# CS61B Lecture #3: Containers

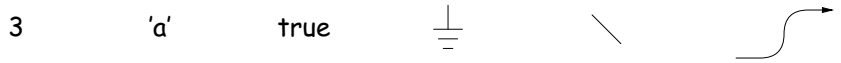
**Announcements**

- **Last day to log in.** Be sure to do the first lab. Get an account form from me, if needed.
- **Reminder about readers.** Three are available at Copy Central. Be sure you have them, or use the on-line versions, available from home page.
- **Today.** Simple classes. Scheme-like lists. Destructive vs. non-destructive operations. Models of memory.
- **Today's Reading:** *Blue Reader:* Chapter 1.
- **Lab #1** for next week is now available on-line (from the homework page). It's a good idea to look at it or even to do it ahead of time (but always check for possible updates).
- **Next Week's Readings:** *Blue Reader:* Chapters 2 and 3. Also please look over Chapter 5, which we will use in fragments.



# Values and Containers

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

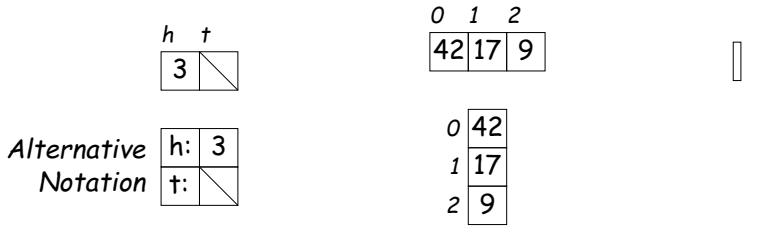



- *Simple containers* contain values:


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

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

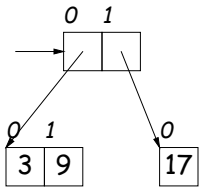
*Class Object* *Array Object* *Empty Object*






# Pointers

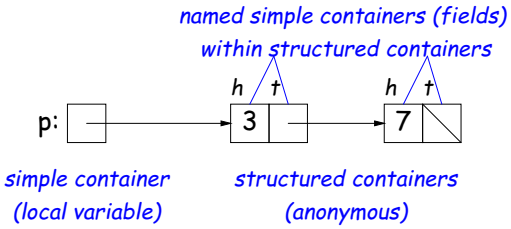
- *Pointers* (or *references*) are values that *reference* (point to) containers.
- One particular pointer, called **null**, points to nothing.
- In Java, structured containers contain only simple containers, but pointers allow us to build arbitrarily big or complex structures anyway.






# 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:

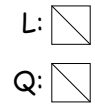
```
public class IntList {
  // Constructor function
  // (used to initialize new object)
  /** List cell containing (HEAD, TAIL). */
  public IntList (int head, IntList tail) {
    this.head = head; this.tail = tail;
  }

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

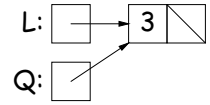


## Primitive Operations

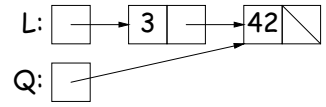
```
IntList Q, L;
```



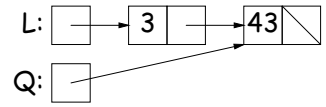

```
L = new IntList(3, null);
Q = L;
```




```
Q = new IntList(42, null);
L.tail = Q;
```




```
L.tail.head += 1;
// Now Q.head == 43
// and L.tail.head == 43
```





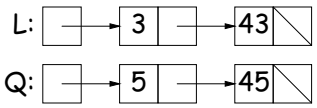

## Destructive vs. Non-destructive

**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 $n$.

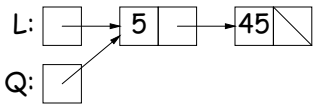
```
/** List of all items in P incremented by n. */
static IntList incrList (IntList P, int n) {
  if (P == null)
    return null;
  else return new IntList (P.head+n, incrList(P.tail, n));
}
```

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
      = new IntList (P.head+n, null);
    last = last.tail;
  }
  return result;
}
```