

TUPLES, LISTS, MUTABILITY, CLONING

TUPLES

- an ordered sequence of elements, can mix element types
- **immutable**, cannot change element values
- represented with parentheses

remember strings?

`te = ()`

empty tuple

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

`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",)`

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

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

extra comma means a tuple with one element

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
```

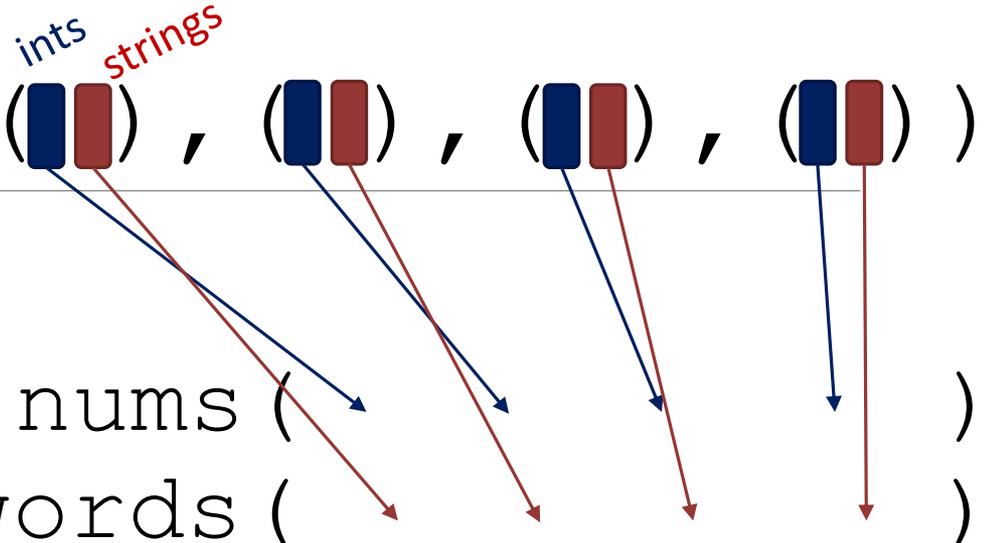
```
    r = x%y
```

```
    return (q, r)
```

```
(quot, rem) = quotient_and_remainder(4, 5)
```

MANIPULATING TUPLES

aTuple ((ints strings), (ints strings), (ints strings), (ints strings))



- can **iterate** over tuples

```
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)
```

empty tuple

singleton tuple



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: \uparrow \uparrow \uparrow
 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

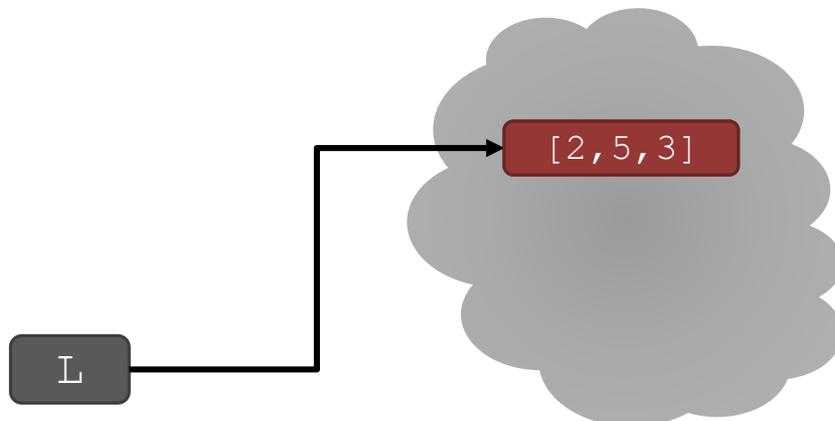
- lists are **mutable!**
- assigning to an element at an index changes the value

```
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 $\text{len}(L) - 1$
 - `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)`

`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

- 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` as 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

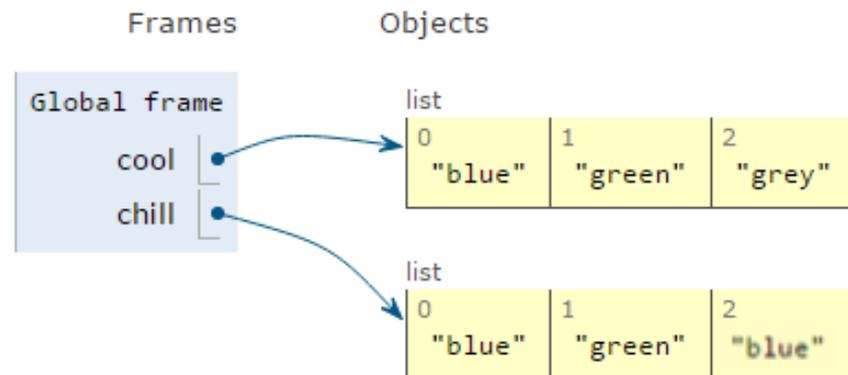
- attributes of a person
 - singer, rich
- he is known by many names
- all nicknames point to the **same person**
 - add new attribute to **one nickname** ...
 - Justin Bieber:** singer, rich , **troublemaker**
 - ... **all his nicknames** refer to old attributes AND all new ones
 - The Bieb is:** singer, 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)
```



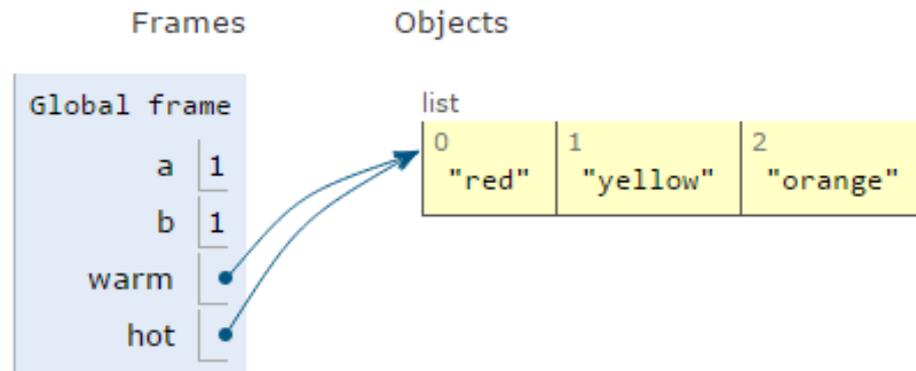
ALIASES

- `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)
```

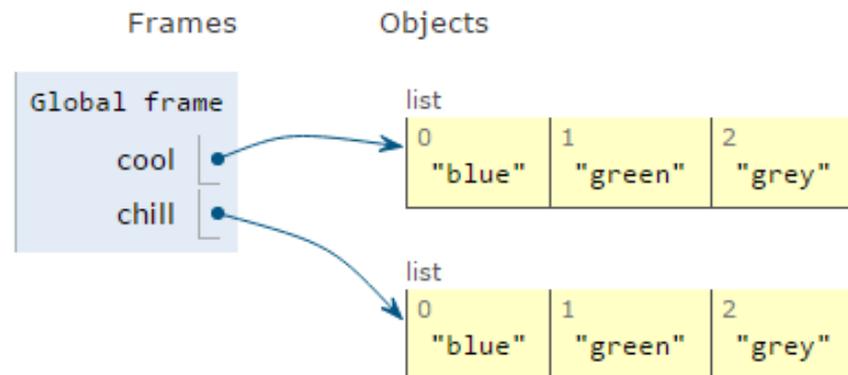


CLONING A LIST

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

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

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

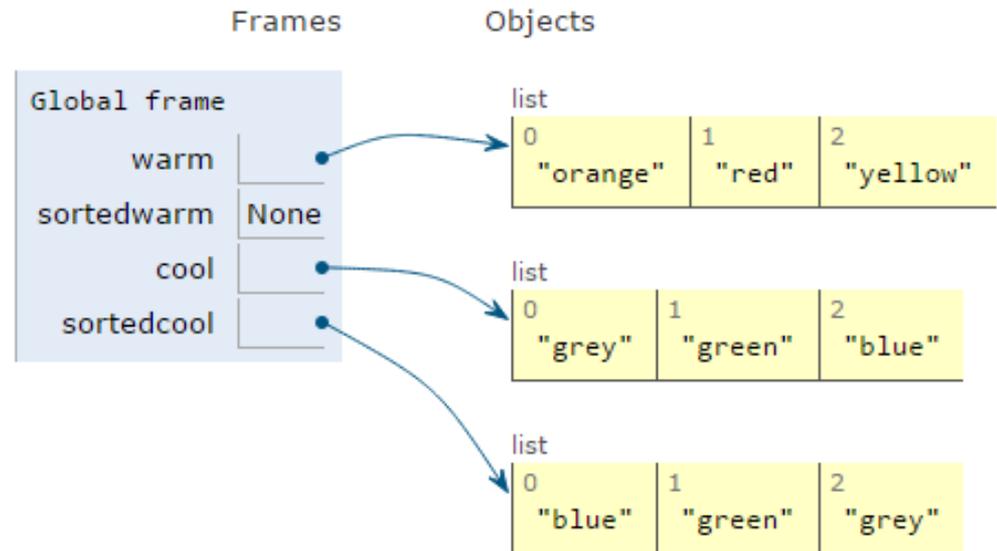


SORTING LISTS

- 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...

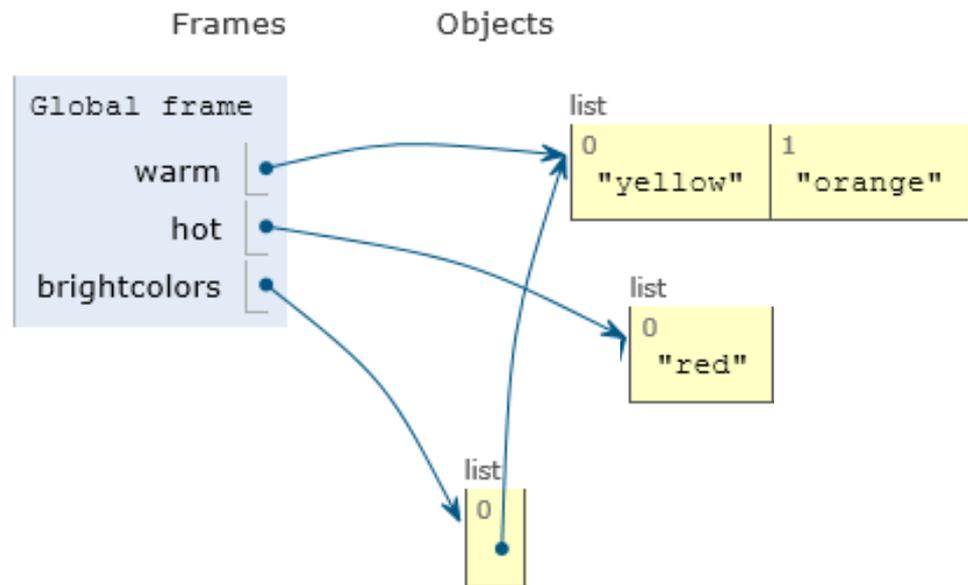
- can have **nested** lists
- side effects still possible after mutation

```
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)
```



```
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

```
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*