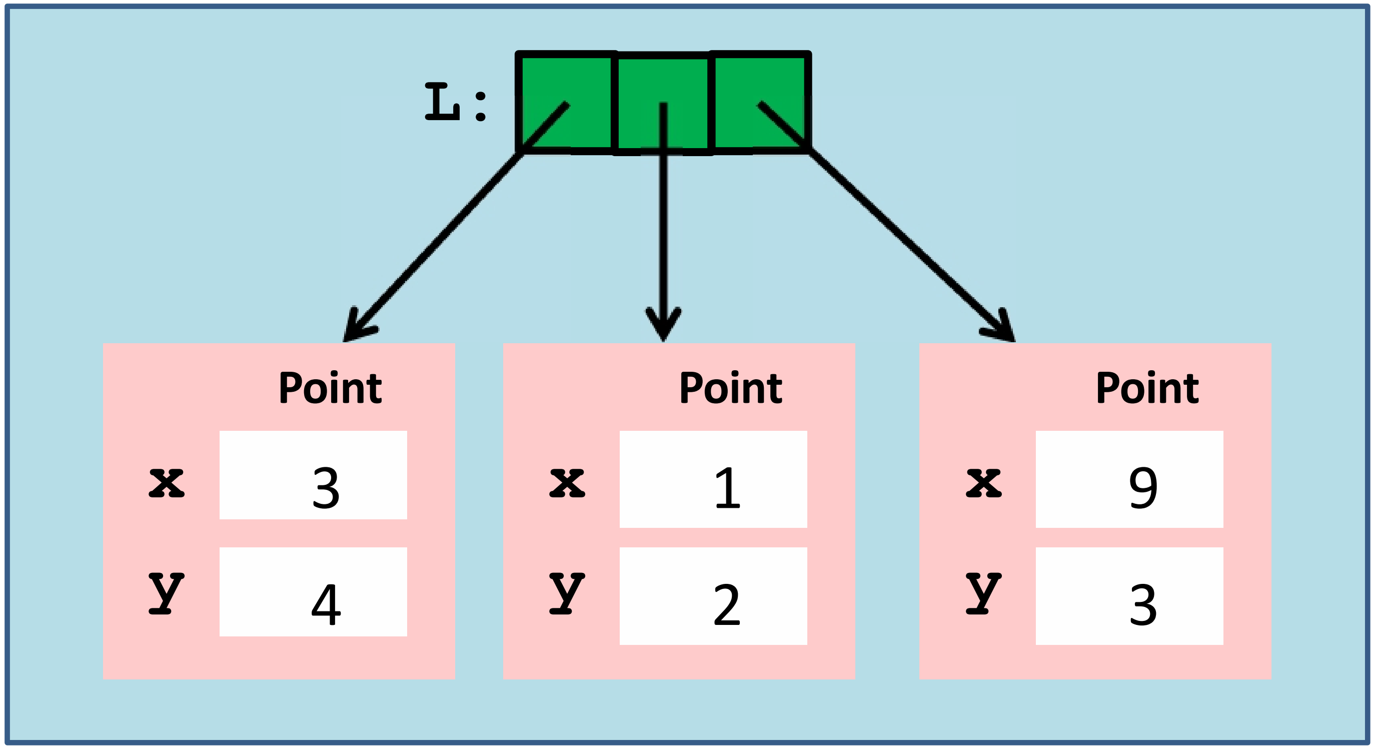
Visualizing a List of Points



```
>>> P = Point(3,4);Q = Point(1,2);R = Point(9,3)
>>> L = [P,Q,R]
```

More accurate: A List of references to Point objects

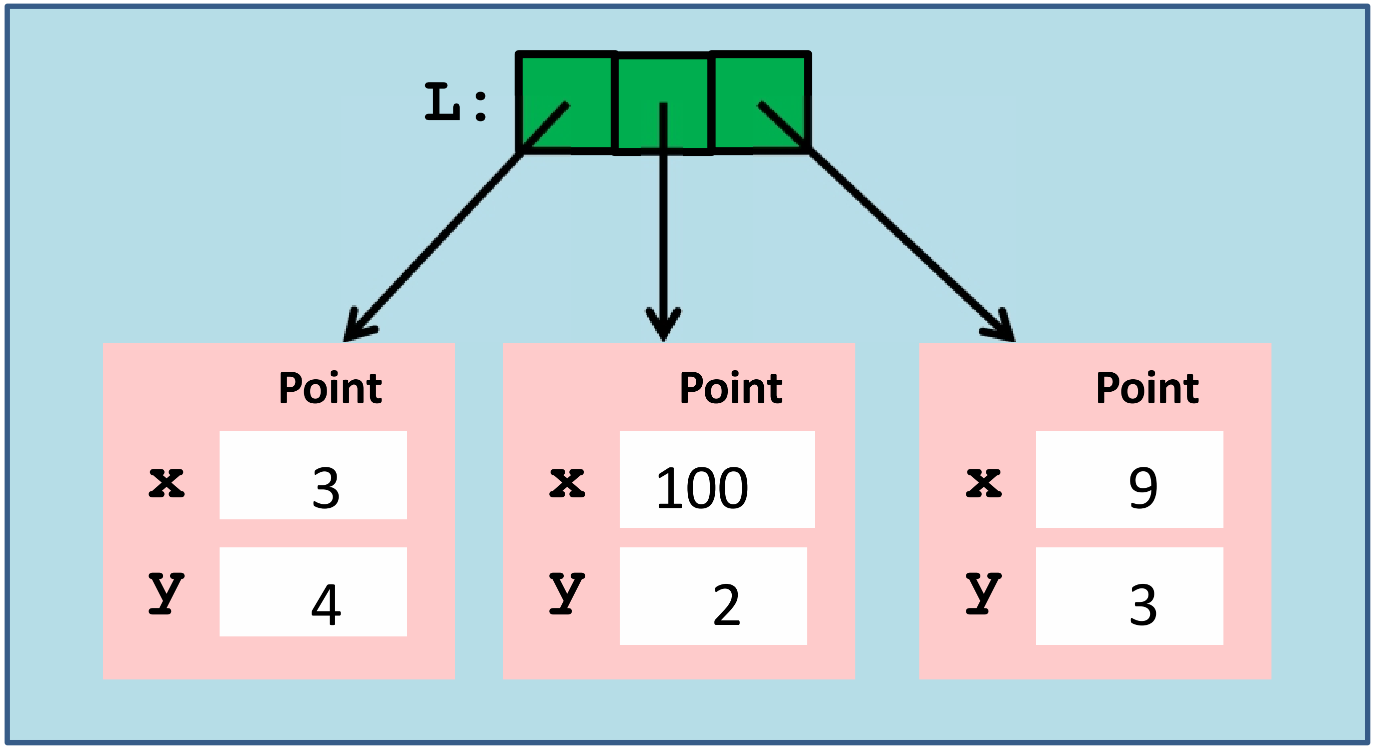
Operations on a List of Points



```
>>> L[1].x = 100
```

Before

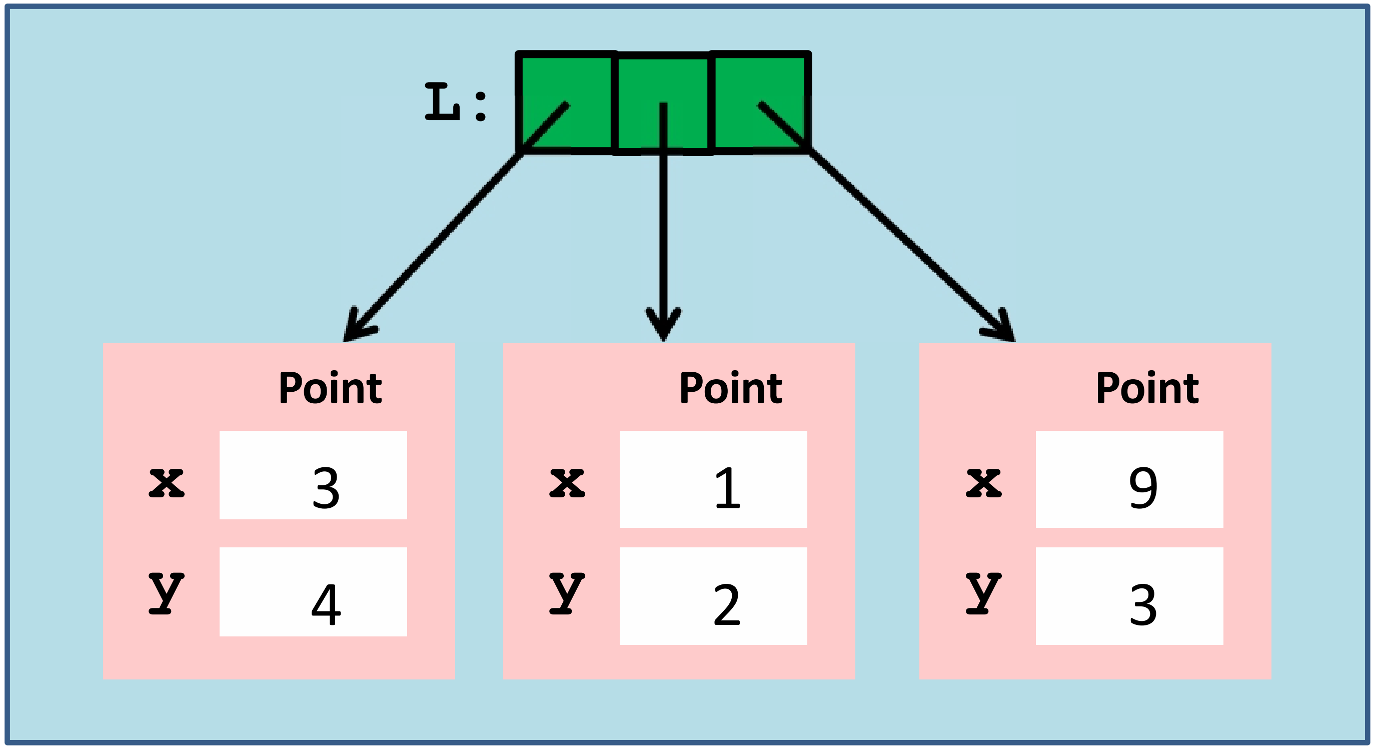
Operations on a List of Points



```
>>> L[1].x = 100
```

After

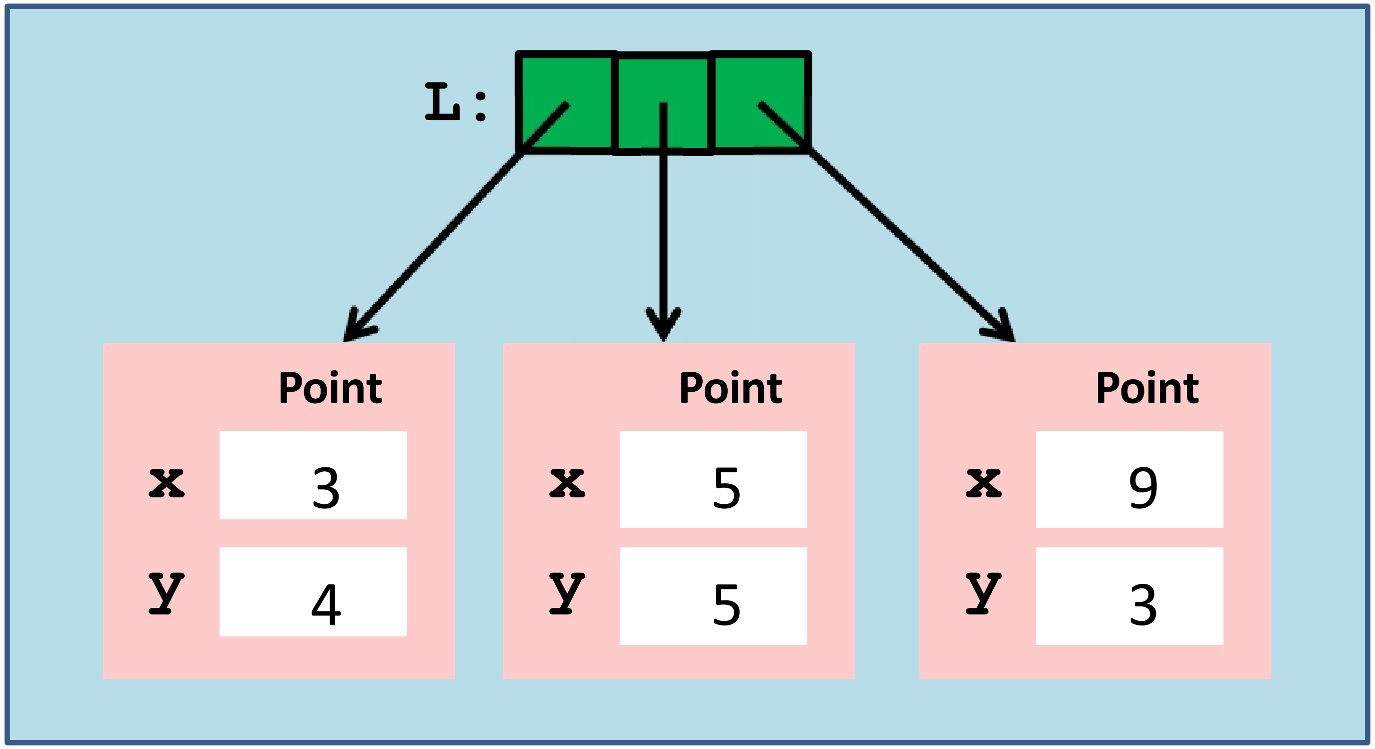
Operations on a List of Points



```
>>> L[1] = Point(5,5)
```

Before

Operations on a List of Points



```
>>> L[1] = Point(5,5)
```

After

Printing a List of Points

```
def printCloud(A):
    """ Prints the points in A

    PreC : A is a list of points.
    """
    for a in A:
        print(a)
```

Synonym for the loop:

```
for k in range(len(A)):
    print A[k]
```

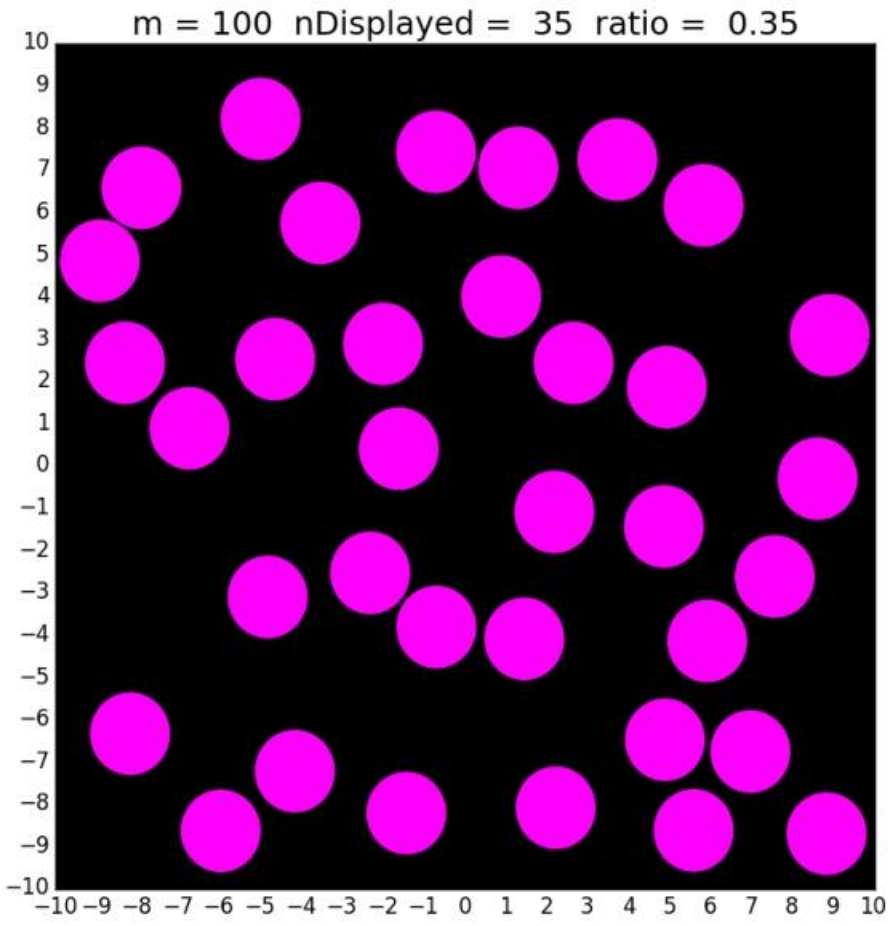
We Now Showcase the Use of Lists of Objects

Example 1. A Disk Intersection Problem

Example 2. A Census Data Problem

A Disk Intersection Problem

An Intersection Problem



We have a 10-by-10 target

```
for k in range(100):

    Generate a random disk  D

    Display D if it does not
    touch any of the
    previously displayed disks
```

Assume all the disks have radius 1 and all inside the target.

A Class for Representing Disks

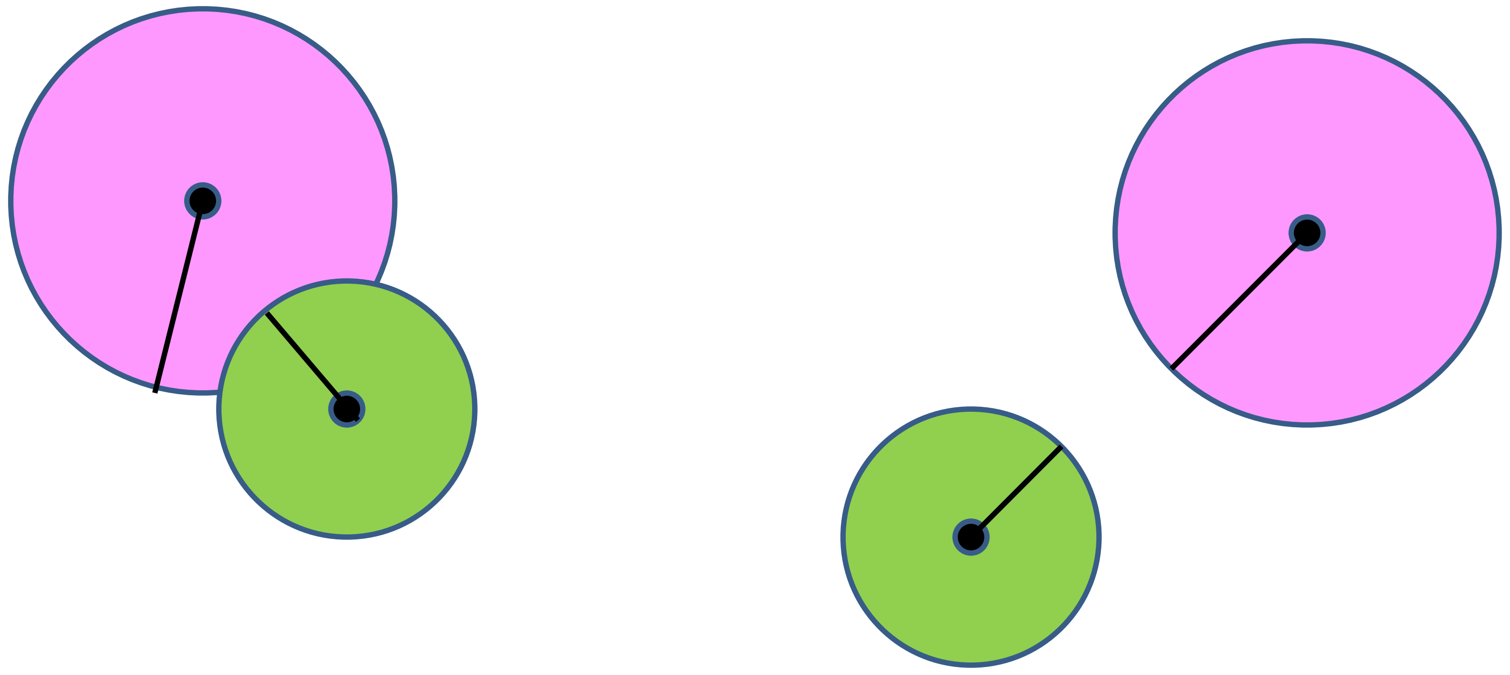
```
class Disk(object):
    """
    Attributes:
        center: Point, the center of the disk
        radius: float, the radius of the disk
    """
    def __init__(self,P,r):
        """ Creates a Disk object with
        center P and radius r
        PreC: P is a Point,r is a pos float
        """
        self.center = P
        self.radius = r
```

Note that an attribute can be an object. The `center`attribute is a `Point`

The RandomDisk Function

```
def RandomDisk(n):
    """ Returns a random radius-1 disk whose
     center is inside the 2n-by-2n square
     centered at (0,0).
    Pre: n is a positive int
    """
    x = randu(-n,n)
    y = randu(-n,n)
    center = Point(x,y)
    radius = 1
    return Disk(center,radius)
```

When Does a Pair of Disks Intersect?

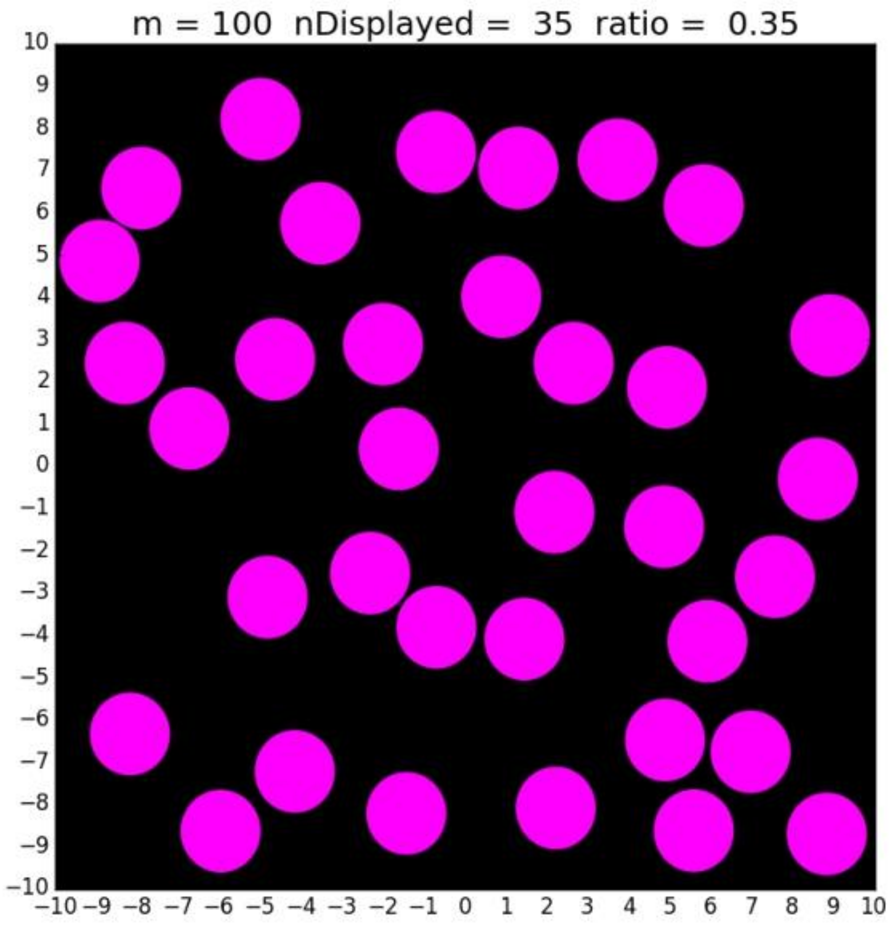


Answer: When the distance between their centers is less than the sum of their radii.

The Method Intersects

```
def Intersects(self,other):
        """ Returns True if self and other
        intersect and False otherwise.
        PreC: self and other are Disk objects
        """
        # The center-to-center distance:
        c1 = self.center
        c2 = other.center
        d = c1.Dist(c2)
        # The sum of the two radii
        radiusSum = self.radius + other.radius
        TheyIntersect = (radiusSum >= d )
        return TheyIntersect
```

An Intersection Problem



We have a 10-by-10 target

```
for k in range(100):

    Generate a random disk  D

    Display D if it does not
    touch any of the
    previously displayed disks
```

Assume all the disks have radius 1 and all inside the target.

A Critical Function

```
def outsideAll(D0,L):
    """ Returns True if D0 doesn't
    intersect any of the disks in L

    PreC: D0 is a Disk and L is a
    list of Disks
    """
    for D in L:
        if D.Intersects(D0):
            return False
    return True
```

Using outsideAll

```
# The list of displayed disks…
m = 10
DiskList = []
for k in range(100):
    D = RandomDisk(m-1)
    if outsideAll(D,DiskList):
        # D does not intersect any
        # of the displayed disks
        ShowDisk(D)
        DiskList.append(D)
nDisplayed = len(DiskList)
```

Starts out as the empty list

Display D and append it to the list of displayed disks

Demonstration!

- Download and run the python file ShowDiskClass.py
- TODO:
  - Run the python program several times and note down the number of disks displayed (nDisplayed)
  - Are the number of displayed disks the same or different across runs?
    - Why or why not?

A Census Data Sorting Problem

What Can We Sort?

We can sort a list of numbers from small to big (or big to small).

We can sort a list of strings from "A-to-Z" (or "Z-to-A").

We can sort a list of objects based on an attribute if that attribute is either a number or a string.

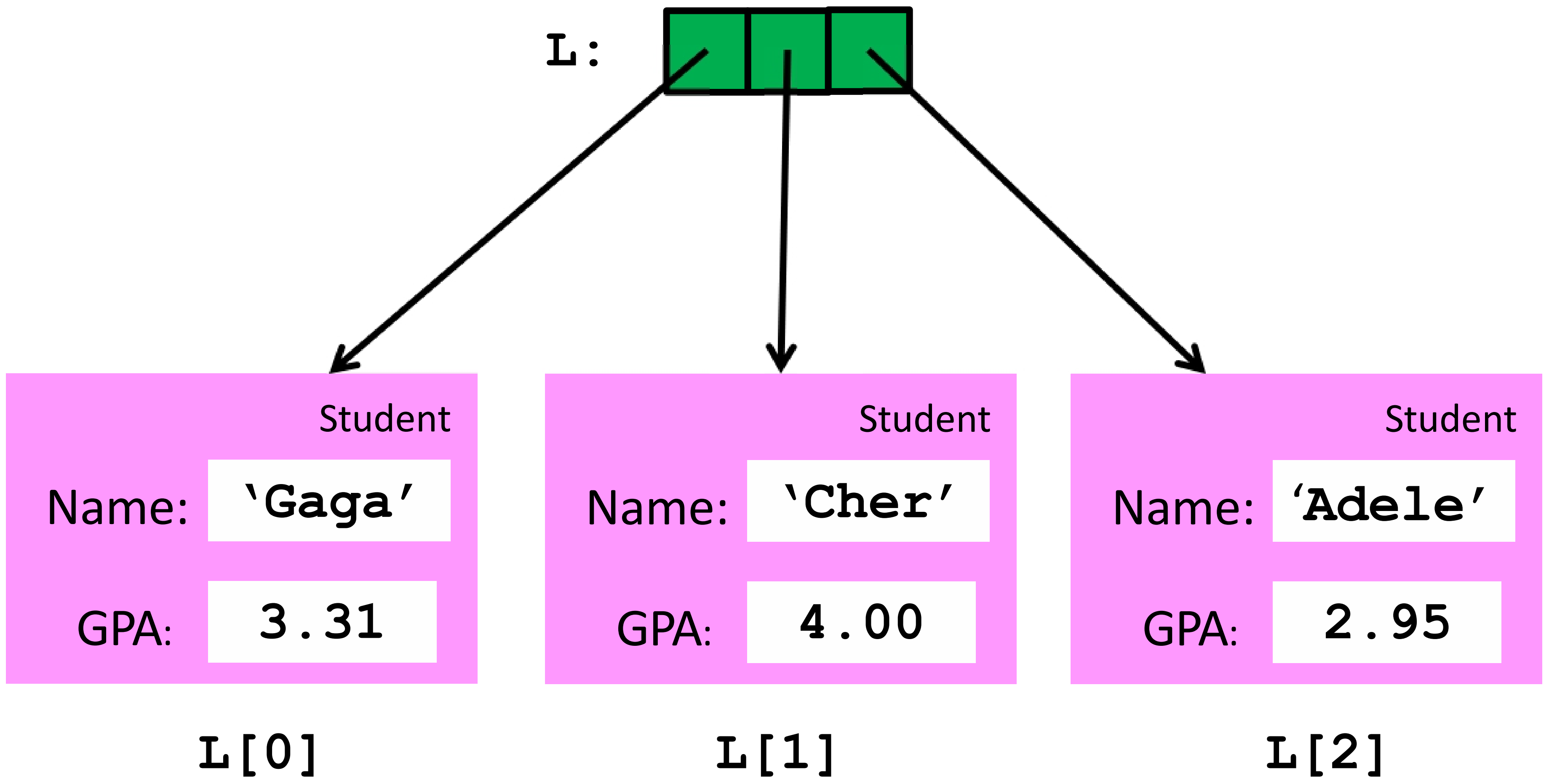
A Sorting Problem

Suppose we have

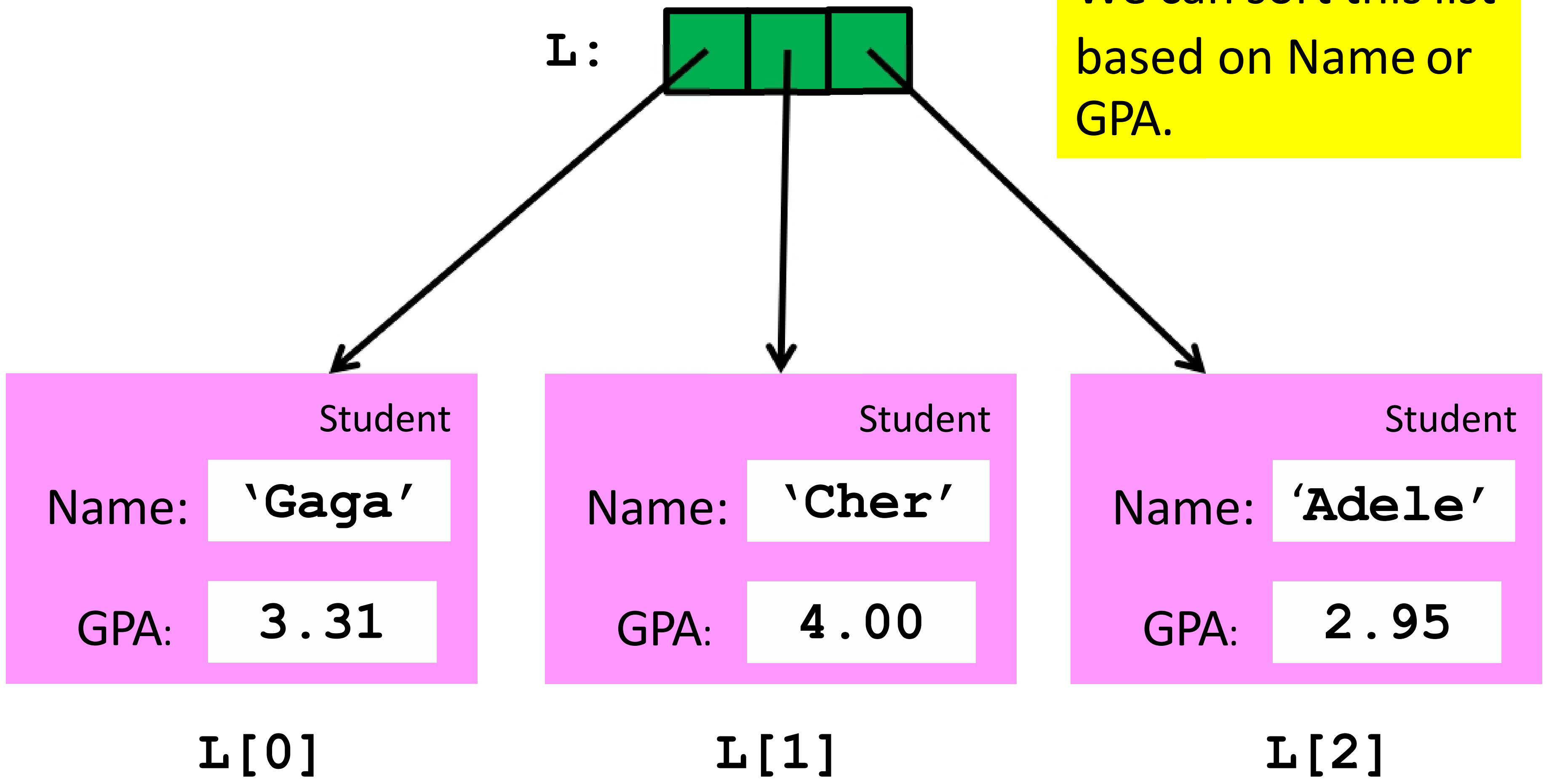
```
class Student(object):
    Attributes:
        Name: string, student's name
        GPA : float, student's gpa
```

and that **`L`** is a list of **`Student`** objects…

A List of Student Objects



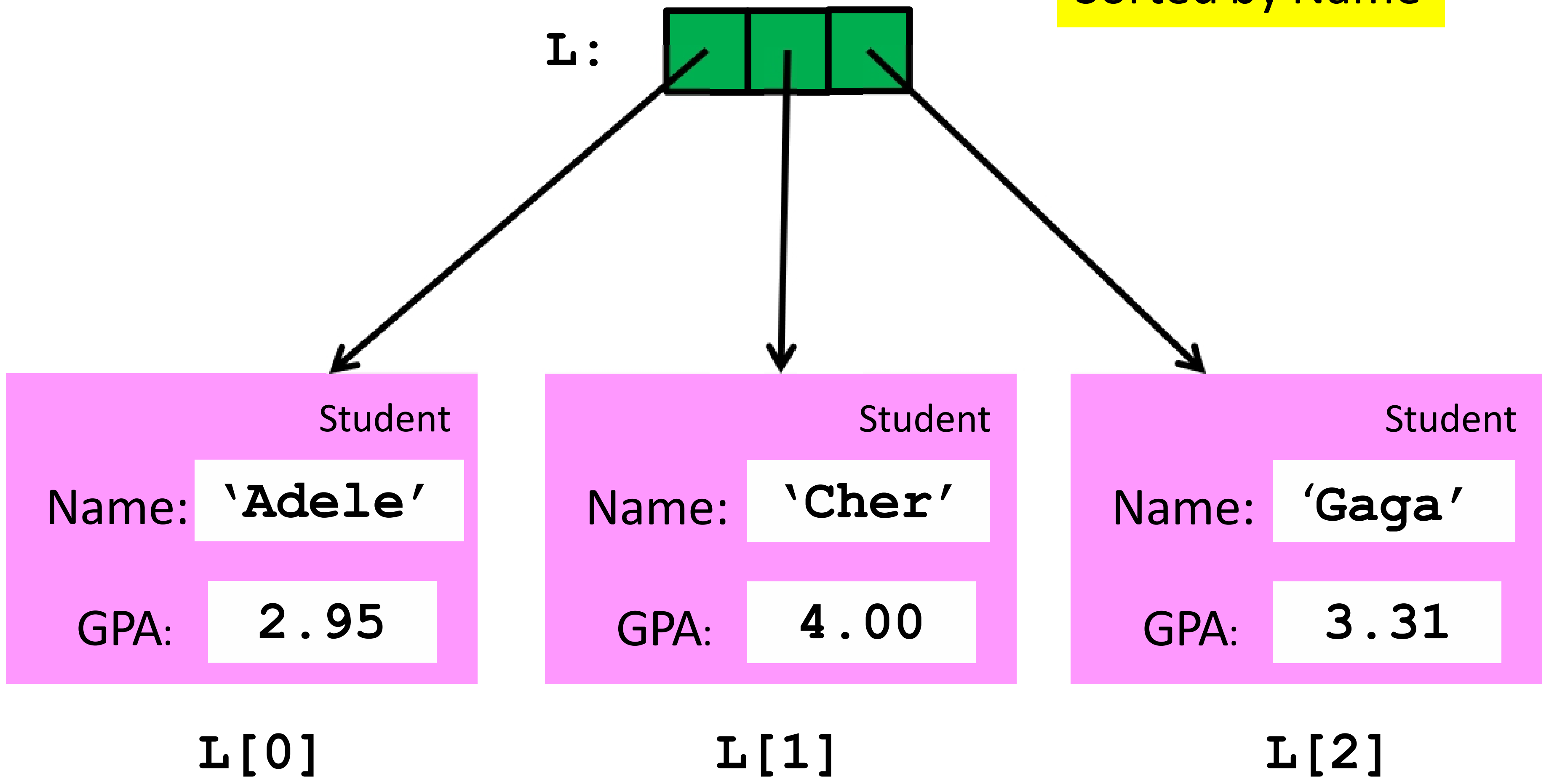
A List of Student Objects



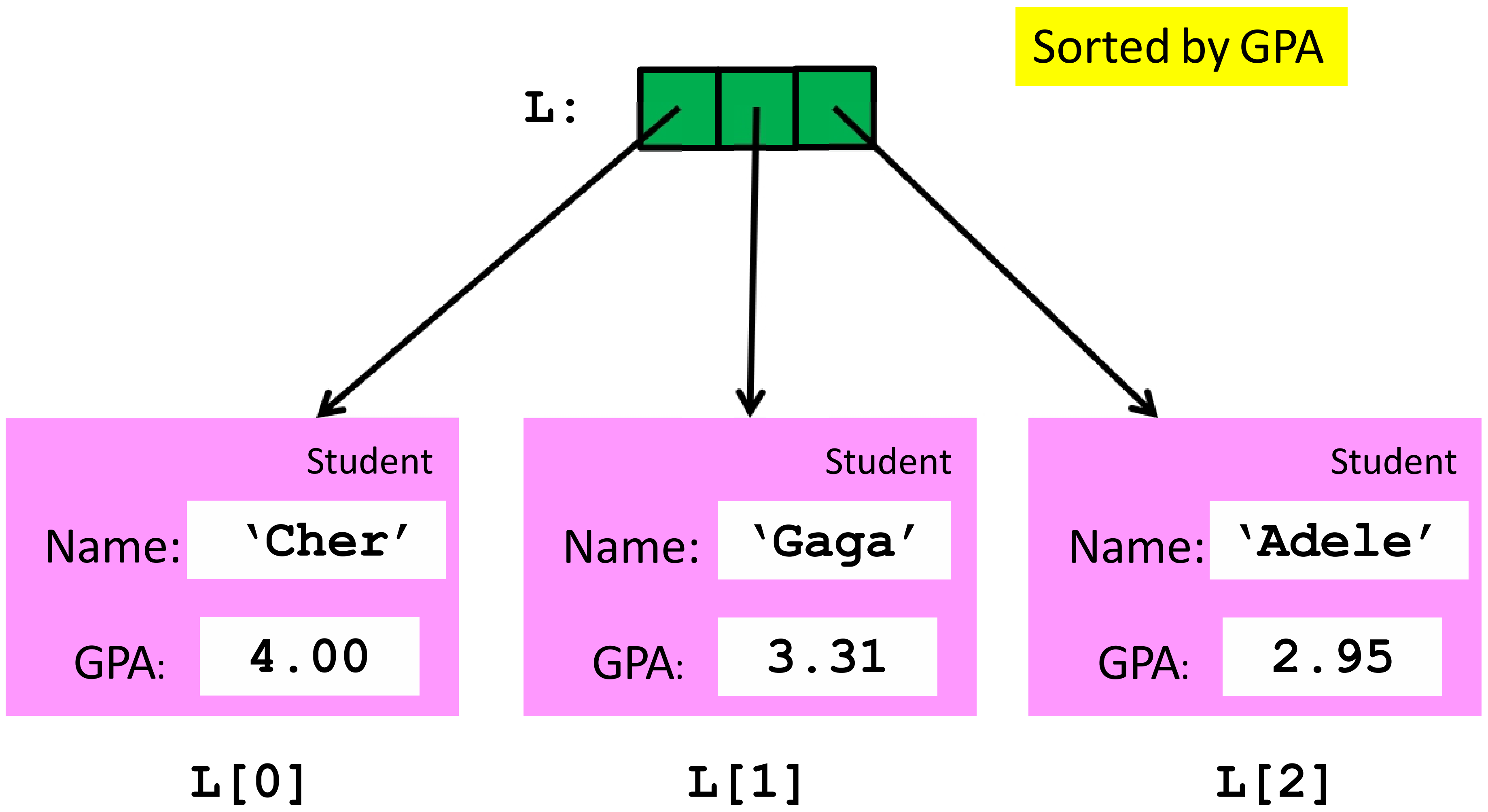
We can sort this list based on Name or GPA.

A List of Student Objects

Sorted by Name



A List of Student Objects



How to Do We Do This?

You have to write a "getter" function that extracts the value of the "key" attribute.

The name of this getter function is then passed as an argument to the sort method.

We illustrate the technique on a problem that involves census data.

The Class County

```
class CountyPop(object):
    """
    Attributes:
      Name: the name of the county (string)
      State: the name of the state (string)
      Pop2010: the 2010 population (int)
      Pop2011: the 2011 population (int)
      Pop2012: the 2012 population (int)
      Pop2013: the 2013 population (int)
      Pop2014: the 2014 population (int)
    """
```

Setting Up the List of `CountyPop` Objects

The file `CensusData.csv` has these columns:

5	State Name
6	County Name
7	2010 county population
10	2011 county population
11	2012 county population
12	2013 county population
13	2014 county population

Setting Up the List of CountyPop Objects

```
TheCounties = fileToStringList('CensusData.csv')
L = []
for c in TheCounties:
   v = c.split(',')
   c = CountyPop(v[6],v[5],int(v[7]),int(v[10]),
                 int(v[11]),int(v[12]),int(v[13]))
   L.append(C)
```

The constructor sets up the `Name`, `State`, `Pop2010`, `Pop2011`, `Pop2012`, `Pop2013`, and `Pop2014` attributes

Let's Sort!

```
def getPop2014(C):
    # C is a County Object
    return C.Pop2014
                  :
if __name__ == '__main__':
                  :
  L.sort(key=getPop2014,reverse=True)

  for k in range(10):
     print(L[k],L[k].Pop2014)
```

This getter function grabs the 2014 population.

And here is how we tell **sort** to use it

Printing the top ten counties in the USA in terms of population.

Top Ten in 2014

```
Los Angeles County, California 10116705
         Cook County, Illinois 5246456
          Harris County, Texas  4441370
      Maricopa County, Arizona  4087191
  San Diego County, California  3263431
     Orange County, California  3145515
     Miami-Dade County, Florida  2662874
        Kings County, New York  2621793
          Dallas County, Texas  2518638
  Riverside County, California  2329271
```

Demonstration!

- Download and run the python file ShowCountyPopClass.py
- TODO:
  - The program currently prints the population of the 50 most populous counties in descending order. Modify the script to print the population of the 50 least populated counties in ascending order.