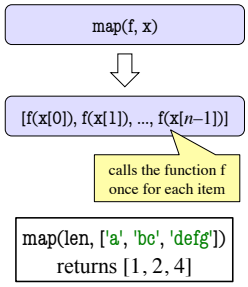
## Processing Lists: builtins

- sum(x) adds up all the elements in the list x
  - They must all be numbers!
- min(x) or max(x) find the min/max value in list x
  - They use the same ordering as sort()
- range(a,b,c) produces [a,a+c,a+2*c,…,a+c*((b-a)/c)]
  - Starts at a, increases by c each time, until b (or less)
  - The argument c is optional; c = 1 by default
- list(x) converts x (such as a string) to a list
  - Example: list('mimsy') produces ['m', 'i', 'm', 's', 'y']

## The Map Function

- map(⟨*function*⟩, ⟨*list*⟩)
  - Function has to have exactly **1 parameter**
  - Otherwise, get an error
  - Returns a new list
- Does the same thing as

```
def map(f,x):
    result = [] # empty list
    for y in x:
        result.append(f(y))
    return result
```



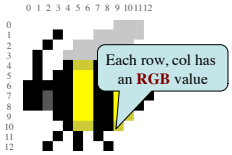

## Two Dimensional Lists

**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:

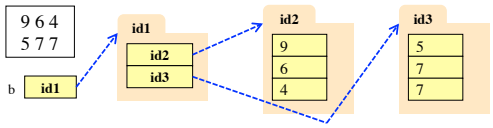
  d[3][2]
- Assign value at row 3, col 2:

  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 |

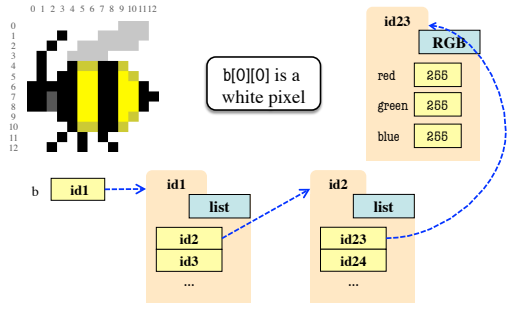
## How Multidimensional Lists are Stored

- 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

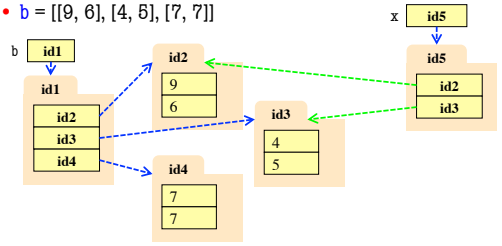
## Image Data: 2D Lists of Pixels



## 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)
    numcols  = len(table[0]) # All rows have same no. cols
    result = [] # Result accumulator
    for m in range(numcols):
        row = [] # Single row accumulator
        for n in range(numrows):
            row.append(table[n][m]) # Build up row
        result.append(row) # Add result to table
    return result
```

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

| 1 | 2 | 3 |
|---|---|---|
| 4 | 5 | 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

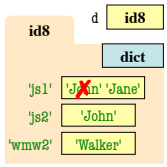
### Python Syntax

- 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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  - Can reassign values
  - d['js1'] = 'Jane'
  - Can add new keys
  - d['aa1'] = 'Allen'
  - Can delete keys
  - del d['wmw2']

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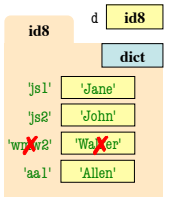


Deleting key deletes both

## Dictionaries and For-Loops

- Dictionaries != sequences
  - Cannot slice them
- *Different* inside for loop
  - Loop variable gets the key
  - Then use key to get value
- Has **methods** to *convert* dictionary to a sequence
  - Seq of keys: d.keys()
  - Seq of values: 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