61A Lecture 22

Announcements

Lists

Lists in Environment Diagrams

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Assume that before each example below we execute:

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s = [2, 3]
t = [5, 6]
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extend adds all elements in one list to another list		

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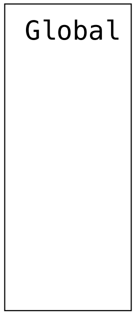

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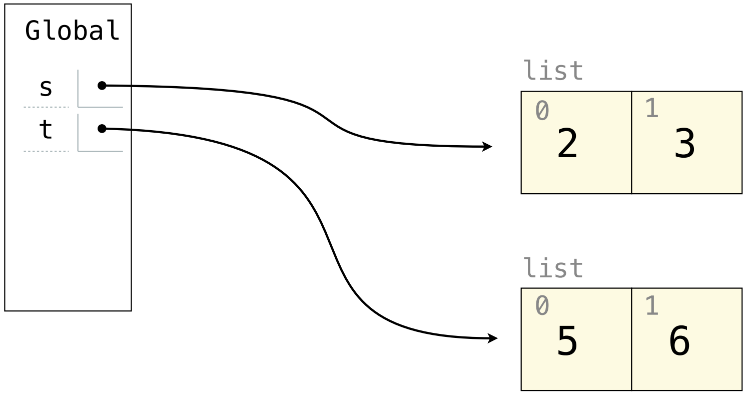

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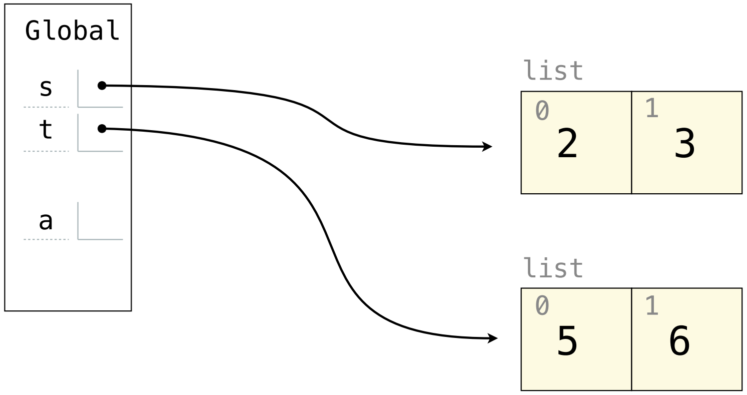

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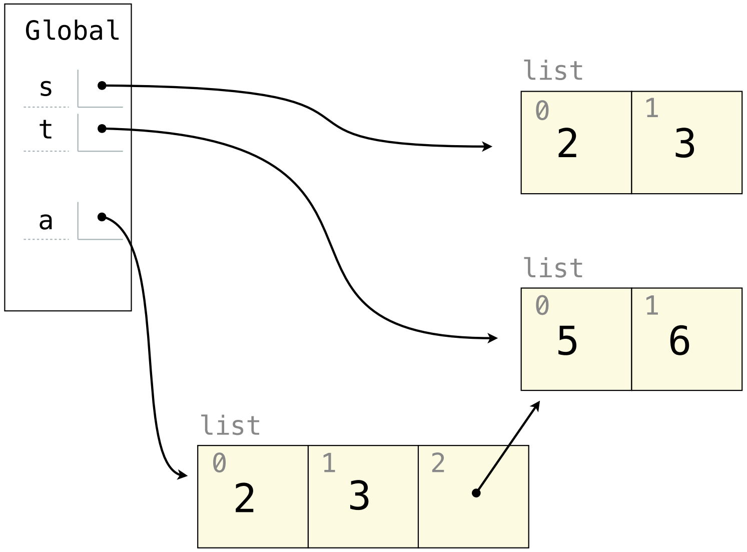

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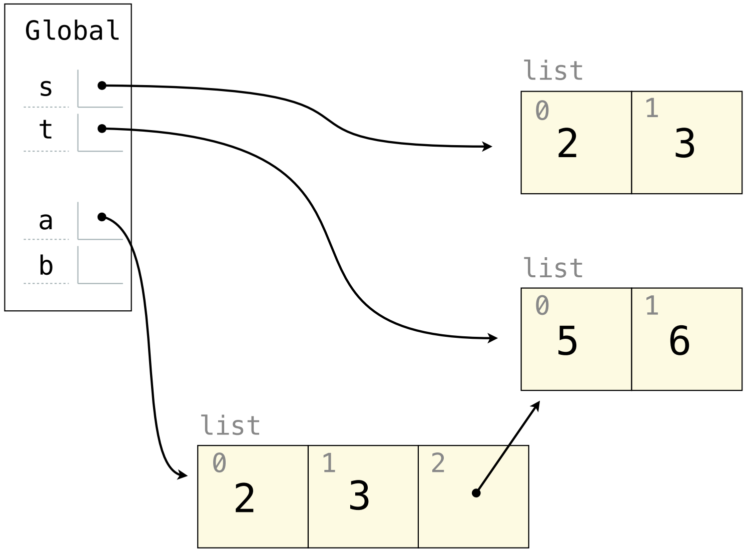

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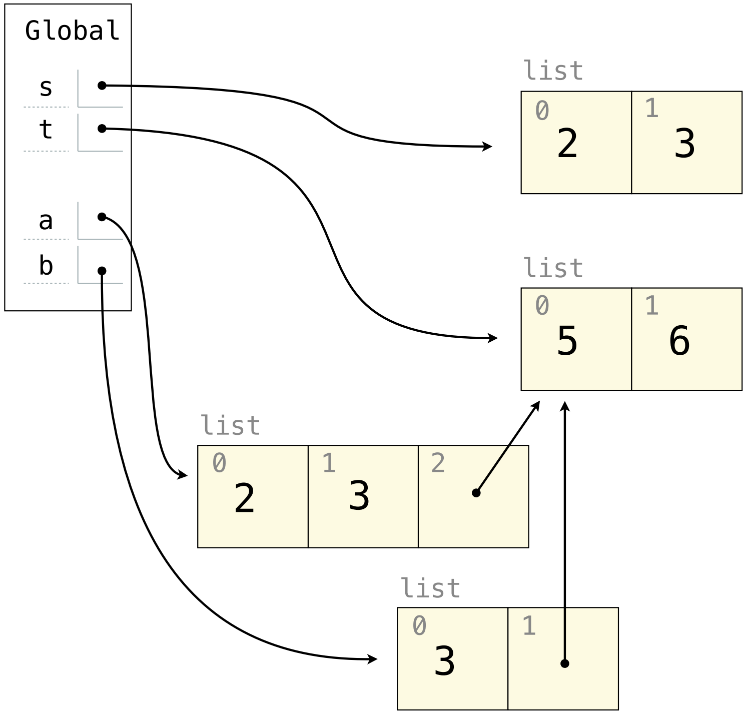

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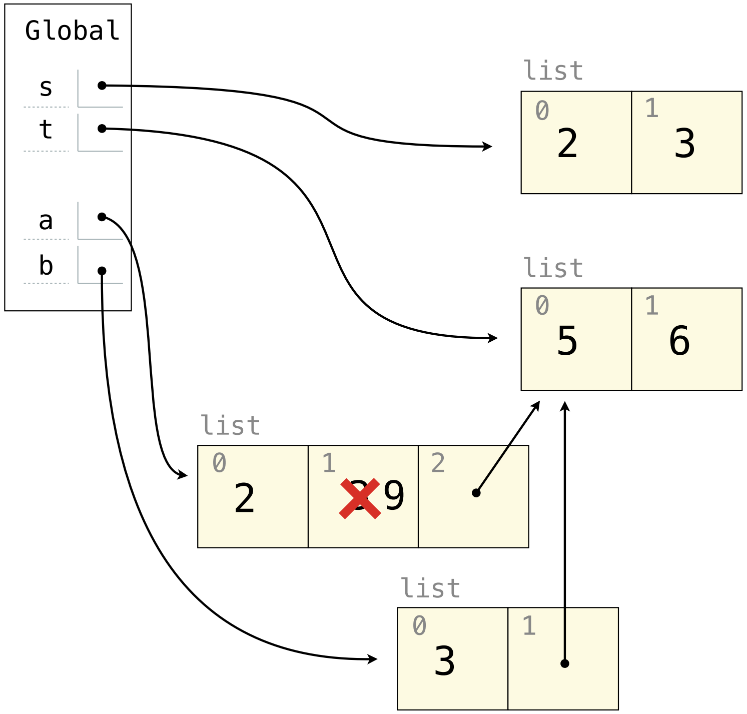

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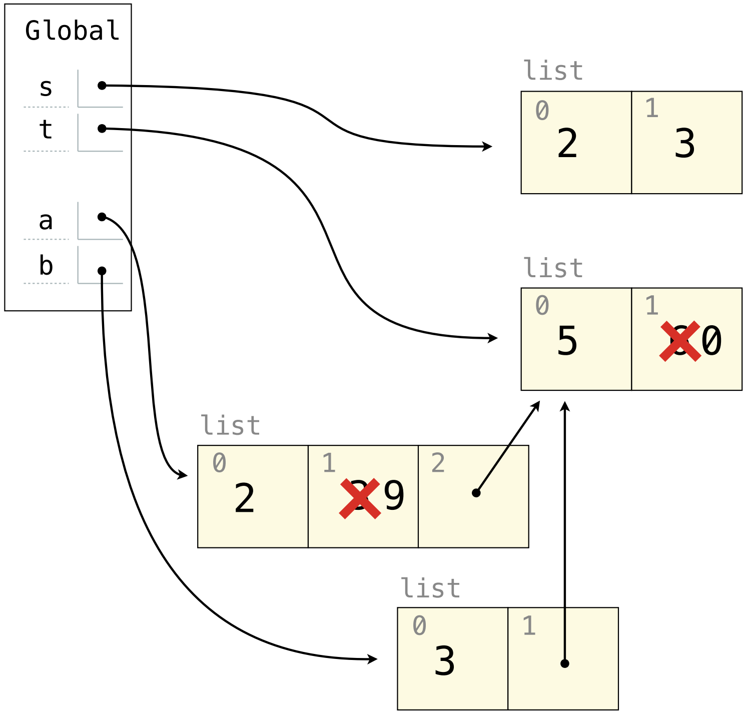

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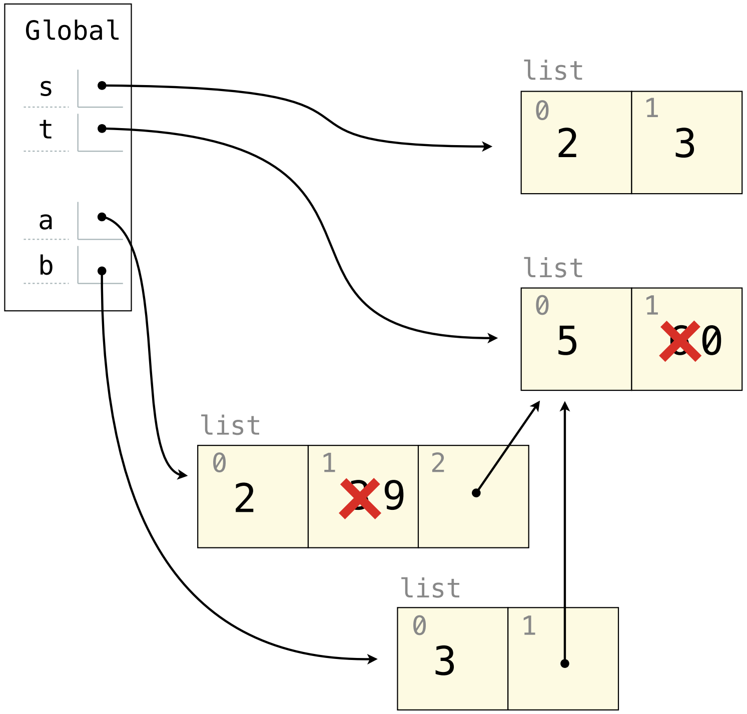

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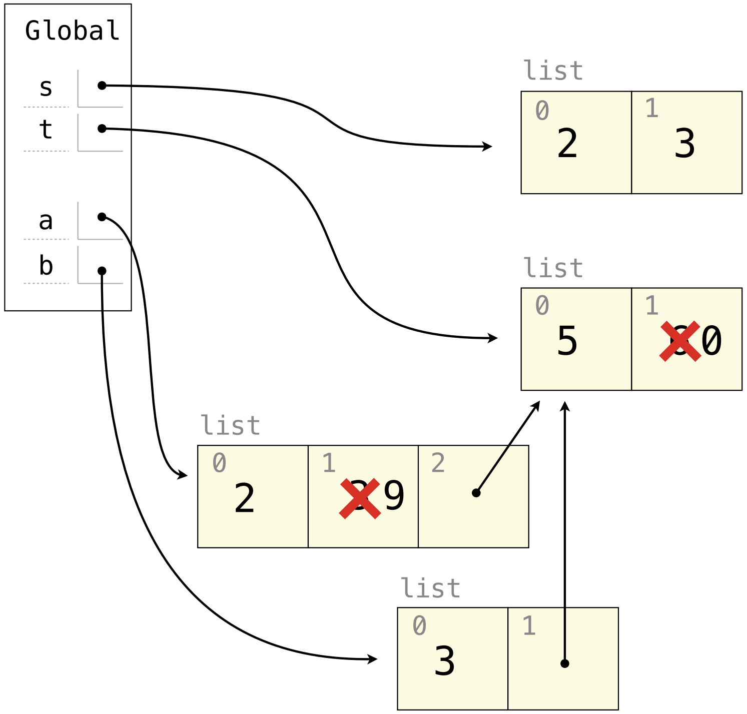

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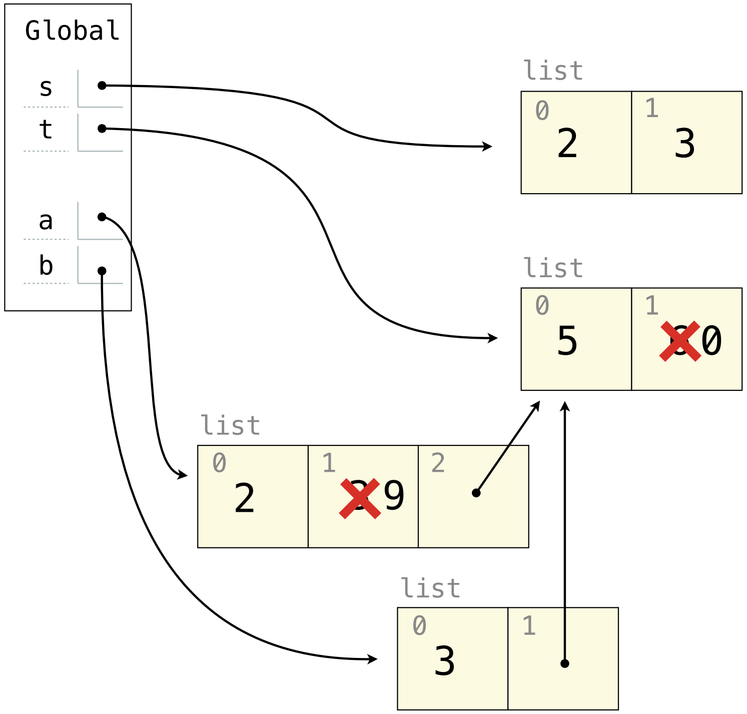

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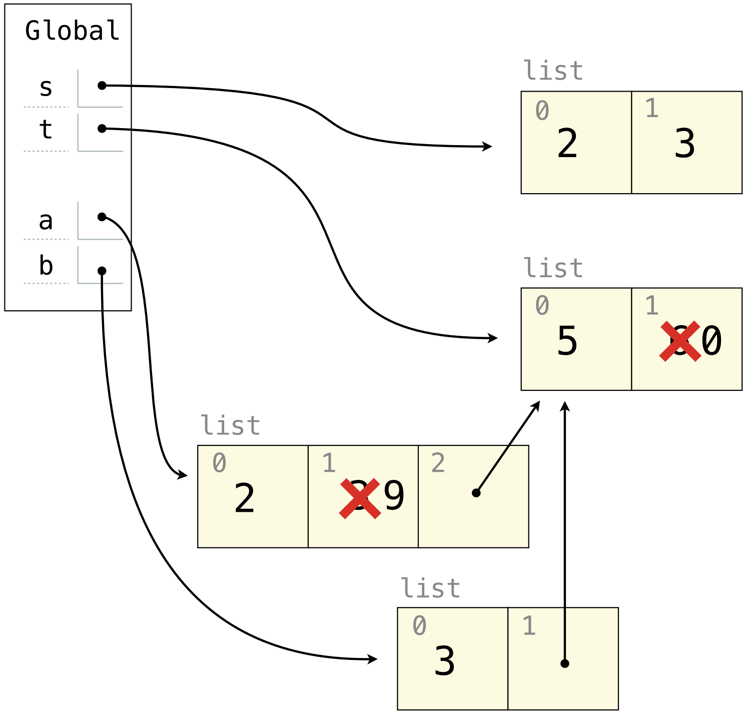

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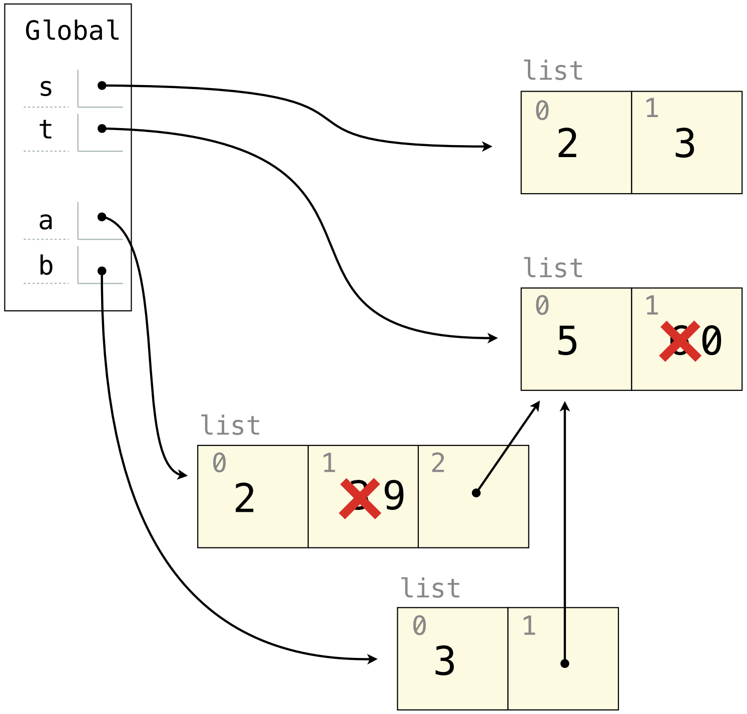
slice assignment replaces a slice with new values		



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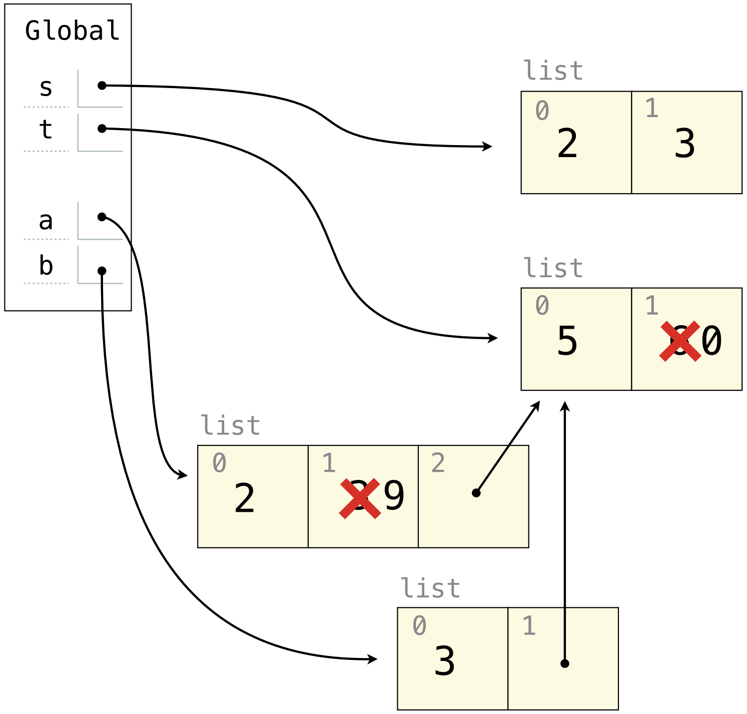

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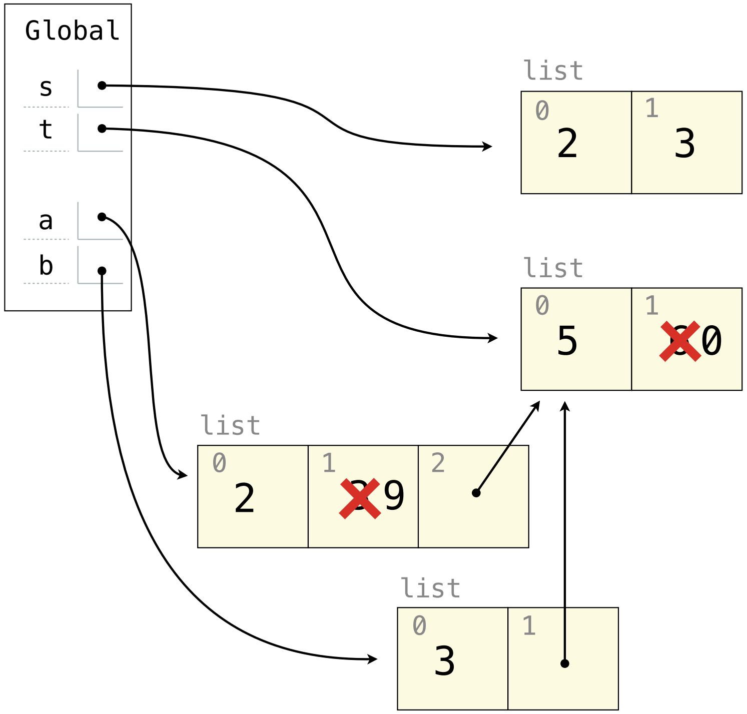

Lists in Lists in Lists in Environment Diagrams

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t = [1, 2, 3]
t[1:3] = [t]
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t = [[1, 2], [3, 4]]
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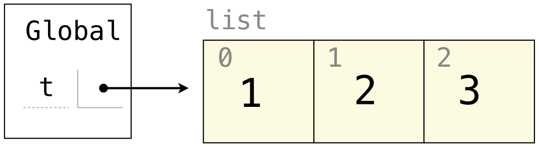

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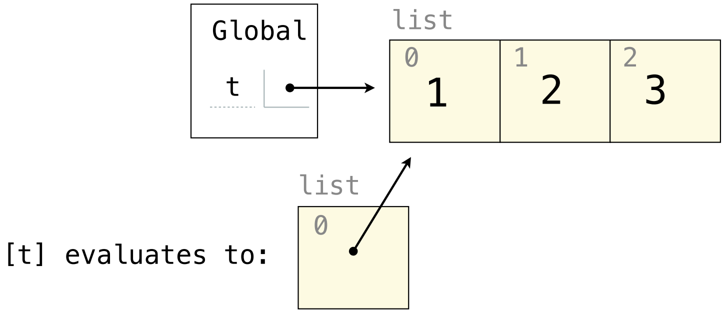

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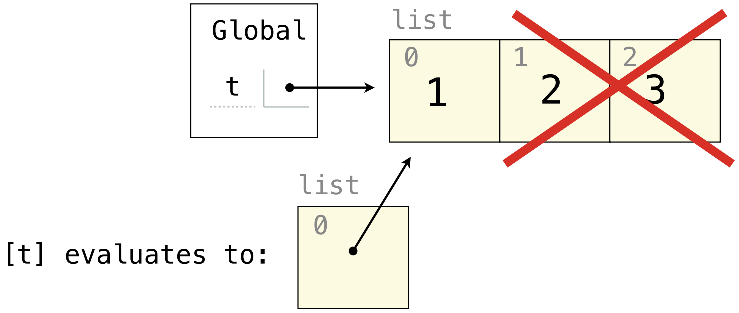

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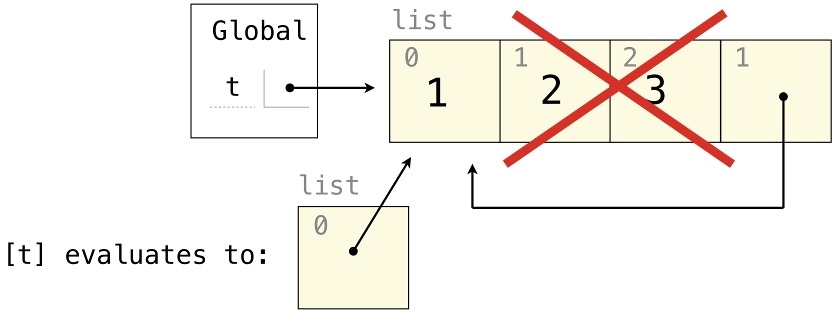

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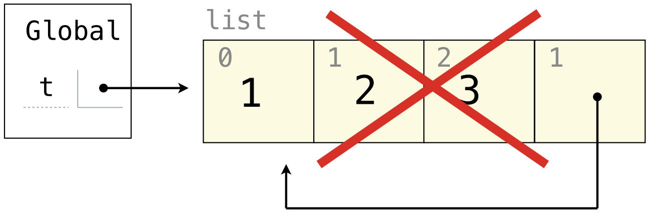

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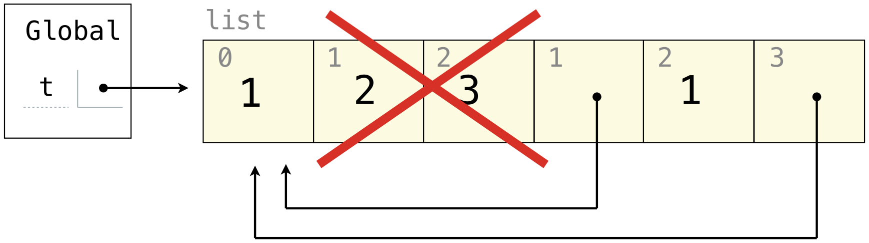

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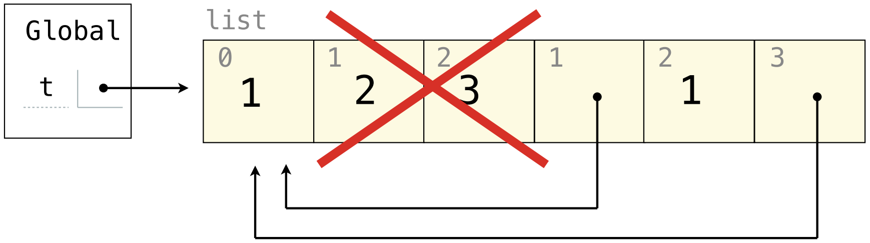

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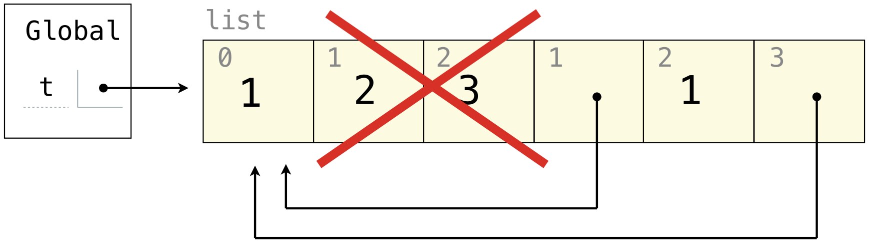

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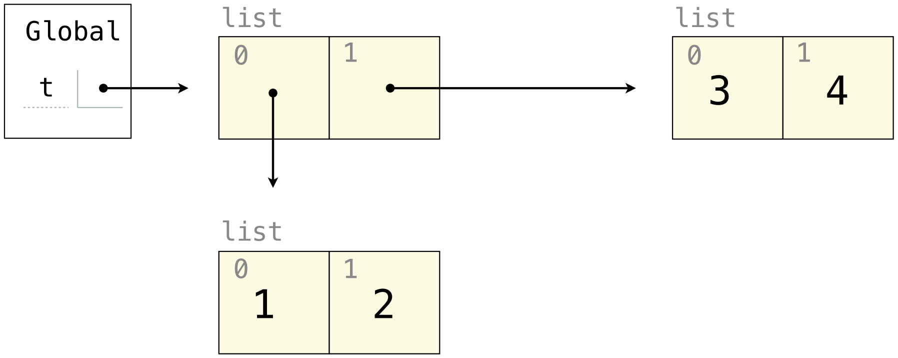
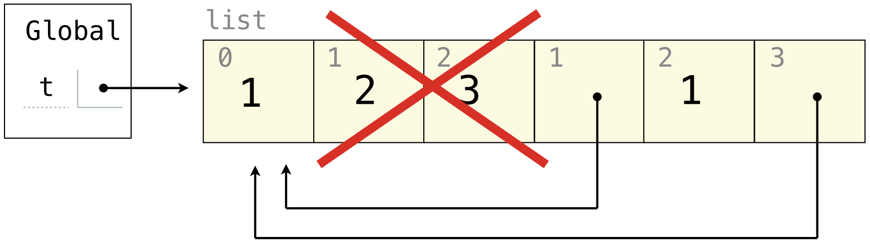
t[0].append(t[1:2])
```



Lists in Lists in Lists in Environment Diagrams

```
t = [1, 2, 3]
t[1:3] = [t]
t.extend(t)
```



```
[1, [...], 1, [...]]
```

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t = [[1, 2], [3, 4]]
t[0].append(t[1:2])
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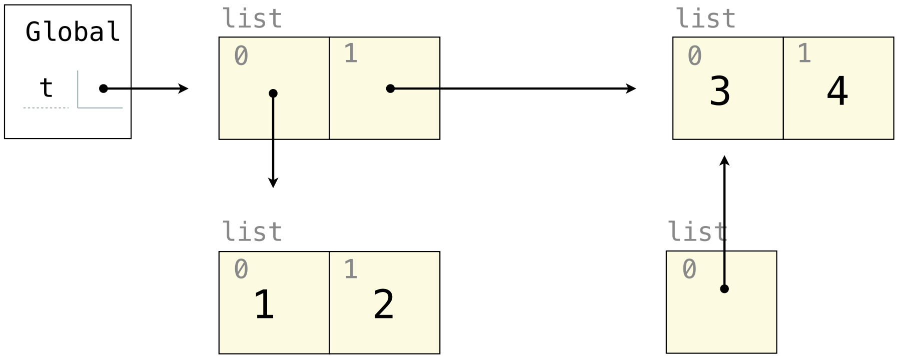

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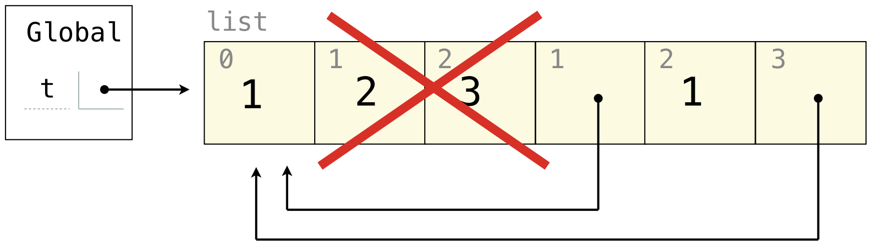

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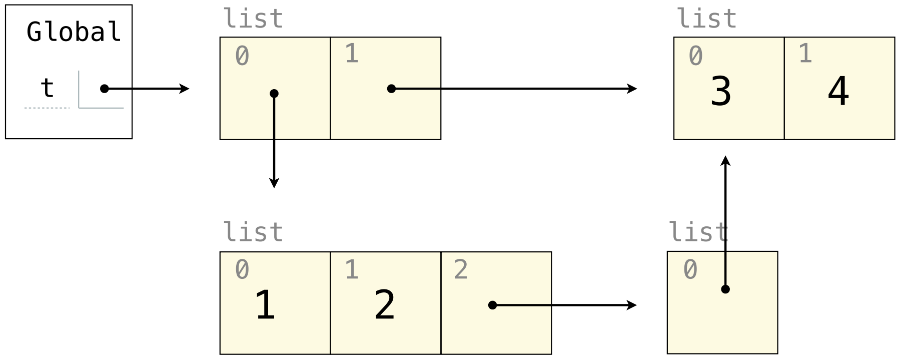

Lists in Lists in Lists in Environment Diagrams

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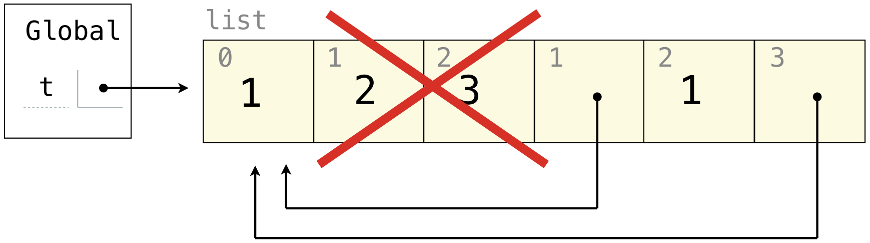

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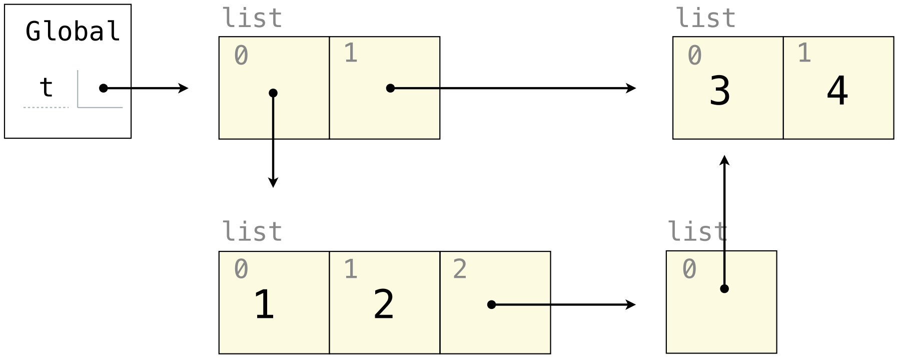

```
[[1, 2, [[3, 4]]], [3, 4]]
```

Objects

Land Owners

Instance attributes are found before class attributes; class attributes are inherited

Land Owners

Instance attributes are found before class attributes; class attributes are inherited

```
class Worker:
```

Land Owners

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```
class Worker:
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Land Owners

Instance attributes are found before class attributes; class attributes are inherited

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class Worker:
    greeting = 'Sir'
    def __init__(self):
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Land Owners

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class Worker:
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Land Owners

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        return Bourgeoisie.greeting
```

Land Owners

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class Bourgeoisie(Worker):
```

Land Owners

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class Bourgeoisie(Worker):
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Land Owners

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Land Owners

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jack = Worker()
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Land Owners

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```

```
>>> Worker().work()


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>>> john.work()


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```

Land Owners

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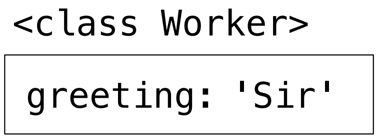
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Land Owners

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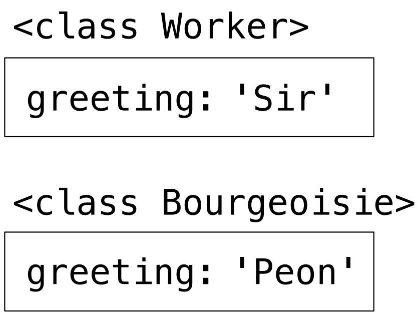

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<class Bourgeoisie>

greeting: 'Peon'

Land Owners

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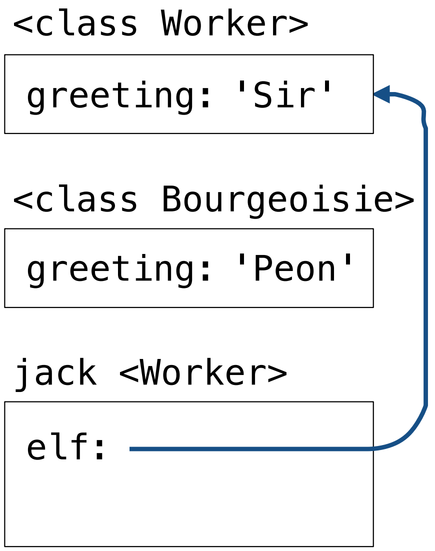

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jack <Worker>

elf:

Land Owners

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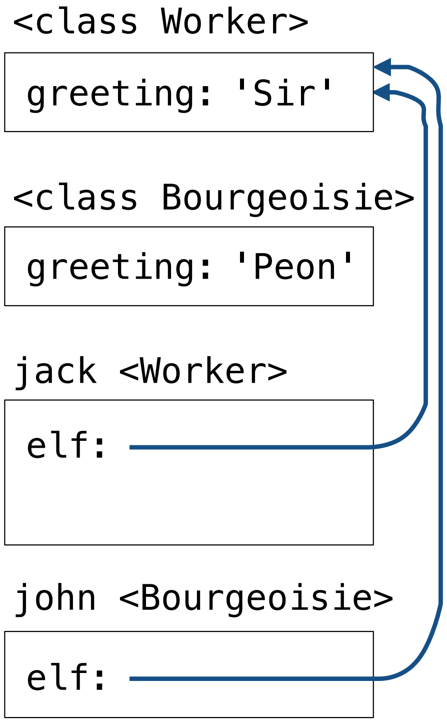

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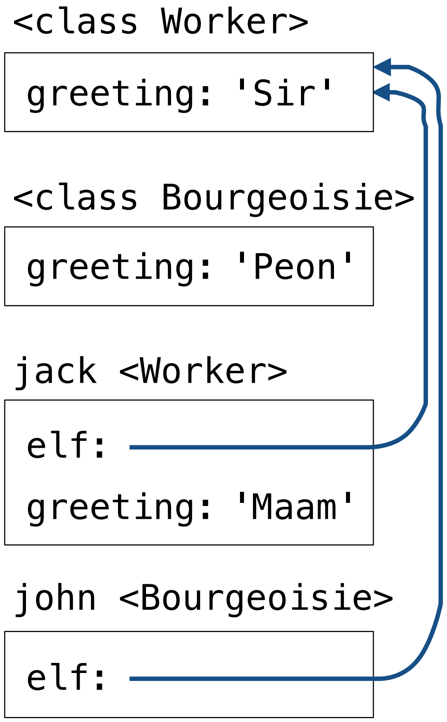

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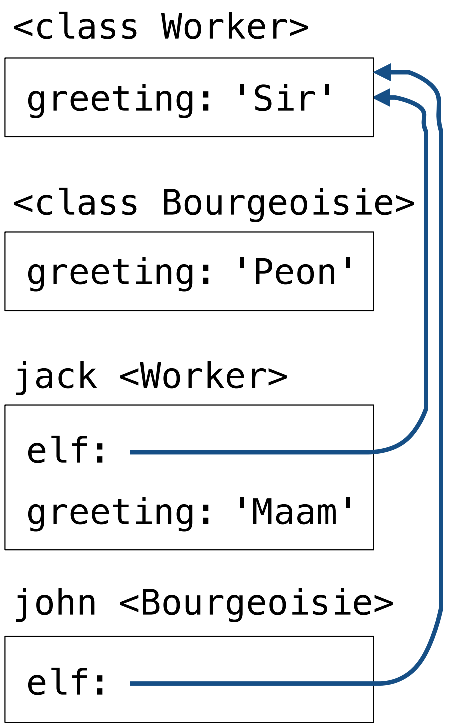

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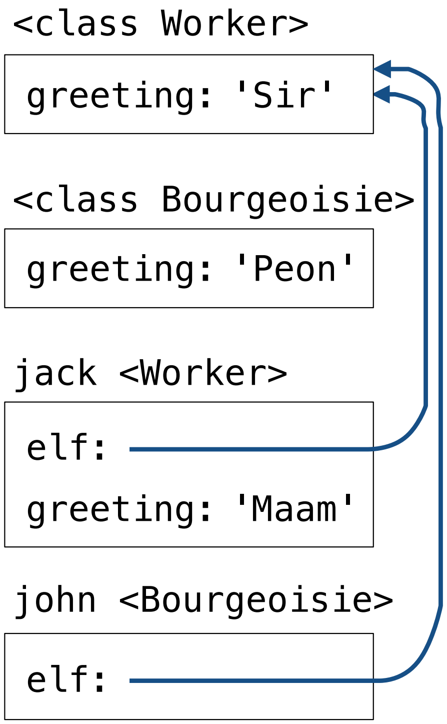

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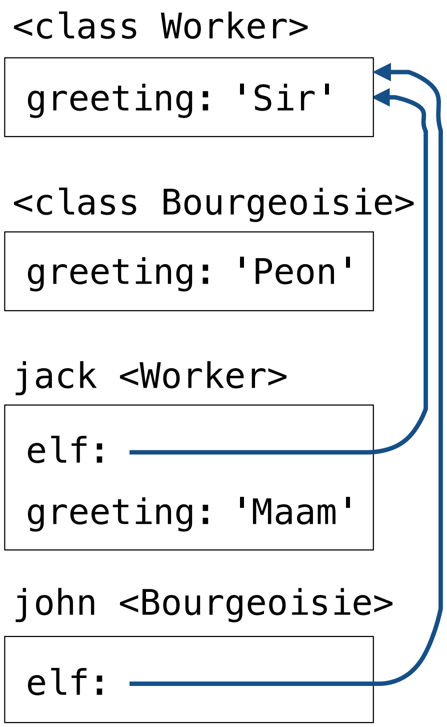

Land Owners

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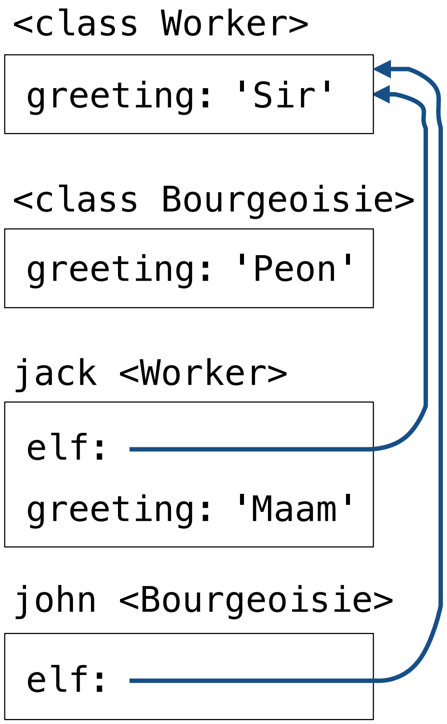

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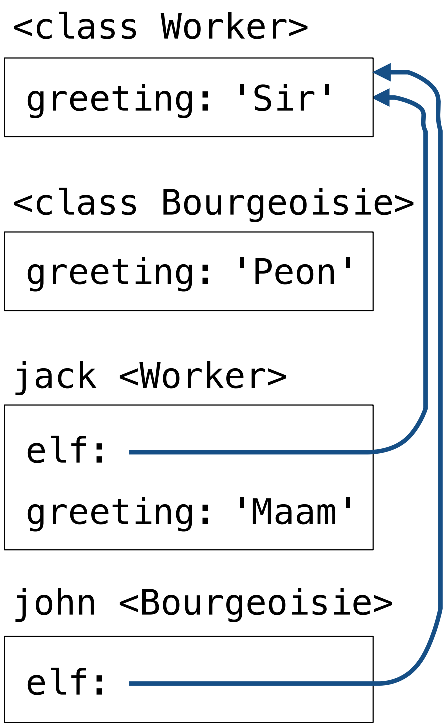

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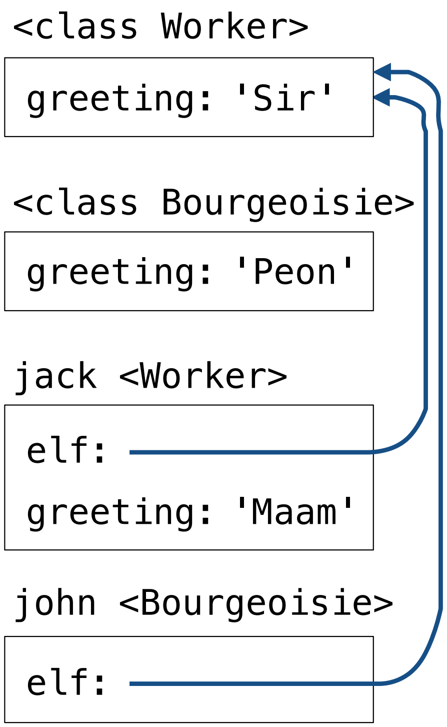

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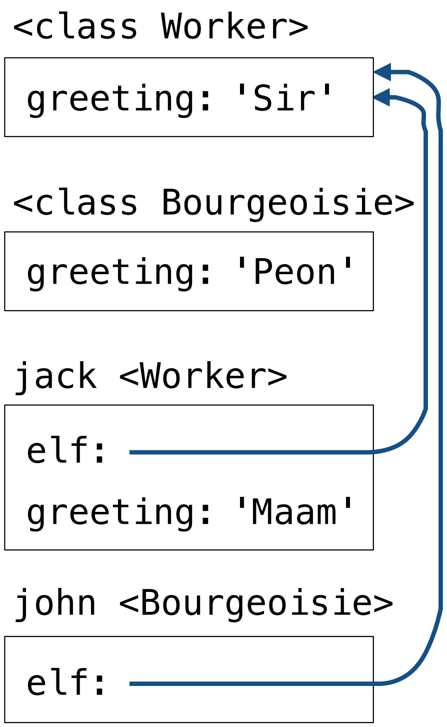

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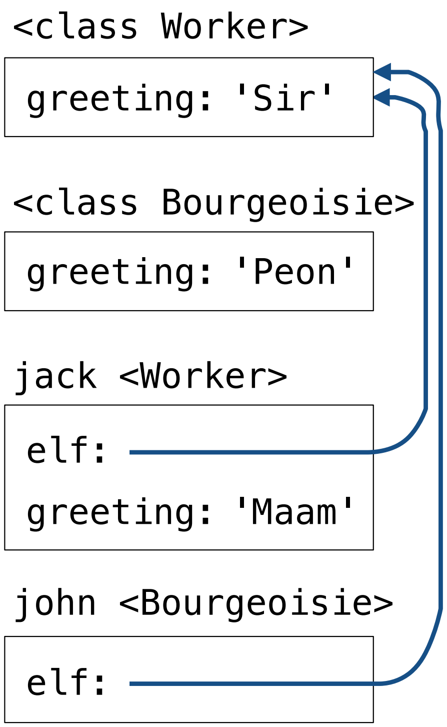

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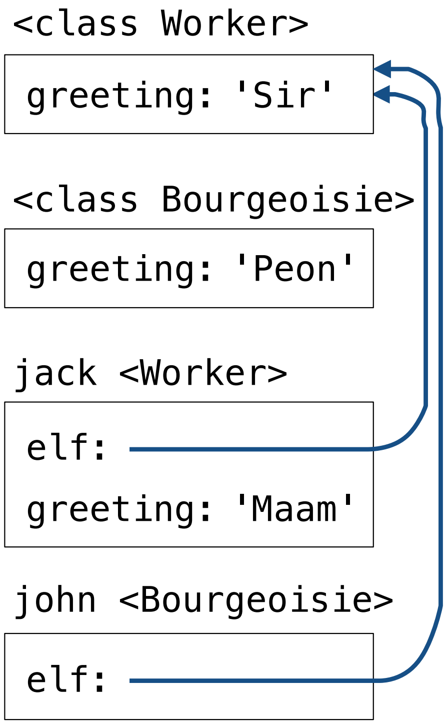

Land Owners

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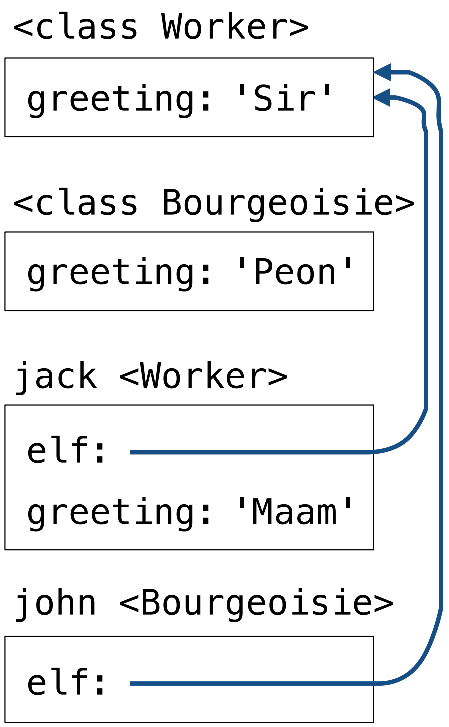

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Linked Lists

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

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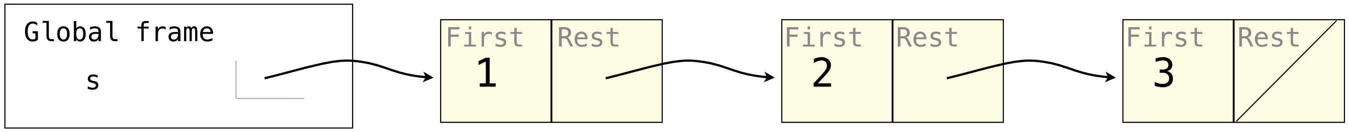
```
>>> s = Link(1, Link(2, Link(3)))
```

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
```

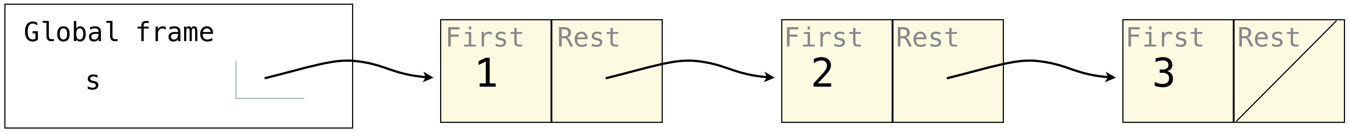


Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
```



Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
>>> t.rest = s
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
>>> t.rest = s
>>> s.first
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
>>> t.rest = s
>>> s.first
5
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
>>> t.rest = s
>>> s.first
5
>>> s.rest.rest.rest.rest.rest.first
```

Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
>>> t.rest = s
>>> s.first
5
>>> s.rest.rest.rest.rest.rest.first
2
```

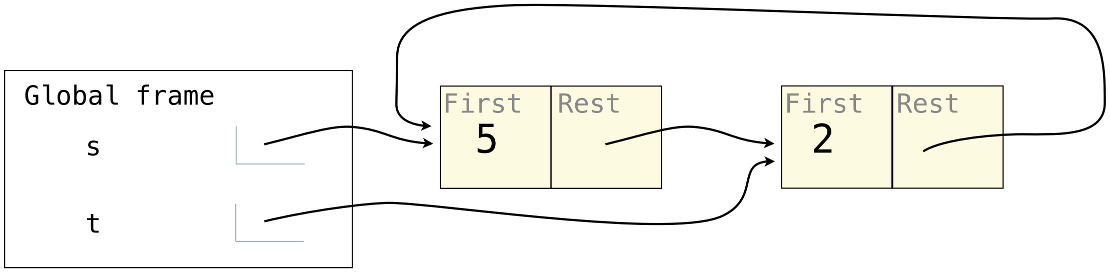
Note: The actual environment diagram is much more complicated.

Recursive Lists Can Change

Attribute assignment statements can change first and rest attributes of a Link

The rest of a linked list can contain the linked list as a sub-list

```
>>> s = Link(1, Link(2, Link(3)))
>>> s.first = 5
>>> t = s.rest
>>> t.rest = s
>>> s.first
5
>>> s.rest.rest.rest.rest.rest.first
2
```



Note: The actual environment diagram is much more complicated.

Trees

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}
```

A: ● ▬

B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

A: ● ▬

B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
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    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

A: ● ▬

B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬

B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
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    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
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    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

```
decode('.', t)
```

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

```
decode('.', t)
```

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬

B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...

?

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
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    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

```
decode('.', t)
```

Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

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    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
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    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

```
decode('.', t)
```

A: ● ▬

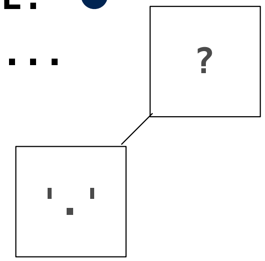
B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

```
decode('.', t)
```

A: ● ▬

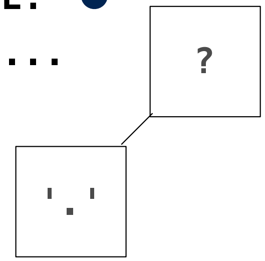
B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
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    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
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    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```
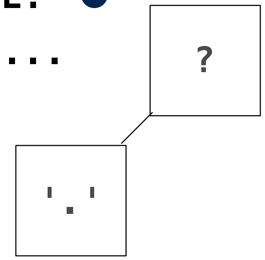

```
def morse(code):
    ....
```

```
decode('.', t)
```



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
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    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

```
decode('.', t)
```

A: ● ▬

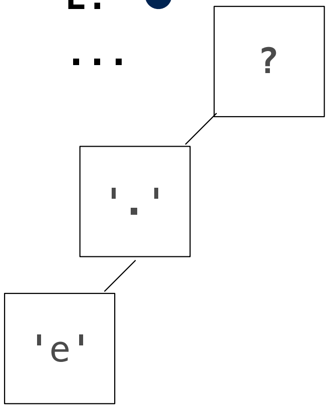
B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

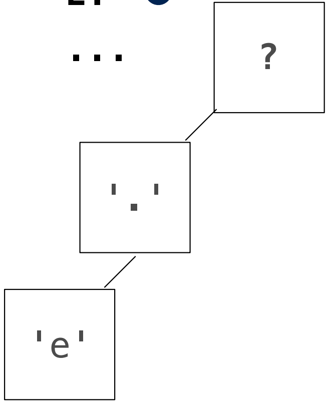
A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

```
abcde = {'a': '.–', 'b': '–...', 'c': '–.–.', 'd': '–..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

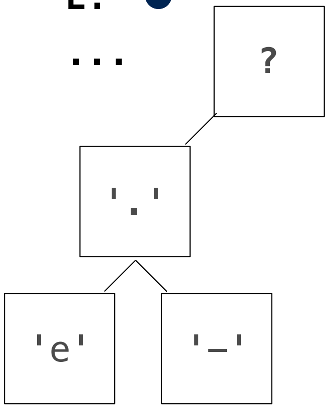
A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
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    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```

A: ● ▬

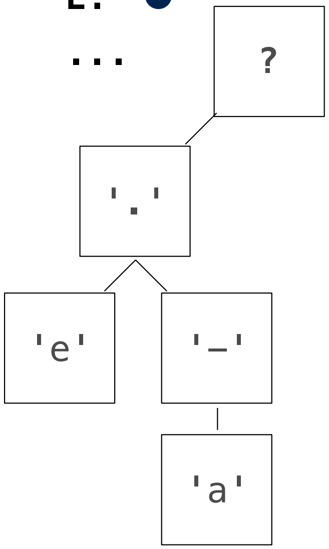
B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

...



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

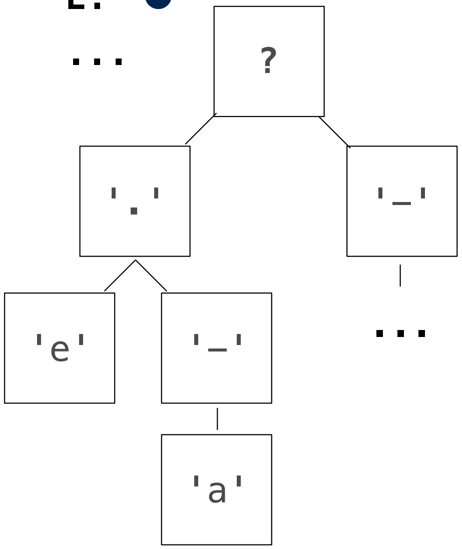
A: ● ▬
B: ▬ ● ● ●
C: ▬ ● ▬ ●
D: ▬ ● ●
E: ●
...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```



Morse Code

Morse code is a signaling protocol that transmits messages by sequences of signals

Problem: Implement **morse** so that **decode** works correctly

A: ● ▬

B: ▬ ● ● ●

C: ▬ ● ▬ ●

D: ▬ ● ●

E: ●

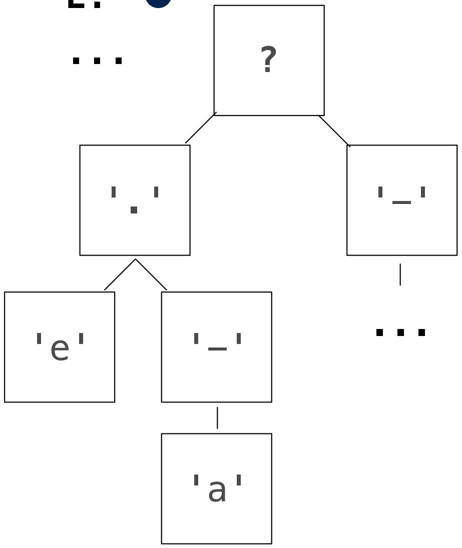
...

```
abcde = {'a': '.-', 'b': '-...', 'c': '-.-.', 'd': '-..', 'e': '.'}

def decode(signals, tree):
    """Decode signals into a letter.

    >>> t = morse(abcde)
    >>> [decode(s, t) for s in ['-..', '.', '-.-.', '.-', '-..', '.']]
    ['d', 'e', 'c', 'a', 'd', 'e']
    """
    for signal in signals:
        tree = [b for b in tree.branches if b.label == signal][0]
    leaves = [b for b in tree.branches if b.is_leaf()]
    assert len(leaves) == 1
    return leaves[0].label
```

```
def morse(code):
    ....
```



(Demo)