

Nested Lists

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

```

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

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How Multidimensional Lists are Stored

- `b = [[9, 6, 4], [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

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Ragged Lists vs Tables

- Ragged is 2d uneven list: `b = [[17,13,19],[28,95]]`

- Table is 2d uniform list: `b = [[9,6,4],[5,7,7]]`

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Representing Tables as Lists

Spreadsheet

	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

- Represent as 2d list
 - Each table row a list
 - List of all rows
 - **Row major order**
- Column major exists
 - Less common to see
 - Limited to some scientific applications

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

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Overview of Two-Dimensional Lists

- Access value at row 3, col 2: `d[3][2]`
- 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])`

	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

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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]`

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Shallow vs. Deep Copy

- **Shallow copy:** Copy top-level list
 - Happens when slice a multidimensional list
- **Deep copy:** Copy top and all nested lists
 - Requires a special function: `copy.deepcopy`
- **Example:**

```
>>> import copy
>>> a = [[1,2],[2,3]]
>>> b = a[:]           # Shallow copy
>>> c = copy.deepcopy(a) # Deep copy
```

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Functions over Nested Lists

- Functions on nested lists similar to lists
 - Go over (nested) list with *for-loop*
 - Use *accumulator* to gather the results
- But two important differences
 - Need **multiple for-loops**
 - One for each part/dimension of loop
 - In some cases need **multiple accumulators**
 - Latter true when result is new table

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Functions on Nested Lists

```
def all_nums(table):
    """Returns True if table contains only numbers
    Precondition: table is a (non-ragged) 2d List"""
    result = True
    # Walk through table
    for row in table:
        # Walk through the row
        for item in row:
            if not type(item) in [int,float]:
                result = False
    return result
```

Annotations: **Accumulator** (points to `result = True`), **First Loop** (points to `for row in table:`), **Second Loop** (points to `for item in row:`)

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Transpose: A Trickier Example

```
def transpose(table):
    """Returns: copy of table with rows and columns swapped
    Precondition: table is a (non-ragged) 2d List"""
    numrows = len(table) # Need number of rows
    numcols = len(table[0]) # All rows have same no. cols
    result = []
    for m in range(numcols):
        row = []
        for n in range(numrows):
            row.append(table[n][m]) # Create a new row list
            result.append(row) # Add result to table
    return result
```

Annotations: **Accumulator for each loop** (points to `row = []` and `result.append(row)`)

Diagram: Original table $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$ \downarrow Transposed table $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$

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A Mutable Example

```
def add_ones(table):
    """Adds one to every number in the table
    Preconditions: table is a 2d List,
    all table elements are int"""
    # Walk through table
    for rpos in range(len(table)):
        # Walk through each column
        for cpos in range(len(table[rpos])):
            table[rpos][cpos] = table[rpos][cpos]+1
    # No return statement
```

Annotation: **Do not loop over the table** (points to the nested loops)

Diagram: Original table $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$ \downarrow Modified table $\begin{bmatrix} 2 & 4 & 6 \\ 3 & 5 & 7 \end{bmatrix}$

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Another Example

```
def strip(table,col):
    """Removes column col from the given table
    Preconditions: table is a (non-ragged) 2d List,
    col valid column"""
    # Walk through table
    for rpos in range(len(table)):
        # Modify each row to slice out column
        table[rpos] = table[rpos][:col] + table[rpos][col+1:]
    # No return statement
```

Annotation: **Do not loop over the table** (points to the loop)

Diagram: Original table $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$ (column 2 is circled) \downarrow Stripped table $\begin{bmatrix} 1 & 5 \\ 2 & 6 \end{bmatrix}$

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