

### Sequences: Lists of Values

| String  | List   |
|---|--|
| <ul style="list-style-type: none"> <li><code>s = 'abc d'</code></li> </ul> <div style="display: flex; justify-content: space-around; border: 1px solid black; padding: 2px;"> <span>0</span><span>1</span><span>2</span><span>3</span><span>4</span> </div> <div style="display: flex; justify-content: space-around; border: 1px solid black; padding: 2px;"> <span>a</span><span>b</span><span>c</span><span> </span><span>d</span> </div> <ul style="list-style-type: none"> <li>Put characters in quotes                             <ul style="list-style-type: none"> <li>Use <code>\</code> for quote character</li> </ul> </li> <li>Access characters with <code>[]</code> <ul style="list-style-type: none"> <li><code>s[0]</code> is 'a'</li> <li><code>s[5]</code> <b>causes an error</b></li> <li><code>s[0:2]</code> is 'ab' (excludes <code>o</code>)</li> <li><code>s[2:]</code> is 'c d'</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li><code>x = [5, 6, 5, 9, 15, 23]</code></li> </ul> <div style="display: flex; justify-content: space-around; border: 1px solid black; padding: 2px;"> <span>0</span><span>1</span><span>2</span><span>3</span><span>4</span><span>5</span> </div> <div style="display: flex; justify-content: space-around; border: 1px solid black; padding: 2px;"> <span>5</span><span>6</span><span>5</span><span>9</span><span>15</span><span>23</span> </div> <ul style="list-style-type: none"> <li>Put values inside <code>[]</code> <ul style="list-style-type: none"> <li>Separate by commas</li> </ul> </li> <li>Access <b>values</b> with <code>[]</code> <ul style="list-style-type: none"> <li><code>x[0]</code> is 5</li> <li><code>x[0]</code> <b>causes an error</b></li> <li><code>x[0:2]</code> is [5, 6] (excludes 2<sup>nd</sup> 5)</li> <li><code>x[3:]</code> is [9, 15, 23]</li> </ul> </li> </ul> |

### Lists Have Methods Similar to String

`x = [5, 6, 5, 9, 15, 23]`

- `index(value)`
  - Return position of the value
  - ERROR** if value is not there
  - `x.index(9)` evaluates to 3
- `count(value)`
  - Returns number of times value appears in list
  - `x.count(5)` evaluates to 2

But you get length of a list with a regular function, not method: `len(x)`

### Lists are Mutable

- Can alter their contents
  - Use an assignment: `<var>[<index>] = <value>`
  - Index is position, not slice
- Does not work for strings
  - `s = 'Hello World!'`
  - `s[0] = 'J'` **ERROR**
- Represent list as a folder
  - Variable holds tab name
  - Contents are attributes

`x[1] = 8`

|   |   |   |    |
|---|---|---|----|
| 0 | 1 | 2 | 3  |
| 5 | X | 4 | -2 |
| 8 |   |   |    |

|          |      |    |
|----------|------|----|
| 23457811 | x[0] | 5  |
| 23457811 | x[1] | 7  |
| 23457811 | x[2] | 4  |
| 23457811 | x[3] | -2 |

### When Do We Need to Draw a Folder?

- When the value **contains** other values
  - This is what we are calling 'objects'
- When the value is **mutable**

| Type  | Container? | Mutable? |
|-------|------------|----------|
| int   | No         | No       |
| float | No         | No       |
| str   | Yes*       | No       |
| Point | Yes        | Yes      |
| RGB   | Yes        | Yes      |
| list  | Yes        | Yes      |

### Lists vs. Custom Objects

| List  | RGB      |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
|---|----------|------|------|---|------|---|------|---|------|----|--|----------|-----|-----|-----|-------|----|------|-----|
| <ul style="list-style-type: none"> <li>Attributes are indexed                             <ul style="list-style-type: none"> <li>Example: <code>x[2]</code></li> </ul> </li> </ul> <div style="margin-top: 10px;"> <code>x</code> <span style="border: 1px solid black; padding: 2px;">23457811</span> </div> <div style="margin-top: 10px;"> <table style="border-collapse: collapse;"> <tr><td style="border: none;">23457811</td><td style="border: none;">list</td></tr> <tr><td style="border: none;">x[0]</td><td style="border: none;">5</td></tr> <tr><td style="border: none;">x[1]</td><td style="border: none;">7</td></tr> <tr><td style="border: none;">x[2]</td><td style="border: none;">4</td></tr> <tr><td style="border: none;">x[3]</td><td style="border: none;">-2</td></tr> </table> </div> | 23457811 | list | x[0] | 5 | x[1] | 7 | x[2] | 4 | x[3] | -2 | <ul style="list-style-type: none"> <li>Attributes are named                             <ul style="list-style-type: none"> <li>Example: <code>c.red</code></li> </ul> </li> </ul> <div style="margin-top: 10px;"> <code>c</code> <span style="border: 1px solid black; padding: 2px;">43001122</span> </div> <div style="margin-top: 10px;"> <table style="border-collapse: collapse;"> <tr><td style="border: none;">43001122</td><td style="border: none;">RGB</td></tr> <tr><td style="border: none;">red</td><td style="border: none;">128</td></tr> <tr><td style="border: none;">green</td><td style="border: none;">64</td></tr> <tr><td style="border: none;">blue</td><td style="border: none;">255</td></tr> </table> </div> | 43001122 | RGB | red | 128 | green | 64 | blue | 255 |
| 23457811  | list     |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| x[0]  | 5        |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| x[1]  | 7        |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| x[2]  | 4        |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| x[3]  | -2       |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| 43001122  | RGB      |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| red   | 128      |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| green   | 64       |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |
| blue  | 255      |      |      |   |      |   |      |   |      |    |  |          |     |     |     |       |    |      |     |

### List Methods Can Alter the List

`x = [5, 6, 5, 9]`

- `append(value)`
  - A **procedure method**, not a function method
  - Adds a new value to the end of list
  - `x.append(-1)` *changes* the list to `[5, 6, 5, 9, -1]`
- `insert(index, value)`
  - Put the value into list at index; shift rest of list right
  - `x.insert(2,-1)` changes the list to `[5, 6, -1, 5, 9,]`
- `sort()` What do you think this does?

See Python API for more

### Lists and Functions: Swap

```
def swap(b, h, k):
    """Procedure swaps b[h] and b[k] in b
    Precondition: b is a mutable list, h
    and k are valid positions in the list"""
    1 temp= b[h]
    2 b[h]= b[k]
    3 b[k]= temp
```

swap(x, 3, 4)

Swaps b[h] and b[k], because parameter b contains name of list.

|      |          |
|------|----------|
| swap |          |
| b    | 82799054 |
| h    | 3        |
| temp | 6        |
| k    | 4        |

|          |   |
|----------|---|
| 82799054 |   |
| 0        | 5 |
| 1        | 4 |
| 2        | 7 |
| 3        | 5 |
| 4        | 6 |

x 82799054

### List Slices Make Copies

x = [5, 6, 5, 9]

|          |   |
|----------|---|
| 23457811 |   |
| list     |   |
| x[0]     | 5 |
| x[1]     | 6 |
| x[2]     | 5 |
| x[3]     | 9 |

y = x[1:3]

|          |   |
|----------|---|
| 82799054 |   |
| list     |   |
| y[0]     | 6 |
| y[1]     | 5 |

copy = new folder

### 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**

|    |         |   |   |   |   |   |   |   |   |   |    |    |    |
|----|---------|---|---|---|---|---|---|---|---|---|----|----|----|
|    | 0       | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 0  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 1  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 2  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 3  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 4  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 5  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 6  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 7  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 8  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 9  | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 10 | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 11 | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |
| 12 | [Image] |   |   |   |   |   |   |   |   |   |    |    |    |

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

- Access value at row 3, col 2:
 

|   |   |   |   |   |
|---|---|---|---|---|
| d | 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 |
- Assign value at row 3, col 2:
 

d[3][2] = 8
- An odd symmetry**
  - Number of rows of d: len(d)
  - Number of cols in row r of d: len(d[r])

### How Multidimensional Lists are Stored

- b = [[0, 6, 4], [5, 7, 7]]

|   |   |   |
|---|---|---|
| 9 | 6 | 4 |
| 5 | 7 | 7 |

→

|          |
|----------|
| 23457811 |
| 82799054 |
| 43001122 |

→

|          |
|----------|
| 82799054 |
| 9        |
| 6        |
| 4        |

→

|          |
|----------|
| 43001122 |
| 5        |
| 7        |
| 7        |

- b holds name of a one-dimensional list
  - Has len(b) elements
  - Its elements are (the names of) 1D lists
- b[i] holds the name of a one-dimensional list (of ints)
  - Has len(b[i]) elements

### Slices and Multidimensional Lists

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

b = [[0, 6], [4, 5], [7, 7]]

x = b[:2]

|          |
|----------|
| 23457811 |
| 82799054 |
| 43001122 |
| 54728599 |

→

|          |
|----------|
| 82799054 |
| 9        |
| 6        |

→

|          |
|----------|
| 43001122 |
| 4        |
| 5        |

→

|          |
|----------|
| 19384760 |
| 82799054 |
| 43001122 |