TUPLES, LISTS, MUTABILITY, CLONING

“array” (可以 concat)

TUPLES

get part by index

- an ordered sequence of elements, can mix element types
- $\boxed{\textbf{immutable},}$ cannot change element values
- represented with parentheses

remember strings?

```
te = ()
```

empty tuple

```
t = (2,"one",3)
```

("one") → "one"

`t[0]` → evaluates to 2

`(2,"one",3) + (5,6)` → evaluates to `(2,"one",3,5,6)`

`t[1:2]` → slice tuple, evaluates to `("one",)`

extra comma means a tuple with one element

`t[1:3]` → slice tuple, evaluates to `("one",3)`

`t[1] = 4` → gives error, can't modify object

TUPLES

- conveniently used to **swap** variable values

```
x = y
y = x
```
✗

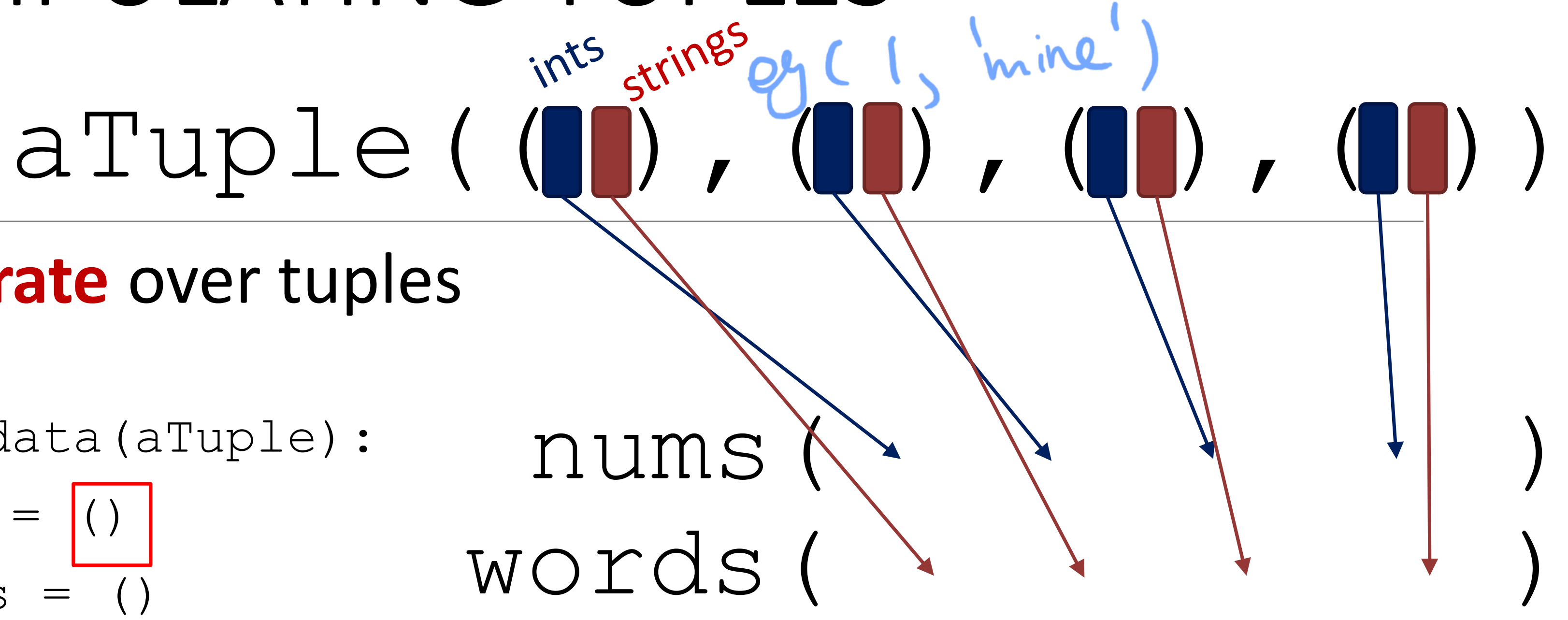
```
temp = x
x = y
y = temp
```
✓

```
(x, y) = (y, x)
```
✓

- used to **return more than one value** from a function

```
def quotient_and_remainder(x, y):
    q = x//y
    r = x%y
    return (q, r)
(quot, rem) = quotient_and_remainder(4,5)
```

MANIPULATING TUPLES



- can **iterate** over tuples

empty tuple

singleton tuple

```
def get_data(aTuple):
    nums = ()
    words = ()
    for t in aTuple:
        nums = nums + (t[0],)
        if t[1] not in words:
            words = words + (t[1],)
    min_nums = min(nums)
    max_nums = max(nums)
    unique_words = len(words)
    return (min_nums, max_nums, unique_words)
```

直接调用min( )函数.

LISTS

- **ordered sequence** of information, accessible by index
- a list is denoted by **square brackets**, `[]`
- a list contains **elements**
  - usually homogeneous (i.e., all integers)
  - can contain mixed types (not common)
- list elements can be changed so a list is **mutable**

INDICES AND ORDERING

- an element of a list is at a position (aka **index**) in list, indices start at 0

variable name

```
a_list = []
```

empty list

```
b_list = [2, 'a', 4, True]
L = [2, 1, 3]
```

```
index:   0   1   2
```

```
len(L)       →  evaluates to 3
L[0]         →  evaluates to 2
L[2]+1       →  evaluates to 4
L[3]         →  gives an error
```

- index can be a **variable or expression**, must evaluate to an `int`

```
i = 2
L[i-1]       →  evaluates to 1 since L[1] = 1 from above
```

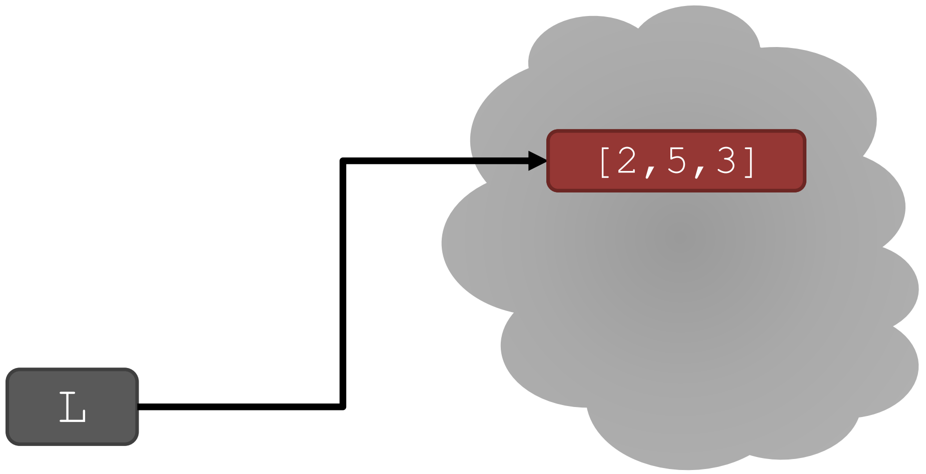
CHANGING ELEMENTS

- lists are **mutable**!
- assigning to an element at an index changes the value

```
L = [2, 1, 3]
L[1] = 5
```

different from strings and tuples!

- `L` is now `[2, 5, 3]`, note this is the **same object** `L`



ITERATING OVER A LIST

- compute the **sum of elements** of a list
- common pattern

```
total = 0
  for i in range(len(L)):
      total += L[i]
  print(total)
```

```
total = 0
  for i in L:
      total += i
  print(total)
```

like strings, can iterate over list elements directly

- notice
  - list elements are indexed `0` to `len(L)-1`
  - `range(n)` goes from `0` to `n-1`

OPERATIONS ON LISTS - ADD

- **add** elements to end of list with `L.append(element)`
- **mutates** the list!

```
L = [2,1,3]
L.append(5)
```
→ L is now `[2,1,3,5]`

↑ what is this dot?

- what is the dot?
  - lists are Python objects, everything in Python is an object
  - objects have data
  - objects have methods and functions
  - access this information by `object_name.do_something()`
  - will learn more about these later

OPERATIONS ON LISTS - ADD

- to combine lists together use **concatenation**, + operator
- **mutate** list with `L.extend(some_list)`

mutate

new list

```
L1 = [2,1,3]
L2 = [4,5,6]
L3 = L1 + L2            → L3 is [2,1,3,4,5,6]
L1.extend([0,6])        → mutated L1 to [2,1,3,0,6]
```

OPERATIONS ON LISTS - REMOVE

哪个它?

- delete element at a **specific index** with `del(L[index])`
- remove element at **end of list** with `L.pop()`, returns the removed element
- remove a **specific element** with `L.remove(element)`
  - looks for the element and removes it
  - if element occurs multiple times, removes first occurrence
  - if element not in list, gives an error

all these operations mutate the list

```
L = [2,1,3,6,3,7,0] # do below in order
L.remove(2)         → mutates L = [1,3,6,3,7,0]
L.remove(3)         → mutates L = [1,6,3,7,0]
del(L[1])           → mutates L = [1,3,7,0]
L.pop()             → returns 0 and mutates L = [1,3,7]
```

CONVERT LISTS TO STRINGS AND BACK

- convert **string to list** with `list(s)`, returns a list with every character from `s` an element in `L`
- can use `s.split()`, to **split a string on a character** parameter, splits on spaces if called without a parameter
- use `''.join(L)` to turn a **list of characters into a string**, can give a character in quotes to add char between every element

```
s = "I <3 cs"              →  s is a string
list(s)         → returns ['I',' ','<','3',' ','c','s']
s.split('<')    → returns ['I ', '3 cs']
L = ['a', 'b', 'c']        →  L is a list
''.join(L)      → returns "abc"
'_'.join(L)     → returns "a_b_c"
```

OTHER LIST OPERATIONS

- `sort()` and `sorted()`
- `reverse()`
- and many more!
  https://docs.python.org/2/tutorial/datastructures.html

`L=[9,6,0,3]`

`sorted(L)` → returns sorted list, does **not mutate** `L`

`L.sort()` → **mutates** `L=[0,3,6,9]`

`L.reverse()` → **mutates** `L=[9,6,3,0]`

BRINGING TOGETHER LOOPS, FUNCTIONS, `range`, and LISTS

- `range` is a special procedure
  - **returns something that behaves like a tuple**!
  - doesn’t generate the elements at once, rather it generates the first element, and provides an iteration method by which subsequent elements can be generated

```
range(5)          →  equivalent to tuple [0,1,2,3,4]
range(2,6)        →  equivalent to tuple [2,3,4,5]
range(5,2,-1)     →  equivalent to tuple [5,4,3]
```

- when use `range` in a `for` loop, what the loop variable iterates over behaves like a list!

```
for var in range(5):
   <expressions>
```

behind the scenes, gets converted to something that will behave like:

```
for var in (0,1,2,3,4):
    <expressions>
```

MUTATION, ALIASING, CLONING

IMPORTANT
and
TRICKY!

Python Tutor is your best friend to help sort this out!

http://www.pythontutor.com/

LISTS IN MEMORY

- lists are **mutable**
- behave differently than immutable types
- is an object in memory
- variable name points to object
- any variable pointing to that object is affected
- key phrase to keep in mind when working with lists is **side effects**

AN ANALOGY

Justin Drew Bieber
Justin Bieber
JB
Bieber
The Bieb
JBeebs

- attributes of a person
  - singer, rich
- he is known by many names
- all nicknames point to the **same person**
  - add new attribute to **one nickname** …

    Justin Bieber: singer, rich **, troublemaker**
  - … **all his nicknames** refer to old attributes AND all new ones

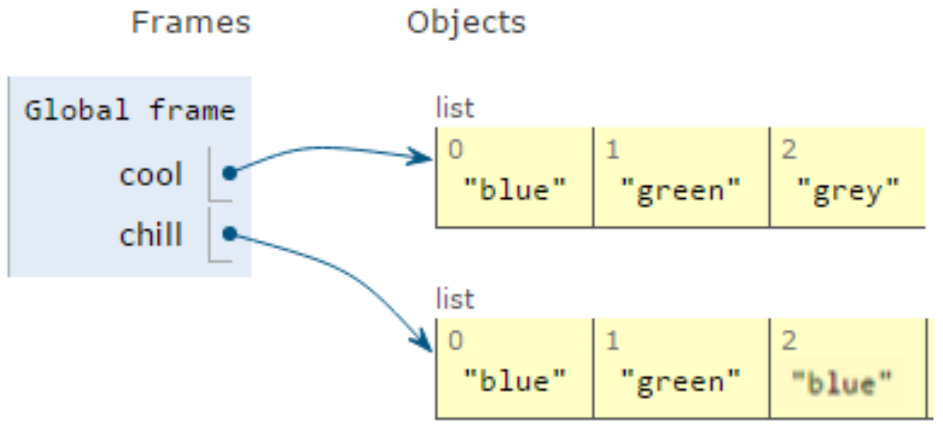
    The Bieb is: singer, rich, **troublemaker**
    JBeebs is: singer, rich, **troublemaker**
    etc…

PRINT IS NOT ==

- if two lists print the same thing, does not mean they are the same structure
- can test by mutating one, and checking

```
cool = ['blue', 'green', 'grey']
chill = ['blue', 'green', 'grey']
print(cool)
print(chill)

chill[2] = 'blue'
print(chill)
print(cool)
```



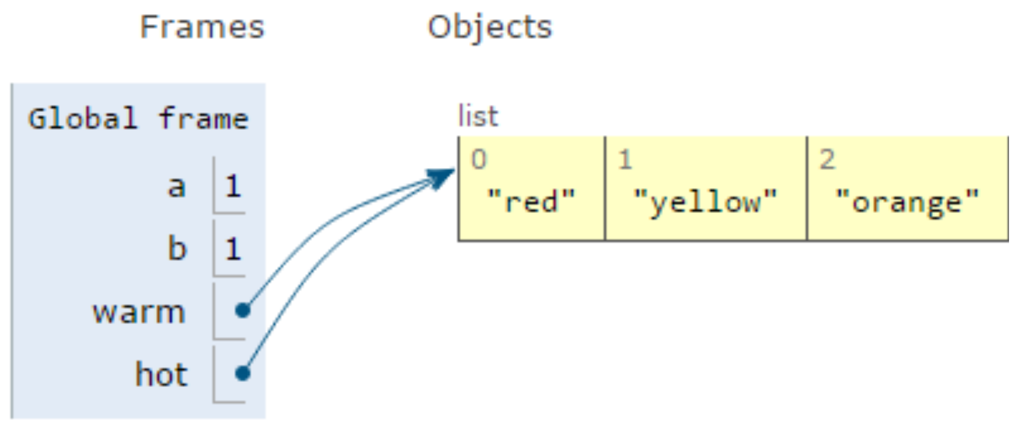
ALIASES

- `hot` is an **alias** for `warm` – changing one changes the other!
- `append()` has a side effect

```
a = 1
b = a
print(a)
print(b)

warm = ['red', 'yellow', 'orange']
hot = warm

hot.append('pink')
print(hot)
print(warm)
```

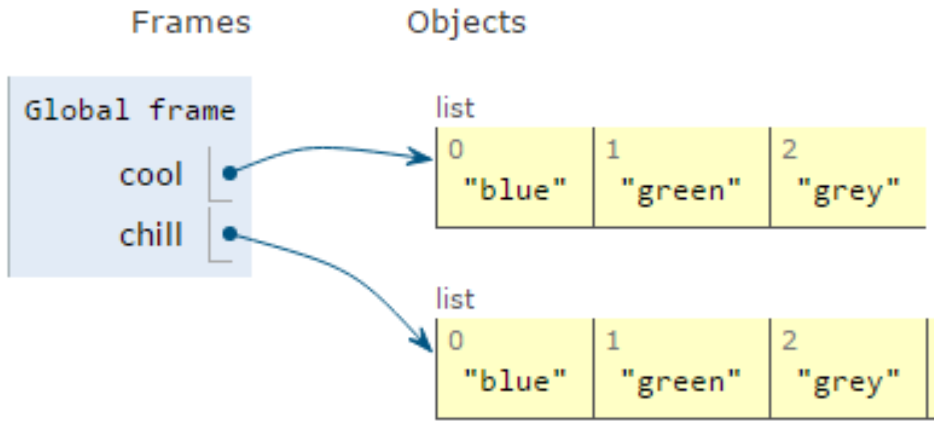


CLONING A LIST

- create a new list and **copy every element** using
  `chill = cool[:]`

```
cool = ['blue', 'green', 'grey']
chill = cool[:]

chill.append('black')
print(chill)
print(cool)
```

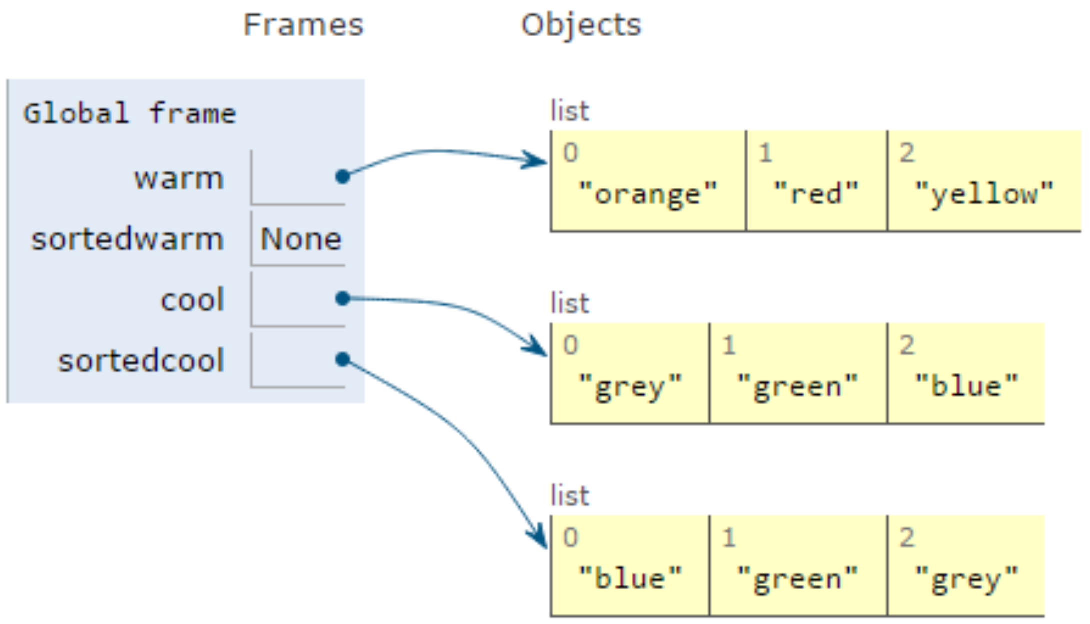


SORTING LISTS

- calling `sort()` **mutates** the list, returns nothing
- calling `sorted()` **does not mutate** list, must assign result to a variable

```
warm = ['red', 'yellow', 'orange']
sortedwarm = warm.sort()
print(warm)
print(sortedwarm)

cool = ['grey', 'green', 'blue']
sortedcool = sorted(cool)
print(cool)
print(sortedcool)
```



LISTS OF LISTS OF LISTS OF....

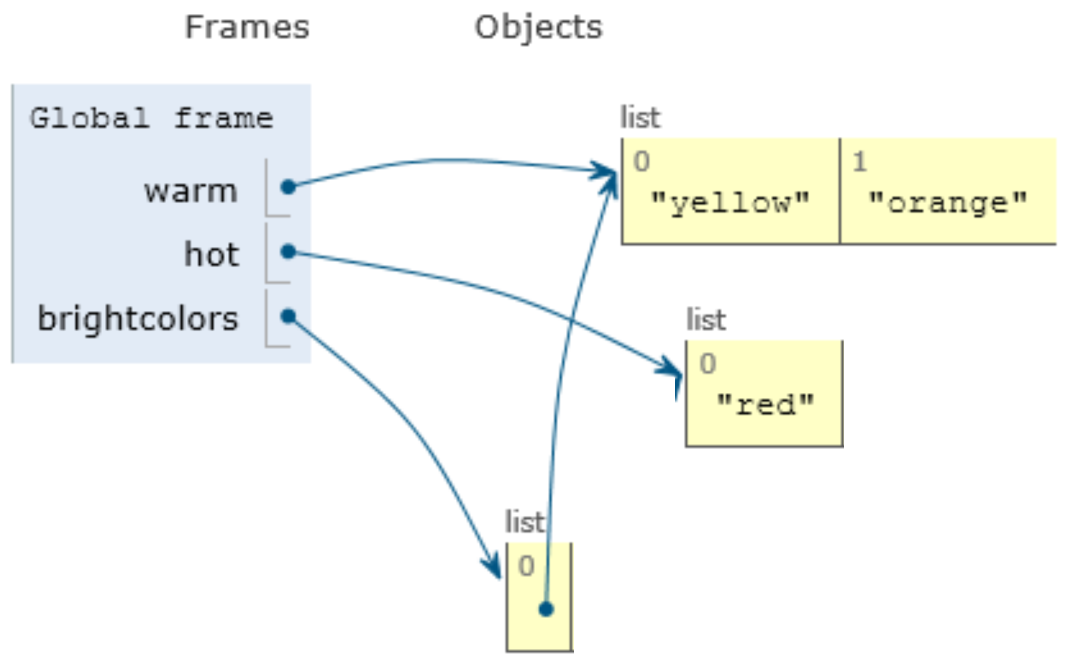
- can have **nested** lists
- side effects still possible after mutation

```
warm = ['yellow', 'orange']
hot = ['red']
brightcolors = [warm]

brightcolors.append(hot)
print(brightcolors)

hot.append('pink')
print(hot)
print(brightcolors)

print(hot + warm)
print(hot)
```



MUTATION AND ITERATION

- **avoid** mutating a list as you are iterating over it

```
def remove_dups(L1, L2):
    for e in L1:
        if e in L2:
            L1.remove(e)
```

✗

```
def remove_dups_new(L1, L2):
    L1_copy = L1[:]
    for e in L1_copy:
        if e in L2:
            L1.remove(e)
```

✓

clone list first, note that `L1_copy = L1` does NOT clone

```
L1 = [1, 2, 3, 4]
L2 = [1, 2, 5, 6]
remove_dups(L1, L2)
```

- `L1` is `[2,3,4]` not `[3,4]` Why?
  - Python uses an internal counter to keep track of index it is in the loop
  - mutating changes the list length but Python doesn't update the counter
  - loop never sees element 2