http://www.cs.cornell.edu/courses/cs1110/2019sp

# Lecture 13: Nested Lists, Tuples, and Dictionaries

(Sections 11.1-11.5, 12.1-12)

## CS 1110

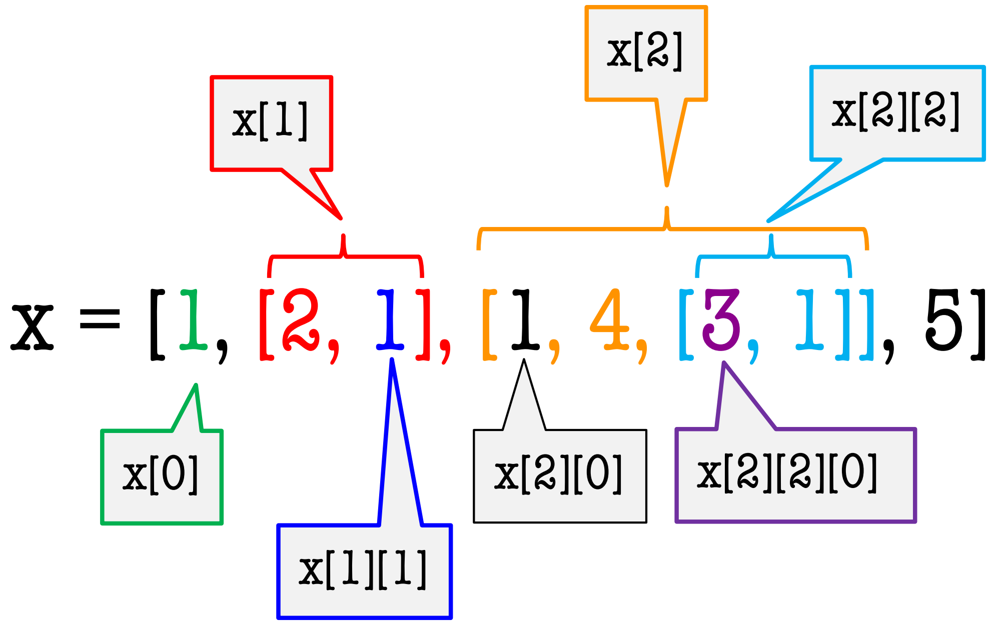
## Introduction to Computing Using Python

[E. Andersen, A. Bracy, D. Gries, L. Lee, S. Marschner, C. Van Loan, W. White]

# Nested Lists

- Lists can hold any objects
- Lists are objects
- Therefore lists can hold other lists!

```
b = [3, 1]
c = [1, 4, b]
a = [2, 1]
x = [1, a, c, 5]
```



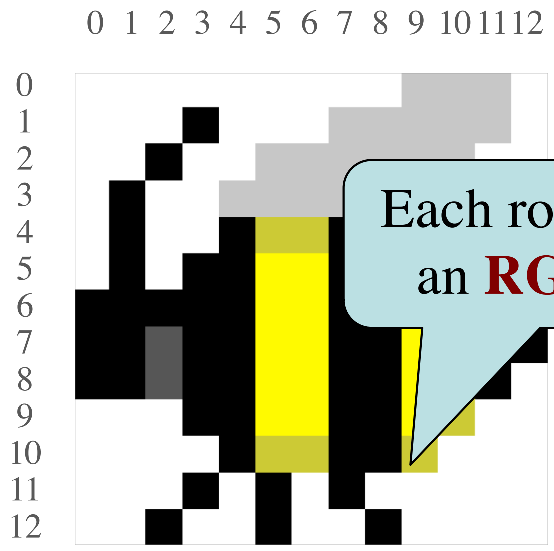
# Two Dimensional Lists

## Table of Data

|   | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| 0 | 5 | 4 | 7 | 3 |
| 1 | 4 | 8 | 9 | 7 |
| 2 | 5 | 1 | 2 | 3 |
| 3 | 4 | 1 | 2 | 9 |
| 4 | 6 | 7 | 8 | 0 |

Each row, col has a value

## Images



Each row, col has an **RGB** value

Store them as lists of lists ("**row-major order**")

```
d = [[5,4,7,3],[4,8,9,7],[5,1,2,3],[4,1,2,9],[6,7,8,0]]
```

# Overview of Two-Dimensional Lists

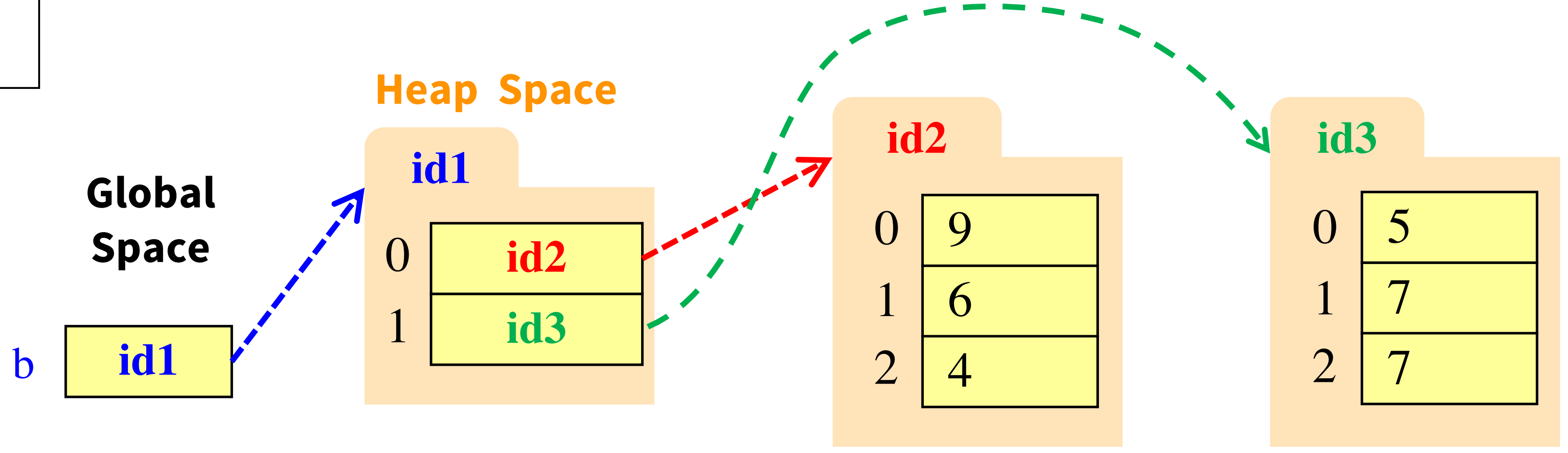
$$\begin{array}{c|cccc}
 & 0 & 1 & 2 & 3 \\
\hline
0 & 5 & 4 & 7 & 3 \\
1 & 4 & 8 & 9 & 7 \\
2 & 5 & 1 & 2 & 3 \\
3 & 4 & 1 & 2 & 9
\end{array}$$

```
>>> d =  [[5,4,7,3],[4,8,9,7],[5,1,2,3],[4,1,2,9]]
>>> d[3][2]               Access value at row 3, col 2
2
>>> d[3][2] = 8           Assign value at row 3, col 2
>>> len(d)                Number of rows of d
4
>>> len(d[2])             Number of cols in row 2 of d
4
>>> d
[[5, 4, 7, 3], [4, 8, 9, 7],[5, 1, 2, 3], [4, 1, 8, 9]]
```

## How Multidimensional Lists are Stored

```
9 6 4
5 7 7
```

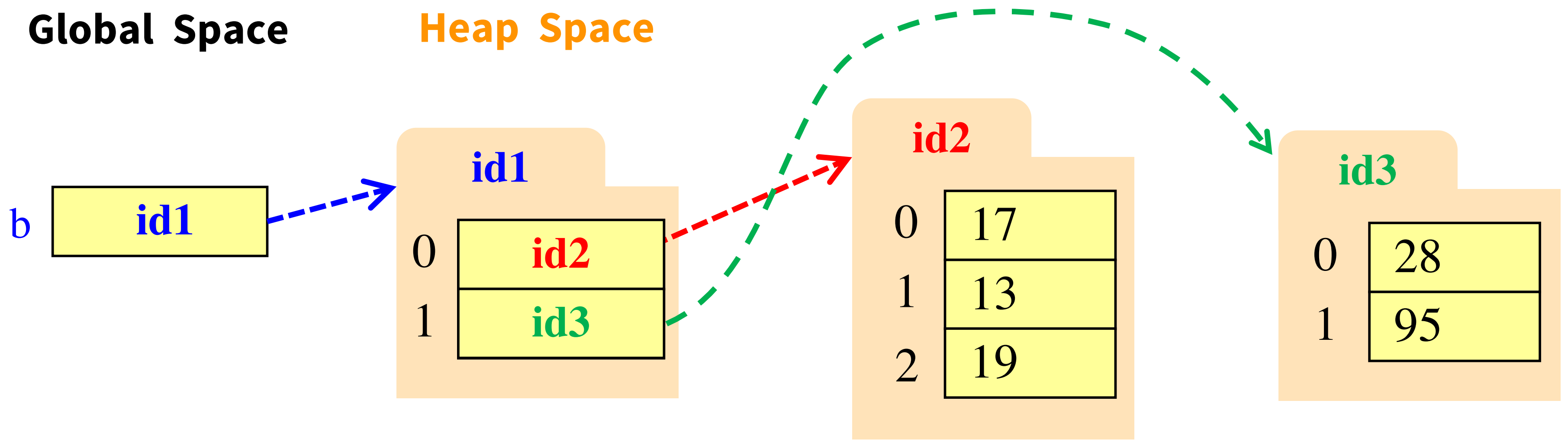
```
b = [[9, 6, 4], [5, 7, 7]]
```



- b holds **id** of a one-dimensional list
  - Has len(b) elements
- b[i] holds **id** of a one-dimensional list
  - Has len(b[i]) elements

## Ragged Lists: Rows w/ Different Length

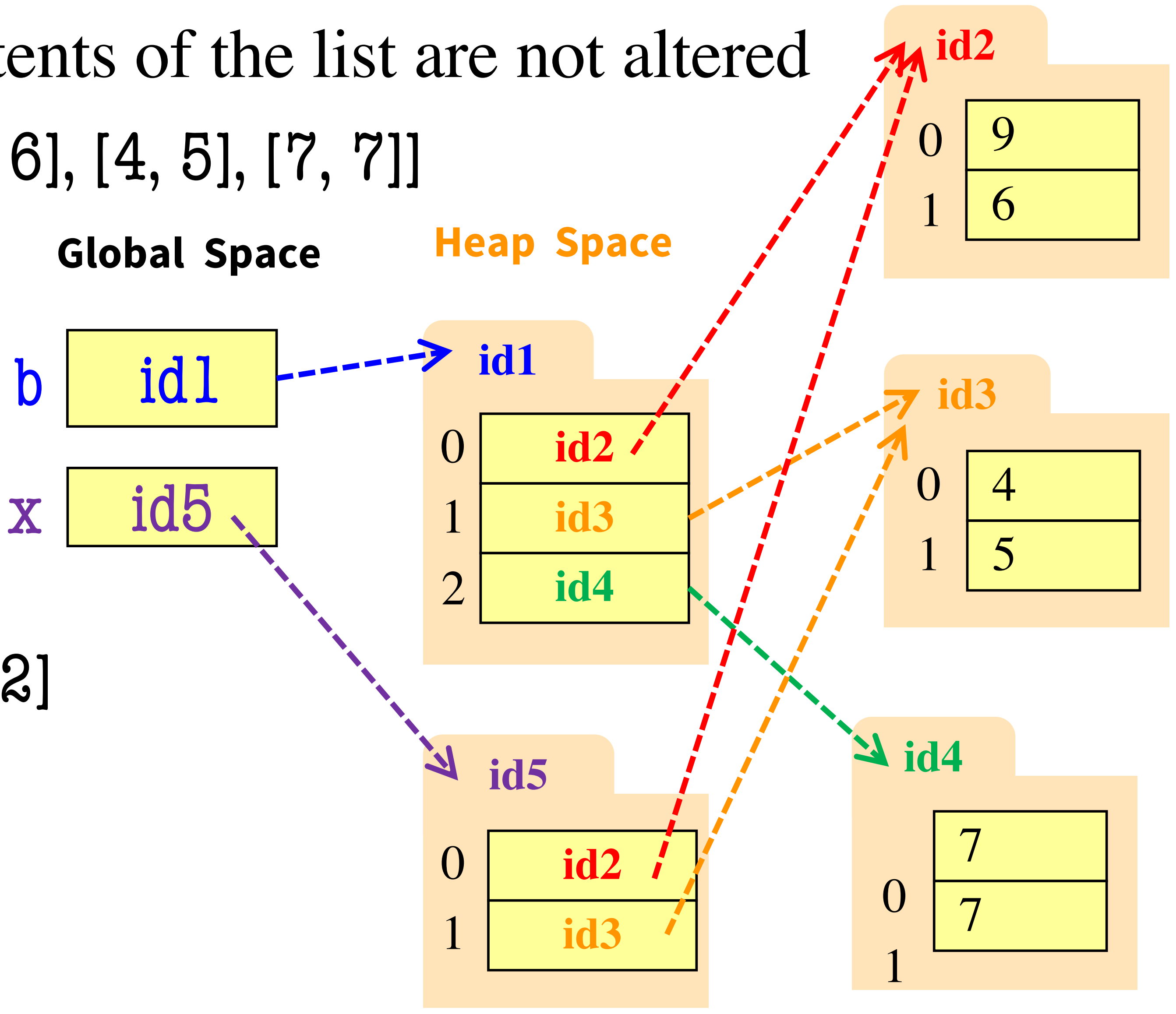
- `b = [[17,13,19],[28,95]]`



## Slices and Multidimensional Lists

- Only “top-level” list is copied.
- Contents of the list are not altered

```
b = [[9, 6], [4, 5], [7, 7]]
```



```
x = b[:2]
```

# Slices & Multidimensional Lists (Q1)

- Create a nested list

```
>>> b = [[9,6],[4,5],[7,7]]
```

- Get a slice

```
>>> x = b[:2]
```

- Append to a row of x

```
>>> x[1].append(10)
```

- What is now in x?

A: [[9,6,10]]
B: [[9,6],[4,5,10]]
C: [[9,6],[4,5,10],[7,7]]
D: [[9,6],[4,10],[7,7]]
E: I don't know

# Slices & Multidimensional Lists (A1)

- Create a nested list

```
>>> b = [[9,6],[4,5],[7,7]]
```

- Get a slice

```
>>> x = b[:2]
```

- Append to a row of x

```
>>> x[1].append(10)
```

- What is now in x?

A: [[9,6,10]]

[✓ B: [[9,6],[4,5,10]]]

C: [[9,6],[4,5,10],[7,7]]

D: [[9,6],[4,10],[7,7]]

E: I don’t know

# Slices & Multidimensional Lists (Q2)

- Create a nested list

```
>>> b = [[9,6],[4,5],[7,7]]
```

- Get a slice

```
>>> x = b[:2]
```

- Append to a row of x

```
>>> x[1].append(10)
```

- x now has nested list

```
[[9, 6], [4, 5, 10]]
```

- What is now in `b`?

A: `[[9,6],[4,5],[7,7]]`
B: `[[9,6],[4,5,10]]`
C: `[[9,6],[4,5,10],[7,7]]`
D: `[[9,6],[4,10],[7,7]]`
E: I don't know

## Slices & Multidimensional Lists (A2)

- Create a nested list

```
>>> b = [[9,6],[4,5],[7,7]]
```

- Get a slice

```
>>> x = b[:2]
```

- Append to a row of x

```
>>> x[1].append(10)
```

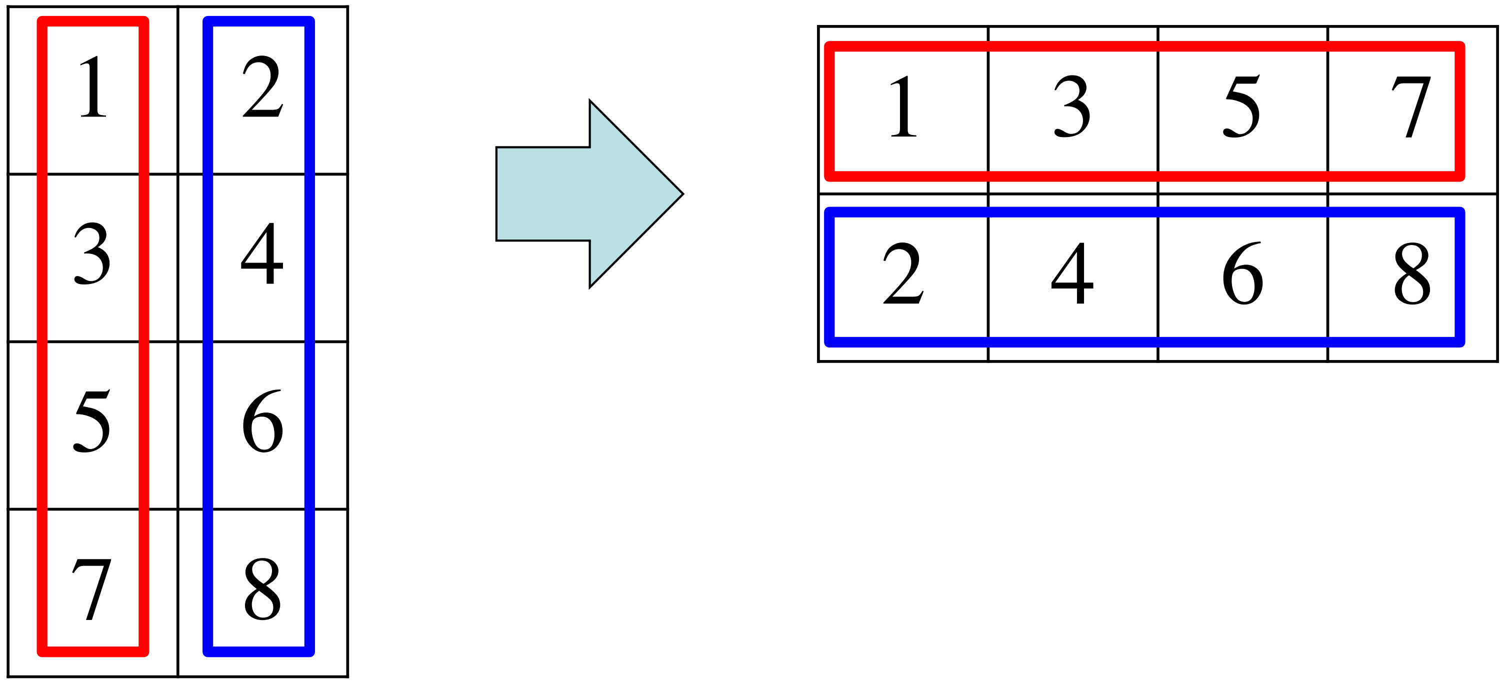
- x now has nested list

```
[[9, 6], [4, 5, 10]]
```

- What is now in b?

A: [[9,6],[4,5],[7,7]]
B: [[9,6],[4,5,10]]
[✓ C: [[9,6],[4,5,10],[7,7]]]
D: [[9,6],[4,10],[7,7]]
E: I don't know

# Data Wrangling: Transpose Idea



| | |
|---|---|
| 1 | 2 |
| 3 | 4 |
| 5 | 6 |
| 7 | 8 |

| | | | |
|---|---|---|---|
| 1 | 3 | 5 | 7 |
| 2 | 4 | 6 | 8 |

4 lists: 2 elements in each 2 lists: 4 elements in each

How to transpose?

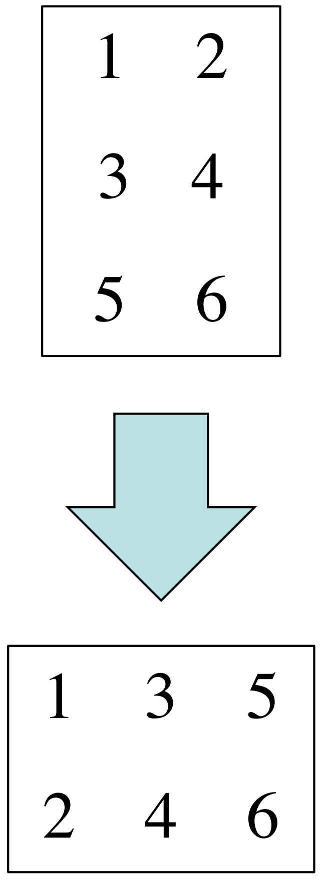
- 1st element of each list gets appended to 1st list
- 2nd element of each list gets appended to 2nd list

# Data Wrangling: Transpose Code

```
def transpose(table):
    """Returns: copy of table with rows and columns swapped

    Precondition: table is a (non-ragged) 2d List"""
    n_rows = len(table)
    n_cols  = len(table[0]) # All rows have same no. cols
    new_table = [] # Result accumulator
    for c in range(n_cols):
        row = [] # Single row accumulator
        for r in range(n_rows):
            row.append(table[r][c]) # Build up new row
        new_table.append(row) # Add new row to new table
    return new_table


d = [[1,2],[3,4],[5,6]]
d_v2 = transpose(d)
```



## Tuples

| strings: | tuples*: | lists: |
|---|---|---|
| **immutable** sequences of **characters** | **immutable** sequences of **any objects** | mutable sequences of **any objects** |

* "tuple" generalizes "pair," "triple," "quadruple," …

- Tuples fall between strings and lists
  - write them with just commas: `42, 4.0, 'x'`
  - often enclosed in parentheses: `(42, 4.0, 'x')`

Use **lists** for:

- long sequences
- homogeneous sequences
- variable length sequences

Use **tuples** for:

- short sequences
- heterogeneous sequences
- fixed length sequences

## Returning multiple values

- Can use lists/tuples to **return** multiple values

```
INCHES_PER_FOOT = 12

def to_feet_and_inches(height_in_inches):
    feet = height_in_inches // INCHES_PER_FOOT
    inches = height_in_inches % INCHES_PER_FOOT
    return (feet, inches)

all_inches = 68
(ft,ins) = to_feet_and_inches(all_inches)
print(You are “+str(ft)+” feet, “+str(ins)+” inches.”)
```

# Dictionaries (Type **dict**)

## Description

- List of key-value pairs
  - Keys are unique
  - Values need not be
- Example: net-ids
  - net-ids are **unique** (a key)
  - names need not be (values)
  - js1 is John Smith (class ’13)
  - js2 is John Smith (class ’16)

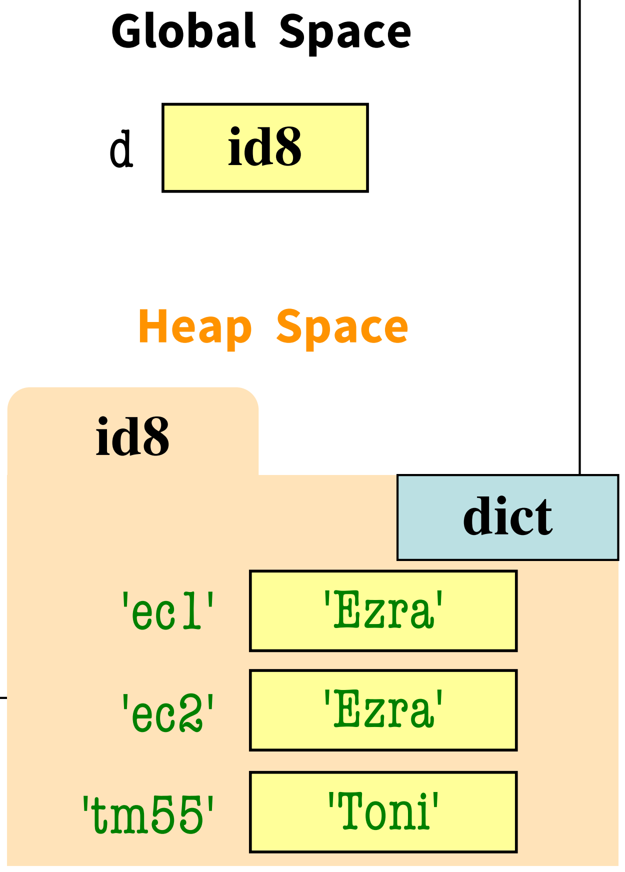
## Python Syntax

- Create with format:
  `{key1:value1, key2:value2, …}`
- Keys must be **immutable**
  - ints, floats, bools, strings
  - **Not** lists or custom objects
- Values can be anything
- Example:

```
d = {'ec1':'Ezra Cornell',
     'ec2':'Ezra Cornell',
     'tm55':'Toni Morrison'}
```

# Using Dictionaries (Type dict)

```
>>> d = {'ec1':'Ezra', 'ec2':'Ezra', 'tm55':'Toni'}
>>> d['ec1']
'Ezra'
>>> d[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 0
>>> d[:1]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unhashable type: 'slice'
>>>
```

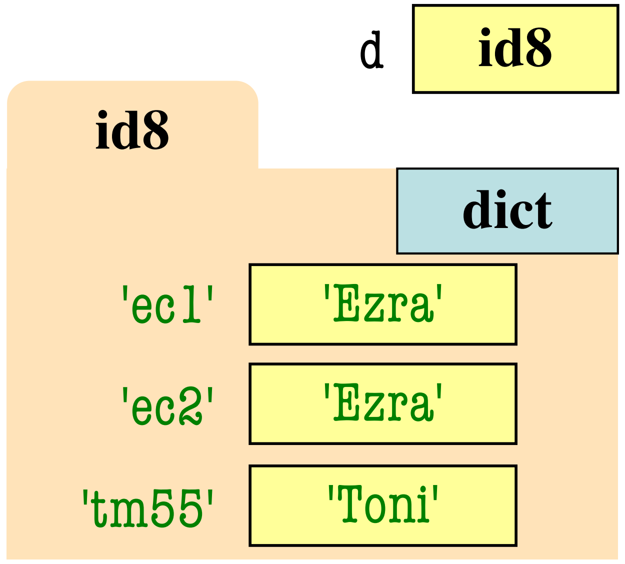


- Can access elements like a list
- Must use the key, not an index
- Cannot slice ranges

## Using Dictionaries (Type `dict`)

- Dictionaries are **mutable**
  - Can reassign values
  - `d['ec1'] = 'Ellis'`

```
d = {'ec1':'Ezra','ec2':'Ezra',
     'tm55':'Toni'}
```



## Using Dictionaries (Type `dict`)

- Dictionaries are **mutable**
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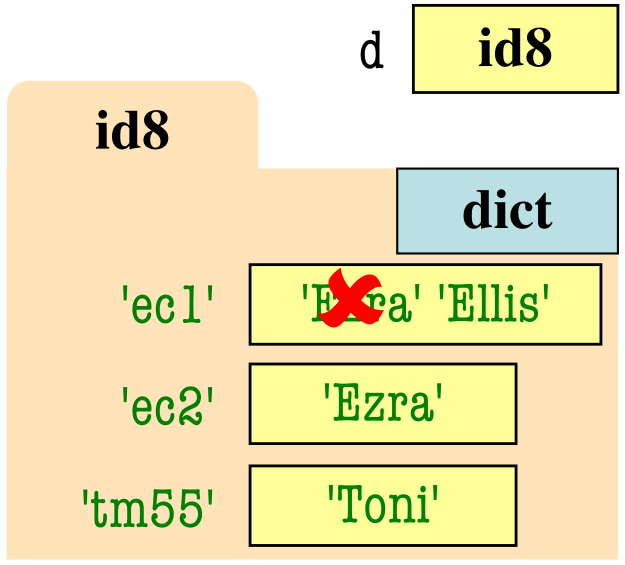
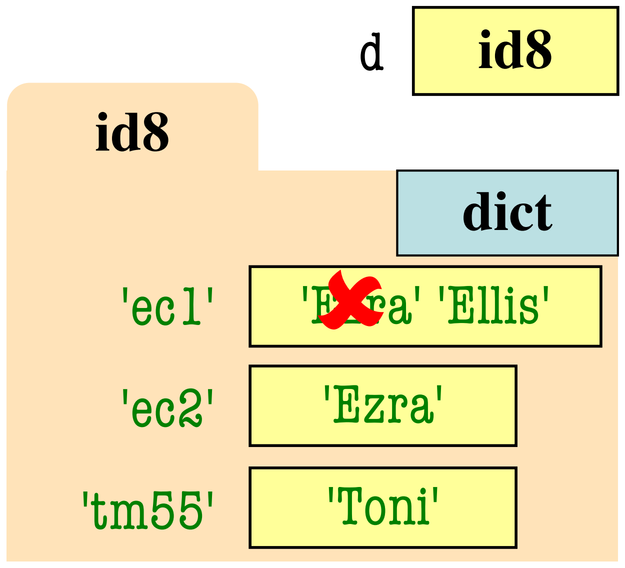


# Using Dictionaries (Type `dict`)

- Dictionaries are **mutable**
  - Can reassign values
  - `d['ec1'] = 'Ellis'`
  - Can add new keys
  - `d['psb26'] = 'Pearl'`

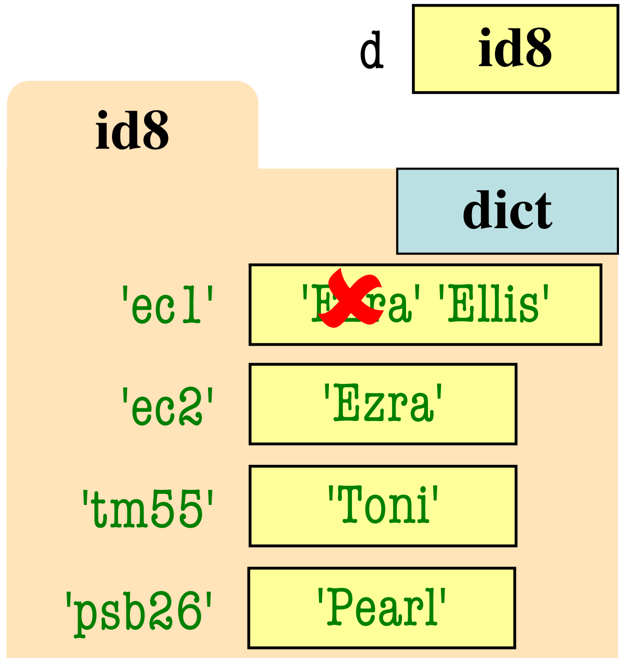
```
d = {'ec1':'Ezra','ec2':'Ezra',
     'tm55':'Toni'}
```



# Using Dictionaries (Type `dict`)

- Dictionaries are **mutable**
  - Can reassign values
  - `d['ec1'] = 'Ellis'`
  - Can add new keys
  - `d['psb26'] = 'Pearl'`

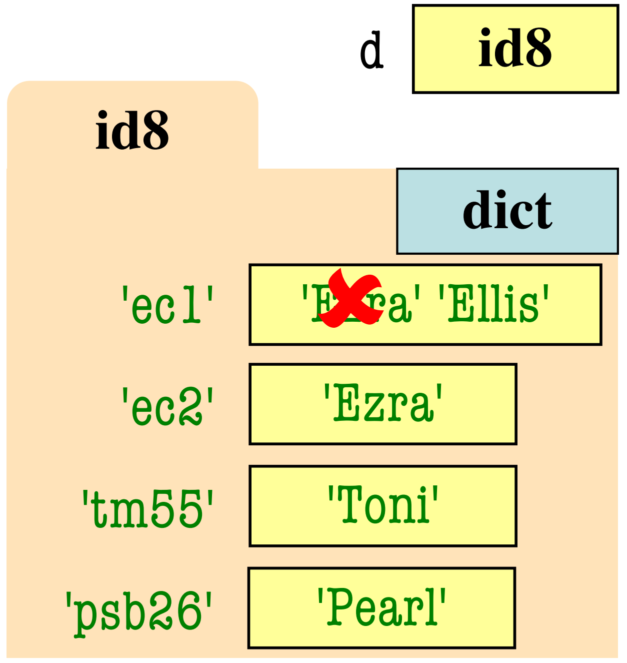
```
d = {'ec1':'Ezra','ec2':'Ezra',
     'tm55':'Toni','psb26':'Pearl'}
```



# Using Dictionaries (Type dict)

- Dictionaries are **mutable**
  - Can reassign values
  - `d['ec1'] = 'Ellis'`
  - Can add new keys
  - `d['psb26'] = 'Pearl'`
  - Can delete keys
  - `del d['tm55']`

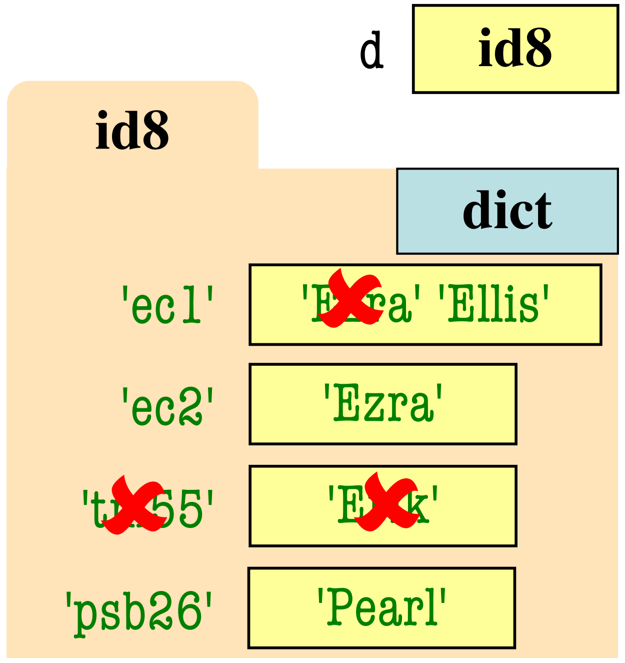
```
d = {'ec1':'Ezra','ec2':'Ezra',
     'tm55':'Toni','psb26':'Pearl'}
```



## Using Dictionaries (Type dict)

- Dictionaries are **mutable**
  - Can reassign values
  - `d['ec1'] = 'Ellis'`
  - Can add new keys
  - `d['psb26'] = 'Pearl'`
  - Can delete keys
  - `del d['tm55']`

```
d = {'ec1':'Ezra','ec2':'Ezra',
     'psb26':'Pearl'}
```



Deleting key deletes both