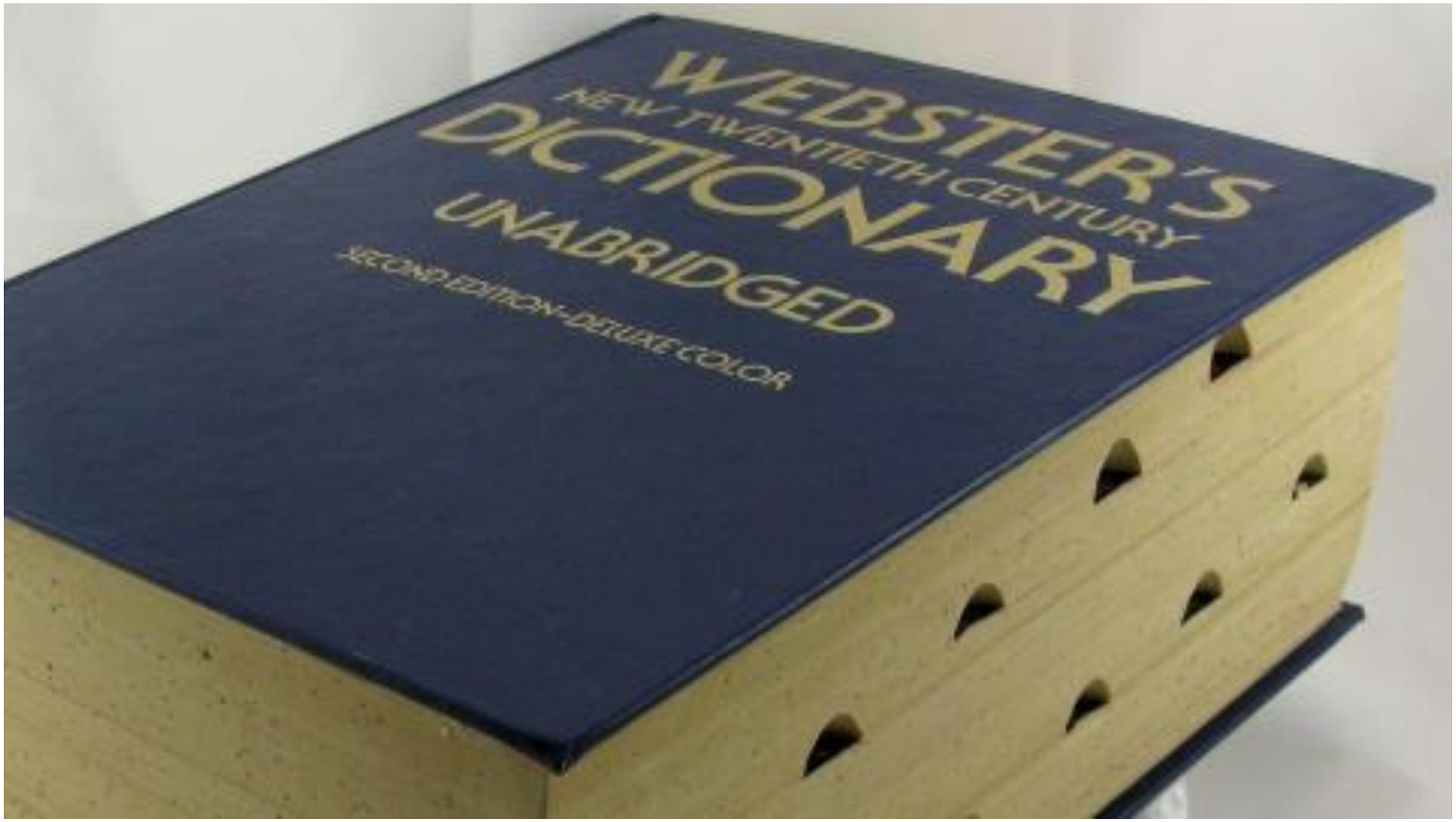

CSCI 141

Lecture 21

Mutability; Variables are References: Implications

Intro to Dictionaries

Announcements

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- No class Monday
  - No lab next week
  - I will move my Monday office hours to Tuesday - time TBA

Reminder

CS Stories: What's it like to be a female professor?

Who: Dr. Sharmin, Dr. Liu, Dr. Islam, AWC professional guests from industry, alumni, friends, YOU!

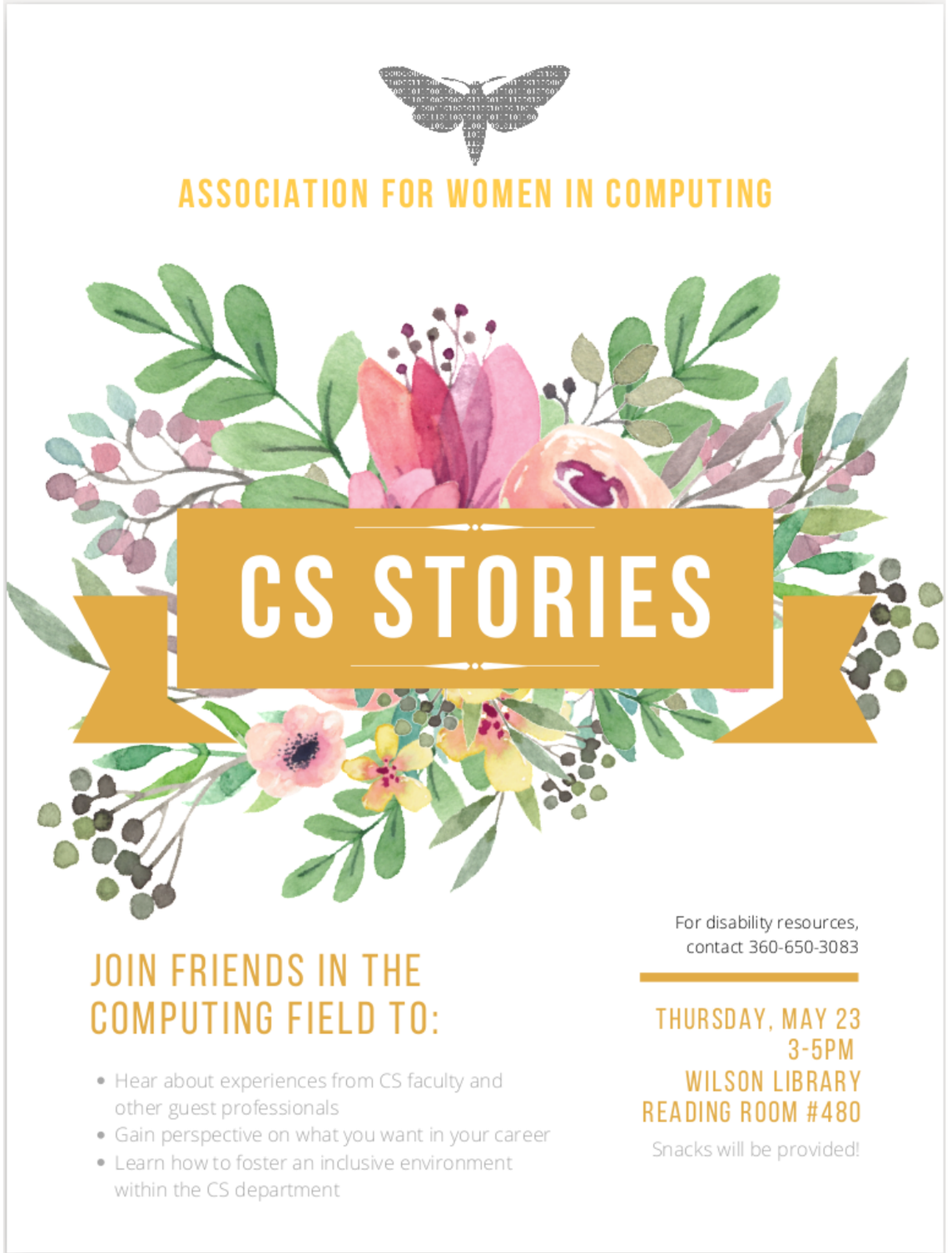
What: Creating the space to open about experiences as students in education with various career goals in addition to equipping our friends to be allies for underrepresented friends.

When: Thursday May 23rd from 3-5pm. Doors open @2:45pm

Where: Wilson Library Reading Room #480 (yes the Harry Potter Reading Room)

Contact: awc.wwu@gmail.com for more info or questions!

See you there!



Reminder

Just in: there will be ice cream and cookies

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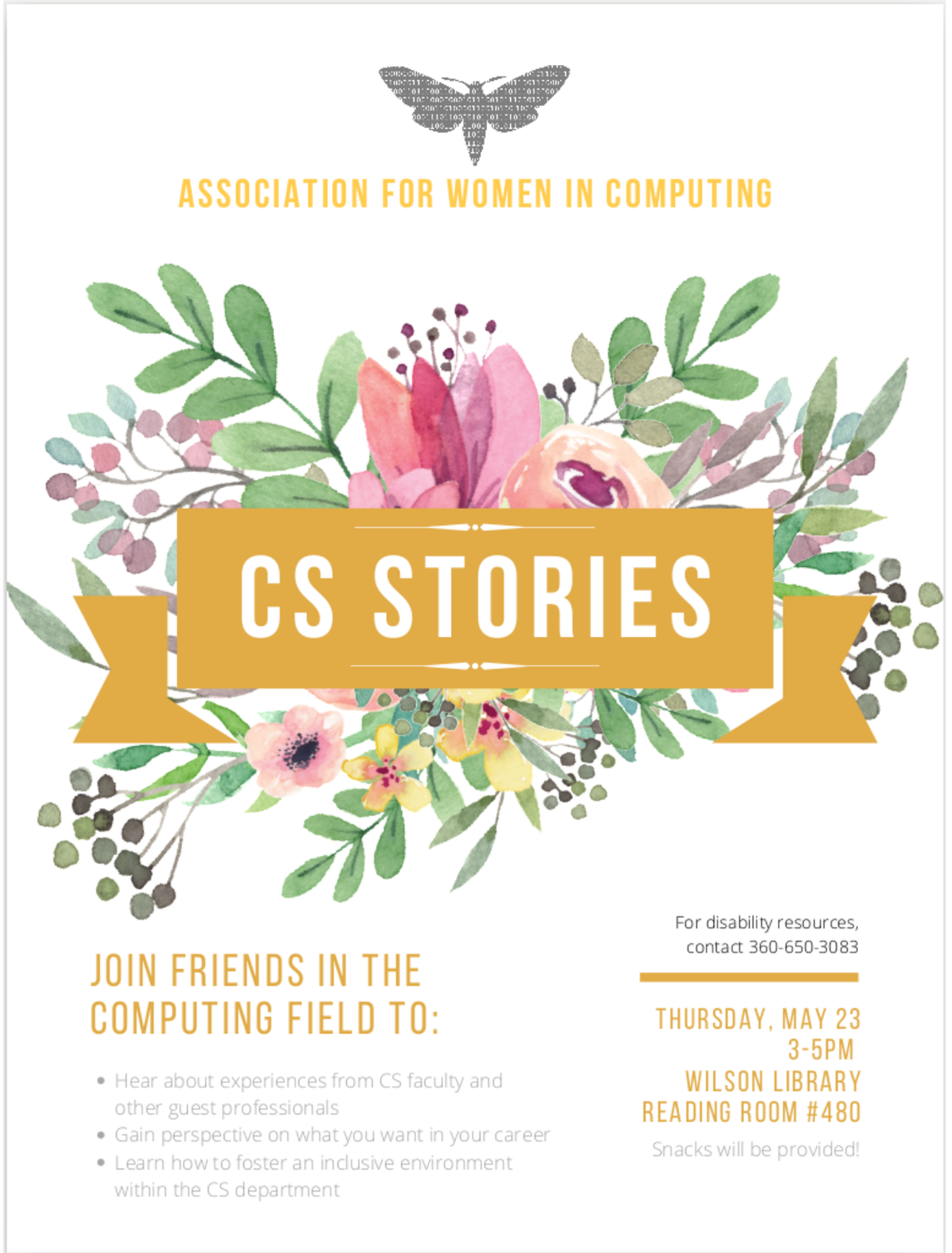


Goals

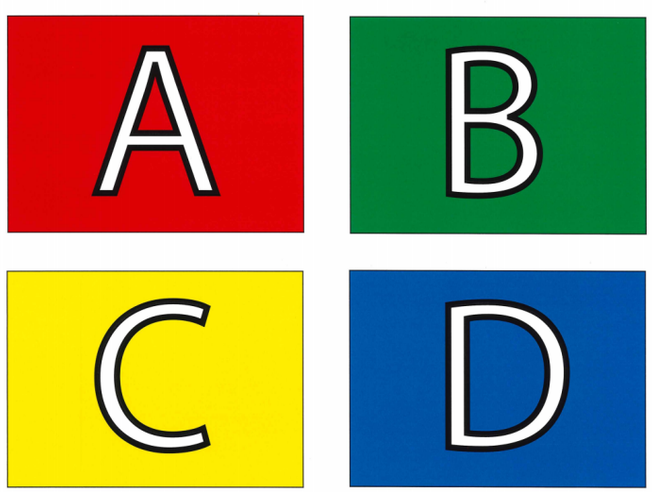
- Understand the implications of variables holding references to mutable objects:
  - multiple variables can refer to the same object
  - function parameters can refer to objects that are also referred to by global variables
- Know how to modify lists using the following:
  - indexed assignment, slice assignment, `insert`, `remove`, `del`
- Know the basics of how to use dictionaries (dicts):
  - Creation , assignment, indexing

Last time

- Know how to create, index, slice, and check for membership in lists.
- Understand the behavior of the `+, *, in, not in,` operators on lists.
- Know how to use the list methods `append`, and `extend`

```
a = ["Tony", "Steve", "Natasha", "T'Challa", "Carol"]
```

What is the value of: `a[2:3]` **?**



A. `["Steve", "Natasha"]`
B. `["Natasha", "T'Challa"]`
C. `["Steve"]`
D. `["Natasha"]`

Last time

- Know how to create, index, slice, and check for membership in lists.
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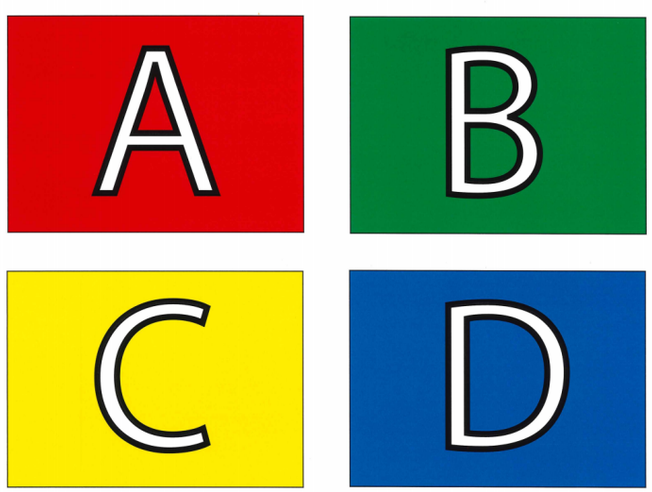
- Know how to use the list methods `append`, and `extend`

```
a = ["Tony", "Steve", "Natasha", "T'Challa", "Carol"]
a.append(["Bruce", "Peter"])
```

What is the value of: `len(a)` **?**



A. 5
B. 6
C. 7
D. 8

Last time

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```

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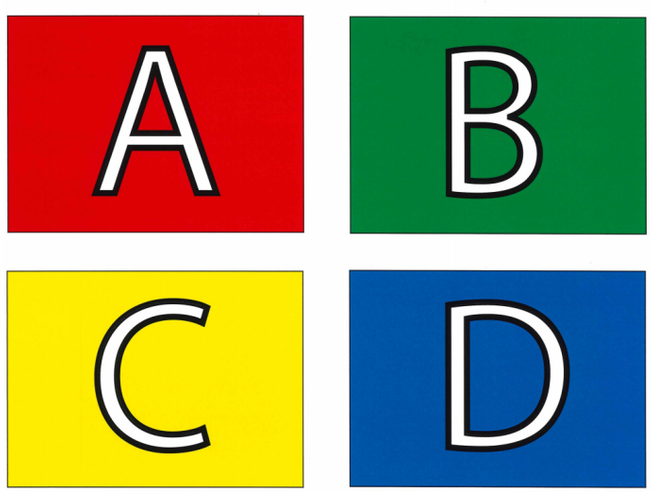

A.5
B.6
C.7
D.8

List assignment + slicing

List assignment + slicing

We can **assign** to indices:

List assignment + slicing

We can **assign** to indices:

```
a = [5, 6, 7, 8]
a[0] = 10
```

List assignment + slicing

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We can **slice** out sublists:

List assignment + slicing

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We can **slice** out sublists:

```
a[0:3] # => [5, 6]
```

List assignment + slicing

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Can we **assign** to **slices**?

List assignment + slicing

We can **assign** to indices:

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a = [5, 6, 7, 8]
a[0] = 10
```

We can **slice** out sublists:

```
a[0:3] # => [5, 6]
```

Can we **assign** to **slices**?

You betcha! (demo)

List assignment + slicing

slice_assign.py

Last time

- Know the definition of mutability, and which sequence types are mutable (lists) and immutable (strings, tuples)

String and **Tuples** are immutable
Lists are mutable

```
a_string = "Scott"
a_tuple = ("a", 14, 27.6)
a_list = ["a", 14, 27.6]

a_string[1] # => "c"
a_tuple[1] # => 14
a_list[1] # => 14

a_string[1] = "C" # causes an error
a_tuple[1] = 0 # causes an error
a_list[1] = 0 # a_list is now ["a", 0, 27.6]
```

Today’s Quiz

- 5 minutes - collaborate at will!

All variables store references to objects

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```
number = 2
```

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What's actually happening:

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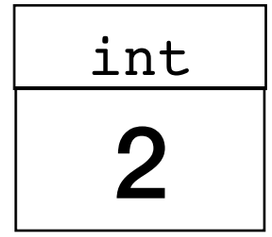

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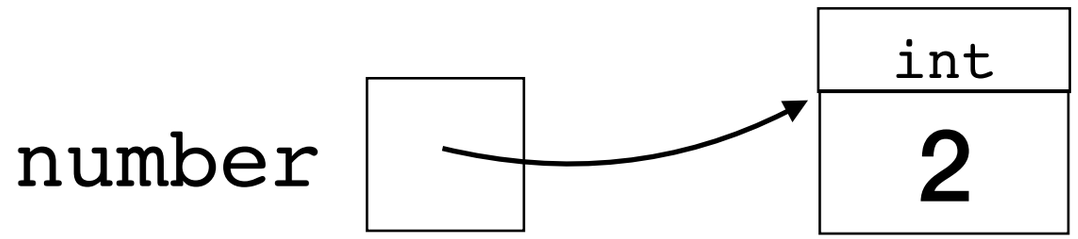

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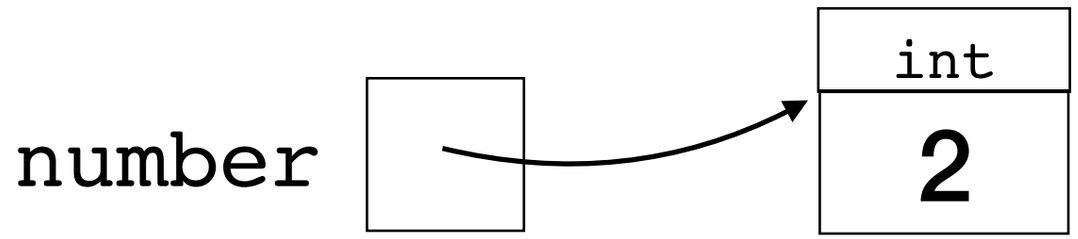

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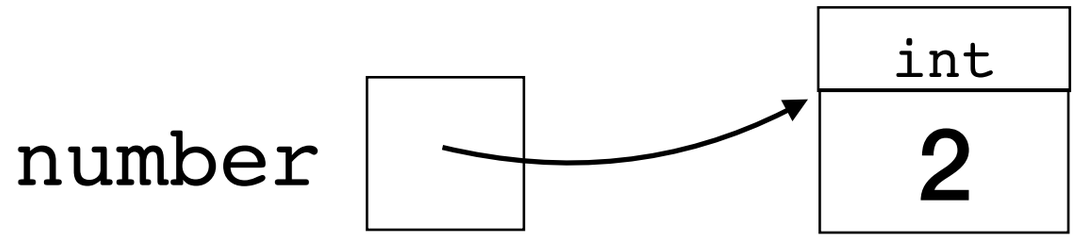
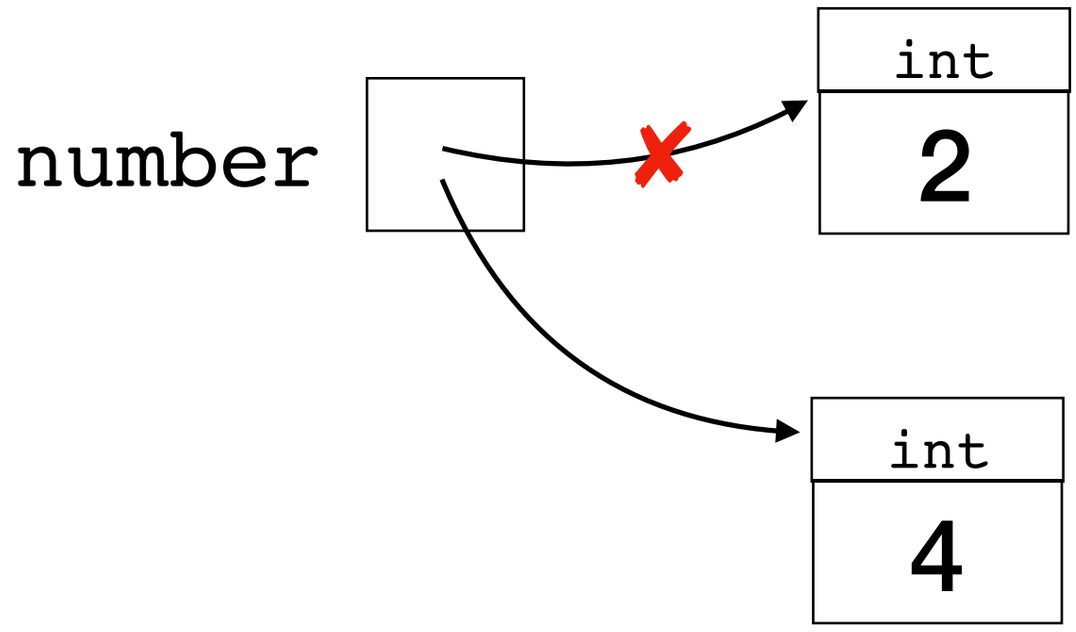



```
number = 4
```

All variables store references to objects

```
number = 2
```

What's actually happening:




```
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```

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```
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```

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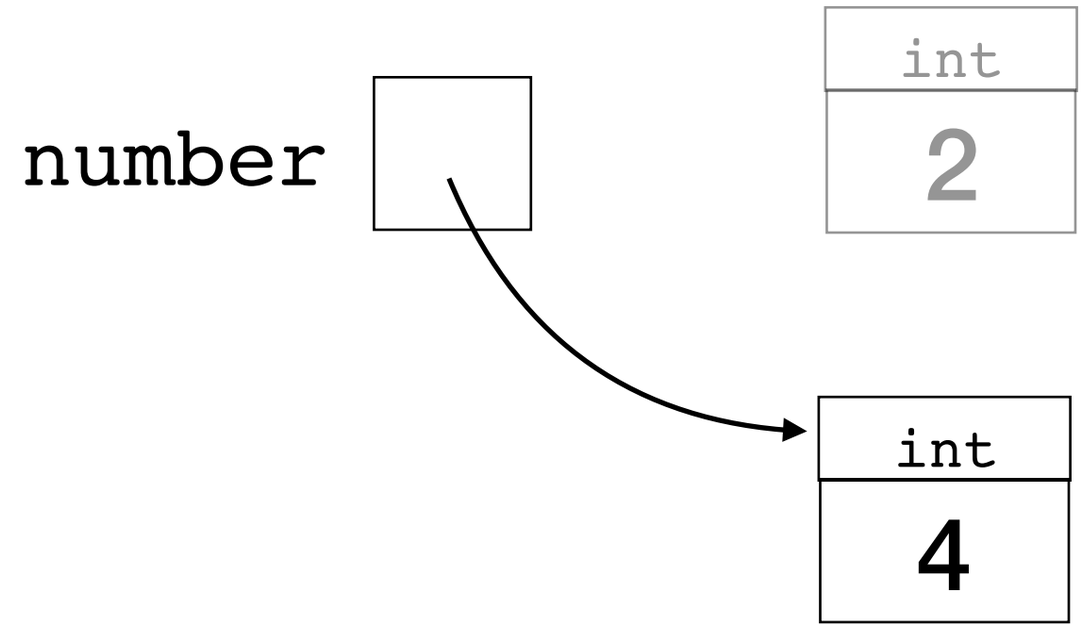


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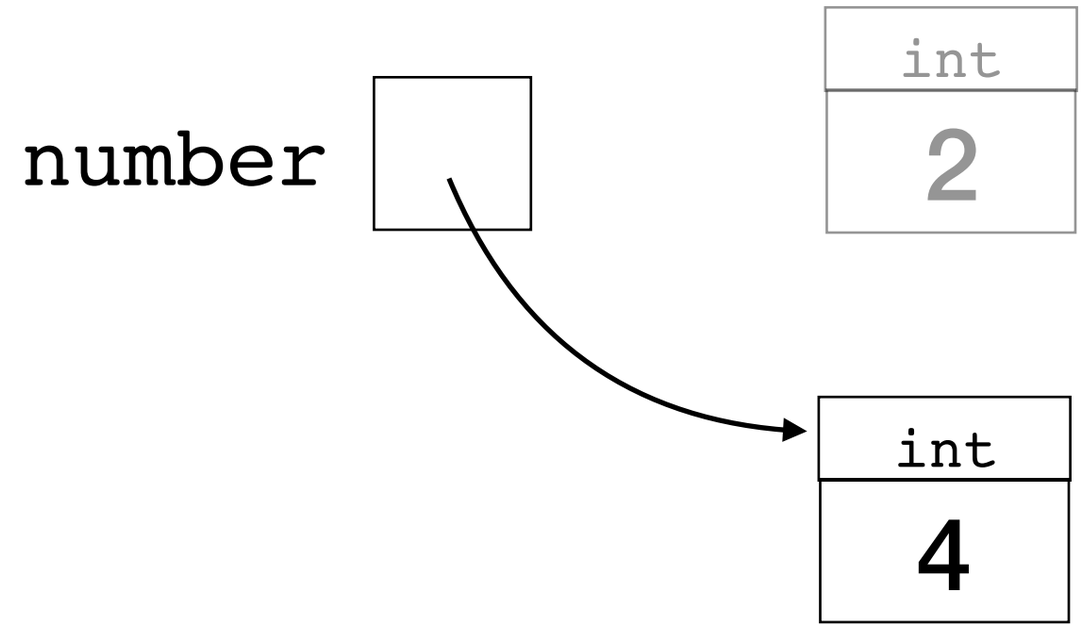


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number = 4
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For immutable objects, we don't have to think about this much.

All variables store references to objects

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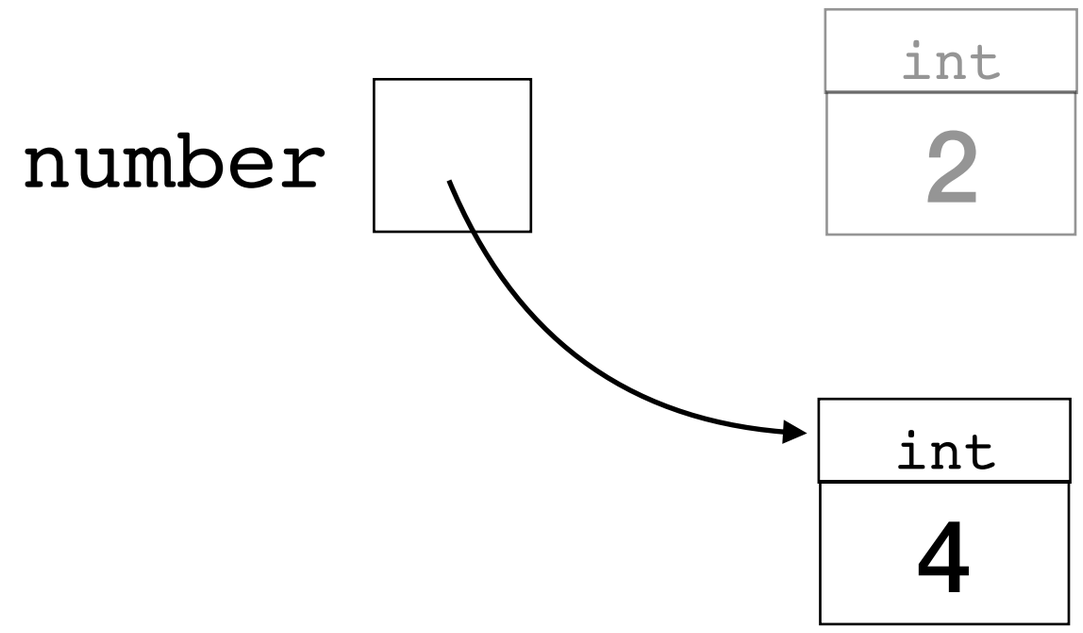


```
number = 4
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Aside: What happens to the 2 object?

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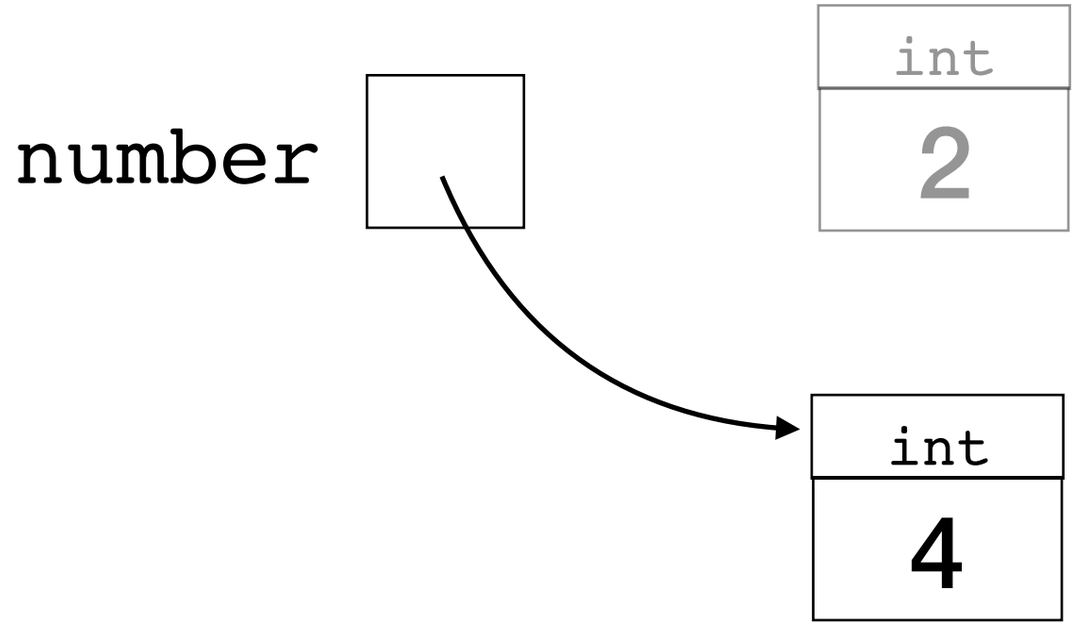


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Aside: What happens to the 2 object?

- If no variables refer to it, Python deletes it automatically.

For immutable objects, we don't have to think about this much.

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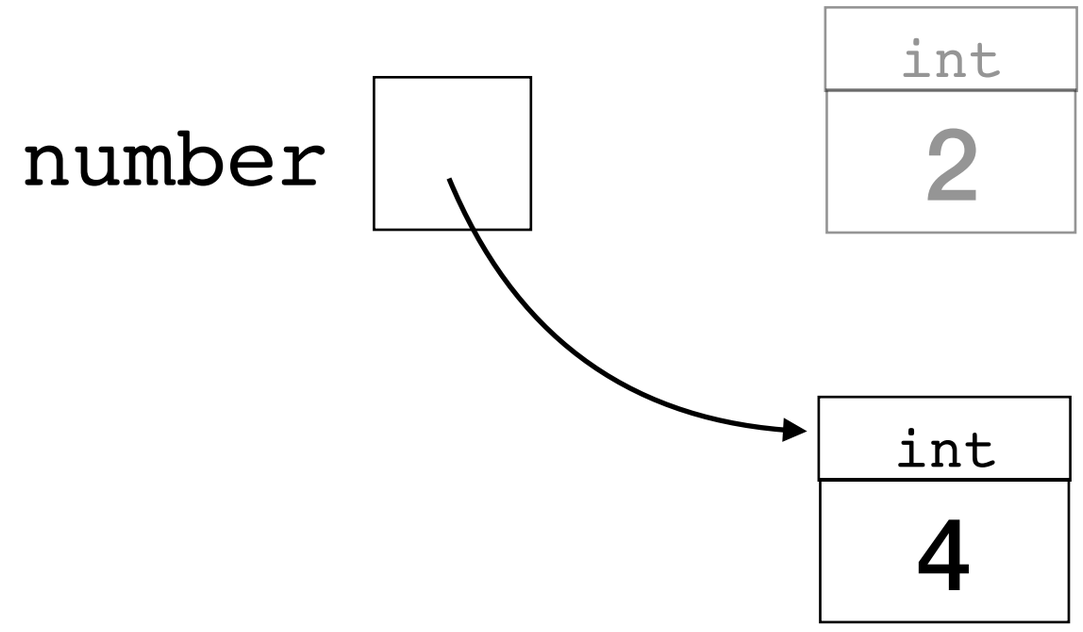


```
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Aside: What happens to the 2 object?

- If no variables refer to it, Python deletes it automatically.
- This is called *garbage collection*.

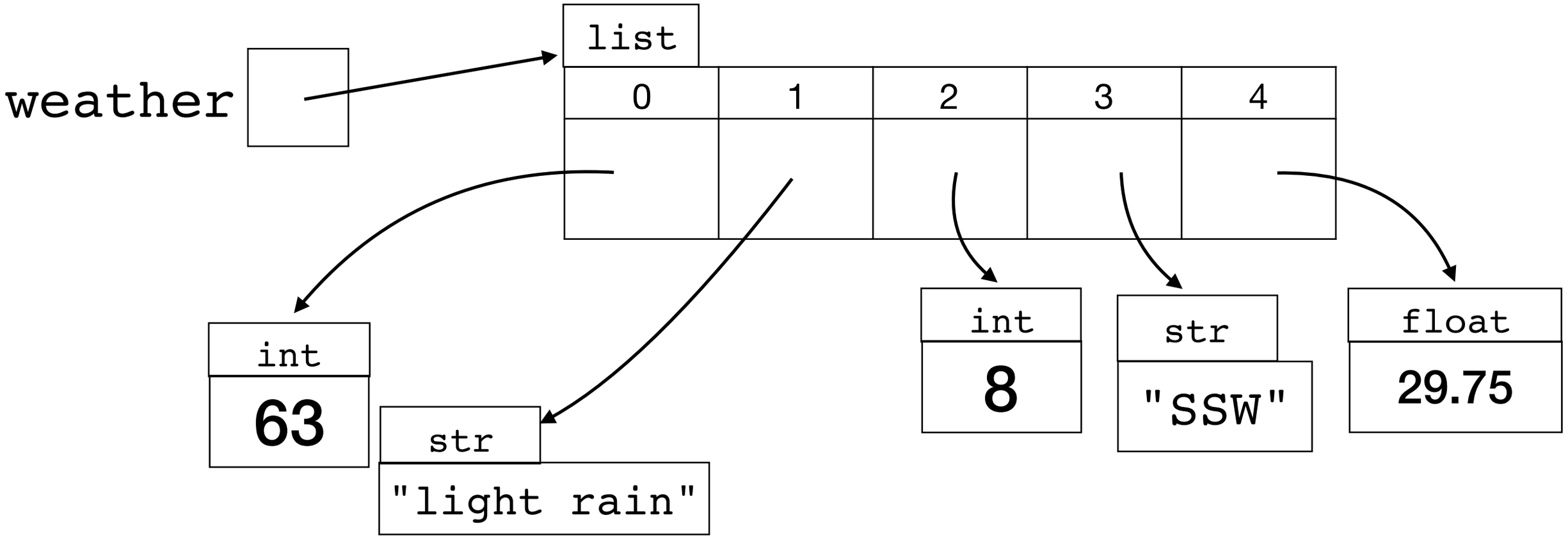
For immutable objects, we don't have to think about this much.

Objects and Variables: Digging a little deeper

Now let's talk about lists:

- each element is like its own variable

```
weather = [63, "light rain", 8, "SSW", 29.75]
```



Objects and Variables: Digging a little deeper

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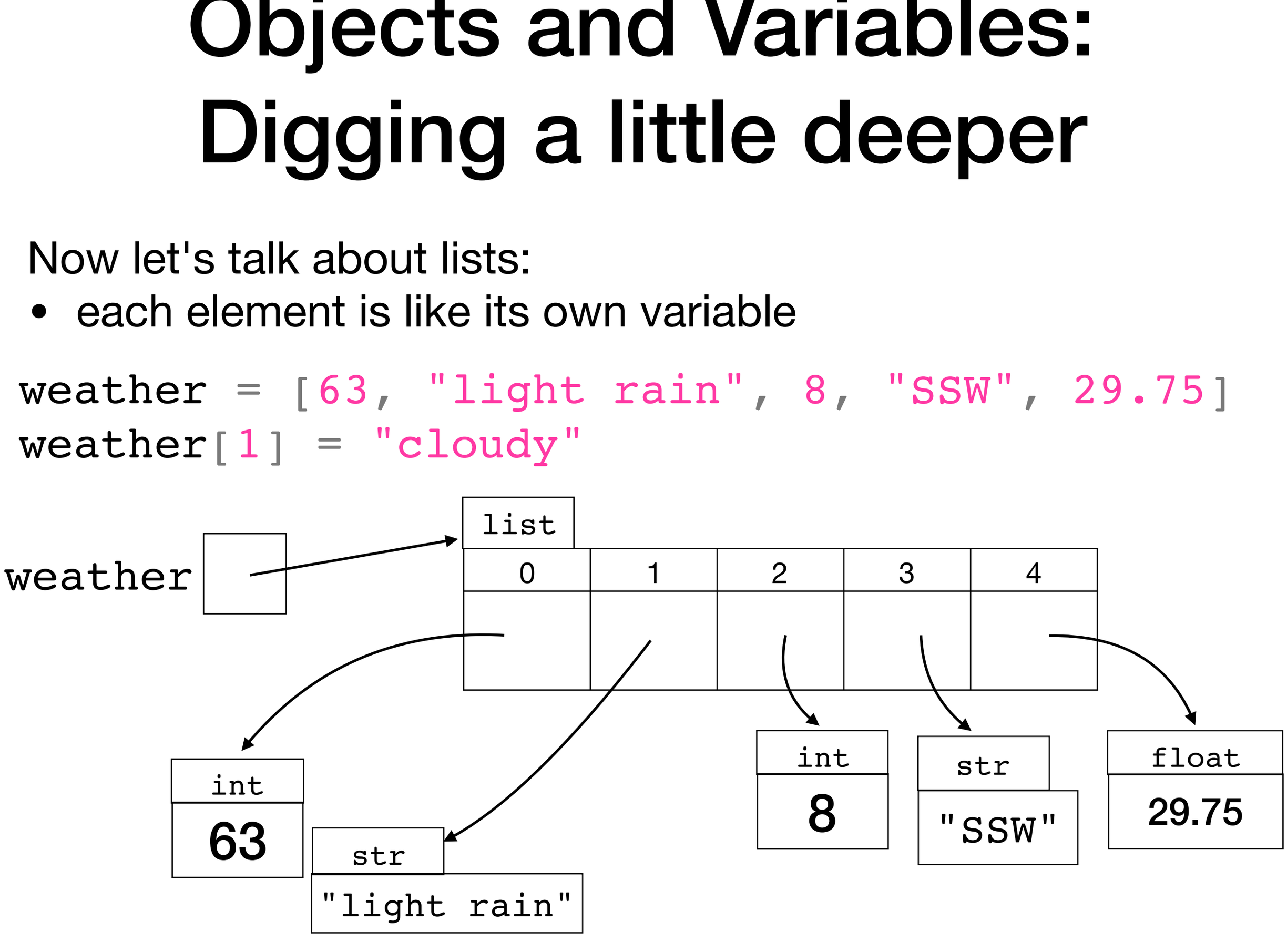

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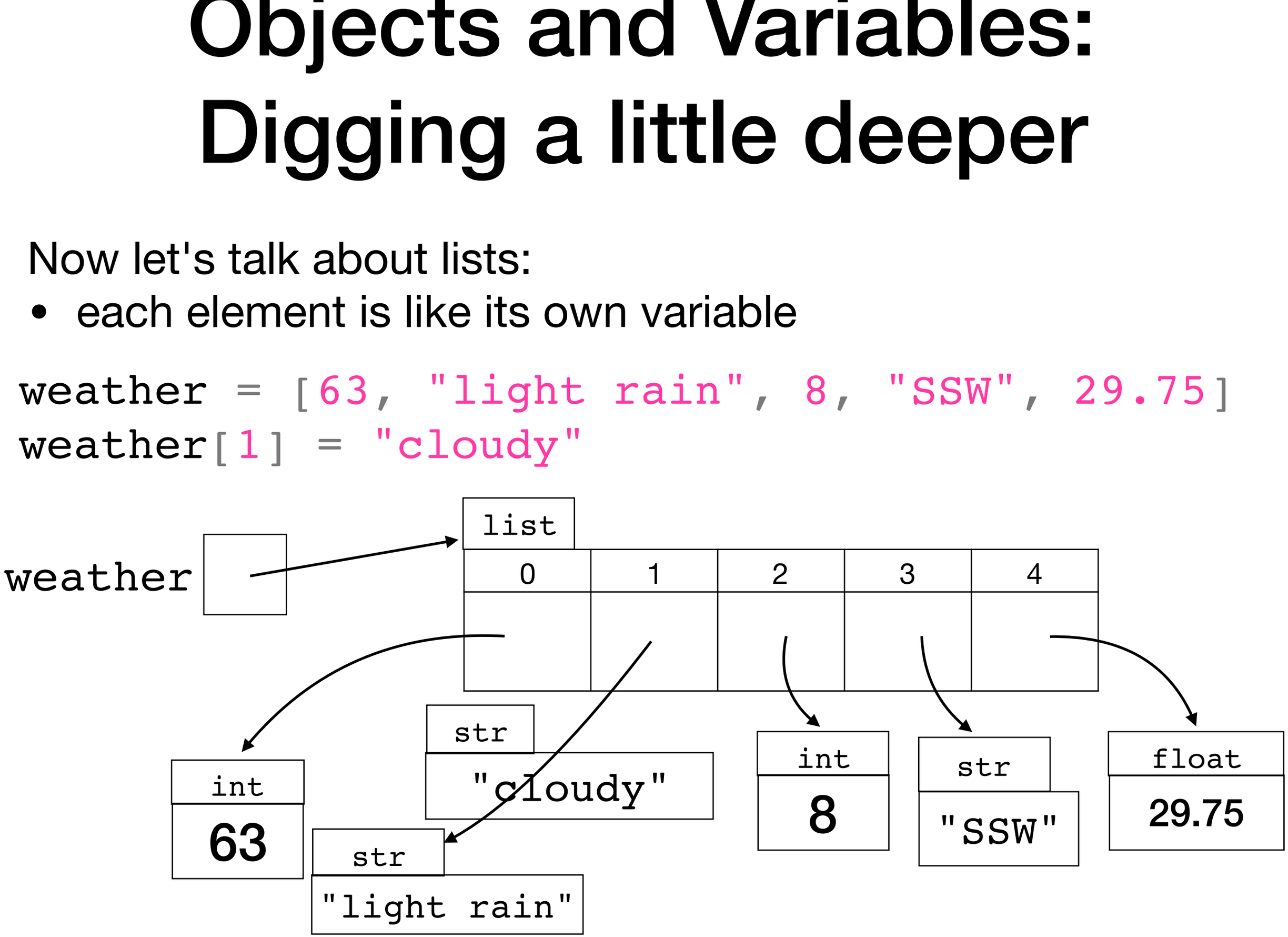

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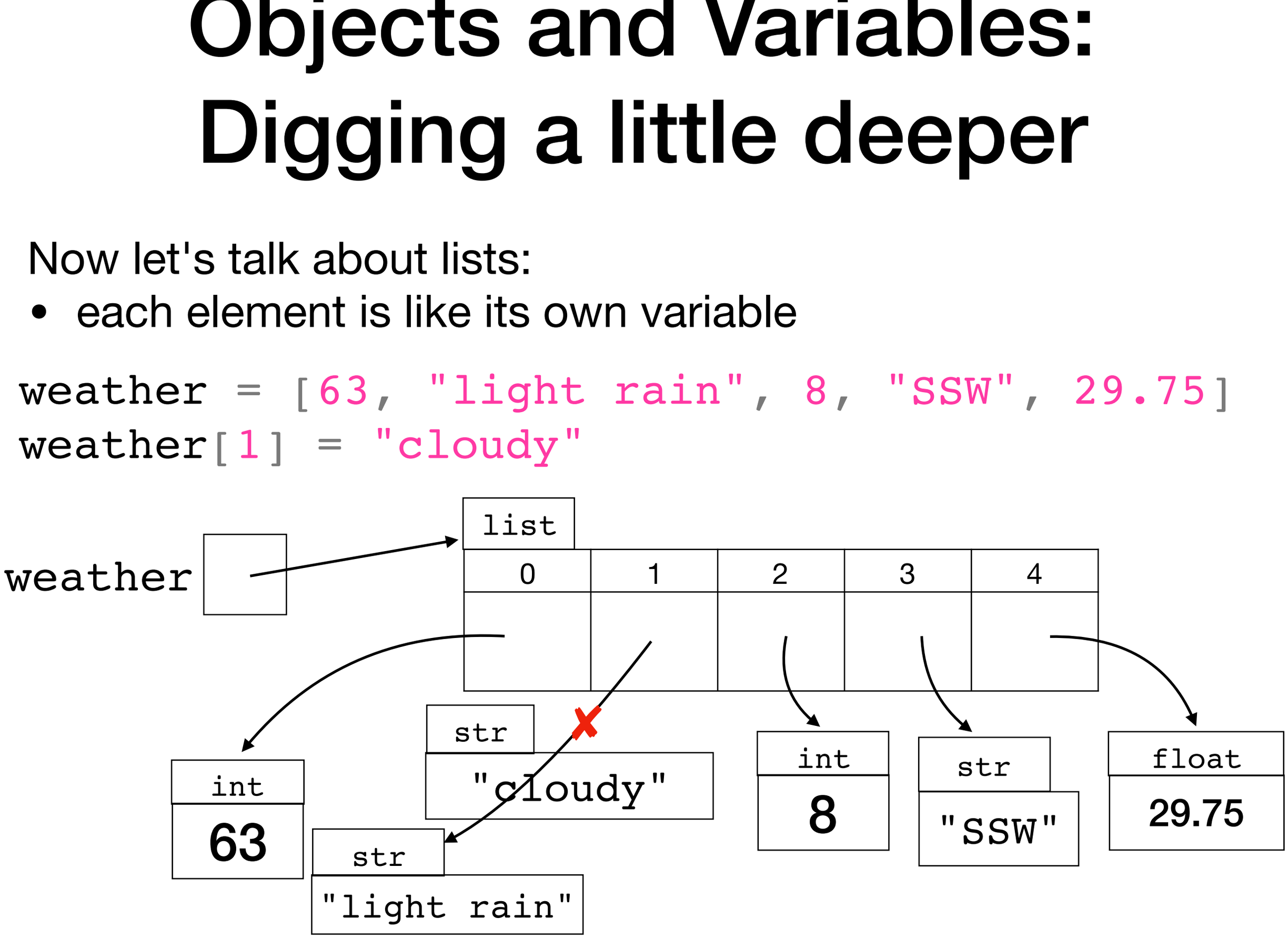

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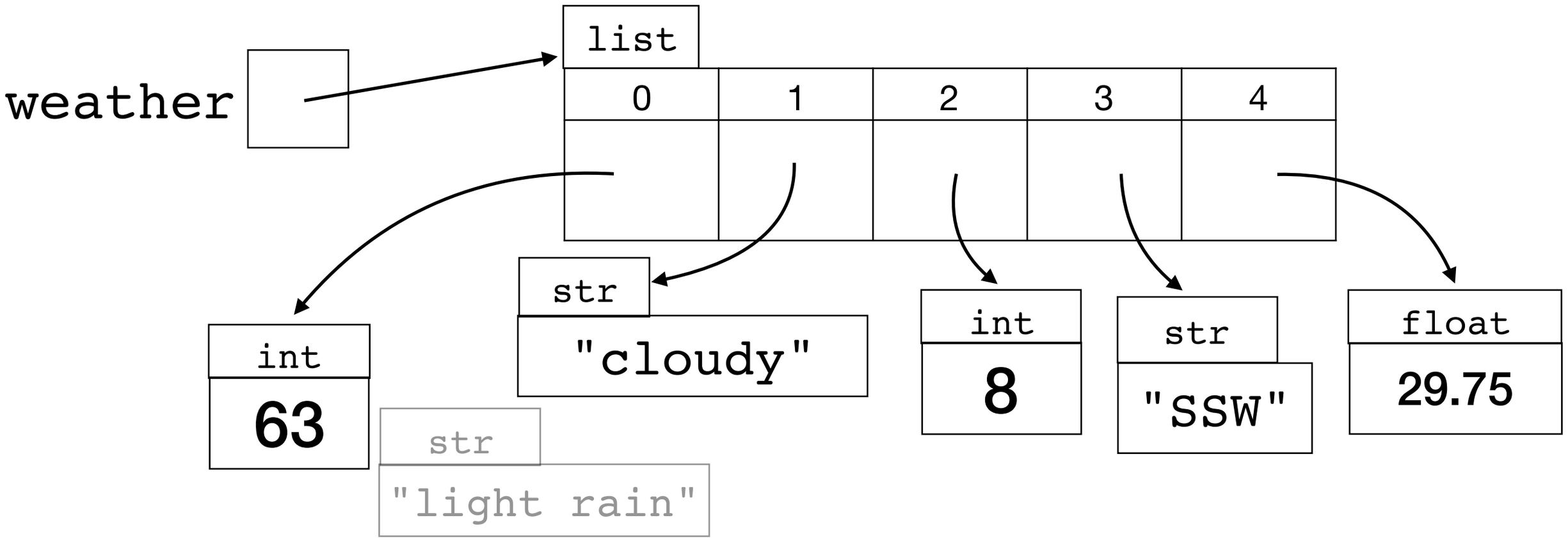
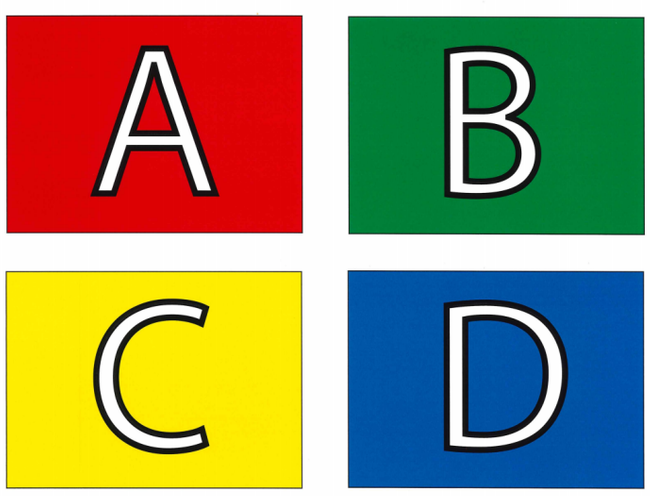


Implications of Mutability

```
weather = [63, "light rain"]
tomorrow_weather = weather
tomorrow_weather[0] = 68
print(weather[0])
```

ABCD: What does the above code print?

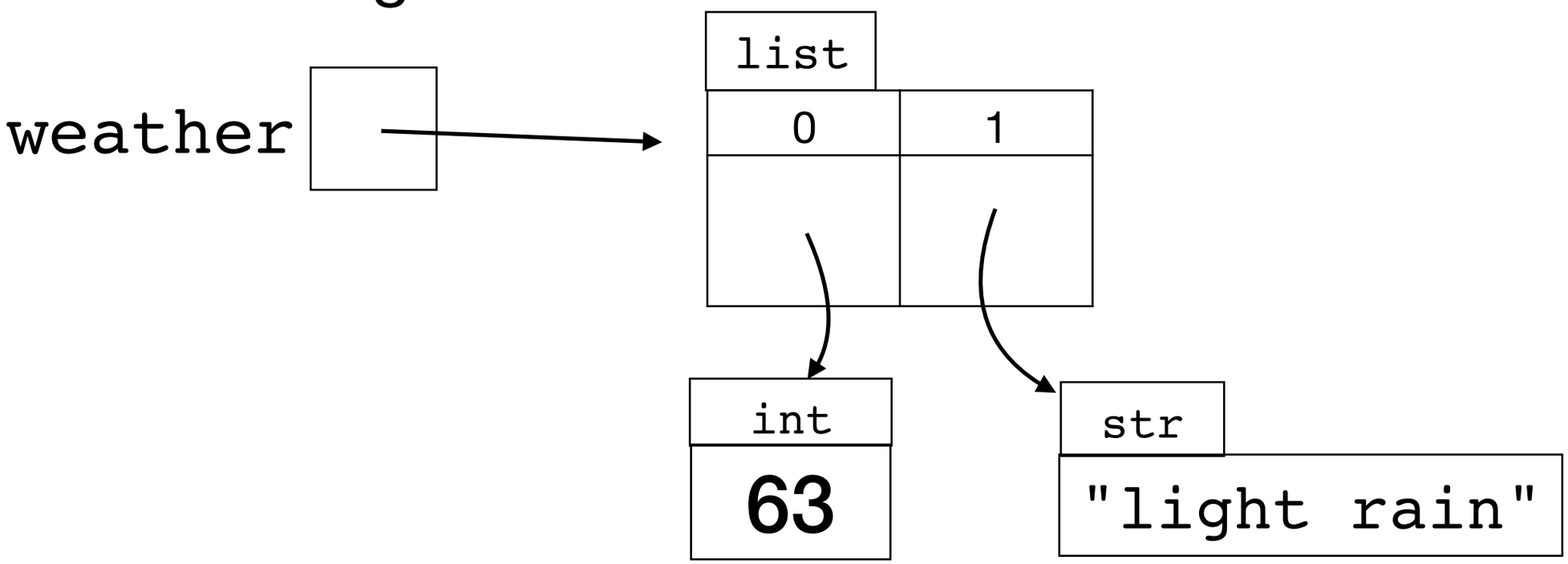


A. "light rain"
B. Error
C. 63
D. 68

Implications of Mutability

```
weather = [63, "light rain"]
tomorrow_weather = weather
tomorrow_weather[0] = 68
print(weather[0])
```

After creating the initial list:



On the board: how does this picture change as the code is executed?

Implications of Mutability

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Implications of Mutability

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More than one variable can refer to the **same object**.

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Changes to an object via one variable are reflected when accessing it via another variable!

Implications of Mutability

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More than one variable can refer to the **same object**.

Changes to an object via one variable are reflected when accessing it via another variable!

To create a true copy of a **mutable** object, you can't simply assign a new variable to the object.

Don't make this mistake

```
a = [1, 2, 3]
b = a
```

you **did not** just create a copy of `a`

Don't make this mistake

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a = [1, 2, 3]
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you **did not** just create a copy of `a`

To create a true copy of a **mutable** object, you **can't** simply assign a new variable to the object.

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a *reference* to the list:

```
def z1(a_list):
    a_list[0] = 0

a = [1, 1, 1]
z1(a)
print(a)
```

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a *reference* to the list:

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```
def z1(a_list):
    a_list[0] = 0

a = [1, 1, 1]
z1(a)
print(a)
```

`a_list` points to the **same** list as the global variable `a`

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a reference to the list:

```
def z2(a_list):
    a_list = []

a = [1, 1, 1]
z2(a)
print(a)
```

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a reference to the list:

```
def z2(a_list):
    a_list = []

a = [1, 1, 1]
z2(a)
print(a)
```

The local variable `a_list` is reassigned to point to a **new** (different) list

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a reference to the list:

```
def z2(a_list):
    a_list = []

a = [1, 1, 1]
z2(a)
print(a)
```

The local variable `a_list` is reassigned to point to a **new** (different) list

The list referenced by `a` is **unchanged**.

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a reference to the list:

```
def z3(x):
    a_list = [x, x, x]
    return a_list
b = 2
a = z3(b)
print(a)
```

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a reference to the list:

```
def z3(x):
    a_list = [x, x, x]
    return a_list
b = 2
a = z3(b)
print(a)
```

The function creates a **new** list, with the local variable `a_list` referring to it.

Mutable Objects and Functions

When you pass a list into a function, you're actually passing a reference to the list:

```
def z3(x):
    a_list = [x, x, x]
    return a_list
b = 2
a = z3(b)
print(a)
```

The function creates a **new** list, with the local variable `a_list` referring to it.

The **reference** to the list is returned and assigned to `a`.

Exercise

Write a function that returns a true copy (i.e., a different list object containing the same values).

```
def copy_list(in_list):
    """ Return a new list object containing
        the same elements as in_list.
        Precondition: in_list's contents are
        all immutable. """
```

Exercise

Write a function that returns a true copy (i.e., a different list object containing the same values).

```
def copy_list(in_list):
    """ Return a new list object containing
        the same elements as in_list.
        Precondition: in_list's contents are
        all immutable. """
```

Hint: one possible approach uses a loop and the `append` method.

Dictionaries

- Lists, tuples, strings are all **sequences** (their contents are ordered)

- Python also has some types that handle non-sequential collections, including dictionaries (type `dict`):

  - A dictionary is an unordered collection of **key-value mappings**

Dictionaries

Another way to think about **lists**:

A **list** is a **mapping**

from *integer indices*

to *arbitrary values*.

Dictionaries

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Example:

Dictionaries

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Example:

```
["B", "A", 7]
```

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```
["B", "A", 7]
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represents the following mapping:

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Example:

```
["B", "A", 7]
```

represents the following mapping:

0: "B"
1: "A"
2: 7

Dictionaries

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Example:

```
["B", "A", 7]
```

represents the following mapping:

0: "B"
1: "A"
2: 7

the index `0` maps to the value `"B"`

Dictionaries

Another way to think about **lists**:

A **list** is a **mapping**

from *integer indices*

to *arbitrary values*.

Example:

```
["B", "A", 7]
```

represents the following mapping:

0: "B" → the index `0` maps to the value `"B"`
1: "A"
2: 7

A **dictionary** is a **mapping**

from *arbitrary immutable keys*

to *arbitrary values*.

Dictionaries

Another way to think about **lists**:

A **list** is a **mapping**

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Example:

```
["B", "A", 7]
```

represents the following mapping:

0: "B" → the index `0` maps to the value `"B"`
1: "A"
2: 7

A **dictionary** is a **mapping**

from *arbitrary immutable keys*

to *arbitrary values*.

```
{"B": 6, "A": 7}
```

Dictionaries

Another way to think about **lists**:

A **list** is a **mapping**

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Example:

```
["B", "A", 7]
```

represents the following mapping:

0: "B" → the index `0` maps to the value `"B"`
1: "A"
2: 7

A **dictionary** is a **mapping**

from *arbitrary immutable keys*

to *arbitrary values*.

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{"B": 6, "A": 7}
```

represents the following mapping:

Dictionaries

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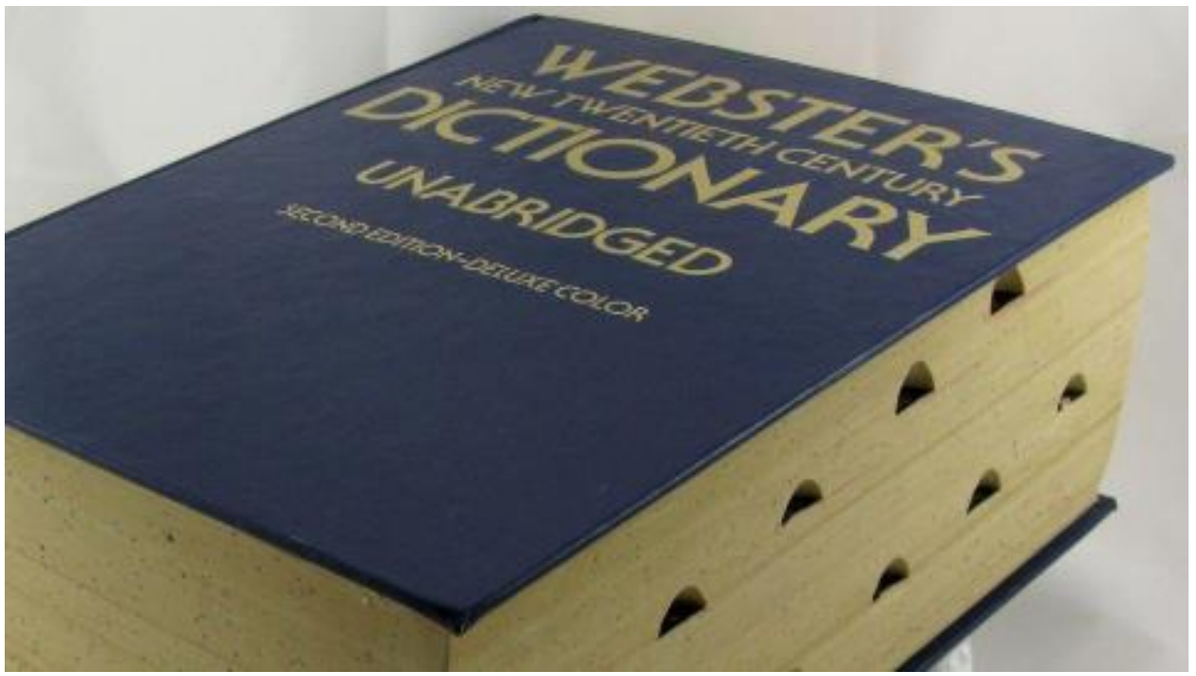
represents the following mapping:

"B": 6 → the key `B` maps to the value 6
"A": 7

Dictionaries

Why do we want this?

Suppose I want to store...




```
english = {}
english["aardvark"] = """a nocturnal burrowing
mammal with long ears, a tubular snout, and a
long extensible tongue, feeding on ants and
termites. Aardvarks are native to Africa and have
no close relatives."""
```

Dictionaries

Why do we want this?

Suppose I want to store...

A list of W#s of all the students in each of the lab sections.

```
sections = {}
sections[20891] = ["W0183782", "W0243810", # ...
sections[20892] = ["W0184582", "W0182368", # ...
# ...
```

Dictionaries

Why do we want this?

Suppose I want to store...

A bunch of different information about a WWU employee:

```
employee = {"First": "Scott",
            "Last": "Wehrwein",
            "Type": "Faculty",
            "W#": 98765438,
            # ...}
```

Dictionaries

Why do we want this?

Suppose I want to store...

The number of students with each letter grade in my class:

```
grade_counts = {"A": 6, "B": 12, "C": 8, "D": 2}
```

Dictionaries: Let's play

- Creation
- Indexing
- Assignment

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- in

```
grades = {"A": 10, "B": 18, "C": 6, "D": 2}
```