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Lecture 22
Iteration vs Recursion

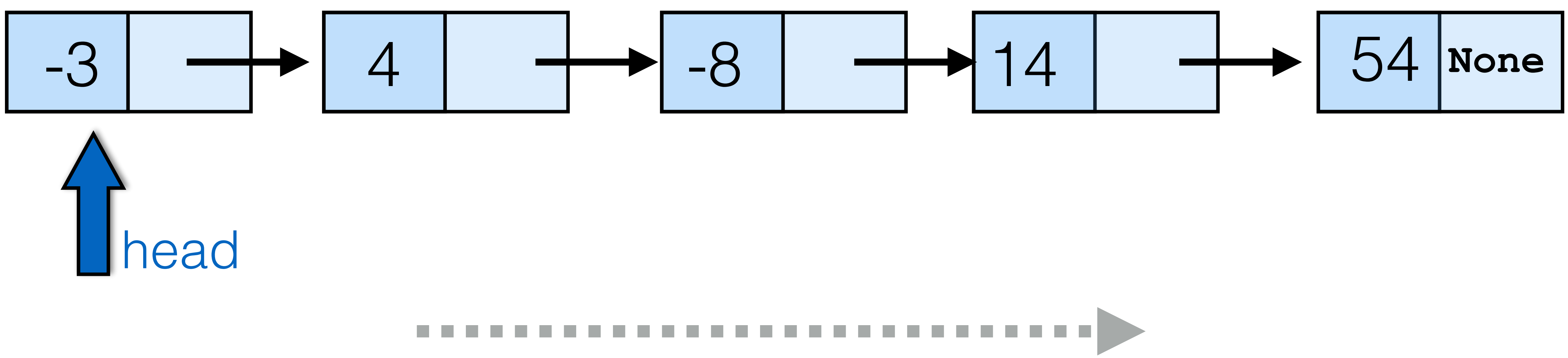
FIT 1008
Introduction to Computer Science

MONASH University
Information Technology

Operation	Class Method
str(obj)	__str__(self)
len(obj)	__len__(self)
item in obj	__contains__(self,item)
y = obj[ndx]	__getitem__(self,ndx)
obj[ndx] = value	__setitem__(self,ndx,value)
obj == rhs	__eq__(self,rhs)
obj < rhs	__lt__(self,rhs)
...	
obj + rhs	__add__(self,rhs)
...	

```python
class List:
    def __init__(self):
        self.head = None
        self.count = 0

    def __len__(self):
        return self.count
```

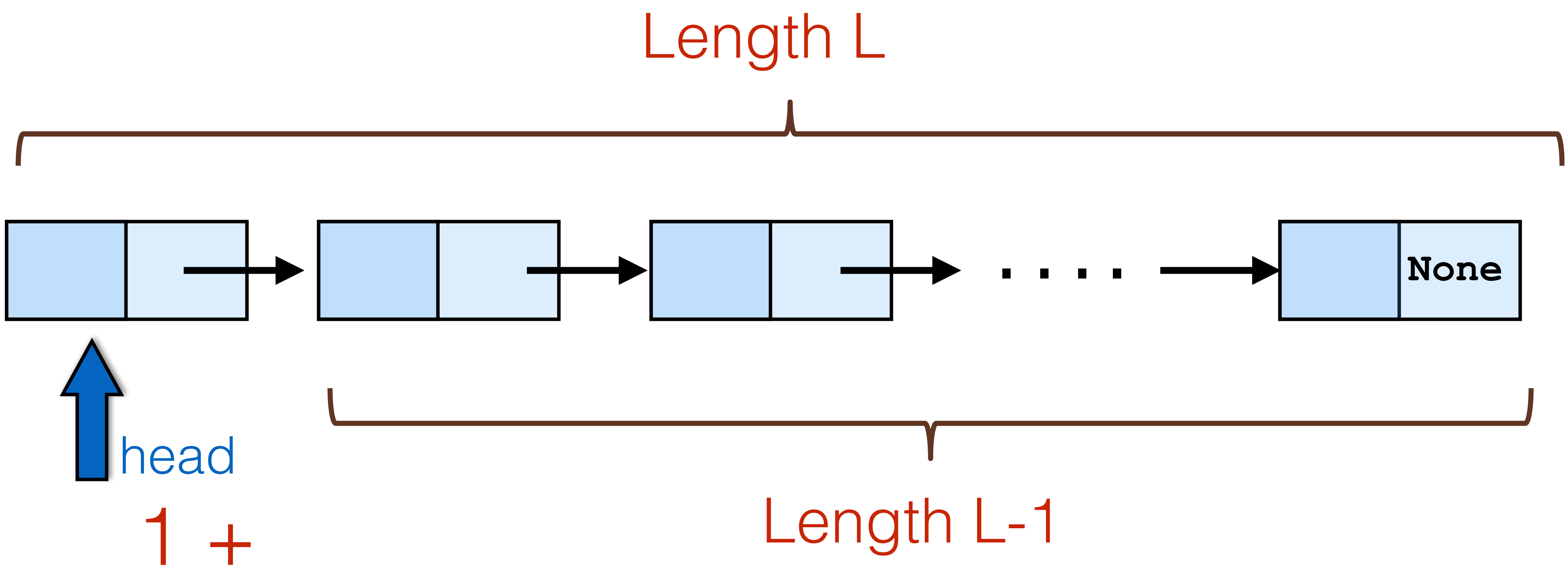
?



count from head to access elements

```python
class List:
    def __init__(self):
        self.head = None

    def __len__(self):
        current = self.head
        count = 0
        while current is not None:
            current = current.next
            count += 1
        return count
```

Complexity: O(n) where n is the size of the list.



Convergence: Call recursion with L-1. Use variable *current*.

Base case: Empty? Size of empty list is 0.

Combining solutions: Add up result of recursive call +

Base case

```python
def _length(self, current):
    if self.current is None: # base case
        return 0
    else:
        return 1  + self._length(current.next)
```

Convergence

Combination

```python
def __len__(self):
    return self._length(self.head)
```

Auxiliary method sets up the initial parameters

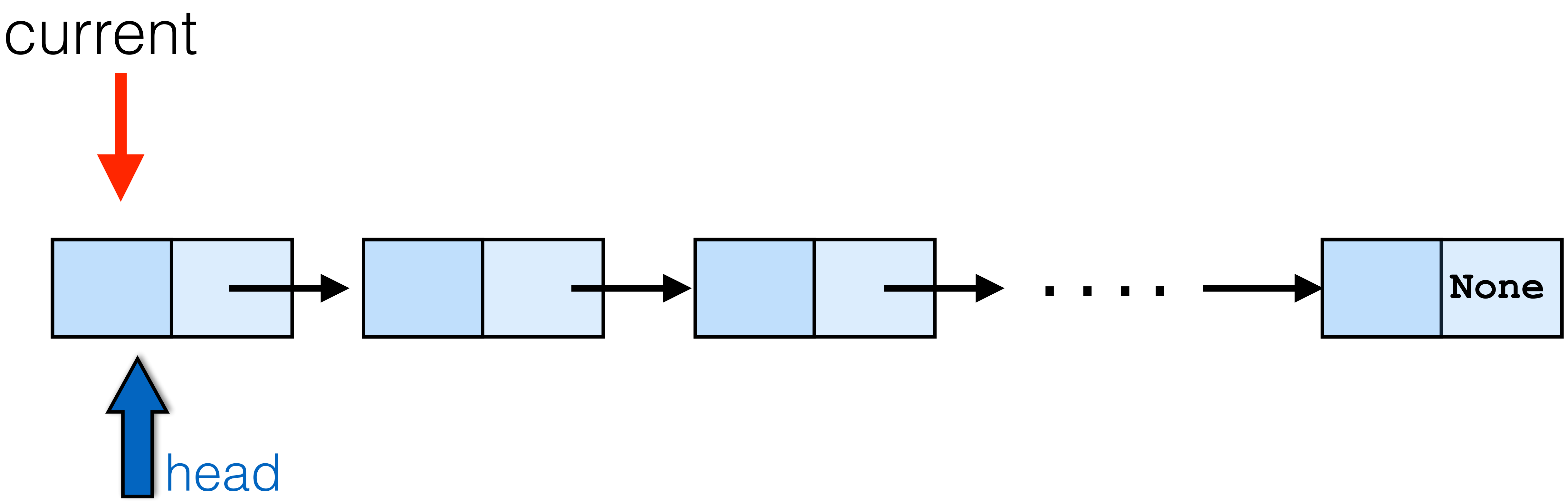
Recursion vs Iteration

- Can every **iterative function** be implemented using **recursion**?
  Yes, it is straightforward.

- Can every **recursive function** be implemented using **iteration**?
  Yes, but you might also need to store past results.

Operation	Class Method
str(obj)	__str__(self)
len(obj)	__len__(self)
item in obj	__contains__(self,item)
y = obj[ndx]	__getitem__(self,ndx)
obj[ndx] = value	__setitem__(self,ndx,value)
obj == rhs	__eq__(self,rhs)
obj < rhs	__lt__(self,rhs)
...	
obj + rhs	__add__(self,rhs)
...	

__contains__



__contains__

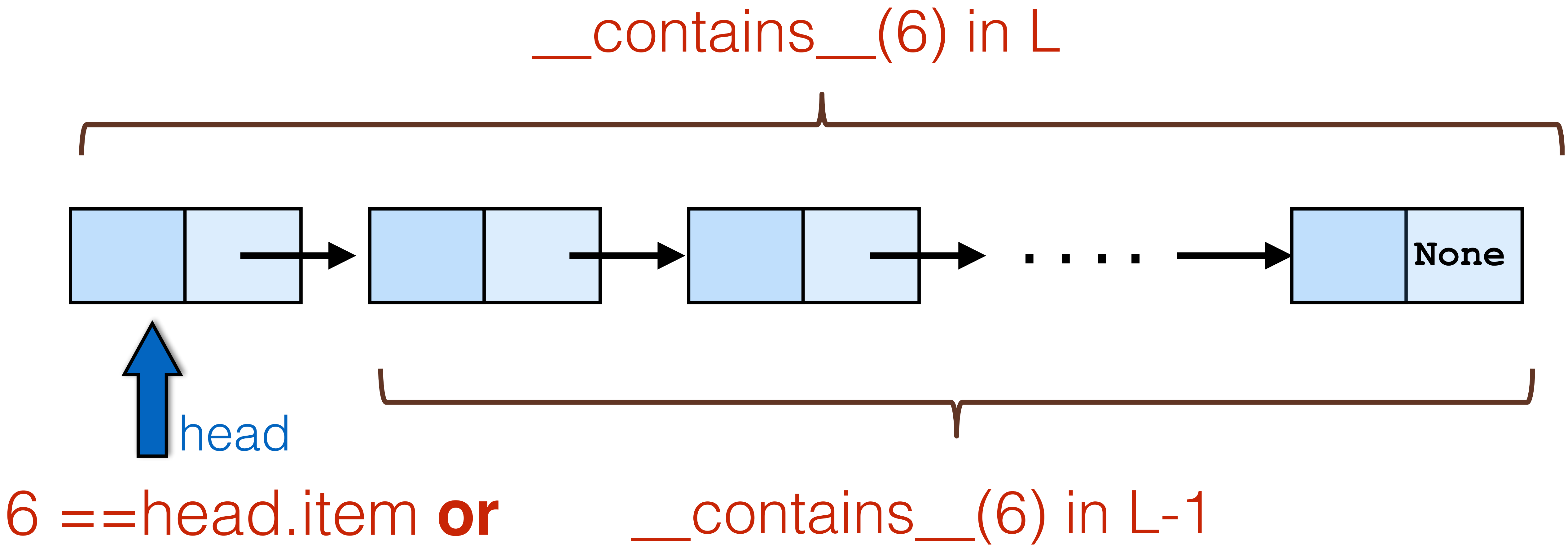
```python
def __contains__(self, item):
    current = self.head
    while current is not None:
        if current.item == item:
            return True
        current = current.next
    return False
```

Complexity: Worst case - O(n) where n is the size of the list.

__contains__

```python
def __contains__(self, item):
    current = self.head
    while current is not None:
        if current.item == item:
            return True
        current = current.next
    return False
```

- **Best case** complexity when found first: **O(1)***CompEq where CompEq is the complexity of == (or __eq__)
- **Worst case** when not found: **O(n)***CompEq where n is the length of the list.



Convergence: Call recursion with L-1. Use variable *current*.

Base case: Empty or Element Found. We need both.

Combining solutions: it's in the head **or** in the remaining list.

Auxiliary method sets up the initial parameters

```
def __contains__(self, item):
    return self._contains_aux(self.head, item)

def _contains_aux(self, current, item):
    if current is None:
        return False
    return current.head == item or self._contains_aux(current.next, item)
```

Base case

Convergence

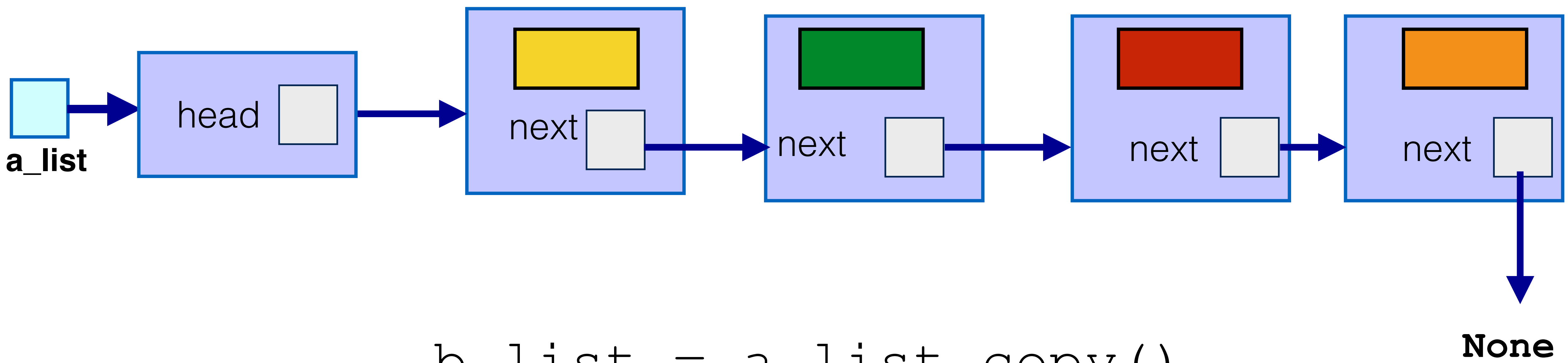
Combination

Alternative coding

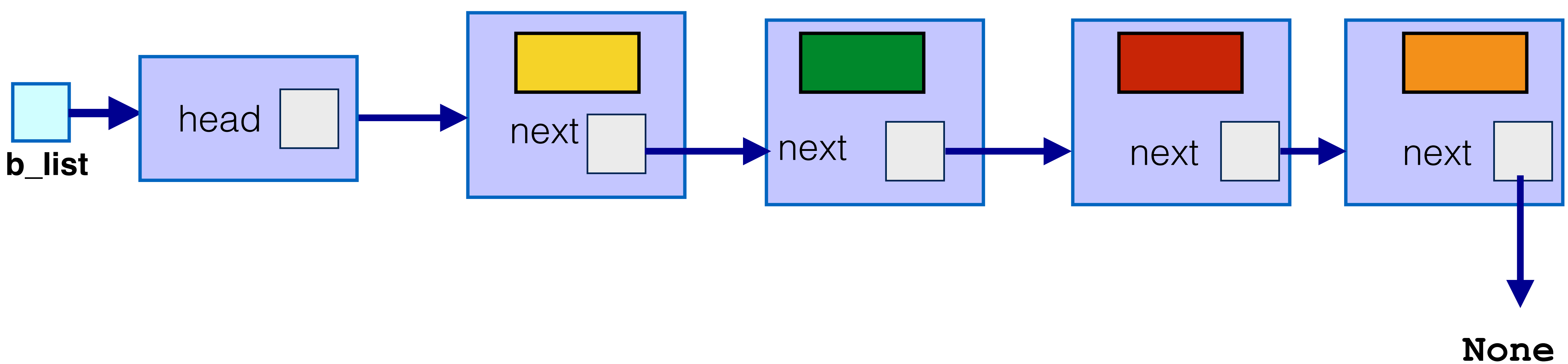
```python
def __contains__(self, item):
    return self._contains_aux(self.head, item)

def _contains_aux(self, current, item):
    if current is None:
        return False
    elif current.head == item:
        return True
    else:
        return self._contains_aux(current.next, item)
```

or is implicit

Copy Linked Lists

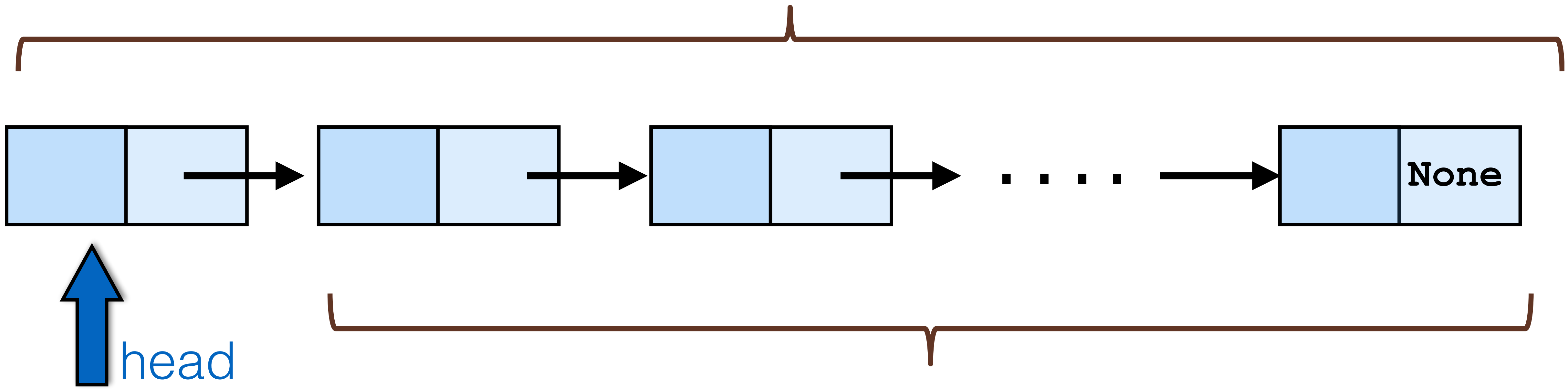


b_list = a_list.copy()



```python
def copy(self):
    new_list = List()
    for item in self:
        new_list.insert(len(new_list), item)
    return new_list
```

_copy(self.head, new_list)



_copy(self.head.next, new_list)

new_list.insert(0, head.item)

copy

Auxiliary method sets up the initial parameters

```
def copy(self):
    new_list = List()
    self._copy_aux(self.head, new_list)
    return new_list

def _copy_aux(self, node, new_list):
    if node is not None:
        self._copy_aux(node.next, new_list)
        new_list.insert(0, node.item)
```

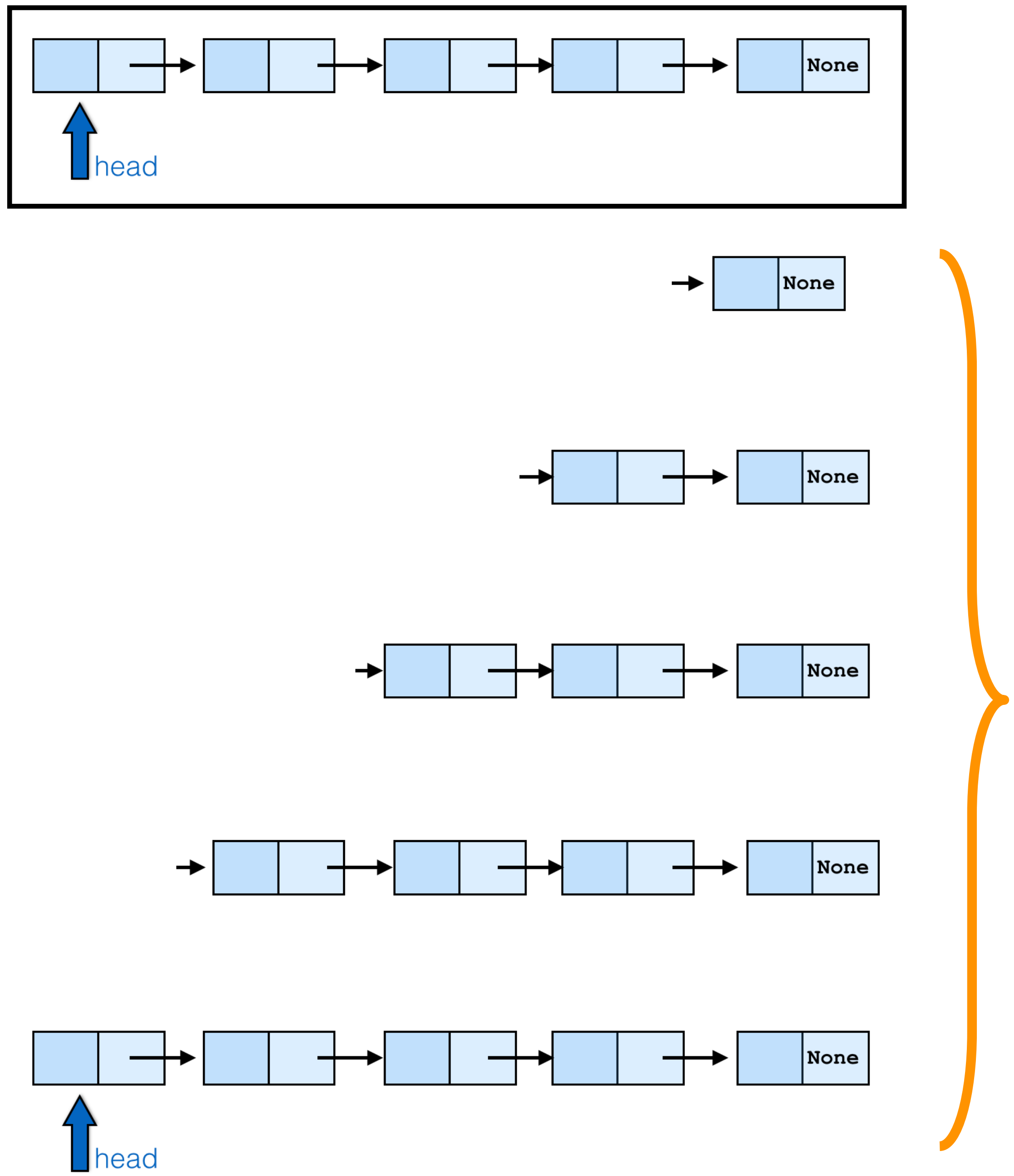
Convergence

Base case

Combination

```python
def copy(self):
    new_list = List()
    self._copy_aux(self.head, new_list)
    return new_list

def _copy_aux(self, node, new_list):
    if node is not None:
        self._copy_aux(node.next, new_list)
        new_list.insert(0, node.item)
```

O(n)



_copy_aux O(1)

_copy_aux O(1)

_copy_aux O(1)

_copy_aux O(1)

_copy_aux O(1)

n times

Using iterators…

```
def copy(a_list):
        new_list = List()
        copy_aux(iter(a_list), new_list)
        return new_list

def copy_aux(iter, new_list):
    try:
        item = next(iter)
        copy_aux(iter, new_list)
        new_list.insert(0, item)
    except StopIteration:
        pass
```

Used when a statement is required
no code needs to be executed.

copy

```python
def copy(self):
    new_list = List()
    for item in self:
        new_list.insert(len(new_list), item)
    return new_list
```

$O(n^2)$

```python
def copy(self):
    new_list = List()
    self._copy_aux(self.head, new_list)
    return new_list

def _copy_aux(self, node, new_list):
    if node is not None:
        self._copy_aux(node.next, new_list)
        new_list.insert(0, node.item)
```

$O(n)$

Advantages/Disadvantages of Recursion

- Advantages:
  - More natural
  - Easier to prove correct
  - Easier to analyse

- Disadvantages:
  - Run-time overhead depending on the quality of the compiler
  - Memory overhead (fewer local variables versus stack space for function call)