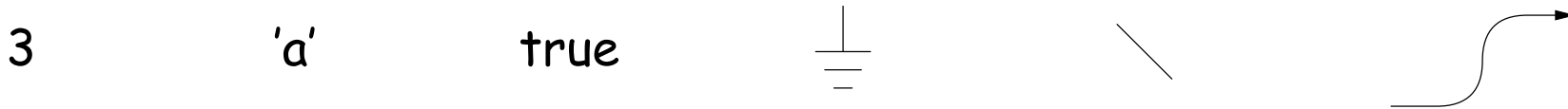


CS61B Lecture #4: Values and Containers

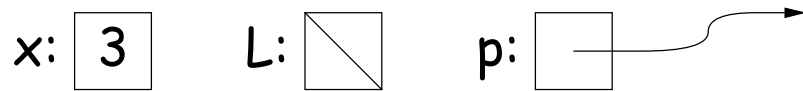
- Today: Chapter 4 from *A Java Reference*.
- Peruse: Chapters 2, 6, 7.
- **Today.** Simple classes. Scheme-like lists. Destructive vs. non-destructive operations. Models of memory.

Values and Containers

- *Values* are numbers, booleans, and pointers. Values never change.



- *Simple containers* contain values:



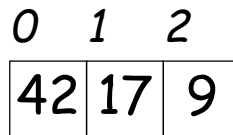
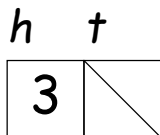
Examples: variables, fields, individual array elements, parameters.

- *Structured containers* contain (0 or more) other containers:

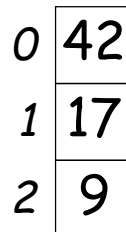
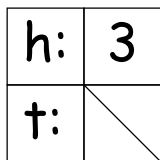
Class Object

Array Object

Empty Object

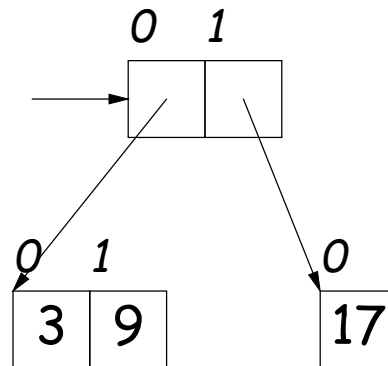


Alternative Notation



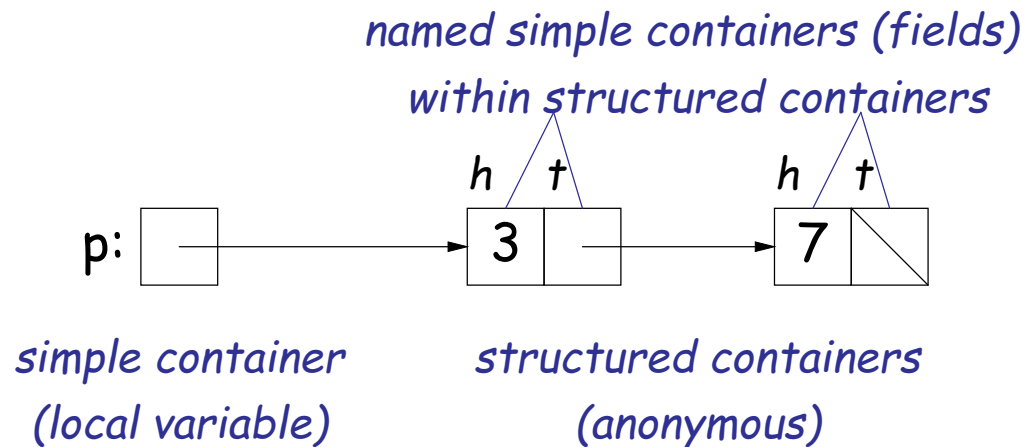
Pointers

- *Pointers* (or *references*) are values that *reference* (point to) containers.
- One particular pointer, called **null**, points to nothing.
- In Java, structured containers contain only simple containers, but pointers allow us to build arbitrarily big or complex structures anyway.



Containers in Java

- Containers may be *named* or *anonymous*.
- In Java, *all* simple containers are named, *all* structured containers are anonymous, and pointers point only to structured containers. (Therefore, structured containers contain only simple containers).



- In Java, assignment copies values into simple containers.
- *Exactly* like Scheme!

Defining New Types of Object

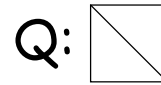
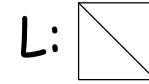
- Class declarations introduce new types of objects.
- Example: list of integers:

```
public class IntList {
    // Constructor function
    // (used to initialize new object)
    /** List cell containing (HEAD, TAIL). */
    public IntList (int head, IntList tail) {
        this.head = head; this.tail = tail;
    }

    // Names of simple containers (fields)
    public int head;
    public IntList tail;
}
```

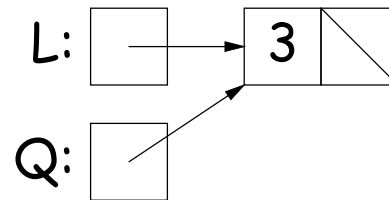
Primitive Operations

```
IntList Q, L;
```



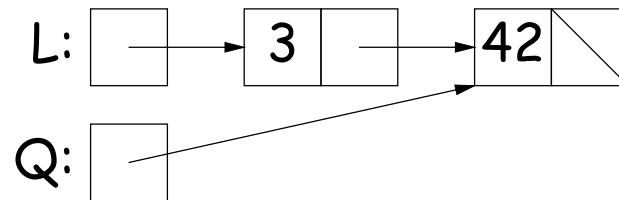
```
L = new IntList(3, null);
```

```
Q = L;
```



```
Q = new IntList(42, null);
```

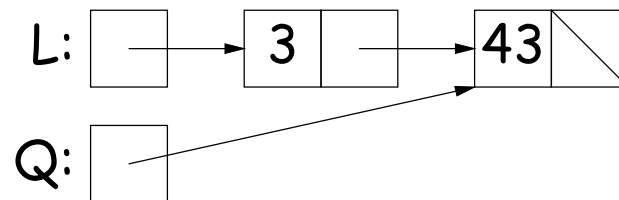
```
L.tail = Q;
```



```
L.tail.head += 1;
```

```
// Now Q.head == 43
```

```
// and L.tail.head == 43
```



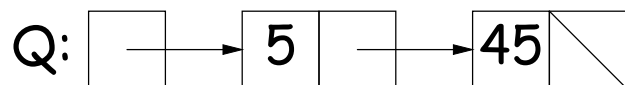
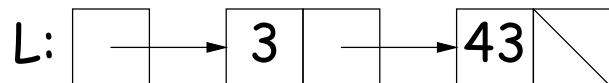
Destructive vs. Non-destructive

Problem: Given a (pointer to a) list of integers, L , and an integer increment n , return a list created by incrementing all elements of the list by n .

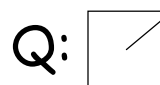
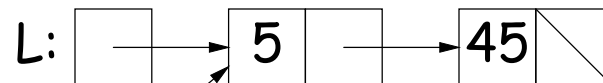
```
/** List of all items in P incremented by n. */
static IntList incrList (IntList P, int n) {
    if (P == null)
        return null;
    else return new IntList (P.head+n, incrList(P.tail, n));
}
```

We say `incrList` is *non-destructive*, because it leaves the input objects unchanged, as shown on the left. A *destructive* method may modify the input objects, so that the original data is no longer available, as shown on the right:

After `Q = incrList(L, 2)`:



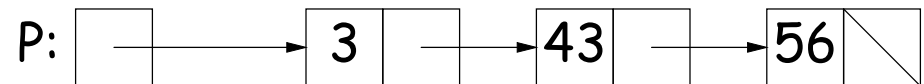
After `Q = dincrList(L, 2)` (destructive):



An Iterative Version

An iterative `incrList` is tricky, because it is *not* tail recursive.
Easier to build things first-to-last, unlike recursive version:

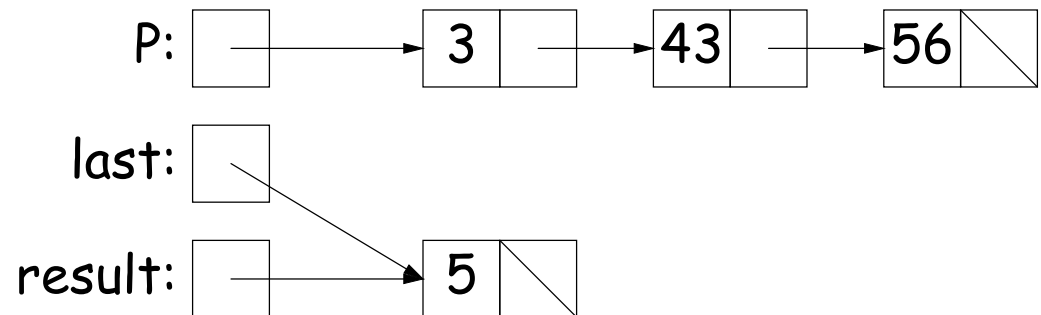
```
static IntList incrList (IntList P, int n) {  
    if (P == null)  
        return null;  
    IntList result, last;  
    result = last  
        = new IntList (P.head+n, null);  
    while (P.tail != null) {  
        P = P.tail;  
        last.tail  
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        last = last.tail;  
    }  
    return result;  
}
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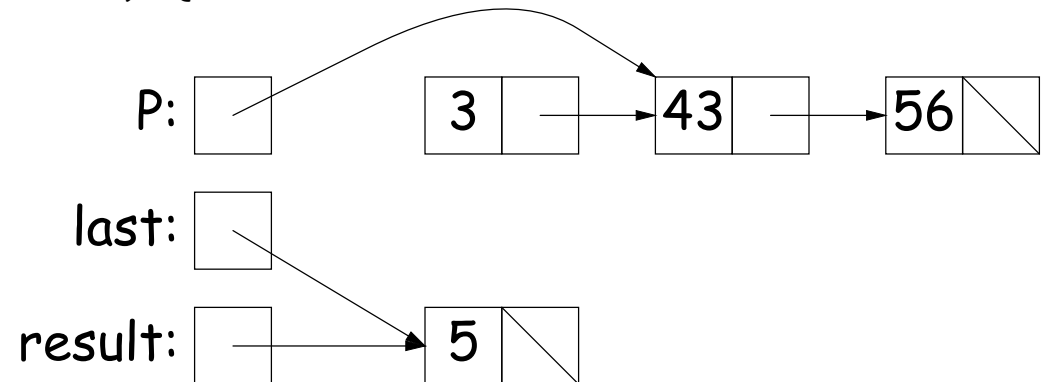
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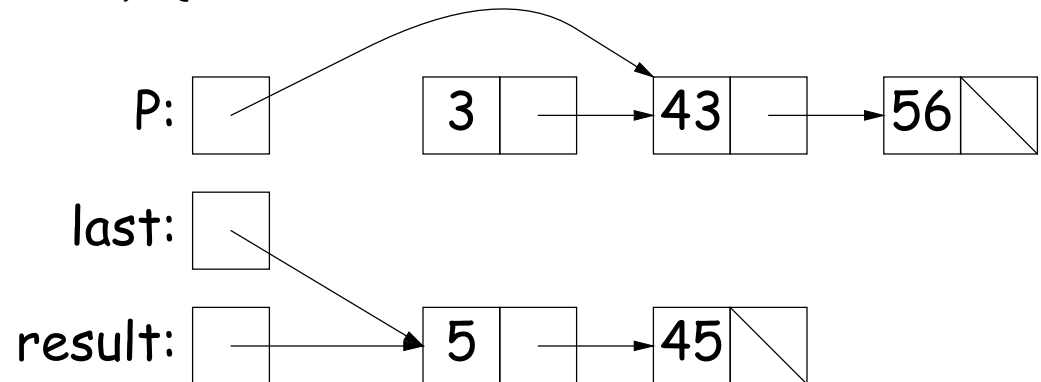
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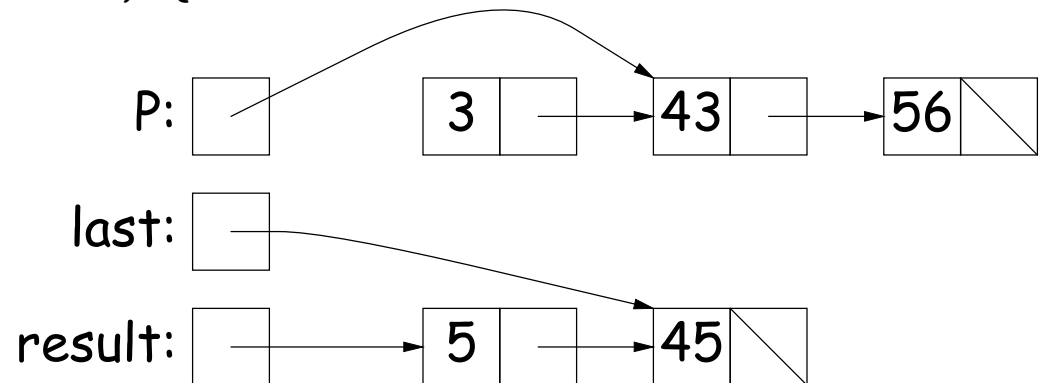
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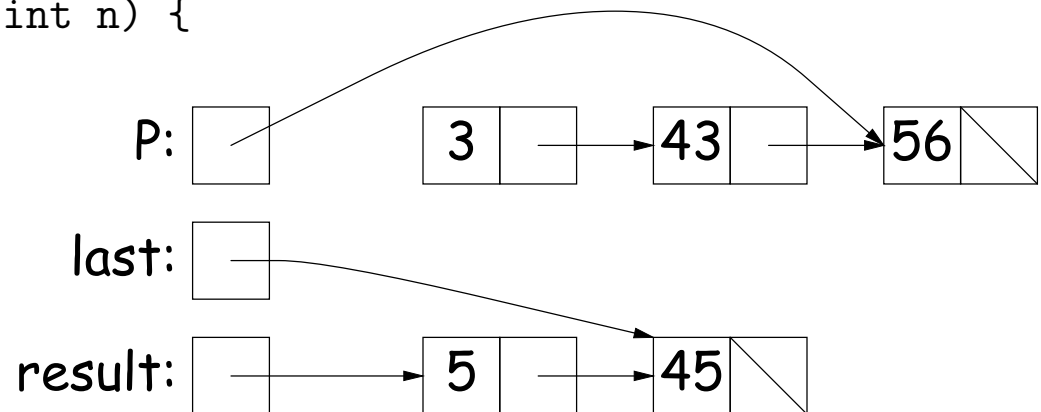
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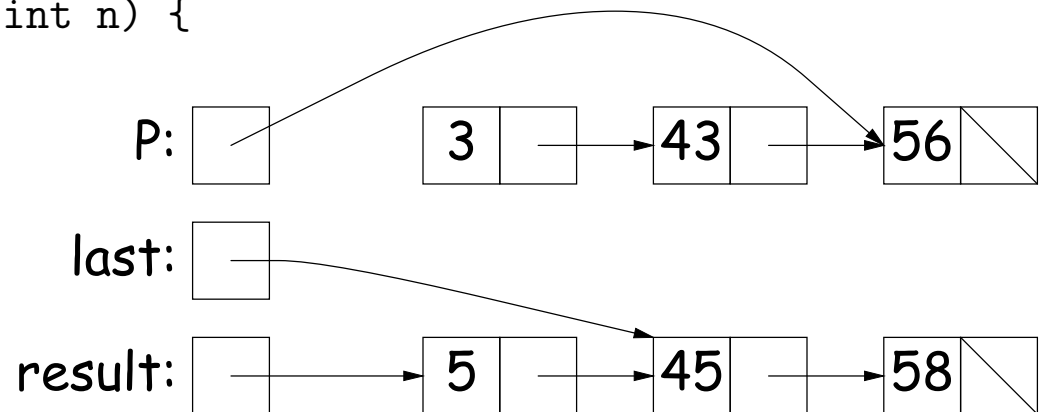
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