CS134 Lecture 14:
Tuples and Sets

Announcements & Logistics

- **HW 6** will be released today and due Mon @ 10 pm
  - Short HW (only 5 questions)
  - Covers topics this week (mutability, aliasing, scope, tuples, sets)
- **Lab 4 Part 2** due Wednesday/Thursday 10pm
- **Midterm reminders:**
  - **Review:** **Monday 3/11** from 7-9pm
  - **Exam** **Thurs 3/14** from 6-7:30pm OR 8-9:30pm
  - Both exam and review are in Bronfman Auditorium
  - Exam only includes material up to HW 6

Do You Have Any Questions?

Last Time: Aliasing

- **Scope**: variables, functions, objects have limited accessibility/visibility.
  - Understanding how this works helps us make decisions about where to define variables/functions/objects

Goal was to demystify surprising behavior: nothing in computer science is magic!

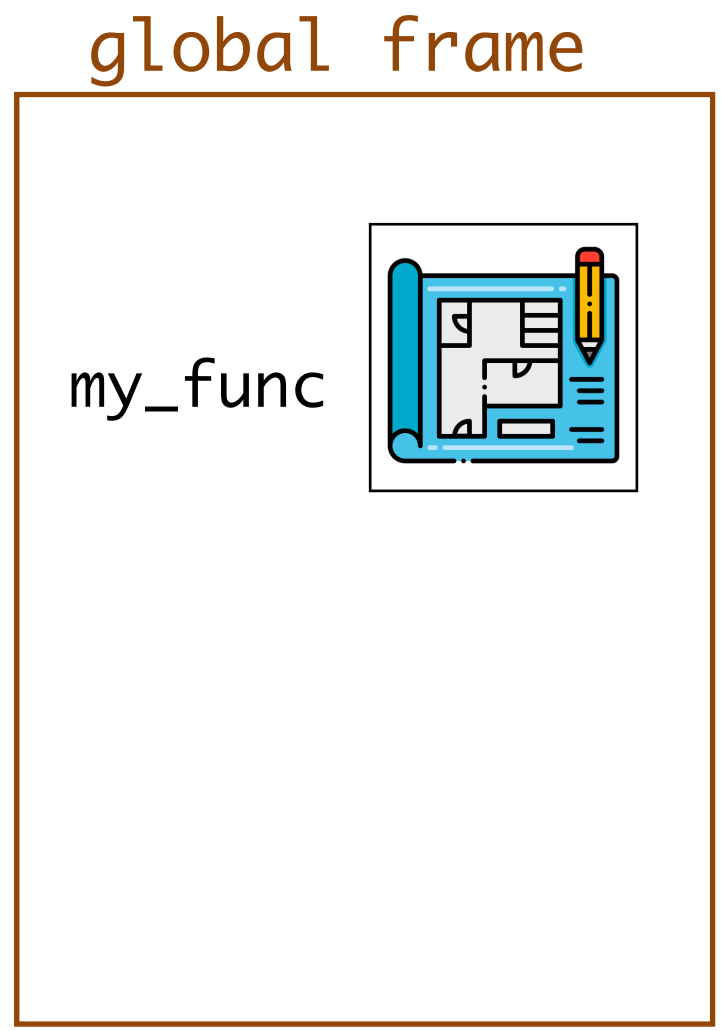
Today's Plan

- Describe how scope works when lists are passed as function parameters (interaction between scope and aliasing)
- Explore two new Python types:
  - tuples: *immutable* *ordered* alternative to lists
  - sets: *mutable* *unordered* collection (if time permits)

Review: Scope Example from Lecture 4

```python
def my_func (lst):
    lst.append(1)   # same effect as lst += [1]
    print('local lst', lst)
    return lst


lst = [3]
new_lst = my_func(lst)
print('global lst', lst)
print('new_lst', new_lst)
```




```
>>> python3 example.py
```

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```
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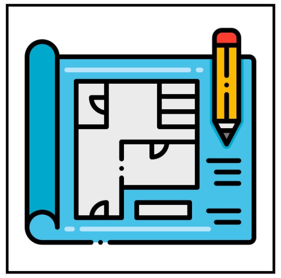
```

global frame

my_func



lst [3]

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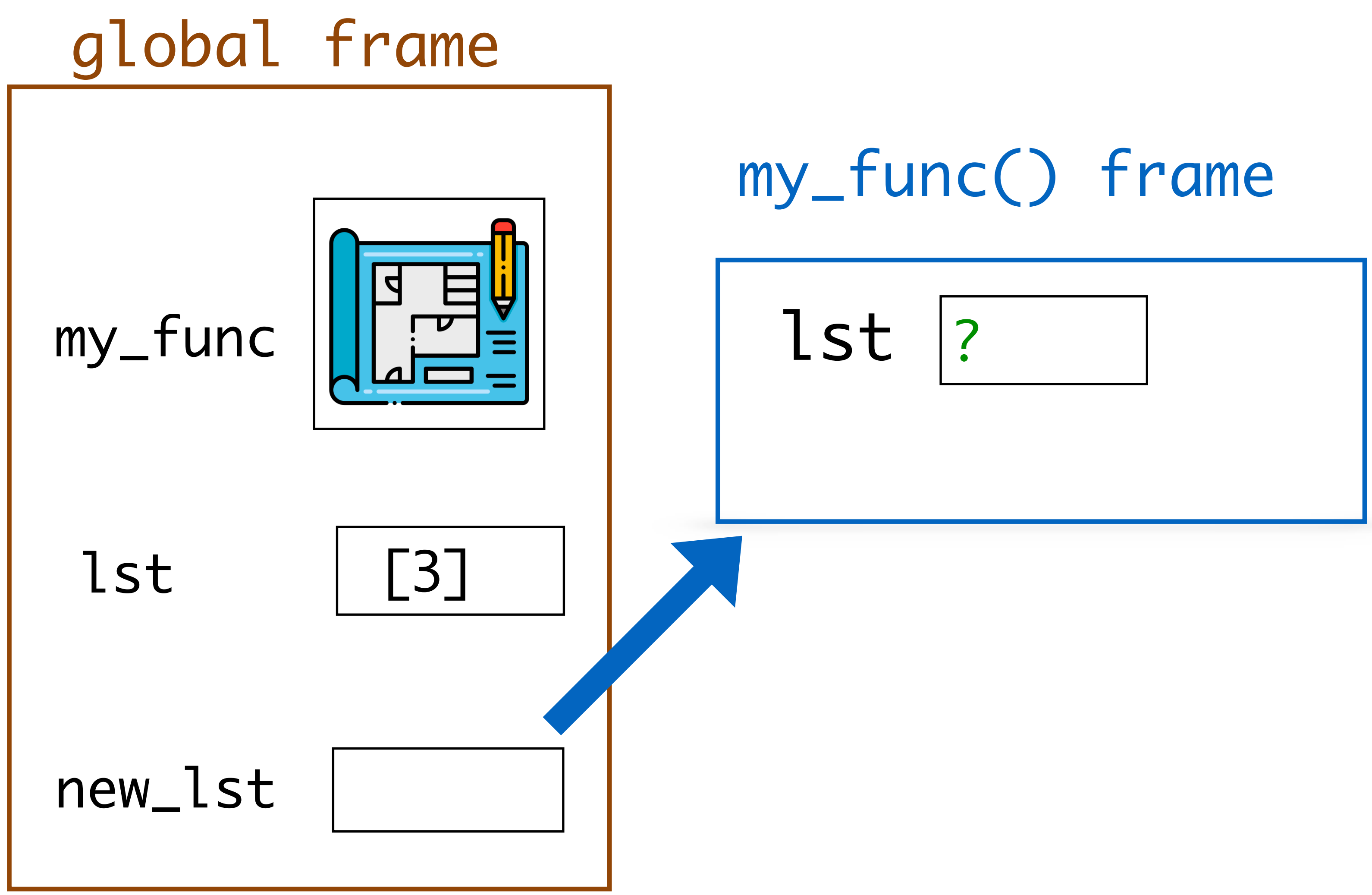

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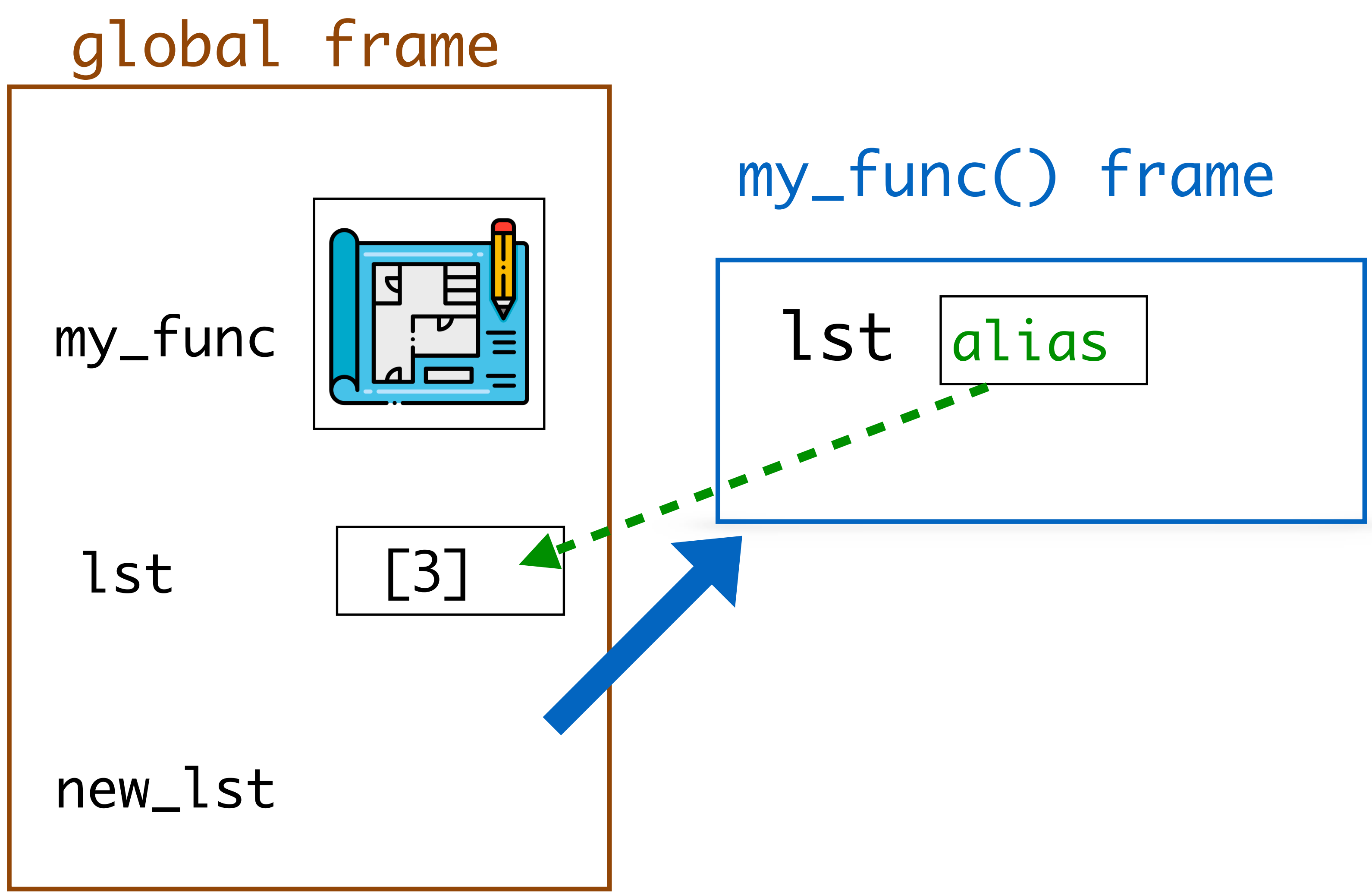

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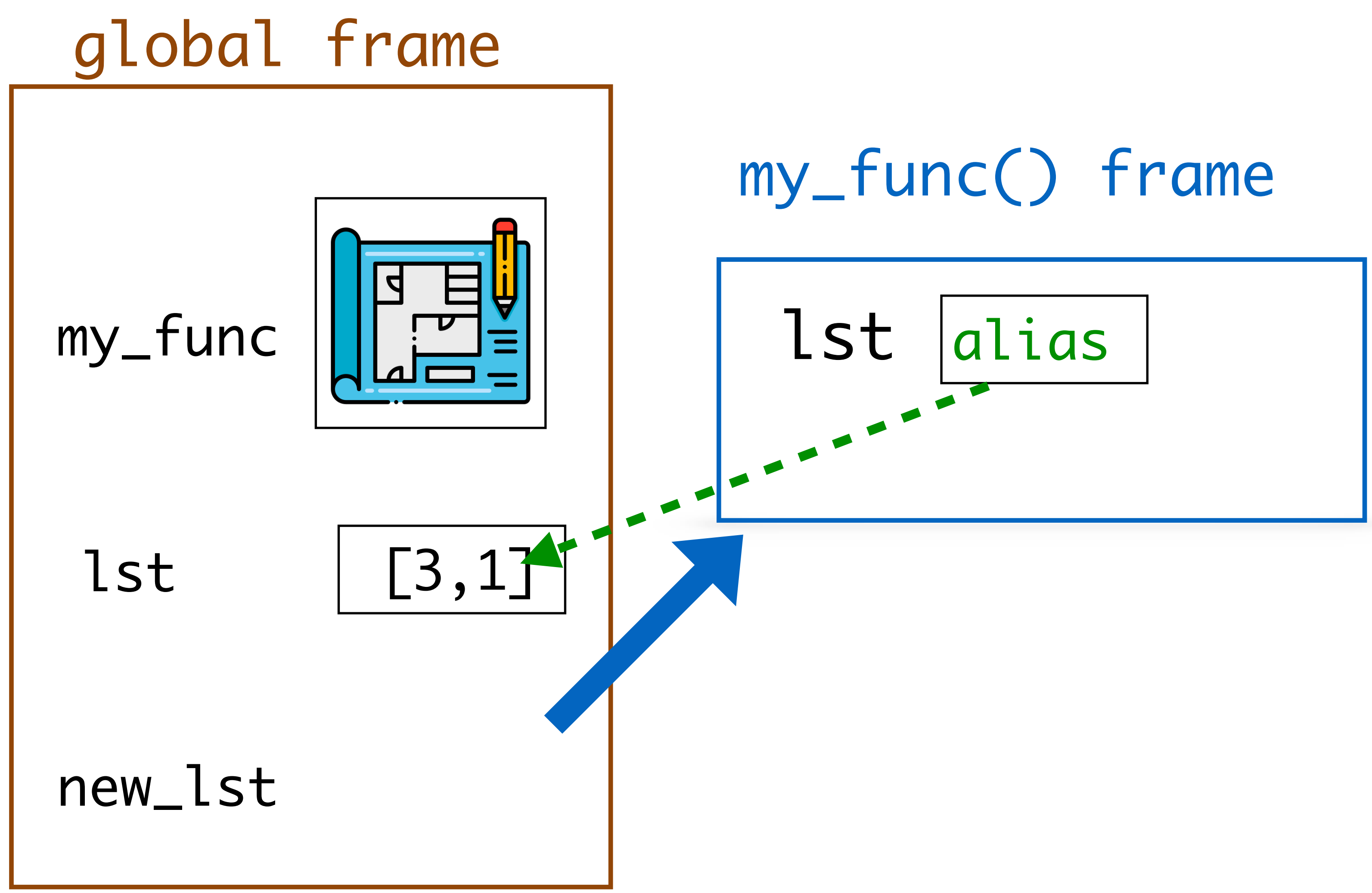
```



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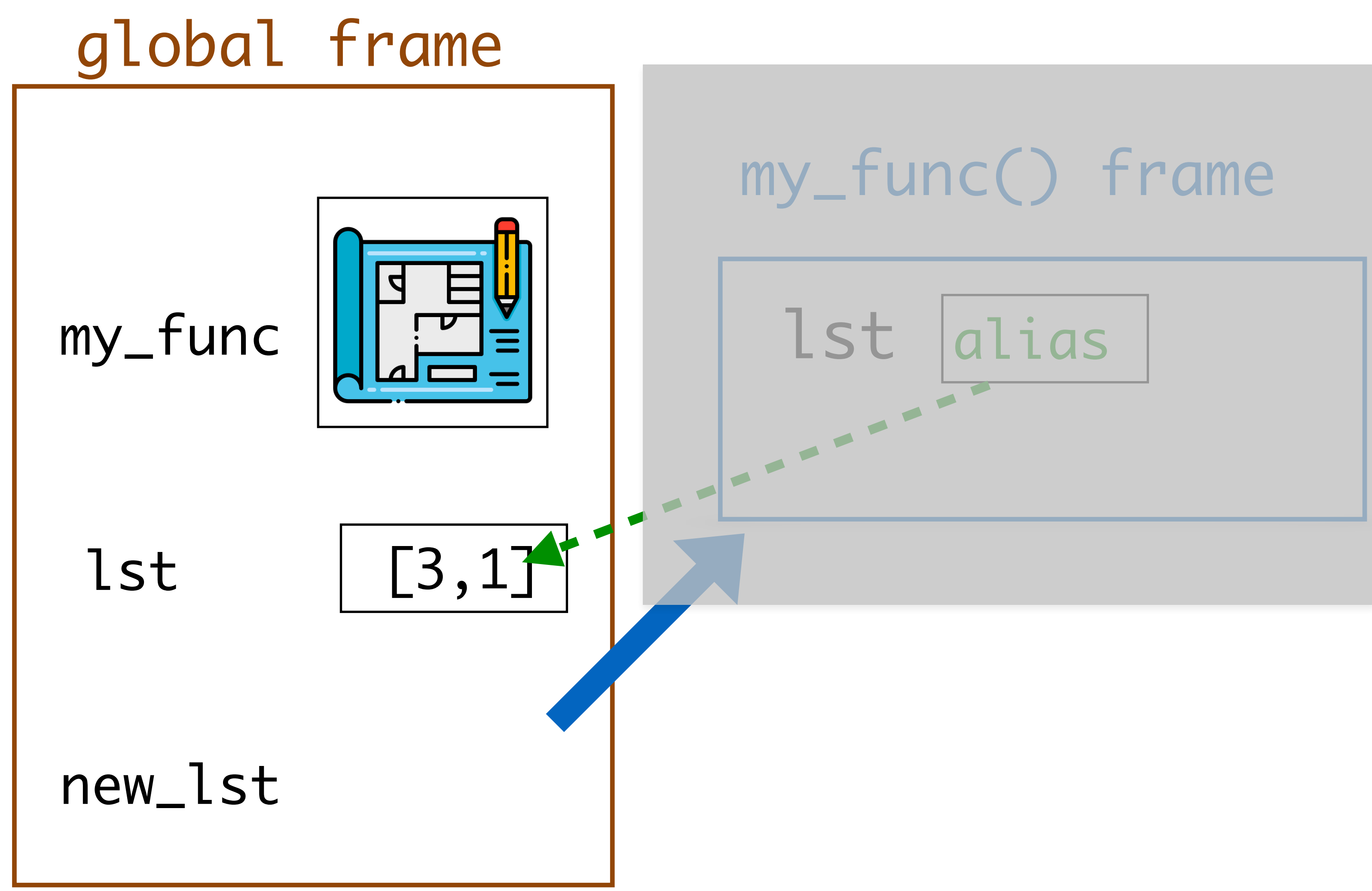

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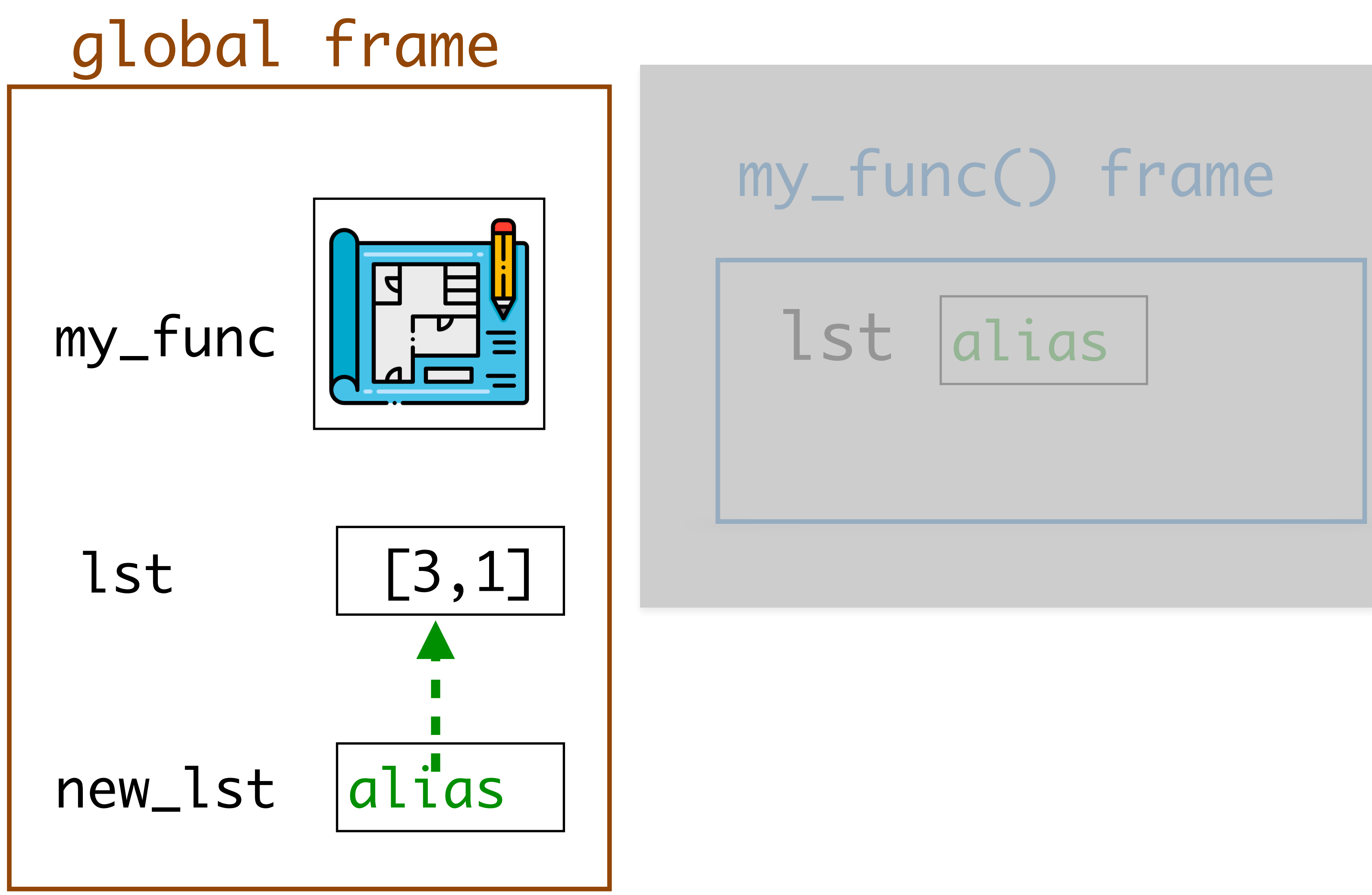


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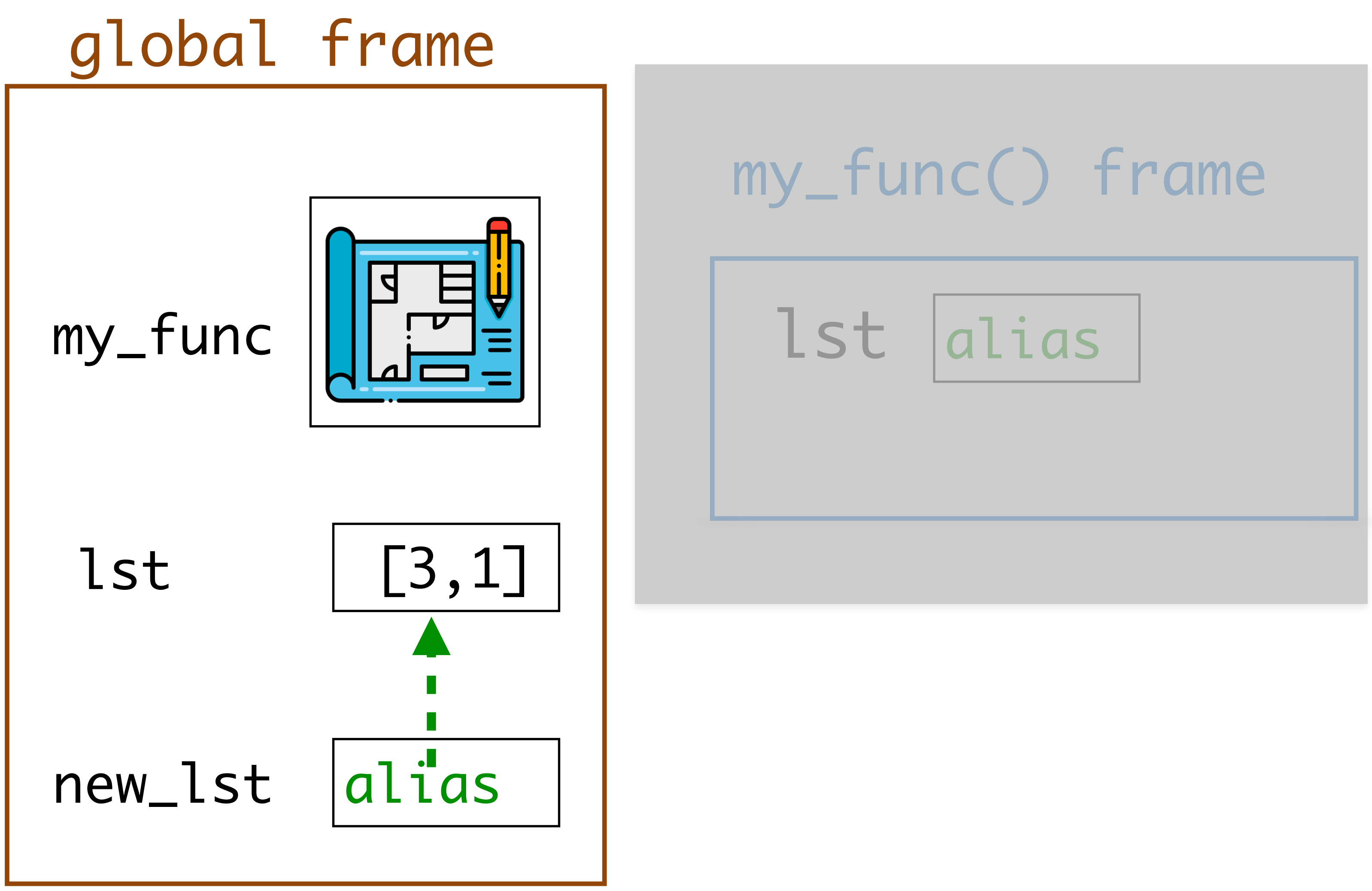

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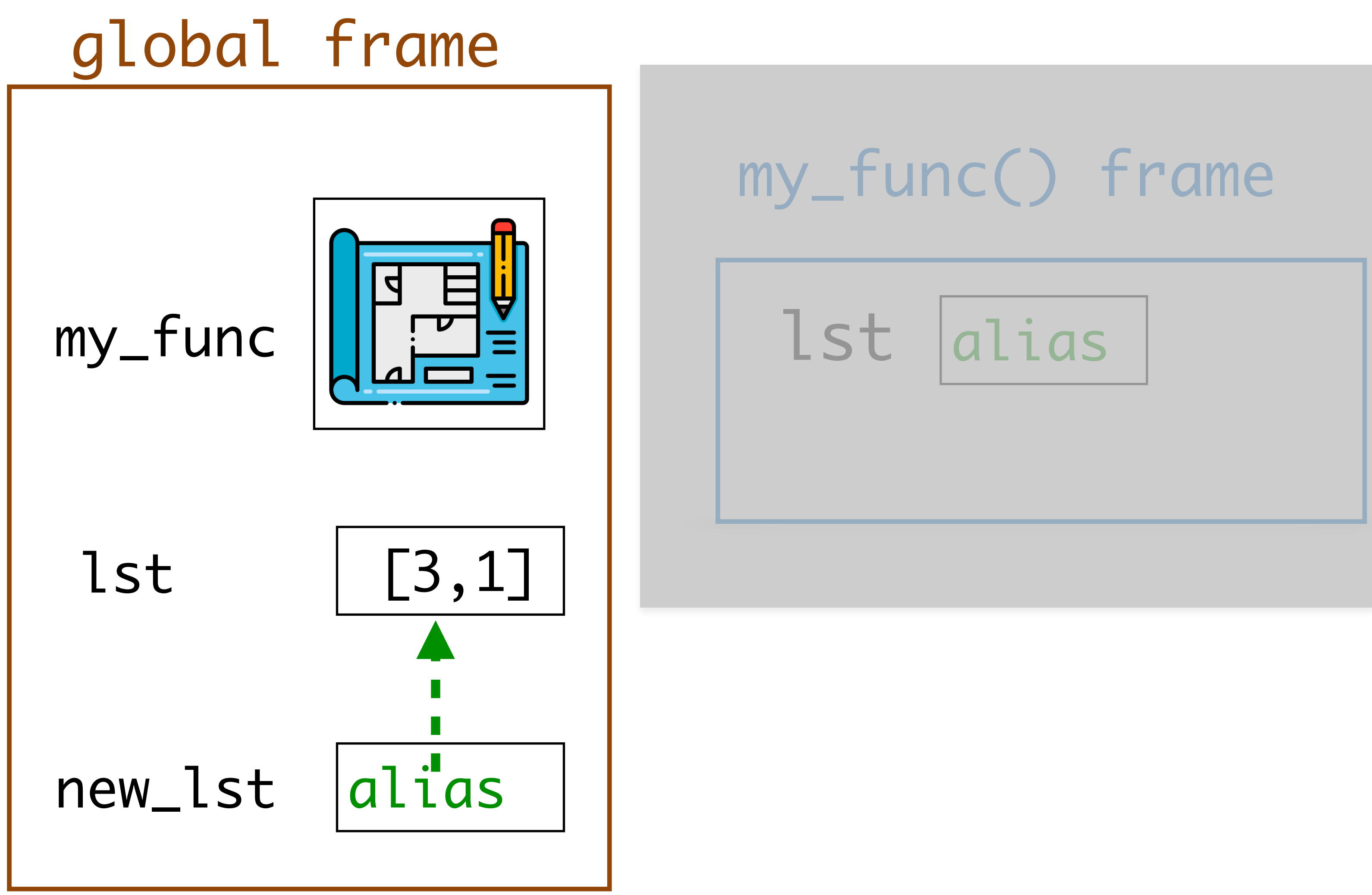

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```
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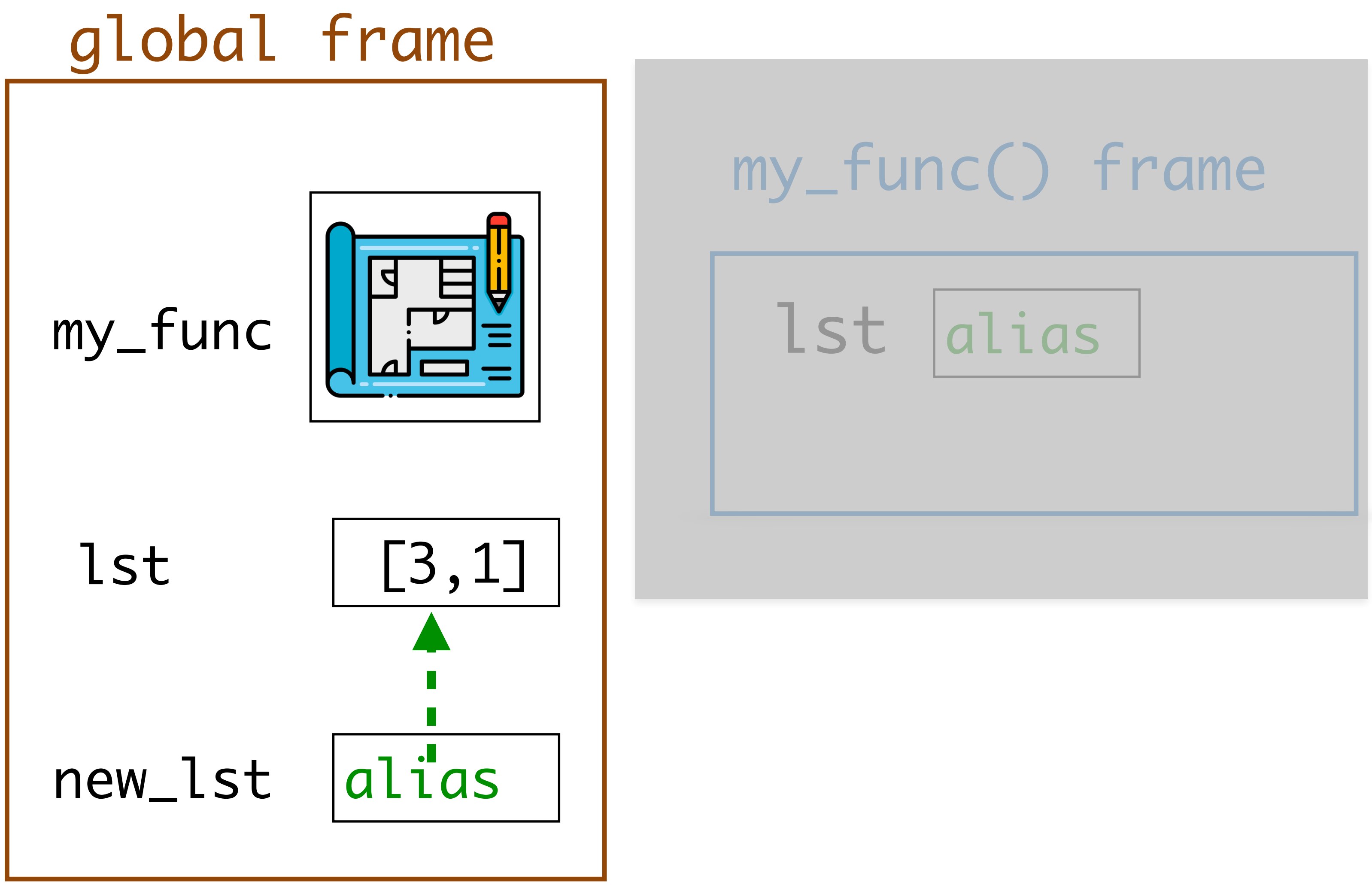
new_lst [3, 1]
$
```



Aliasing and Scope

- When we pass a mutable object as a parameter to a function, within the function, that local parameter variable is an alias
  - Since a list is mutable, changes to the alias affect the original!
- When we pass an immutable object as a parameter to a function, within the function, that local parameter variable is a clone
  - Wouldn't it be nice to have an immutable form of a list?

Tuples

Tuples: An Immutable Sequence

- Tuples are an **immutable sequence of values** (almost like immutable lists) separated by commas and enclosed within parentheses **( )**

```
# string tuple
>>> names = ("Bill", "Lida", "Shikha")

# int tuple
>>> primes = (2, 3, 5, 7, 11)

# singleton
>>> num = (5, )

# parentheses are optional
>>> values = 5, 6

# empty tuple
>>> emp = ()
```

A tuple of size **one** is called a **singleton**. Note the (funky) syntax.

Tuples as Immutable Sequences

- Tuples, like strings, support any sequence operation that ***does not*** **involve mutation**: e.g,
    - `len()` function: returns number of elements in tuple
    - `[]` indexing: access specific element
    - `+, *`: tuple concatenation
    - `[:]`: slicing to return subset of a tuple (as a new tuple)
    - `in` and `not in`: check membership of an object in a tuple
    - `for-loops`: iterate over elements in tuple

Multiple Assignment and Unpacking

- Tuples support a simple syntax for assigning multiple values at once, and also for "unpacking" sequence values

```
>>> a, b = 4, 7 # after evaluating: a == 4, b == 7
# reverse the order of values in tuple
>>> b, a = a, b
# tuple assignment to “unpack” list elements
>>> cb_info = ['Charlie Brown', 8, False]
>>> name, age, glasses = cb_info
```

- Note that the preceding line is just a more compact way of writing:

```
>>> name = cb_info[0]
>>> age = cb_info[1]
>>> glasses = cb_info[2]
```

Multiple Return from Functions

- Tuples come in handy when returning multiple values from functions

```
# multiple return values as a tuple
def arithmetic(num1, num2):
    '''Takes two numbers and returns their sum and product'''
    return num1 + num2, num1 * num2
```

```
>>> arithmetic(10, 2)
(12, 20)
>>> type(arithmetic(3, 4))
<class 'tuple'>
```

Conversion between Sequences

- The functions **`tuple()`**, **`list()`**, and **`str()`** convert between sequences

```
>>> word = "Williamstown"
>>> char_lst = list(word) # string to list
>>> char_lst
['W', 'i', 'l', 'l', 'i', 'a', 'm', 's', 't', 'o', 'w', 'n']
>>> char_tuple = tuple(char_lst) # list to tuple
>>> char_tuple
('W', 'i', 'l', 'l', 'i', 'a', 'm', 's', 't', 'o', 'w', 'n')
>>> list((1, 2, 3, 4, 5)) # tuple to list
[1, 2, 3, 4, 5]
```

Conversion between Sequences

- The functions `tuple()`, `list()`, and `str()` convert between sequences

```
>>> str(('hello', 'world')) # tuple to string
"('hello', 'world')"
>>> num_range = range(12)
>>> list(num_range) # range to list
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]
>>> str(list(num_range)) # range to list to string
'[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]'
```

Takeaways

- **Tuples** are a new *immutable* sequence that:
  - support all sequence operations such as indexing and slicing
  - are useful for argument unpacking, multiple assignments
  - are useful for handling list-like data without aliasing issues

Sets

New Unordered Data Structure: Sets

- Lists are **ordered** collections of objects
- What if we only need an unordered collection of individual items?
  - We can use a new data structure: **sets**
- Sets are ***mutable***, **unordered** collections of **immutable** objects
  - Sets can change (e.g., we can add and remove items), but an item cannot be changed once the item is added to the set
- Sets are written as comma separated values between curly braces { }
- Elements in a set must be **unique** and **immutable**
  - Sets can be an effective way of **eliminating duplicate values**

```
>>> nums = {42, 17, 8, 57, 23}
>>> flowers = {"tulips", "daffodils", "asters", "daisies"}
>>> empty_set = set() # empty set
```

New Unordered Data Structure: Sets

- **Question:** What is the potential downside of removing duplicates w/sets?

```
>>> first_choice = {'a', 'b', 'a', 'a', 'b', 'c'}
>>> uniques = set(first_choice)
>>> uniques
# ???
>>> set("aabrakadabra")
# ???
```

New Unordered Data Structure: Sets

- **Question:** What is the potential downside of removing duplicates w/sets?
  - Might lose the ordering of elements

```
>>> first_choice = {'a', 'b', 'a', 'a', 'b', 'c'}
>>> uniques = set(first_choice)
>>> uniques
{'a', 'b', 'c'}
>>> set("aabrakadabra")
{'a', 'b', 'd', 'k', 'r'}
```

Sets: Creating New Sets

- There are two ways to create a new set:
  - By placing curly brackets around elements:

```
>>> set_brack = {'aardvark'}
>>> set_brack
{'aardvark'}
```

  - By converting an iterable collection into a set:

```
>>> set_func = set('aardvark')
>>> set_func
{'d', 'v', 'a', 'r', 'k'}
```

Why letters here instead of the word?

Strings are iterable collection!

- And only one way to create an empty set:

```
>>> empty_set = set()
>>> empty_set
set()
```

Sets: Membership and Iteration

- Can check membership in a **set** using `in`, `not in`
- Can check length of a set using `len()`
- Can iterate over values in a loop (order will be arbitrary)

```
>>> nums = {42, 17, 8, 57, 23}
>>> flowers = {"tulips", "daffodils", "asters", "daisies"}
>>> 16 in nums
False
>>> "asters" in flowers
True
>>> len(flowers)
4
>>> # iterable
>>> for f in flowers:
>>> ...   print(f)
```

```
tulips
daisies
daffodils
asters
```

Sets are Unordered

- Therefore we **cannot**:
  - Index into a set (no notion of "position")
  - Concatenate (+) two sets (concatenation implies ordering)
  - Create a set of ***mutable*** objects:
    - Such as lists, sets, and *dictionaries* (foreshadowing...)

```
>>> {[3, 2], [1, 5, 4]}
TypeError
----> 1 {[3, 2], [1, 5, 4]}

TypeError: unhashable type: 'list'
```

Set Operations

- The usual operations you think of in set theory are implemented as follows

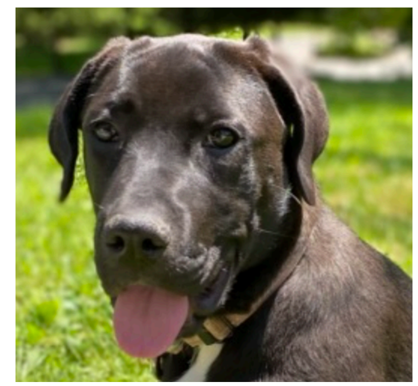
The following operations always return a new set.

- `s1 | s2` **(Set Union)**
  - Returns a new set that has all elements that are either in `s1` or `s2`
- `s1 & s2` **(Set Intersection)**
  - Returns a new set that has all the elements that are common to both sets.
- `s1 - s2` **(Set Difference)**
  - Returns a new set that has all the elements of `s1` that are not in `s2`
- `s1 |= s2`, `s1 &= s2`, `s1 -= s2` are versions of `|, &, -` that mutate `s1` to become the result of the operation on the two sets.

Set Operations

```
>>> cs134_dogs = {"wally", "pixel", "linus", "chelsea", "sally", "artie"}
```



```
>>> peanuts = {"sally", "linus", "charlie", "franklin", "lucy", "patty"}
```

Set Operations

```
>>> cs134_dogs = {"wally", "pixel", "linus", "chelsea", "sally", "artie"}
>>> peanuts = {"sally", "linus", "charlie", "franklin", "lucy", "patty"}

>>> union = cs134_dogs | peanuts
>>> union
{'sally', 'wally', 'patty', 'chelsea', 'pixel',
'franklin', 'lucy', 'artie', 'linus', 'charlie'}

>>> intersect = cs134_dogs & peanuts
>>> intersect
{'sally', 'linus'}

>>> diff = cs134_dogs - peanuts
>>> diff
{'chelsea', 'artie', 'wally', 'pixel'}

>>> cs134_dogs
{'sally', 'wally', 'linus', 'artie', 'chelsea', 'pixel'}
```

Original set is unchanged!

Set Operations: Mutators

```
>>> cs134_dogs = {"wally", "pixel", "linus", "chelsea", "sally", "artie"}
>>> peanuts = {"sally", "linus", "charlie", "franklin", "lucy", "patty"}
```

```
>>> cs134_dogs |= peanuts
>>> cs134_dogs
{'sally', 'wally', 'patty', 'chelsea', 'pixel',
'franklin', 'lucy', 'artie', 'linus', 'charlie'}
```

Original set is mutated!

```
>>> cs134_dogs = {"wally", "pixel", "linus", "chelsea", "sally", "artie"}
>>> cs134_dogs &= peanuts
>>> cs134_dogs
{'sally', 'linus'}
```

Original set is mutated!

```
>>> cs134_dogs = {"wally", "pixel", "linus", "chelsea", "sally", "artie"}
>>> cs134_dogs -= peanuts
>>> cs134_dogs
{'wally', 'artie', 'chelsea', 'pixel'}
```

Original set is mutated!

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Set Examples
(live coding)