Mutable Values

Announcements

Objects

(Demo)

Objects

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  - All **objects** have **attributes**
  - A lot of data manipulation happens through object **methods**
  - Functions do one thing; objects do many related things

Example: Strings

(Demo)

Representing Strings: the ASCII Standard

American Standard Code for Information Interchange

ASCII Code Chart

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DEL

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2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
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0 1 0	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0 1 1	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
1 0 0	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 0 1	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
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0 1 0	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0 1 1	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
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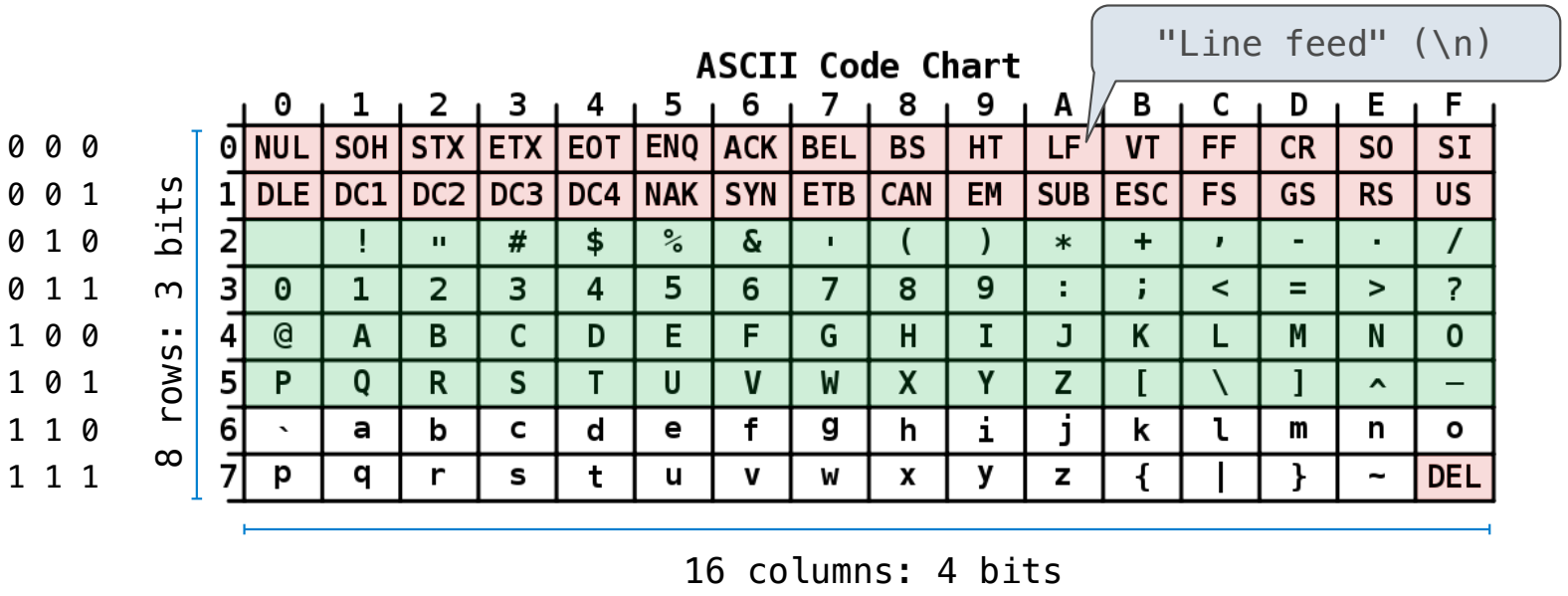

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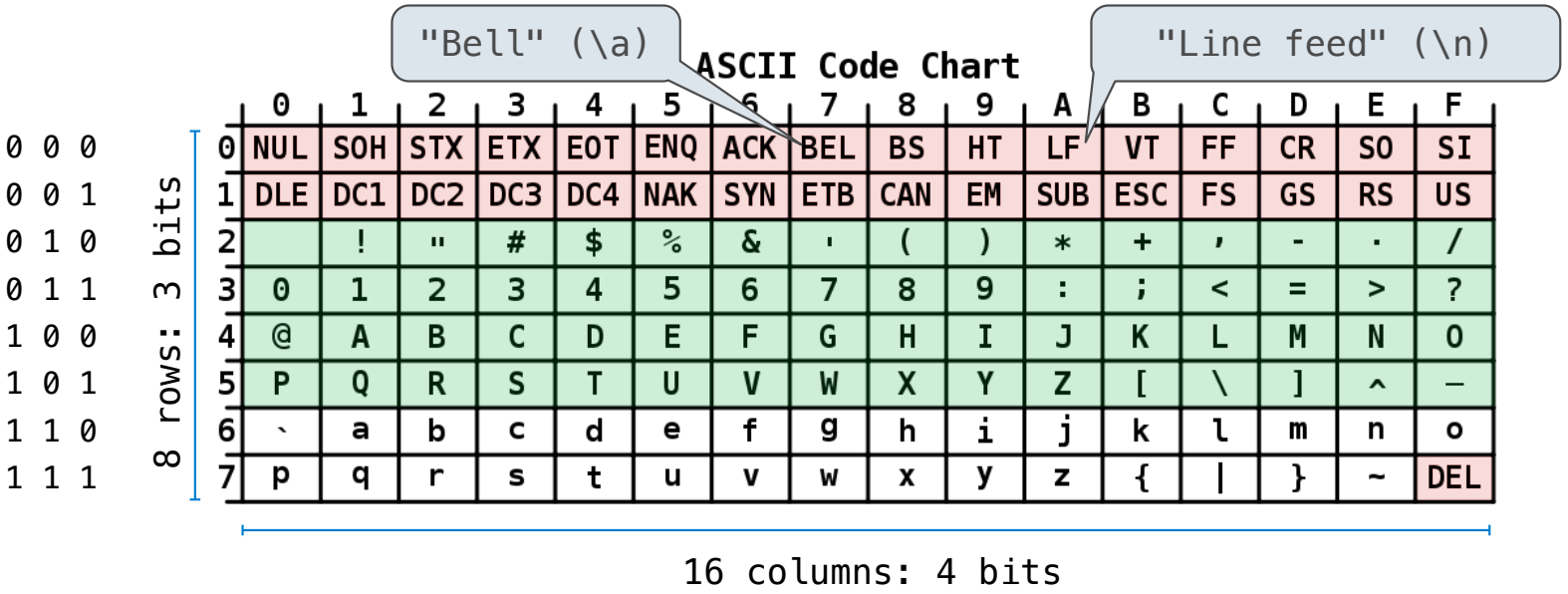

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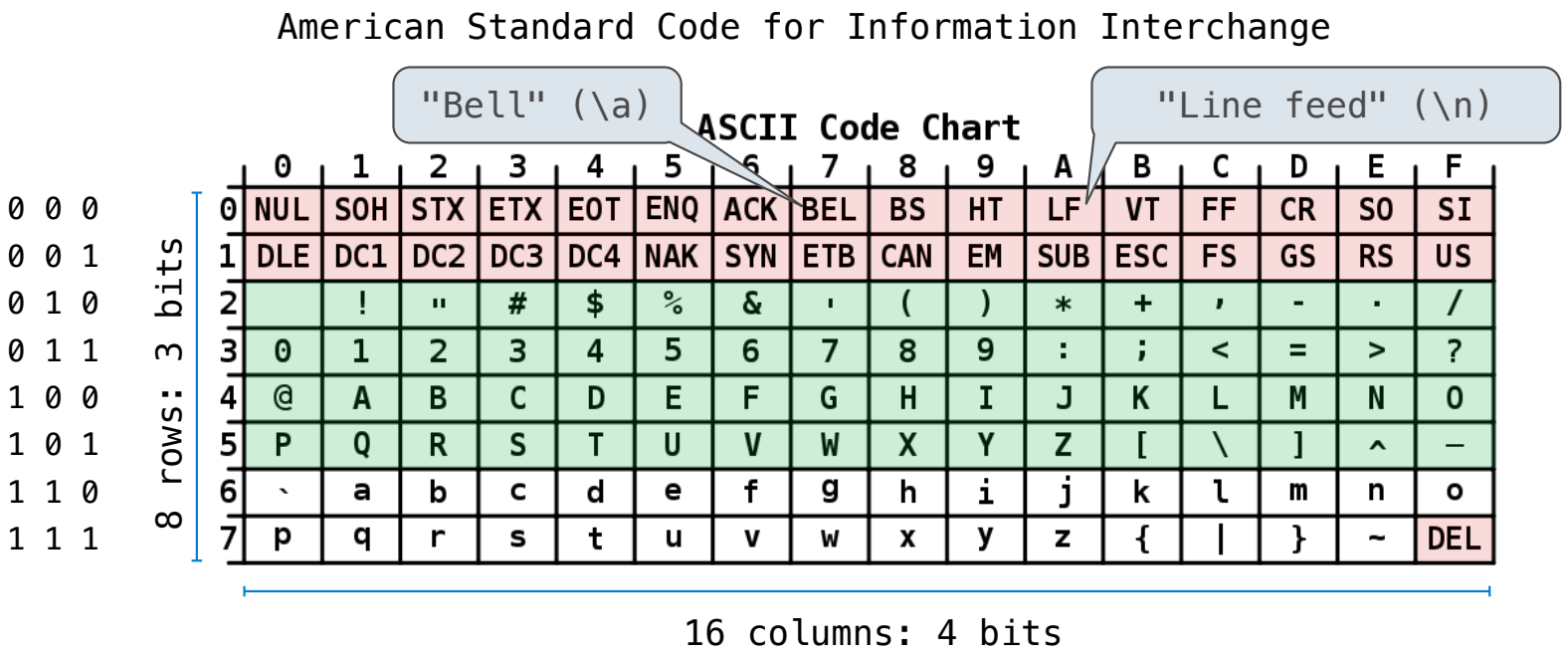

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(Demo)

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http://ian-albert.com/unicode_chart/unichart-chinese.jpg

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LATIN CAPITAL LETTER A

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DIE FACE-6

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EIGHTH NOTE
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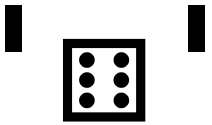

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EIGHTH NOTE

(Demo)

Mutation Operations

Some Objects Can Change

[Demo]

Some Objects Can Change

[Demo]

First example in the course of an object changing state

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[Demo]

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The same object can change in value throughout the course of computation

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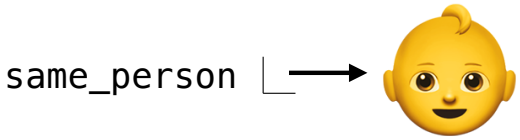

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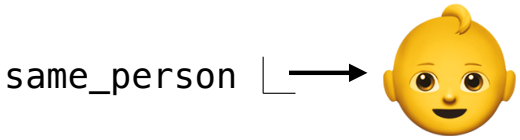

BABY

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[Demo]

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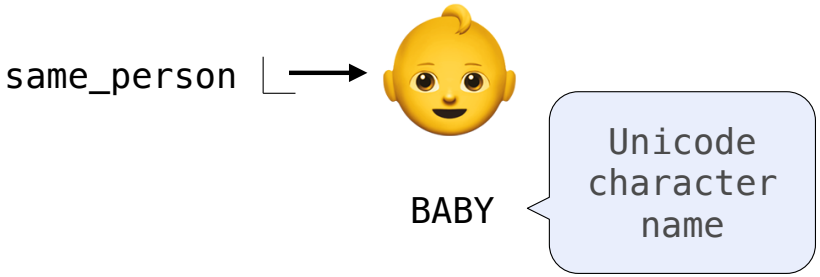

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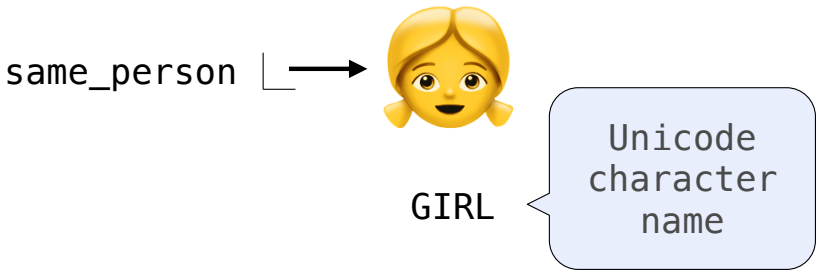

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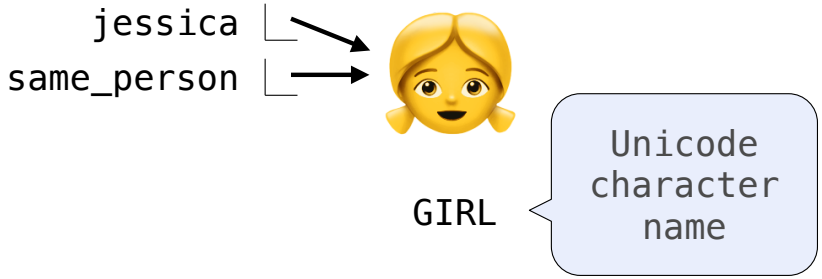

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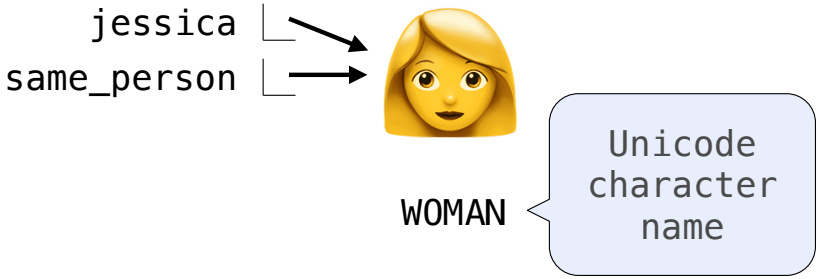

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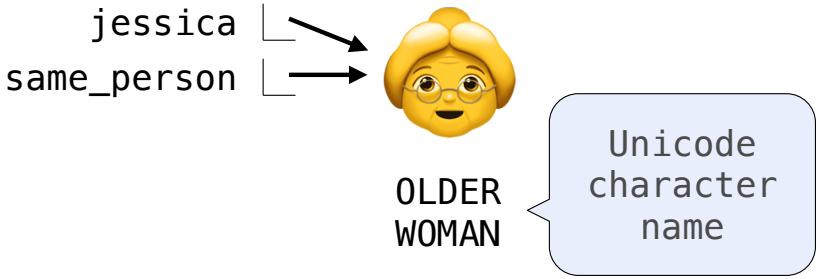

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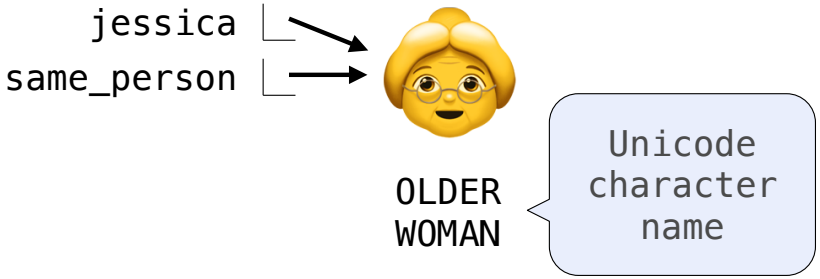

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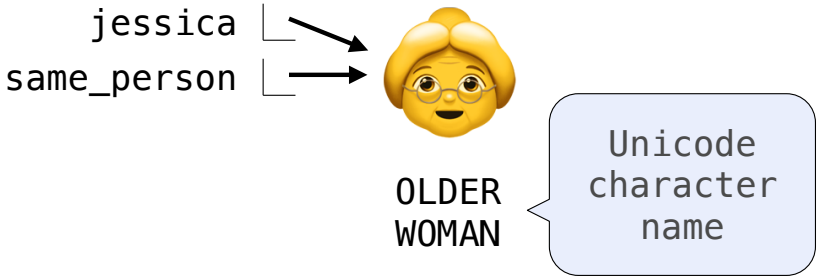

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Only objects of *mutable* types can change: lists & dictionaries

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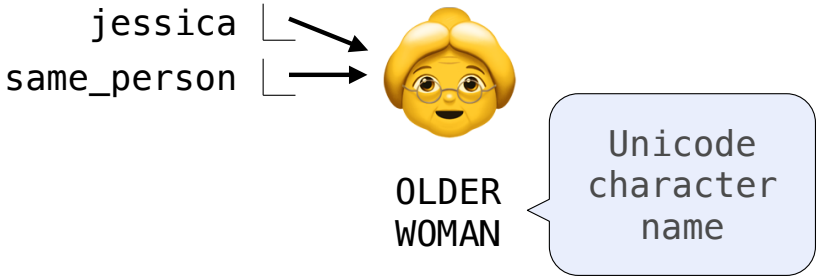
[Demo]

First example in the course of an object changing state

The same object can change in value throughout the course of computation



All names that refer to the same object are affected by a mutation

Only objects of *mutable* types can change: lists & dictionaries

{Demo}

Mutation Can Happen Within a Function Call

A function can change the value of any object in its scope

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>>> four = [1, 2, 3, 4]
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>>> four = [1, 2, 3, 4]
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>>> four = [1, 2, 3, 4]
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```
def mystery(s):
    s.pop()
    s.pop()
```


pythontutor.com/composingprograms.html#code=def%20mystery%28s%29%3A%0A%20%20%20%20s.pop%28%29%0A%20%20%20%20s.pop%28%29%0A%0Afour%20%3D%20[1,%202,%203,%204]%0Amystery%28four%29&mode=display&origin=composingprograms.js&cumulative=true&py=3&rawInputLstJSON=[]&curInstr=0

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Tuples

(Demo)

Tuples are Immutable Sequences

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>>> s
([4, 2], 3)
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Mutation

Sameness and Change

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```
>>> a = [10]
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```
>>> a = [10]
>>> b = a
```

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>>> a = [10]
>>> b = a
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(Demo)

Mutable Default Arguments are Dangerous

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>>> def f(s=[]):
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>>> f()
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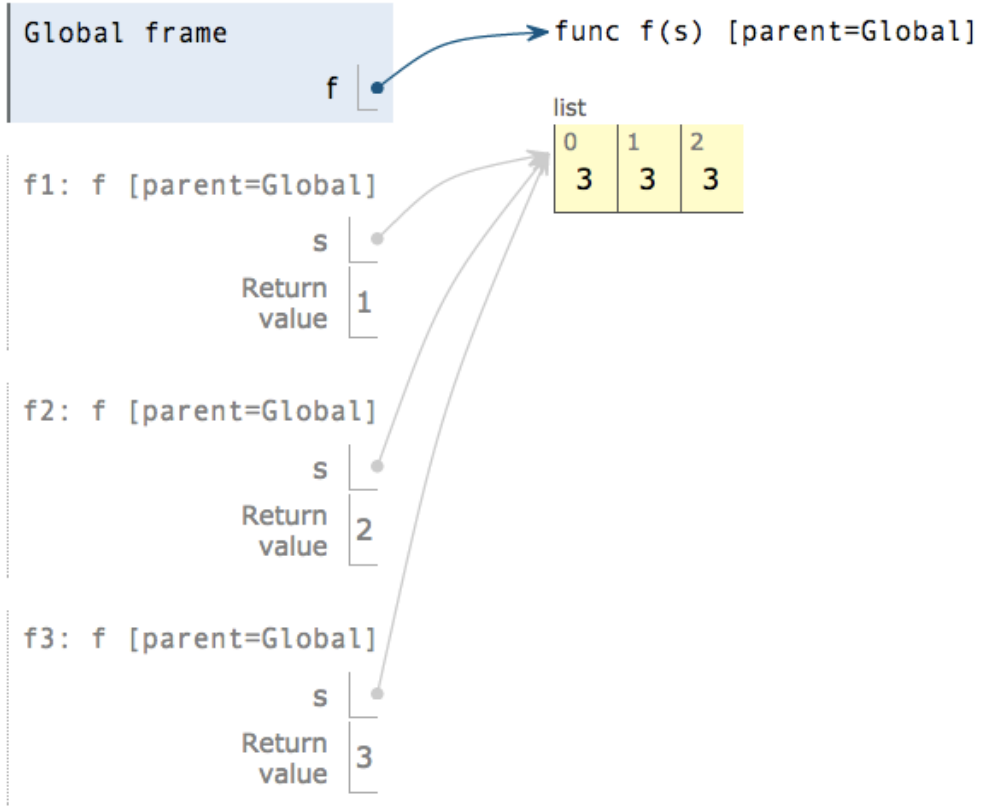

pythontutor.com/composingprograms.html#code=def%20f%28s%3D[]%29%3A%0A%20%20%20%20s.append%283%29%0A%20%20%20%20return%20len%28s%29%0A%20%20%20%20%0Af%28%29%0Af%28%29%0Af%28%29&mode=display&origin=composingprograms.js&cumulative=true&py=3&rawInputLstJSON=[]&curInstr=0

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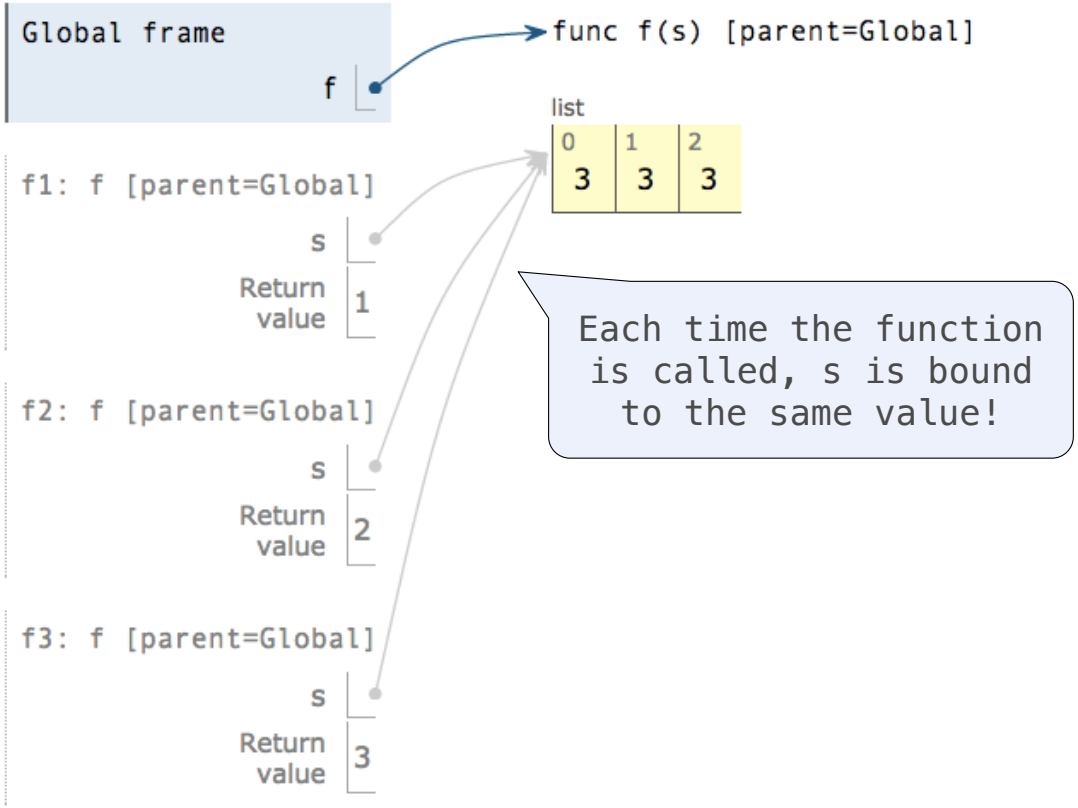

Lists

Lists in Environment Diagrams

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Assume that before each example below we execute:

```
s = [2, 3]
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Operation	Example	Result
append adds one element to a list		

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Assume that before each example below we execute:

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Operation	Example	Result
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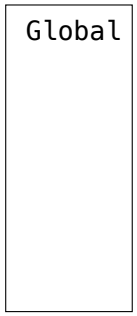

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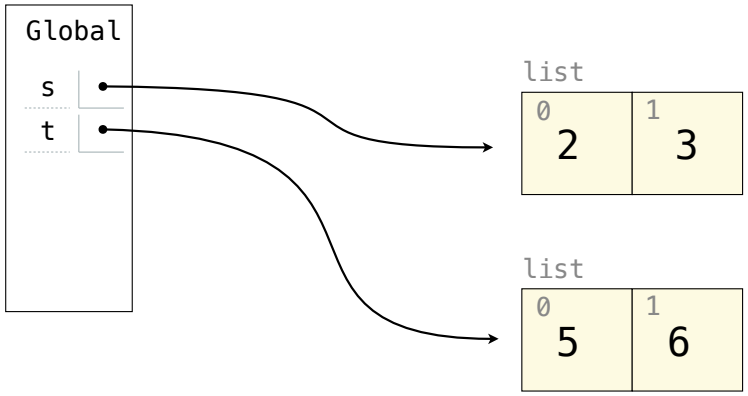

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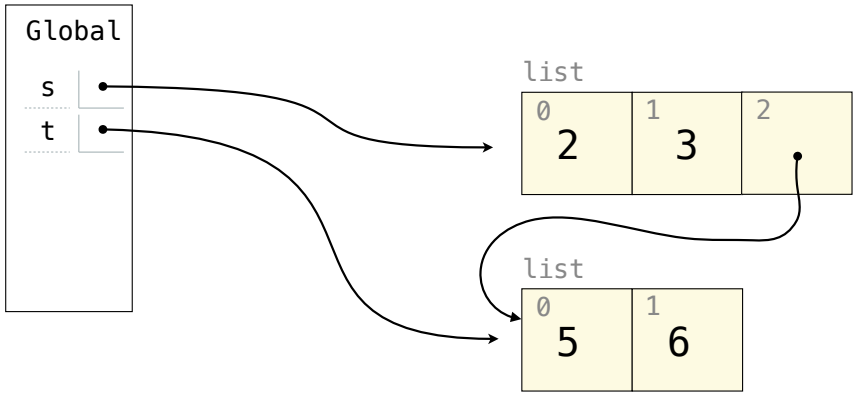

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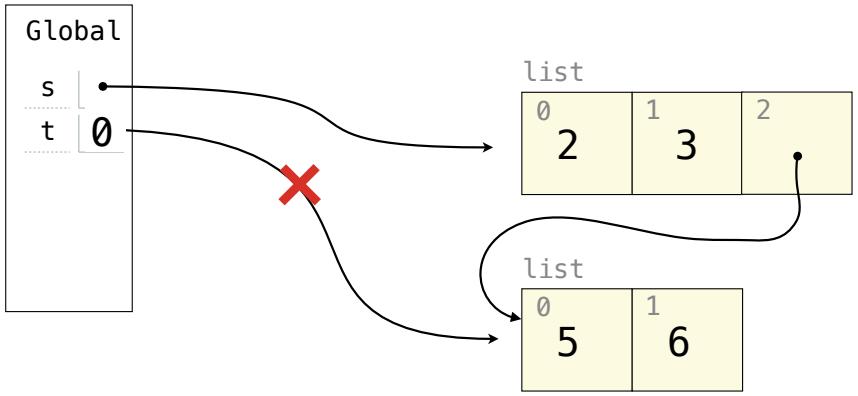

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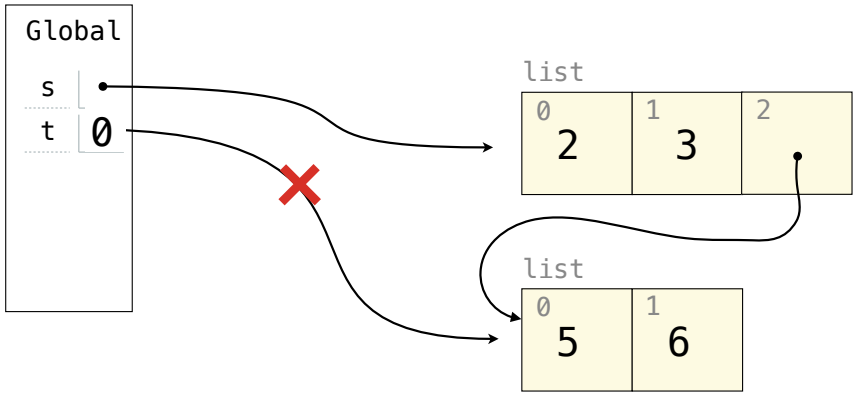

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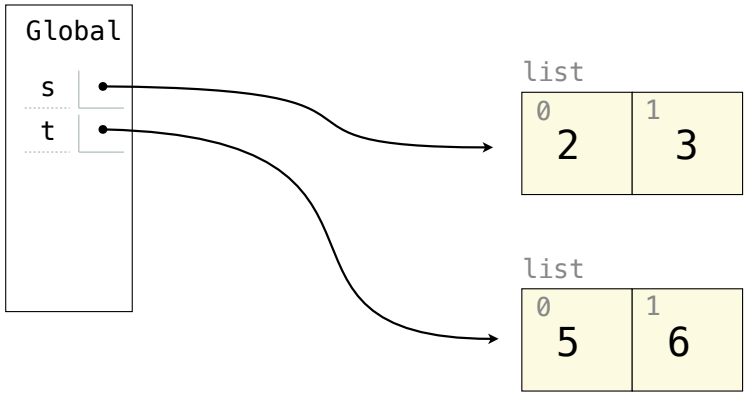

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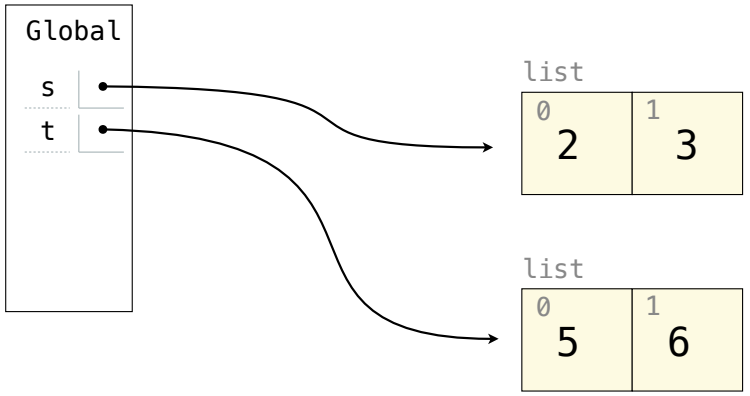

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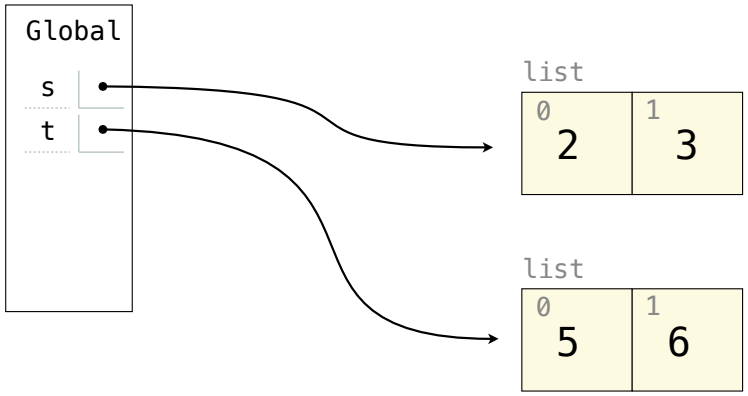

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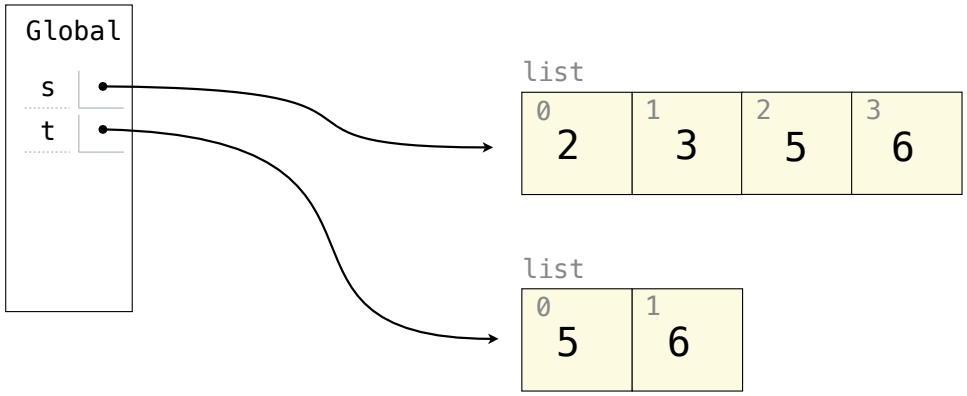

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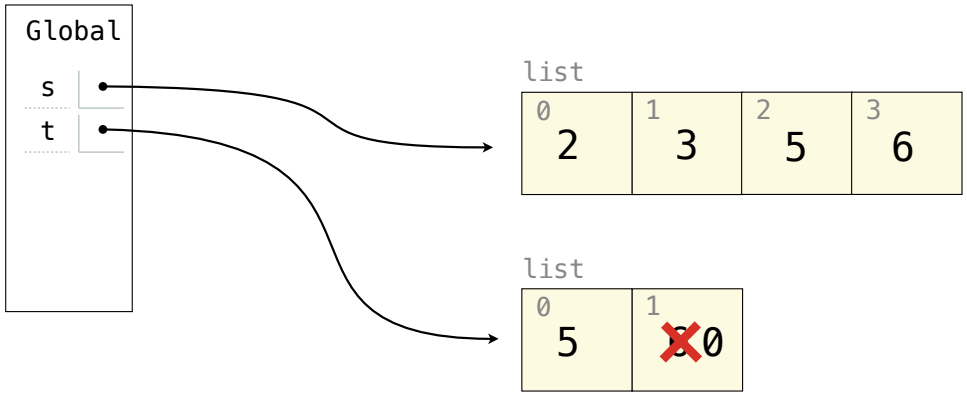

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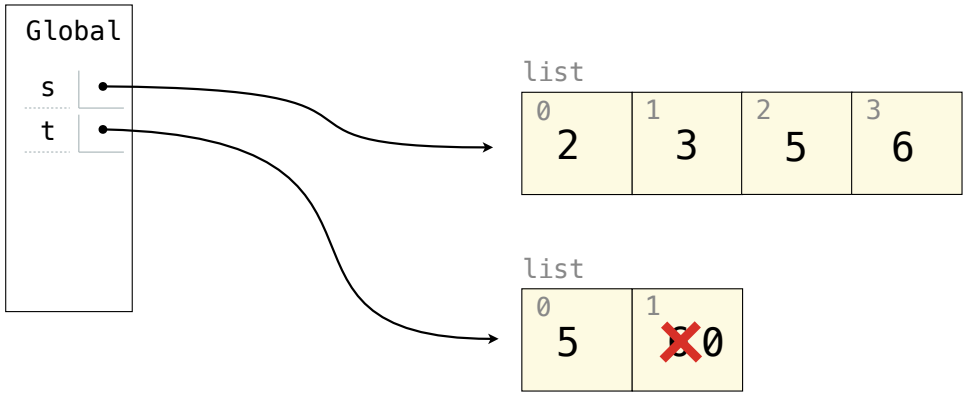

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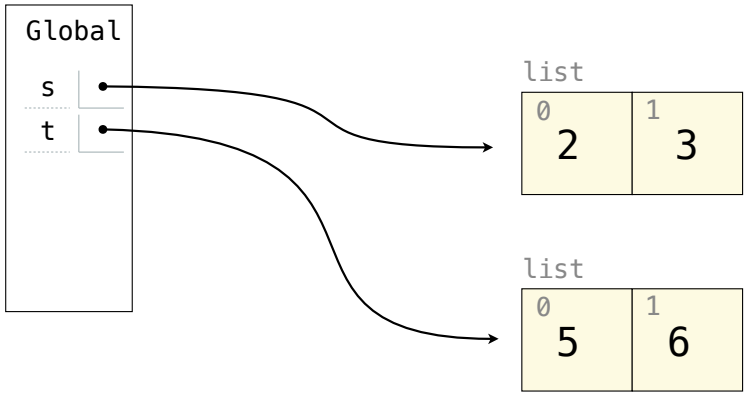

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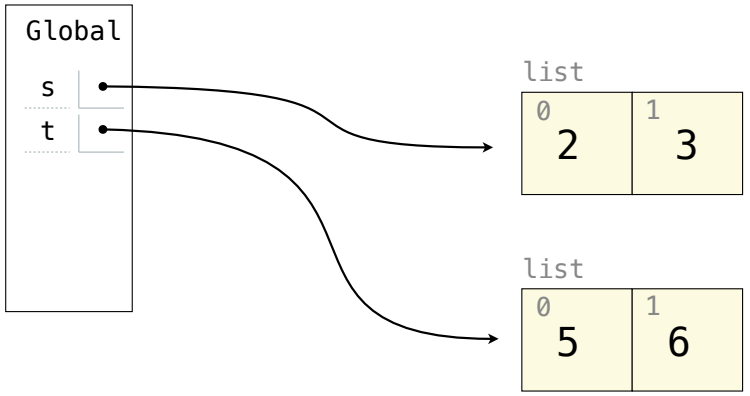

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	`b = a[1:]`
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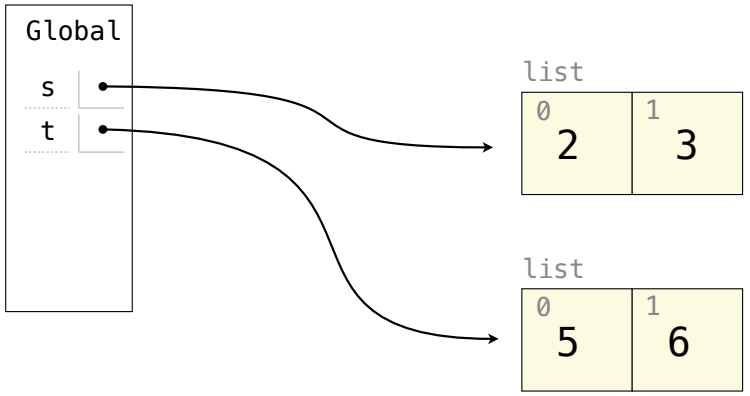

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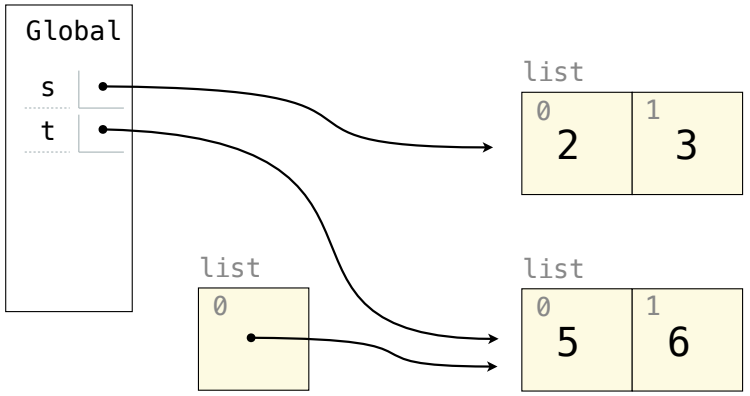

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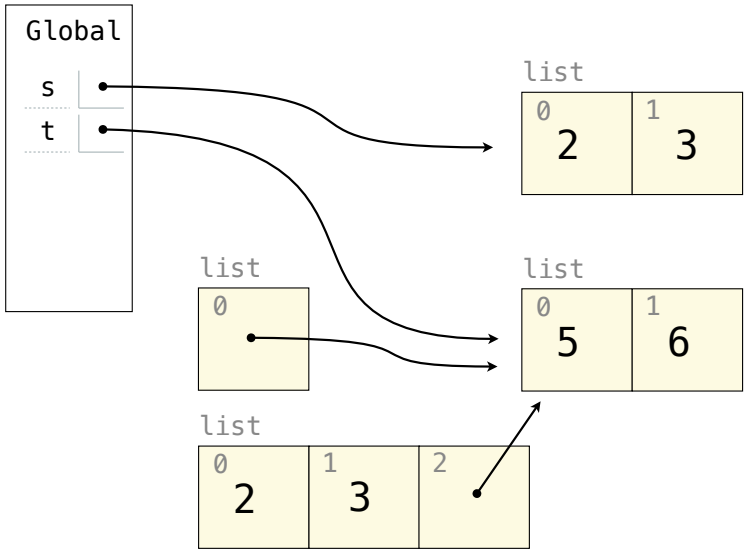

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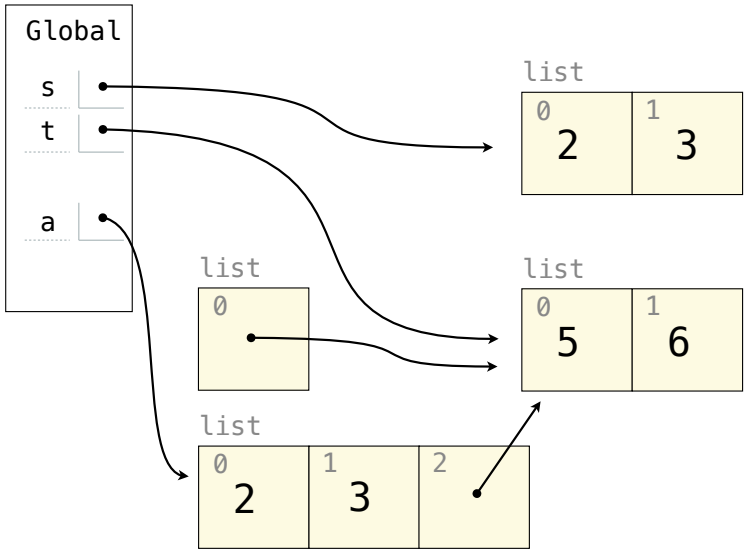
append adds one element to a list	`s.append(t)` `t = 0`	`s → [2, 3, [5, 6]]` `t → 0`
extend adds all elements in one list to another list	`s.extend(t)` `t[1] = 0`	`s → [2, 3, 5, 6]` `t → [5, 0]`

addition & **slicing** create new lists containing existing elements	`a = s + [t]`
	`b = a[1:]`
	`a[1] = 9`
	`b[1][1] = 0`	



Lists in Environment Diagrams

Assume that before each example below we execute:

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t = [5, 6]
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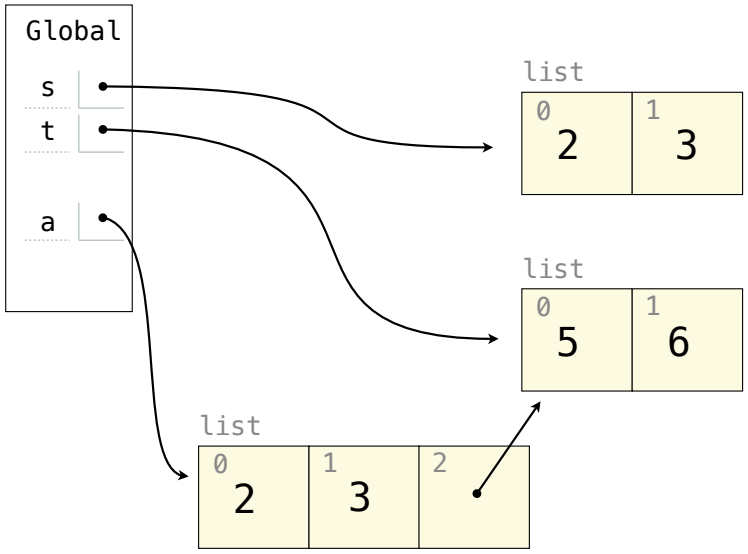

Lists in Environment Diagrams

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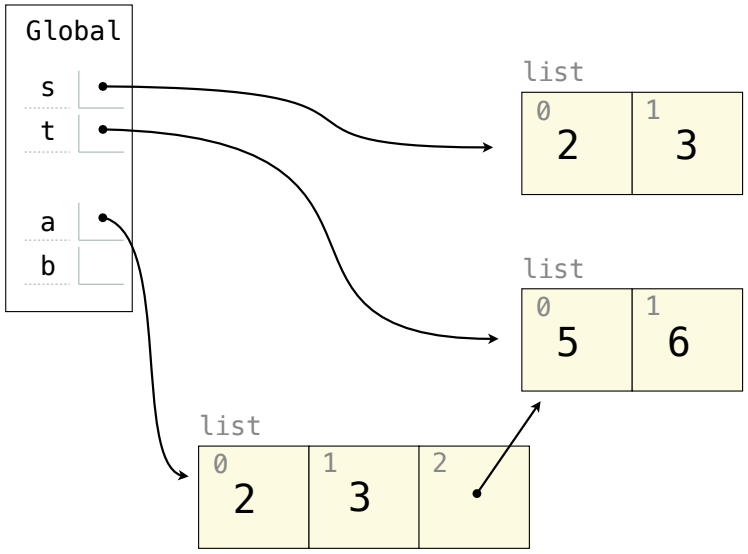

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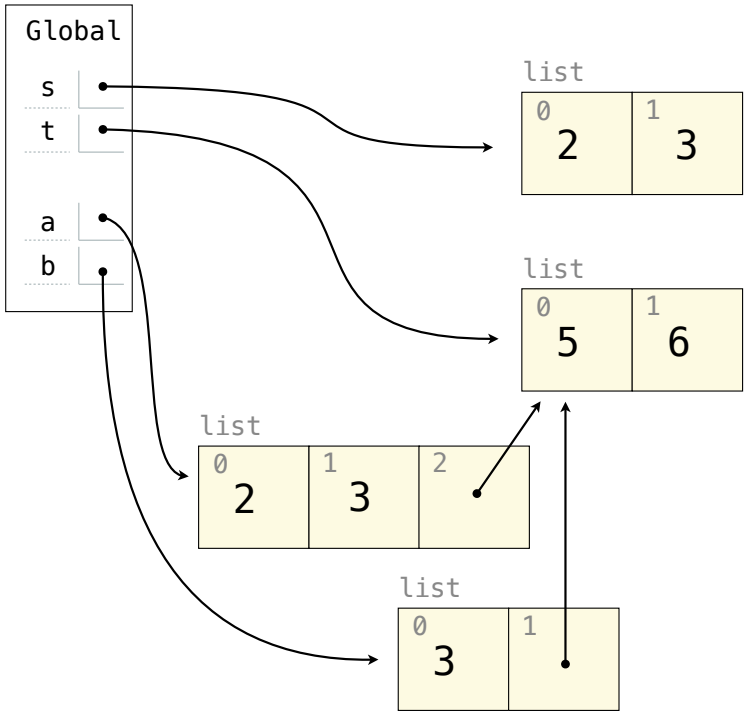

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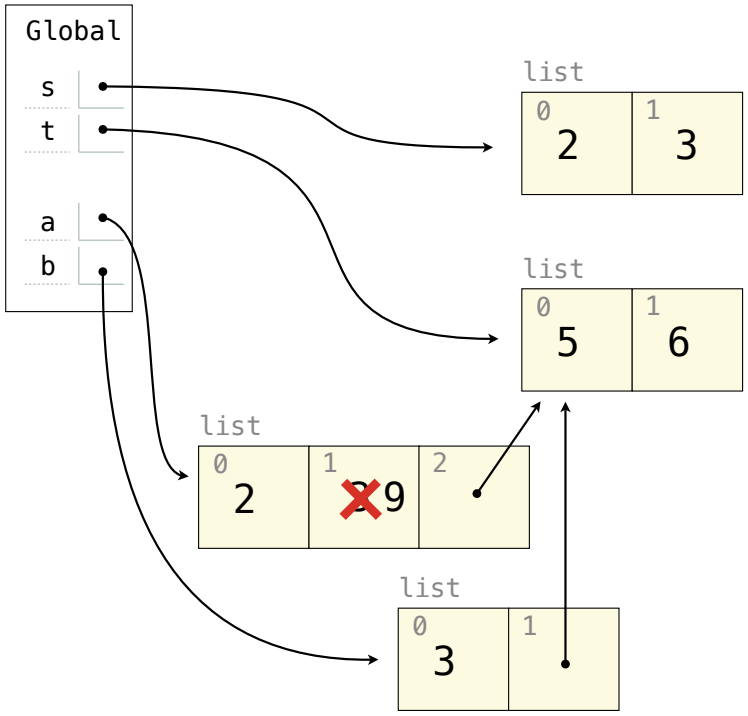

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t = [5, 6]
```

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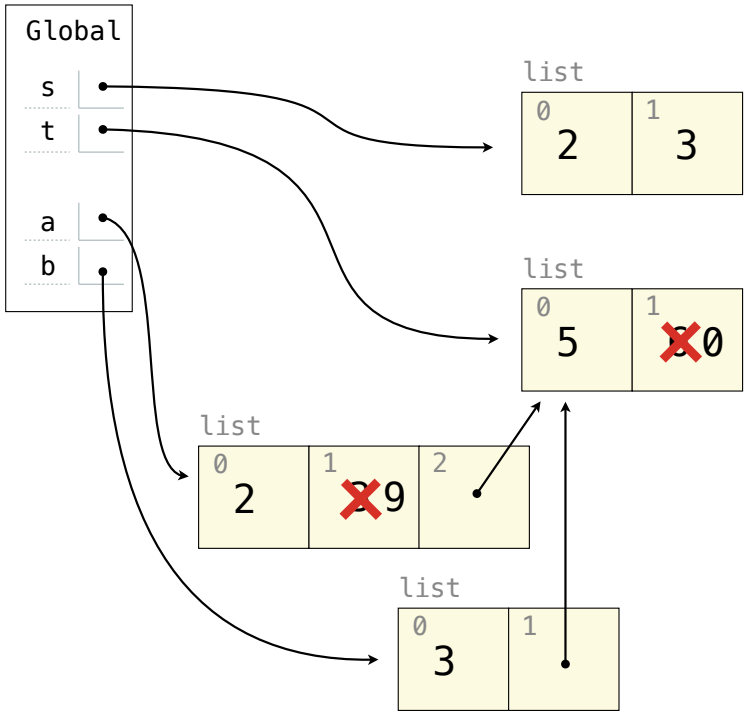

Lists in Environment Diagrams

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t = [5, 6]
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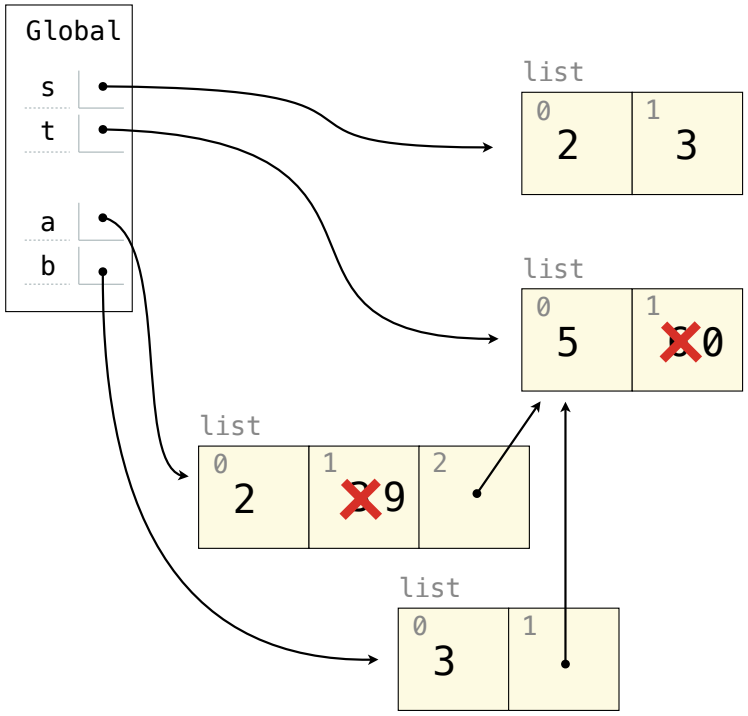
Operation	Example	Result
append adds one element to a list	s.append(t) t = 0	s → [2, 3, [5, 6]] t → 0
extend adds all elements in one list to another list	s.extend(t) t[1] = 0	s → [2, 3, 5, 6] t → [5, 0]
addition & **slicing** create new lists containing existing elements	a = s + [t] b = a[1:] a[1] = 9 b[1][1] = 0	s → [2, 3] t → [5, 0] a → [2, 9, [5, 0]] b → [3, [5, 0]]



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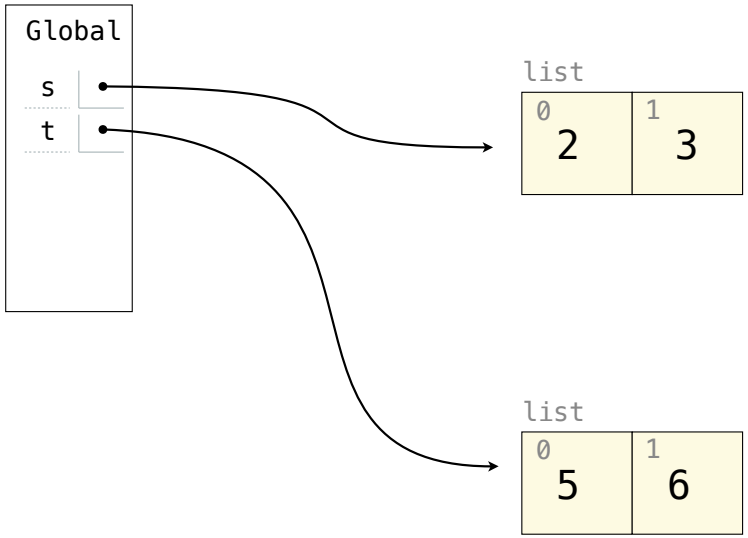
The **list** function also creates a new list containing existing elements	`t = list(s)` `s[1] = 0`	



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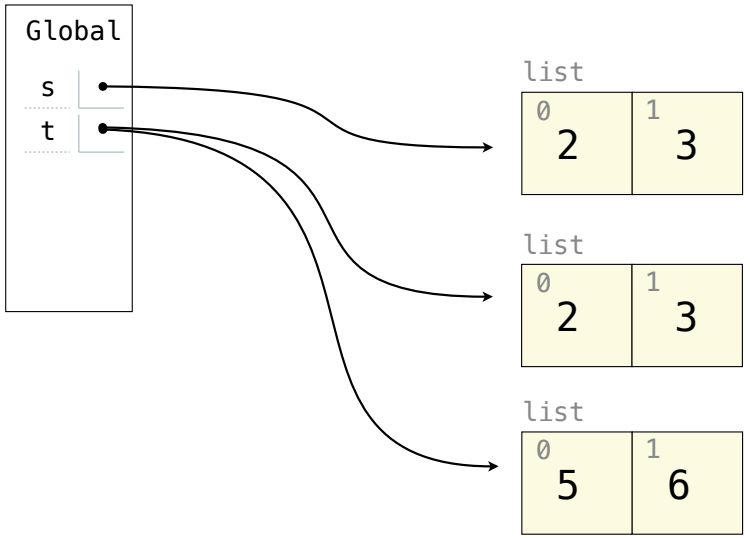

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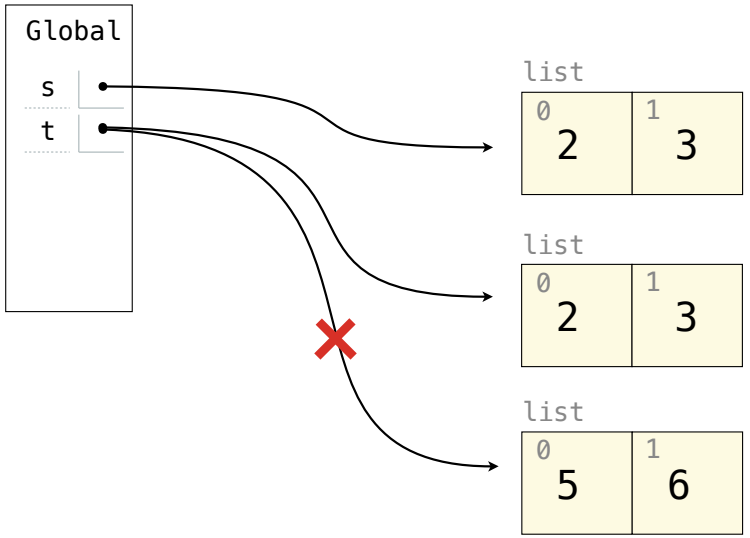

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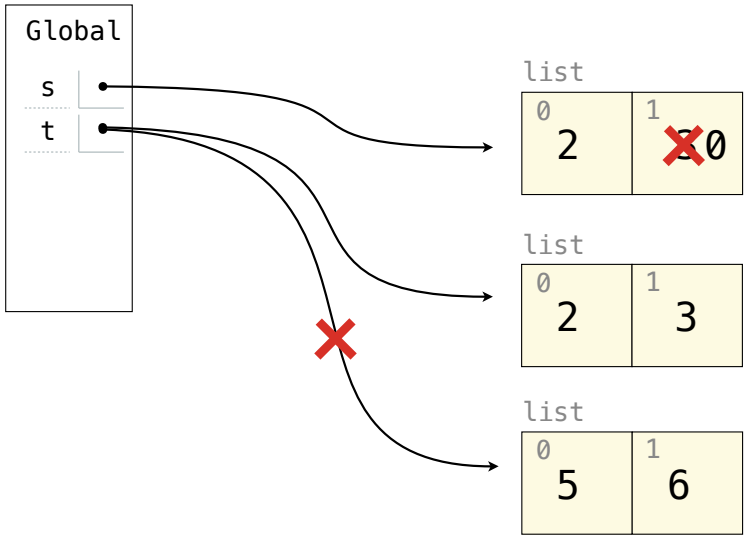

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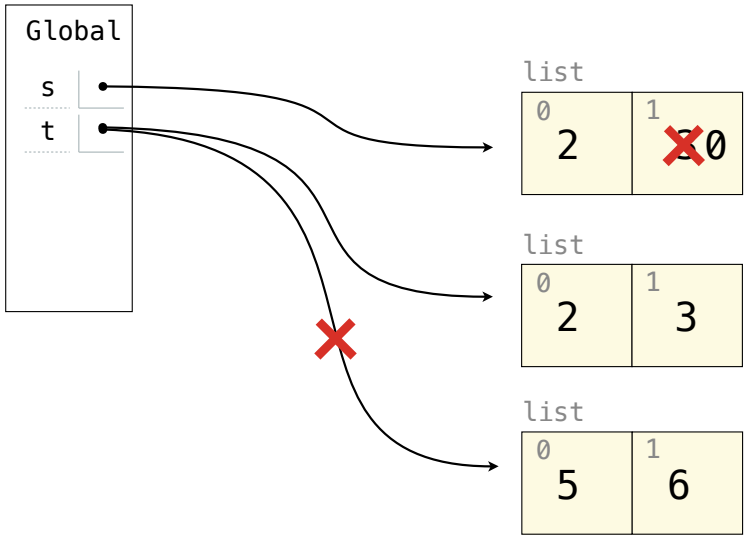

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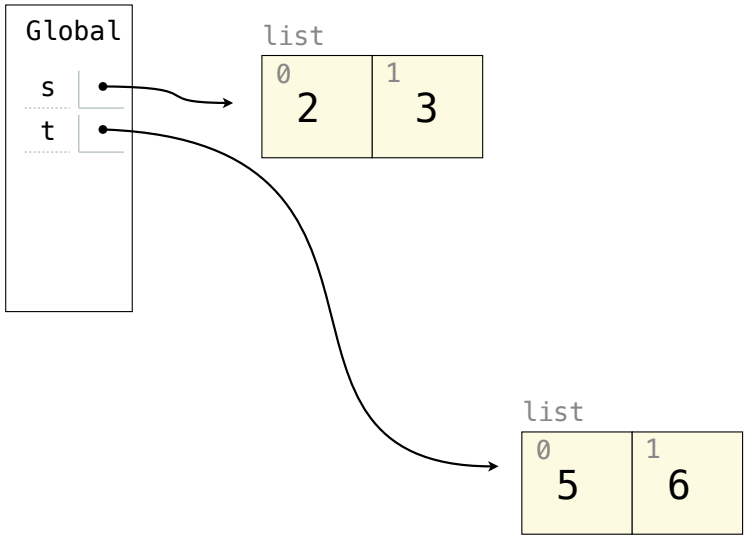

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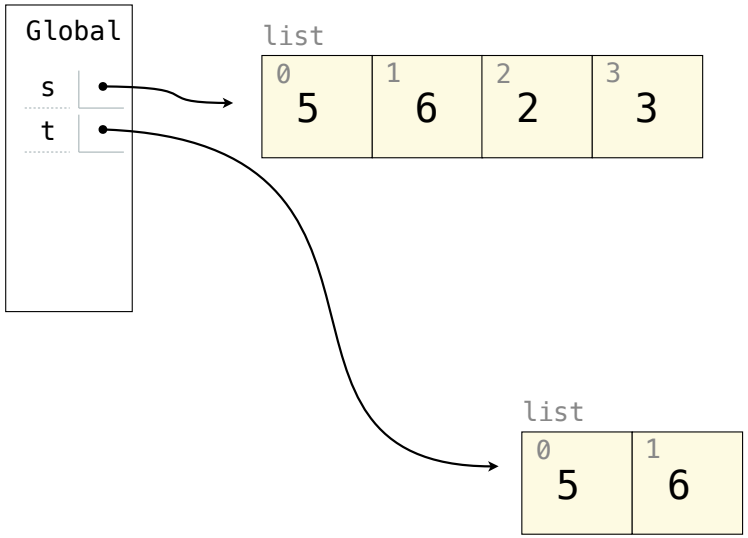

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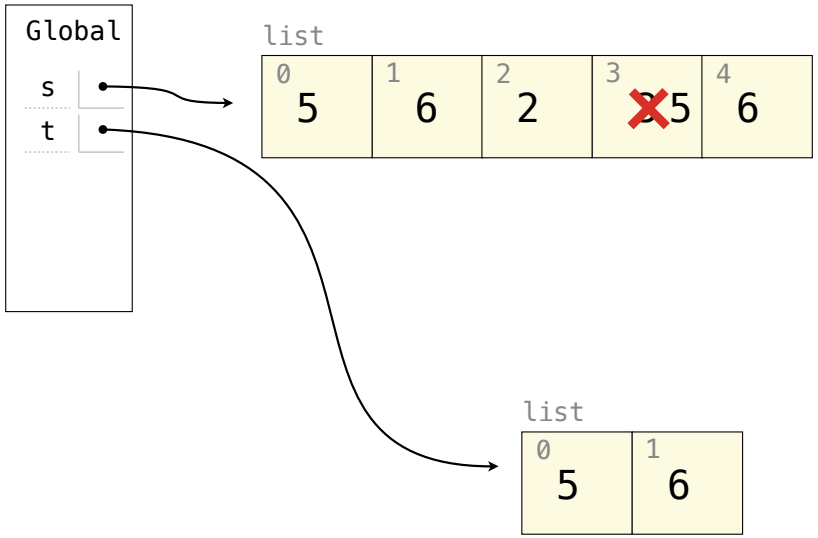

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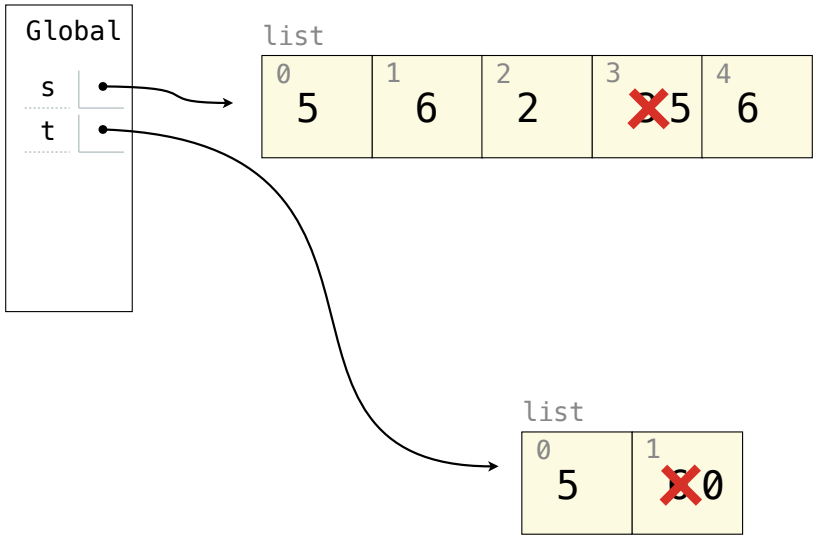

Lists in Environment Diagrams

Assume that before each example below we execute:

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Operation	Example	Result
append adds one element to a list	`s.append(t)` `t = 0`	`s → [2, 3, [5, 6]]` `t → 0`
extend adds all elements in one list to another list	`s.extend(t)` `t[1] = 0`	`s → [2, 3, 5, 6]` `t → [5, 0]`

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		`a → [2, 9, [5, 0]]`
		`b → [3, [5, 0]]`

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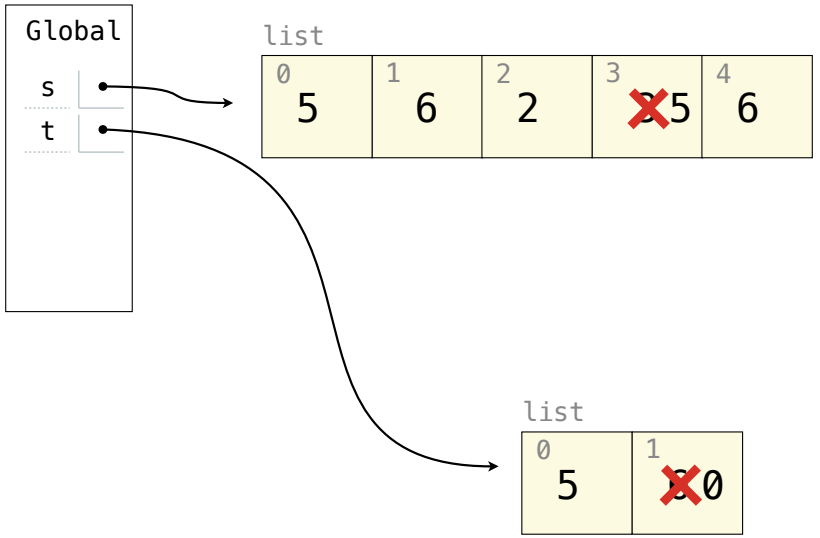
slice assignment replaces a slice with new values	`s[0:0] = t`
	`s[3:] = t`
	`t[1] = 0`
		`s → [5, 6, 2, 5, 6]`
		`t → [5, 0]`



Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Lists in Environment Diagrams

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```
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```

Operation	Example	Result

Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
pop removes & returns the last element		

Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
pop removes & returns the last element	t = s.pop()	

Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
pop removes & returns the last element	t = s.pop()	s → [2] t → 3

Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
pop removes & returns the last element	t = s.pop()	s → [2] t → 3
remove removes the first element equal to the argument		

Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
pop removes & returns the last element	`t = s.pop()`	`s → [2]` `t → 3`
remove removes the first element equal to the argument	`t.extend(t)` `t.remove(5)`	

Lists in Environment Diagrams

Assume that before each example below we execute:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
pop removes & returns the last element	`t = s.pop()`	`s → [2]` `t → 3`
remove removes the first element equal to the argument	`t.extend(t)` `t.remove(5)`	`s → [2, 3]` `t → [6, 5, 6]`

Lists in Environment Diagrams

Assume that before each example below we execute:

```
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Operation	Example	Result
pop removes & returns the last element	`t = s.pop()`	`s → [2]` `t → 3`
remove removes the first element equal to the argument	`t.extend(t)` `t.remove(5)`	`s → [2, 3]` `t → [6, 5, 6]`
slice assignment can remove elements from a list by assigning [] to a slice.		

Lists in Environment Diagrams

Assume that before each example below we execute:

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s = [2, 3]
t = [5, 6]
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Operation	Example	Result
pop removes & returns the last element	`t = s.pop()`	`s → [2]` `t → 3`
remove removes the first element equal to the argument	`t.extend(t)` `t.remove(5)`	`s → [2, 3]` `t → [6, 5, 6]`
slice assignment can remove elements from a list by assigning [] to a slice.	`s[:1] = []` `t[0:2] = []`	

Lists in Environment Diagrams

Assume that before each example below we execute:

```
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```

Operation	Example	Result
pop removes & returns the last element	`t = s.pop()`	`s → [2]` `t → 3`
remove removes the first element equal to the argument	`t.extend(t)` `t.remove(5)`	`s → [2, 3]` `t → [6, 5, 6]`
slice assignment can remove elements from a list by assigning [] to a slice.	`s[:1] = []` `t[0:2] = []`	`s → [3]` `t → []`

Lists in Lists in Lists in Environment Diagrams

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

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

Lists in Lists in Lists in Environment Diagrams

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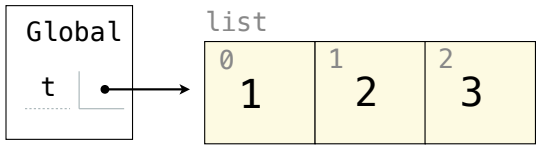

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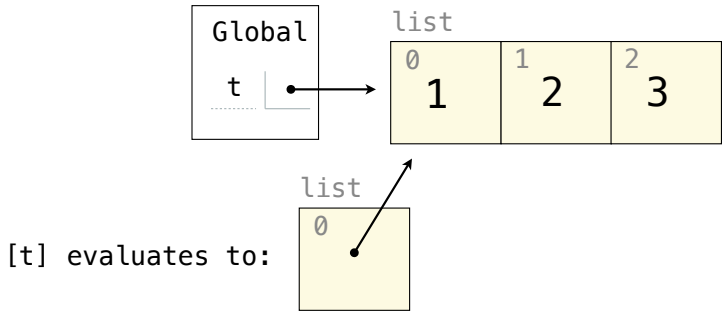

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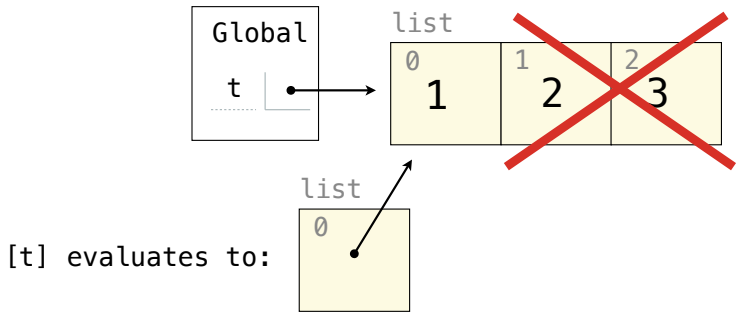

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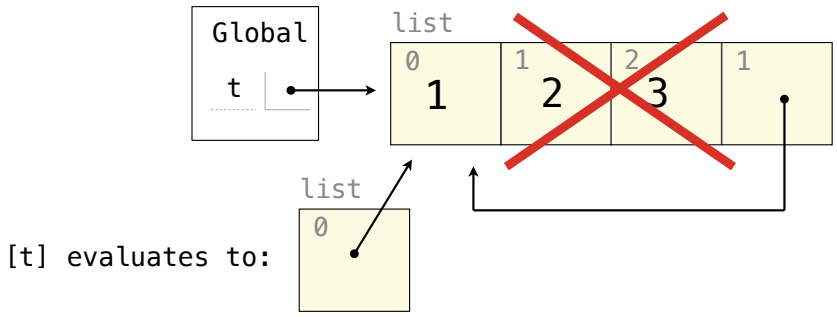

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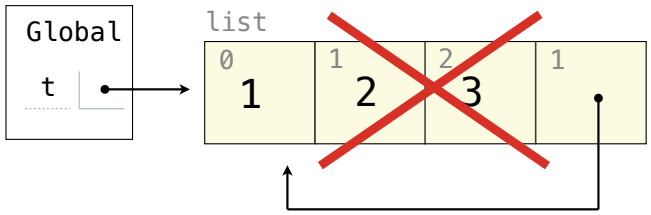

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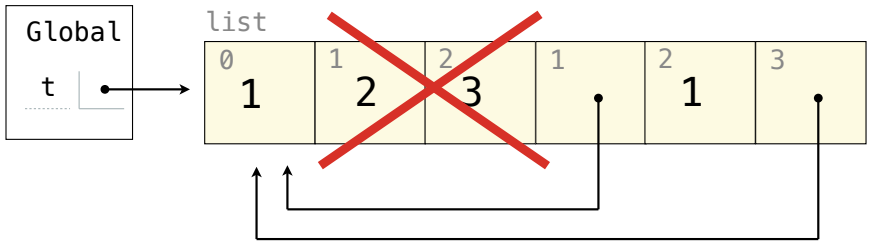

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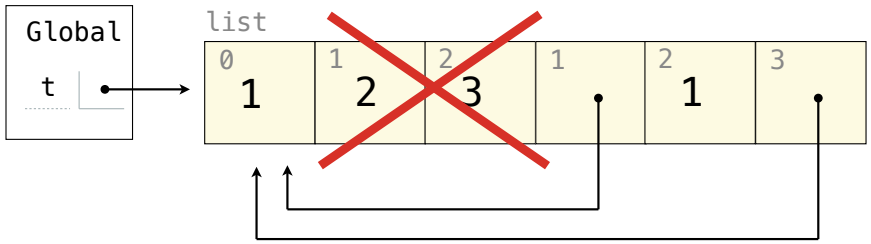


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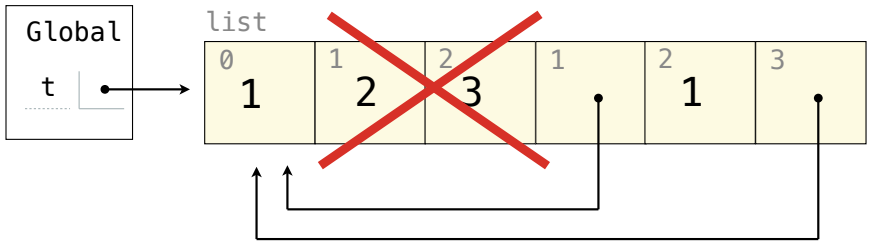


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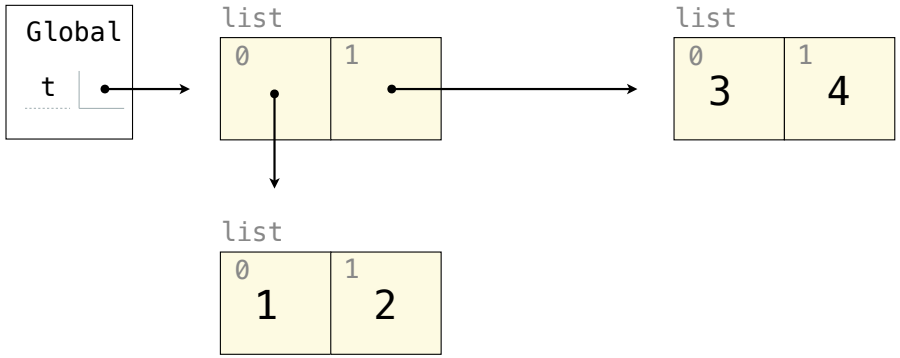

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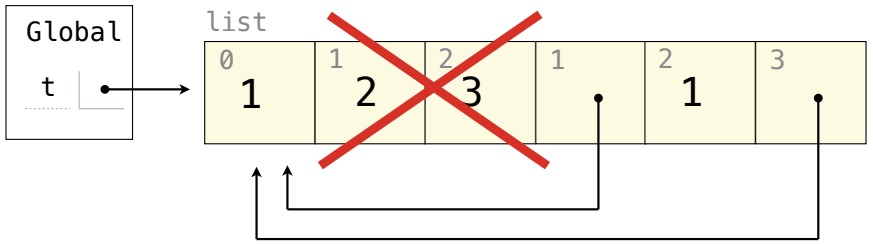


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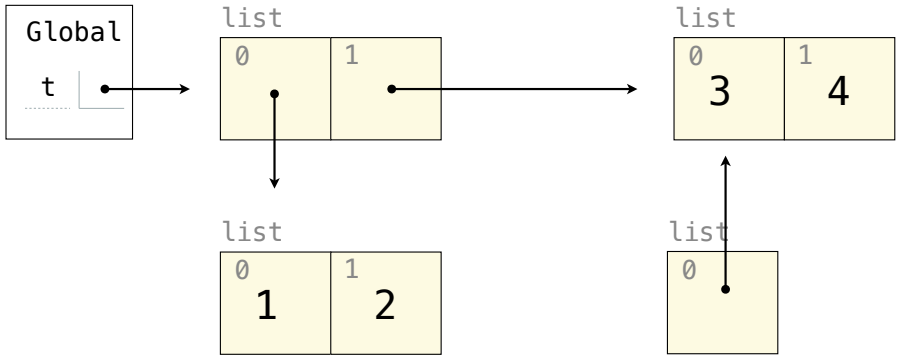

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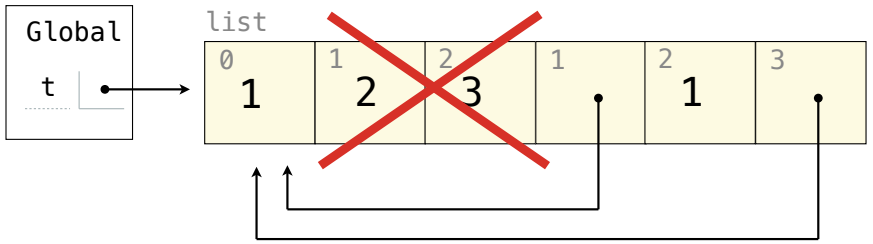


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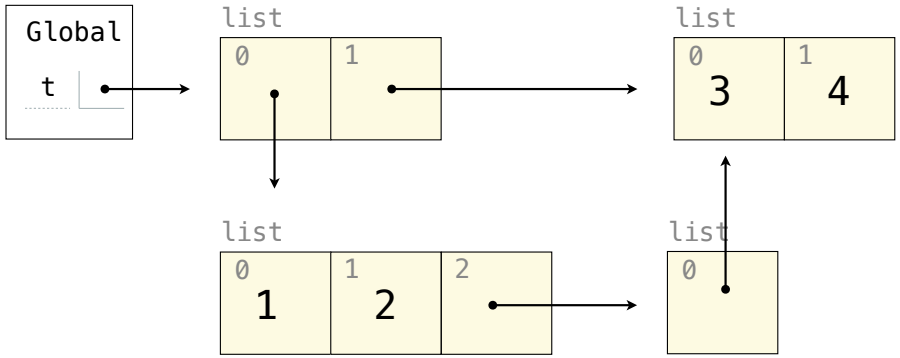

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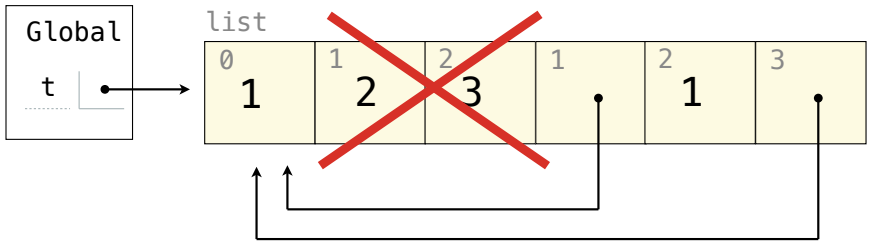


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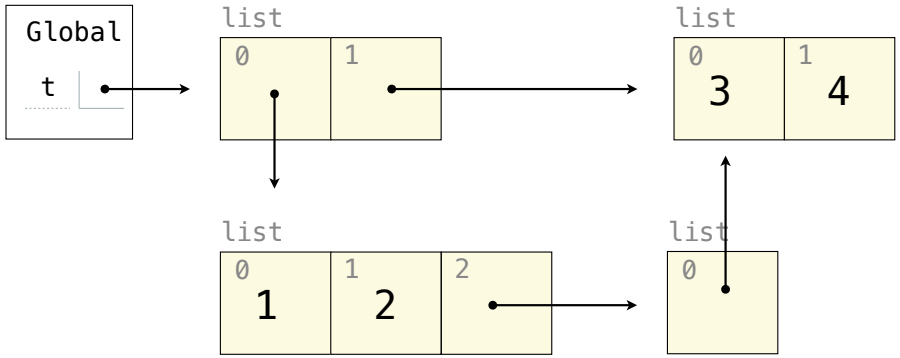


```
[[1, 2, [[3, 4]]], [3, 4]]
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