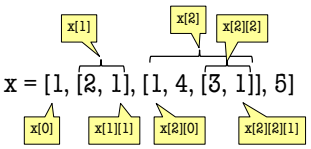
Nested Lists

- 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]
```



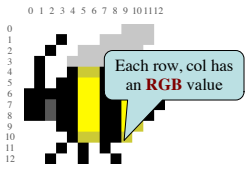
Two Dimensional Lists

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



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[3][2]`

- Assign value at row 3, col 2:

  `d[3][2] = 8`

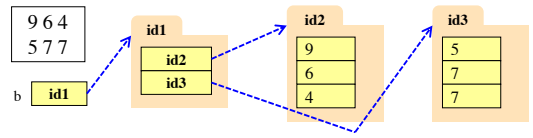
- **An odd symmetry**
  - Number of rows of d: `len(d)`
  - Number of cols in row r of d: `len(d[r])`

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

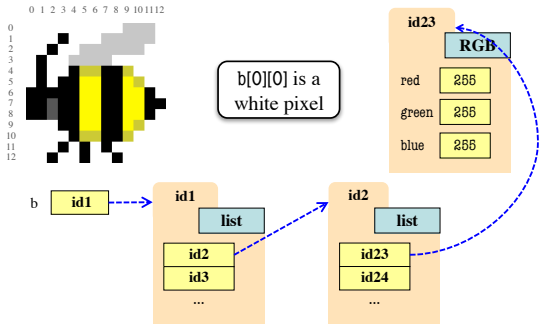
How Multidimensional Lists are Stored

- `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

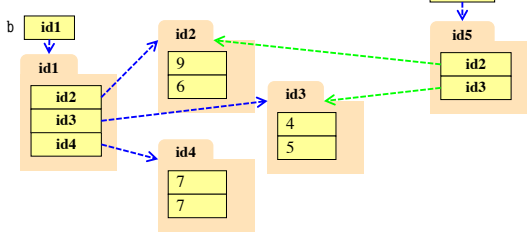
Image Data: 2D Lists of Pixels



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]`



Functions and 2D Lists

```
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 = []             # Result (new table) accumulator
    for m in range(numcols):
        # Get the column elements at position m
        # Make a new list for this column
        # Add this row to accumulator table

    return result
```

1	2
3	4
5	6

⇩

1	3	5
2	4	6

Functions and 2D Lists

```
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 = []             # Result (new table) accumulator
    for m in range(numcols):
        row = []                    # Single row accumulator
        for n in range(numrows):
            row.append(table[n][m]) # Create a new row list
        result.append(row)          # Add result to table
    return result
```

1	2
3	4
5	6

⇩

1	3	5
2	4	6

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)
- Many other applications

Python Syntax

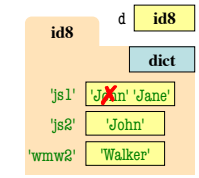
- Create with format: {k1:v1, k2:v2, ...}
- Keys must be non-mutable
  - ints, floats, bools, strings
  - **Not** lists or custom objects
- Values can be anything
- Example:

```
d = {'js1':'John Smith',
     'js2':'John Smith',
     'wmw2':'Walker White'}
```

Using Dictionaries (Type dict)

- Access elts. like a list
  - d['js1'] evaluates to 'John'
  - But cannot slice ranges!
- Dictionaries are **mutable**
  - Can reassign values
  - d['js1'] = 'Jane'
  - Can add new keys
  - d['aa1'] = 'Allen'
  - Can delete keys
  - del d['wmw2']

```
d = {'js1':'John','js2':'John',
     'wmw2':'Walker'}
```



Key-Value order in folder is not important

Using Dictionaries (Type dict)

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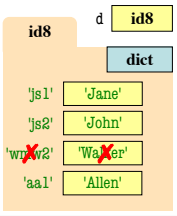

Deleting key deletes both

Dictionaries and For-Loops

- Dictionaries != sequences
  - Cannot slice them
- *Different* inside for loop
  - Loop variable gets the key
  - Then use key to get value
- Can **extract iterators** with dictionary *methods*
  - Key iterator: d.keys()
  - Value iterator: d.values()
  - key-value pairs: d.items()

```
for k in d:
    # Loops over keys
    print(k)    # key
    print(d[k]) # value

# To loop over values only
for v in d.values():
    print(v)    # value
```

See grades.py