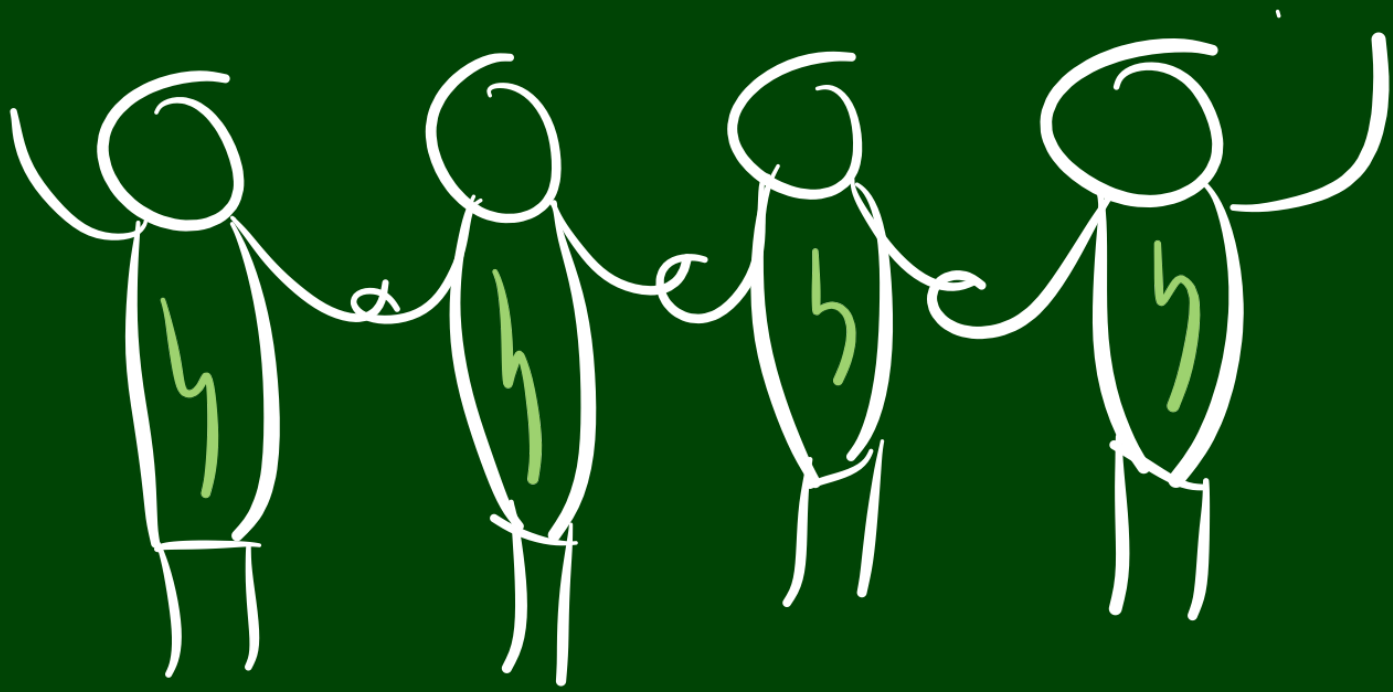
CSE 143

Computer Programming II

List Nodes



Today's Goals

- Get familiar with the idea of "references" (things that point to objects)
- Define and explore **ListNode**
- Learn about `null`
- Practice modifying linked lists
- Get familiar with matching up code and pictures of linked lists

Consider the following two documents in a text editor:

- A normal book
- A "choose your own adventure" book

Which tasks are easy/hard in each type of book?

- Find the last page
- Add a new page in the middle of the book
- Add a new page at the end of the book

Books as Data Structures

- Arrays are stored in memory like a normal book; it's **contiguous**, and **random-access**
- For the next three lectures, we'll discuss the data structure equivalent to a "choose your own adventure" book

Mystery

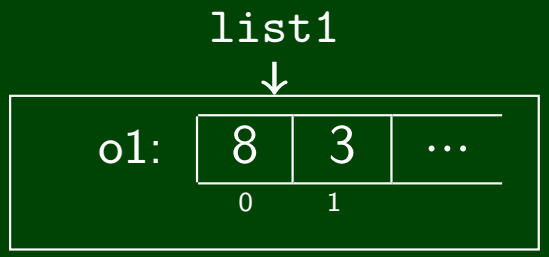
```
 1  List<Integer> list1 = new ArrayList<Integer>();
 2  list1.add(8);
 3  list1.add(3);
 4  List<Integer> list2 = new ArrayList<Integer>();
 5  list2.add(100);
 6  List<Integer> list3 = list2;
 7  list2 = list1;
 8  list2.add(5);
 9  list1.add(2);
10  System.out.println("A: " + list1);
11  System.out.println("B: " + list2);
12  System.out.println("C: " + list3);
```

What does this code print?

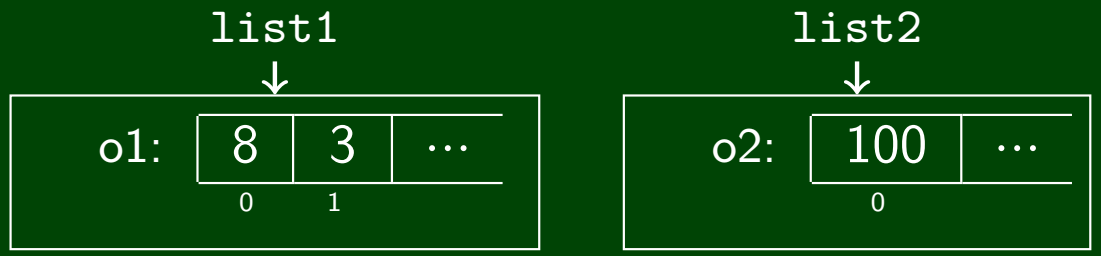
OUTPUT

```
>> A: [8, 3, 5, 2]
>> B: [8, 3, 5, 2]
>> C: [100]
```

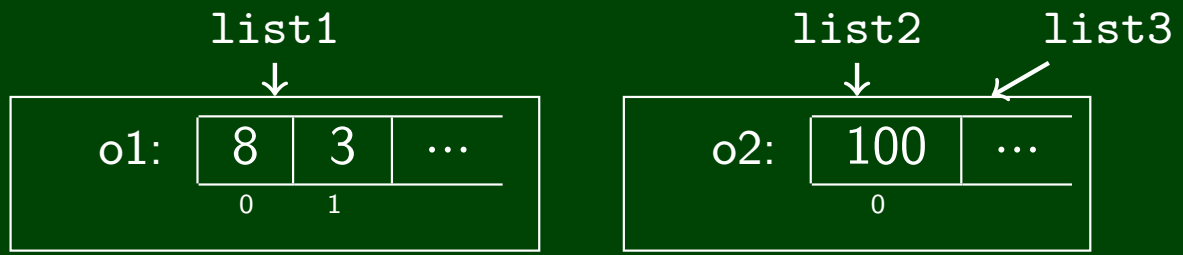
```
1 List<Integer> list1 = new ArrayList<Integer>(); //o1
2 list1.add(8);
3 list1.add(3);
```



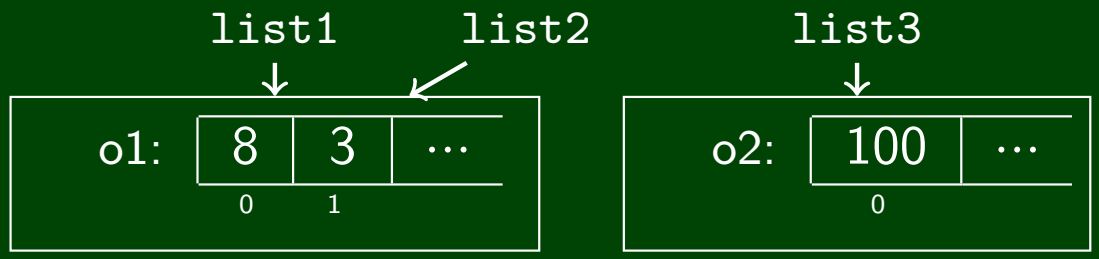

```
4 List<Integer> list2 = new ArrayList<Integer>(); //o2
5 list2.add(100);
```



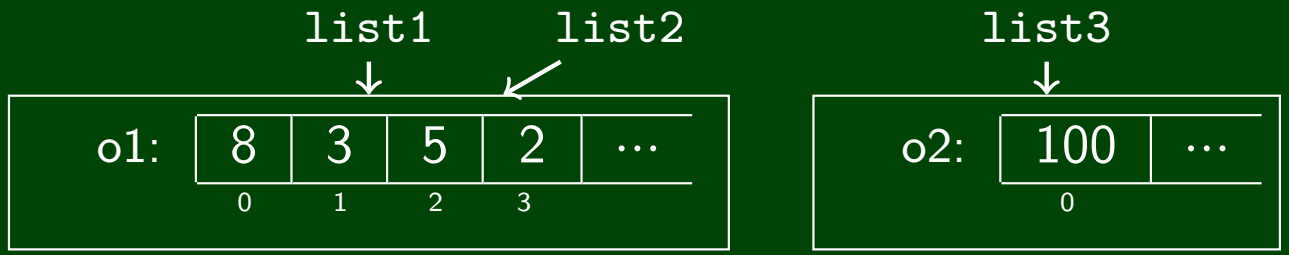

```
6 List<Integer> list3 = list2;
```



```
7  list2 = list1;
```




```
8  list2.add(5);
9  list1.add(2);
```



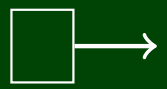
What's Going On?

- The keyword **new** creates an actual new object to point to (o1, o2).
- All the other variables just point to objects that were created with new (`list1`,`list2`,`list3`).

ListNode Class

```
1 public class ListNode {
2    int data;
3    ListNode next;
4 }
```

A `ListNode` is:



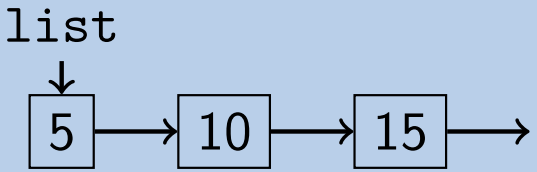
The **box** represents `data`, and the **arrow** represents `next`.

Since `next` is of `ListNode` type, the arrow can either point to nothing (`null`) or another `ListNode`.

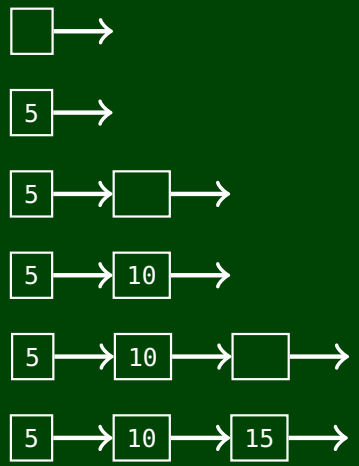
ListNode Class

```
1 public class ListNode {
2    int data;
3    ListNode next;
4 }
```

How can we use code to make this list?




```
1 ListNode list = new ListNode();
2 list.data = 5;
3 list.next = new ListNode();
4 list.next.data = 10;
5 list.next.next = new ListNode();
6 list.next.next.data = 15;
```



ListNode Class

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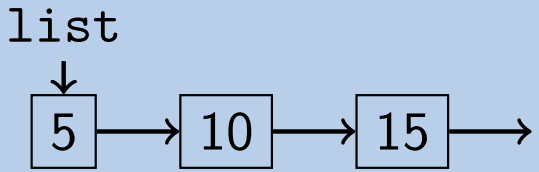
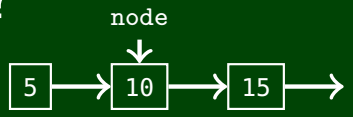
How can we use code to make this list?

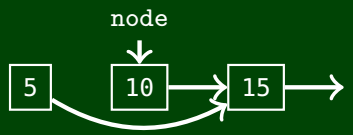


What does this code do to our list?

```
1 ListNode node = list.next;
```



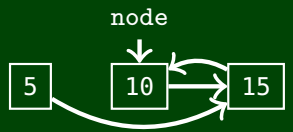

```
2 list.next = list.next.next;
```



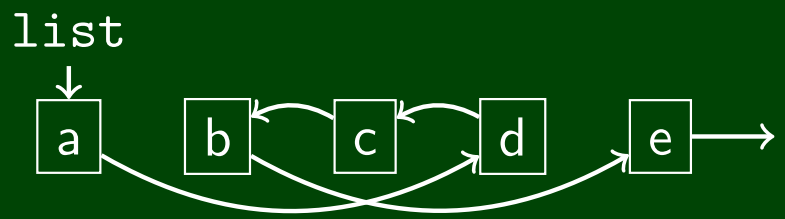
This isn't quite

What's wrong?

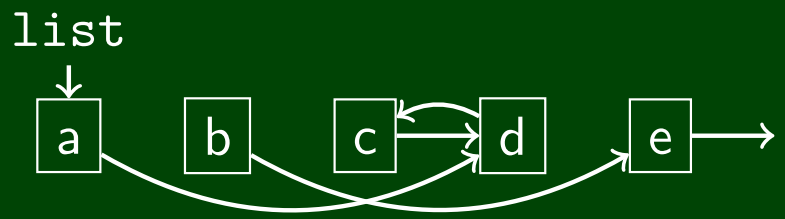
```
3 list.next.next = node;
```



```
list.next.next.next = list.next;
```



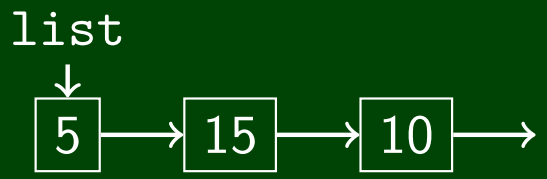
The code sets **the arrow** coming out of c to **the node** d.



The **left side** of the assignment is **an arrow**.

The **right side** of the assignment is **a node**.

When we call `.next`, we follow an **arrow** in the list. What happens if we have this list:



And we call the following code:

```
1 System.out.println(list.next.next.next);
```

Or this code:

```
1 System.out.println(list.next.next.next.data);
```

The first one prints `null`. The second throws a `NullPointerException`.

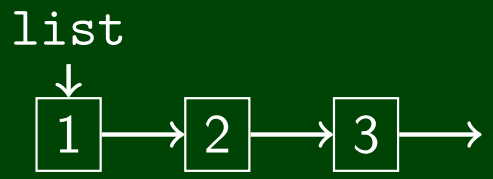
`null` means "end of the list"!

Constructors!

```
 1  public class ListNode {
 2     int data;
 3     ListNode next;
 4
 5     public ListNode(int data) {
 6        this(data, null);
 7     }
 8
 9     public ListNode(int data, ListNode next) {
10        this.data = data;
11        this.next = next;
12     }
13  }
```

What list does this code make?

```
ListNode list = new ListNode(1, null);
list.next = new ListNode(2, null);
list.next.next = new ListNode(3, null);
```



Can we do this without ever using `.next`?

```
ListNode list = new ListNode(1, new ListNode(2, new ListNode(3, null)));
```