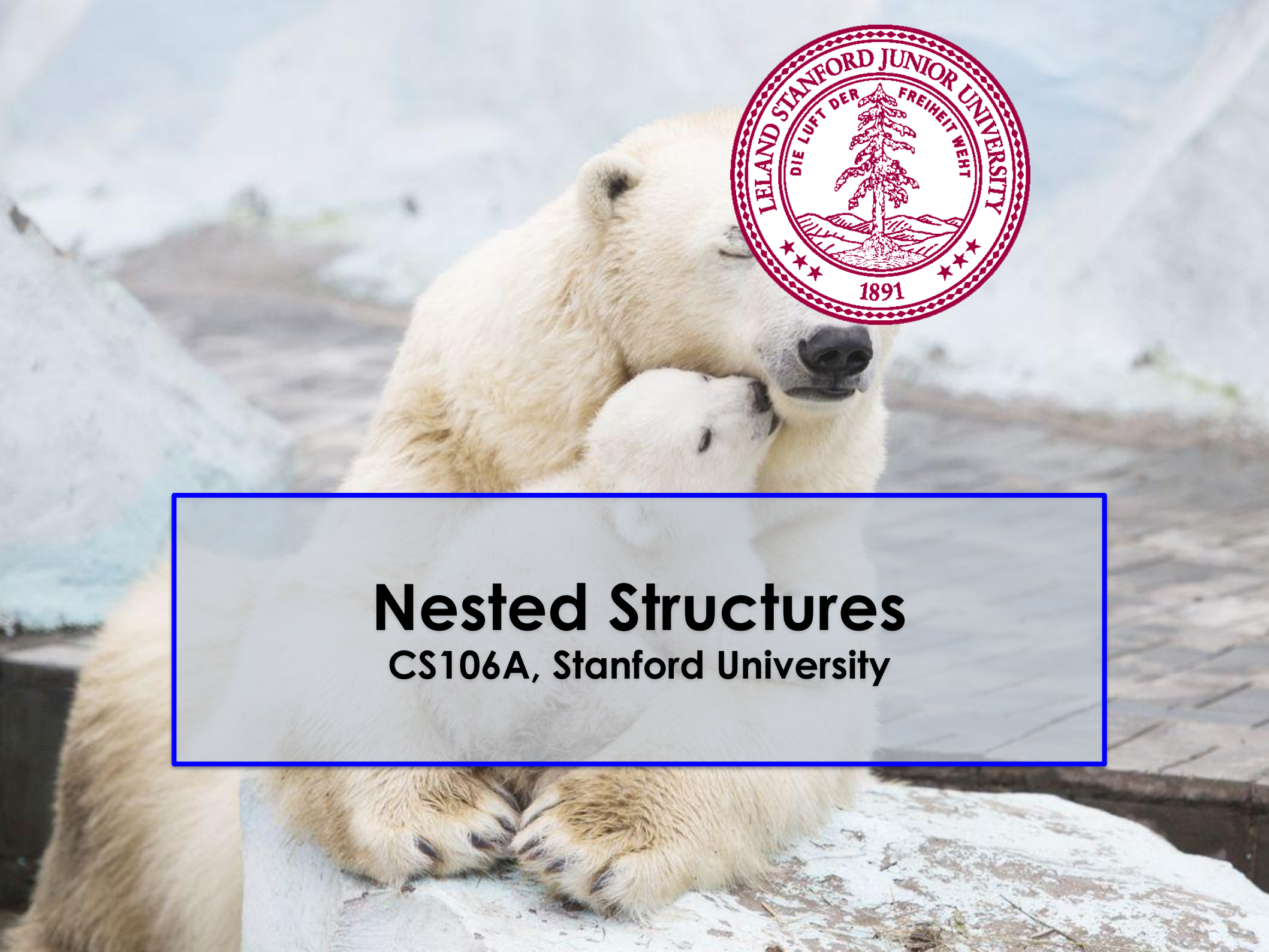
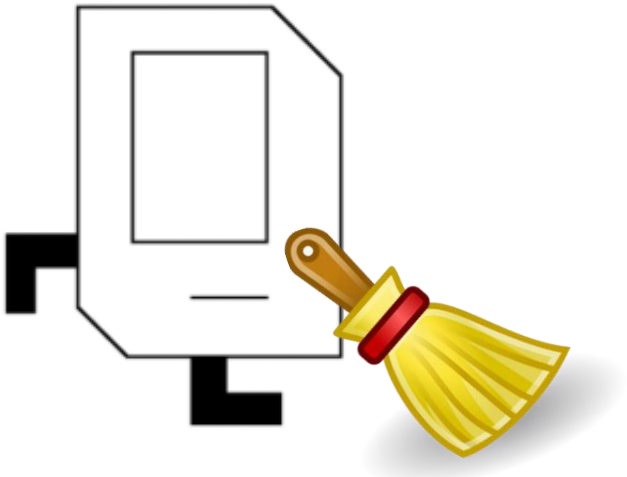


Nested Structures

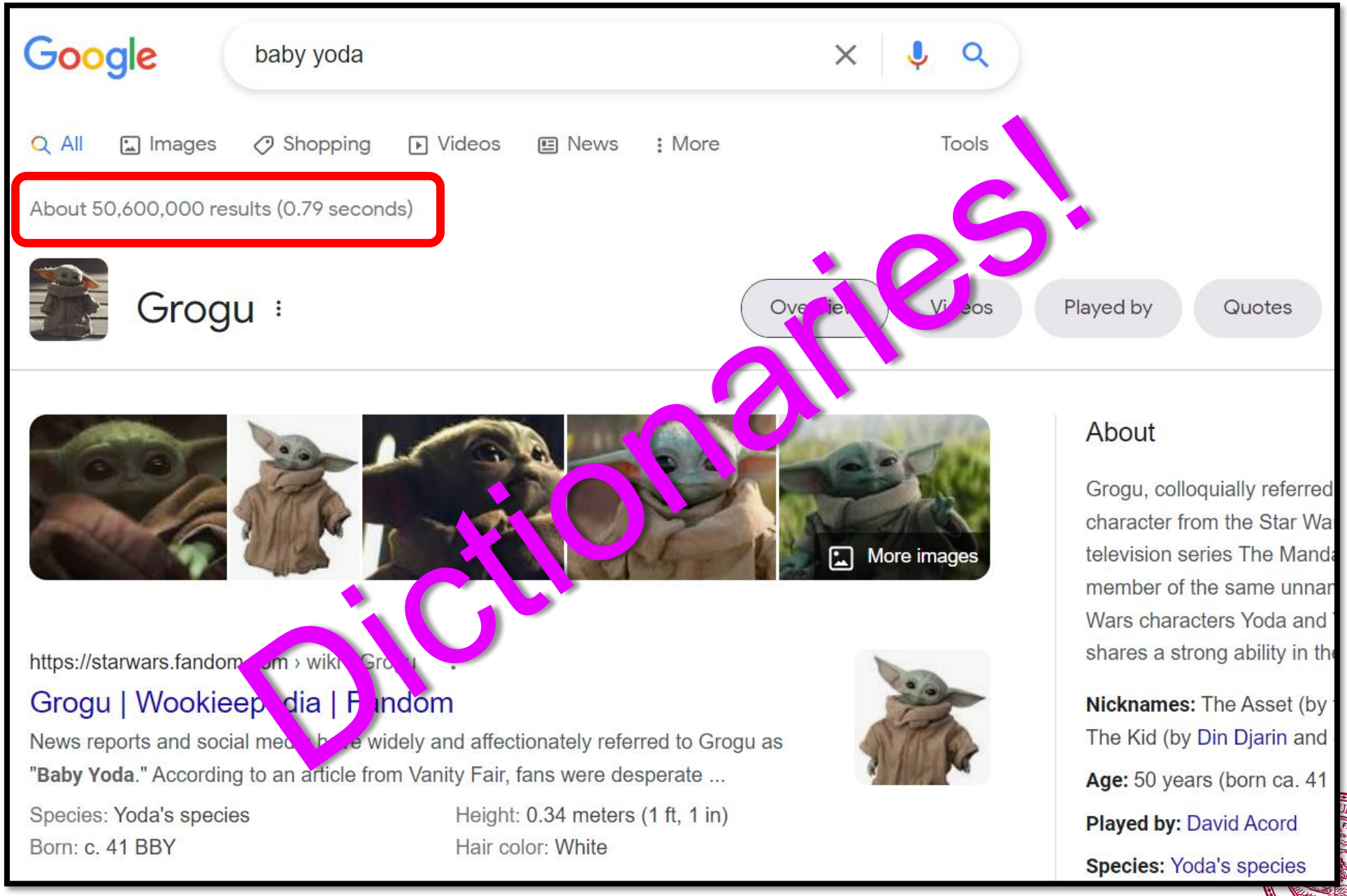
CS106A, Stanford University

Housekeeping



- No class lecture on Friday, May 6th
  - Day off to make-up for evening midterm
- Happy Star Wars Day!
  - May the 4th be with you!

Why is this so fast?



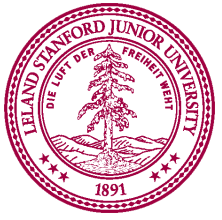
Dictionaries!

Core Data Structures

Many forms of data can be represented by a combination of:

dictionaries
lists
strings
floats
ints
bools

But sometimes you just need to combine them in funky ways!



dictionary review

Common Use of Dictionary

1. Make and empty dictionary (or dict, for short):

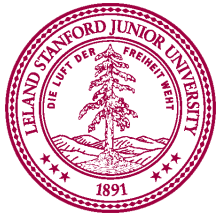
```
phonebook = {}
```

2. Add key/value pairs to the dict

```
name = input("Name: ")          # key
number = input("Number: ")      # value
# Creates new key/value pair if key is not in dict.
# Overwrites value associated with key if key is in dict.
phonebook[name] = number
```

3. Look up keys in the dict

```
name = input("Enter name to lookup: ")
if name in phonebook:    # see if key exists
    # gets the value associated with the key
    print(name + ": " + phonebook[name])
```

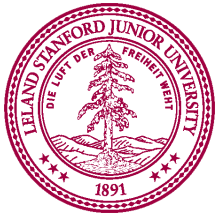


Adding Elements to Dictionary

- Can add pairs to a dictionary:

```
phonebook = {}
```

phonebook ⟶ *Empty dictionary*



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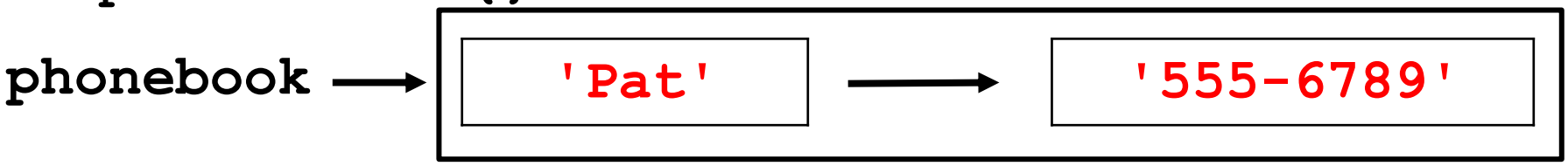
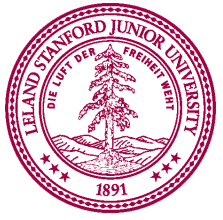



```
phonebook['Pat'] = '555-6789'
```



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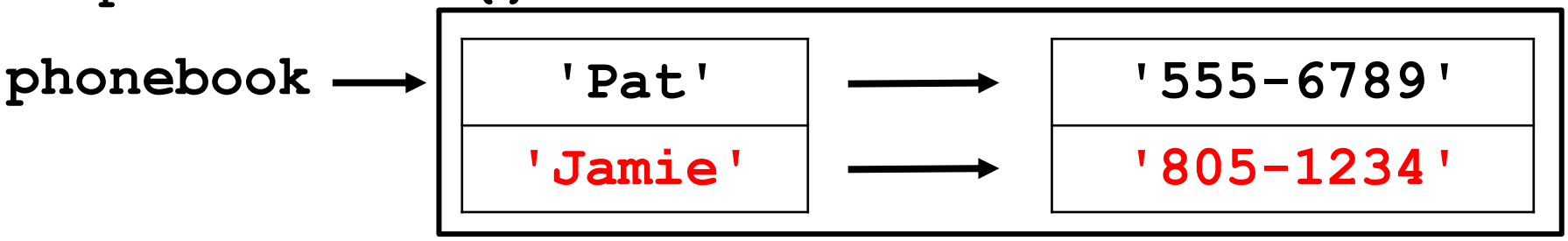


```
phonebook['Pat'] = '555-6789'
phonebook['Jamie'] = '805-1234'
```

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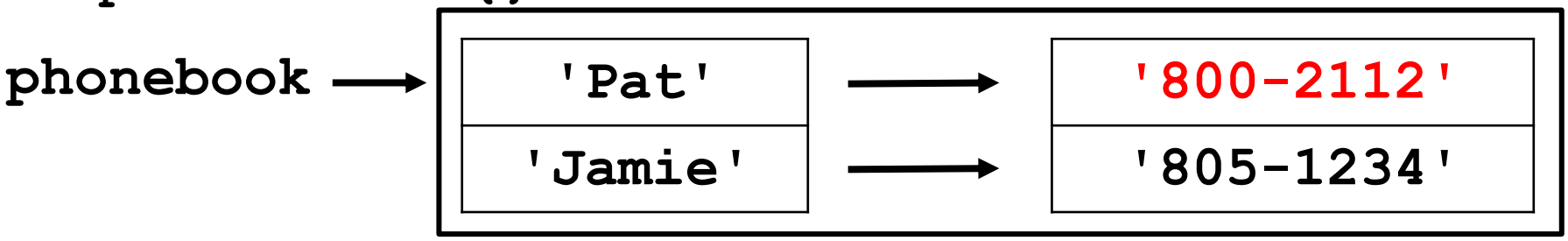
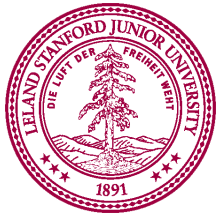



```
phonebook['Pat'] = '555-6789'
phonebook['Jamie'] = '805-1234'
phonebook['Pat'] = '800-2112'
```

Each key has only one value!

If you put a key in the dictionary twice, it will overwrite old value.



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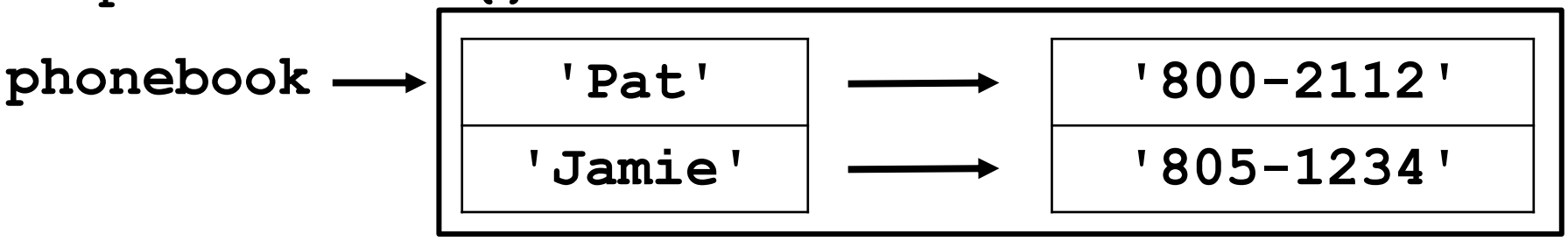


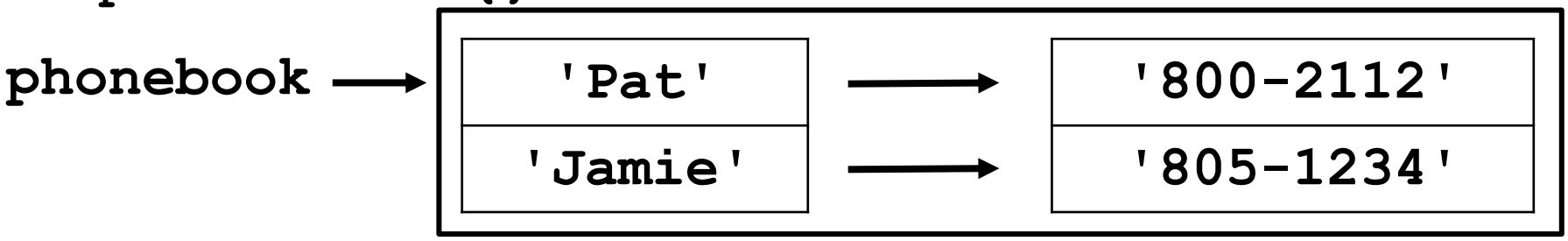

```
phonebook['Pat'] = '555-6789'
phonebook['Jamie'] = '805-1234'
phonebook['Pat'] = '800-2112'

print(phonebook['Pat'])
```

Adding Elements to Dictionary

- Can add pairs to a dictionary:

```
phonebook = {}
```




```
phonebook['Pat'] = '555-6789'
phonebook['Jamie'] = '805-1234'
phonebook['Pat'] = '800-2112'

print(phonebook['Pat'])
```

Terminal:

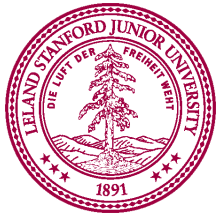
```
800-2112
```

Dictionaries are one way!

In dictionaries you can only look up values by keys.

You can't look up keys by value.


```
phonebook['Pat']  ------>  '800-2112'
```



Common Bug

Differentiate between key lookups that are literals versus variables!

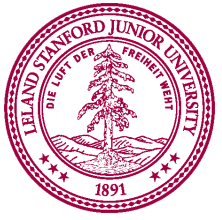
```
phonebook = {'Pat': '555-6789',
             'Jamie': '805-1234'}
```

A

```
name = input('? ')
print(phonebook["name"])
```

B

```
name = input('? ')
print(phonebook[name])
```



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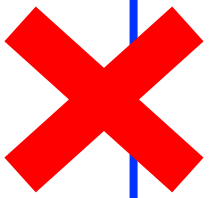
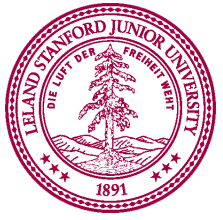


B

```
name = input('? ')
print(phonebook[name])
```



Lists vs. Dictionaries

List
index -> value

Dictionary
key -> value

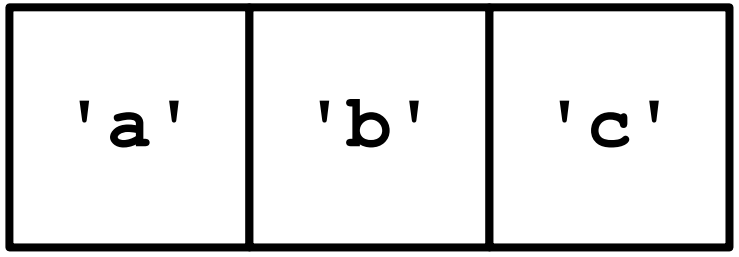
List

```
my_list = ['a', 'b', 'c']


print(my_list[1])

for i in range(len(my_list)):
    value = my_list[i]
    print(i, value)
```

my_list



indices

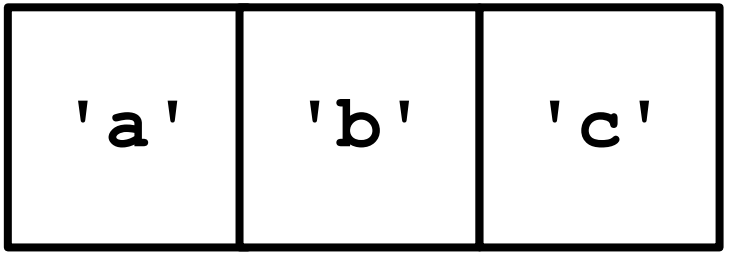
Dictionary

```
my_dict = {
   'x': 'a',
   'y': 'b',
   'z': 'c'
}

print(my_dict['y'])

for key in my_dict:
    value = my_dict[key]
    print(key, value)
```

my_dict



keys

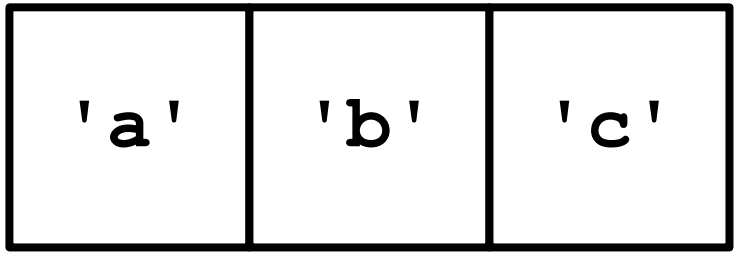
List

```
my_list = ['a',
           'b',
           'c']


print(my_list[1])

for i in range(len(my_list)):
    value = my_list[i]
    print(i, value)
```

my_list



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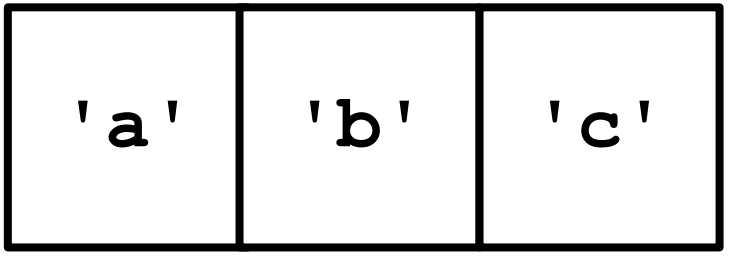

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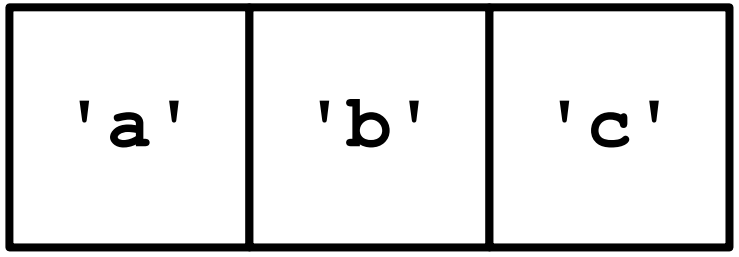

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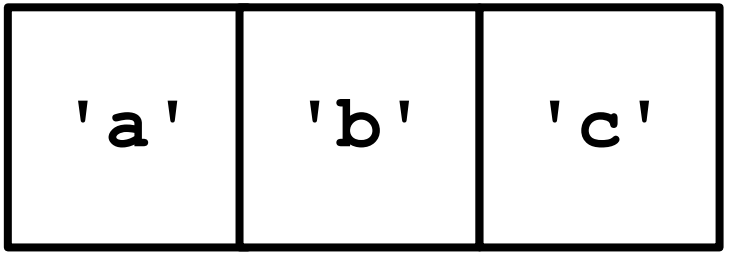

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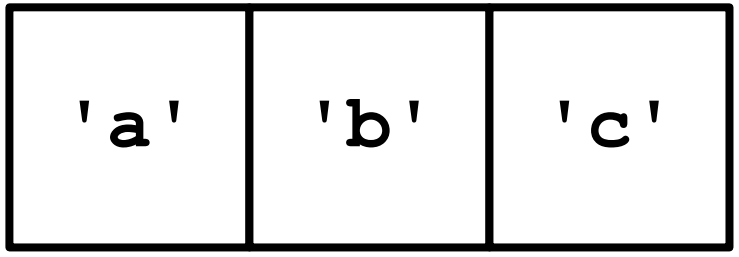

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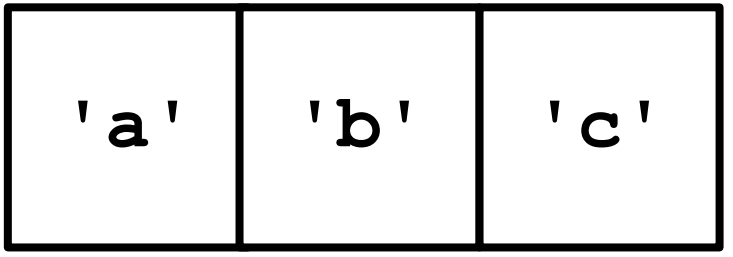

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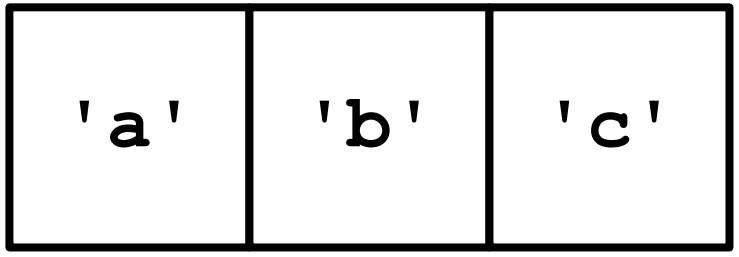

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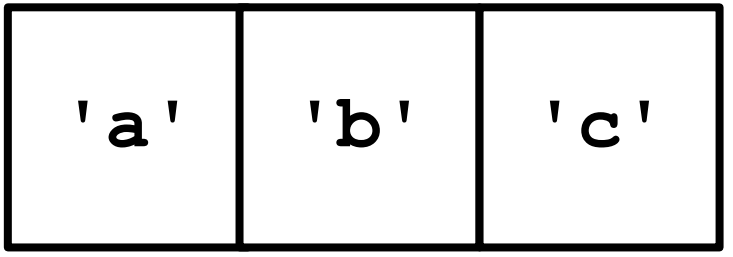


keys

End Review

Are you ready?

For…

The ULTIMATE cs106a question?

Ultimate CS106A: Reverse a Dict

Normal Dict:

Key → Value

Reversed Dict:

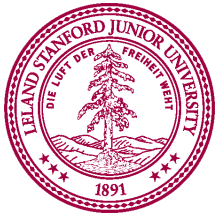
Value → Keys

What's the issue?

Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah', 'Jennifer Connelly'],
     1988: ['Chris Piech'],
     2003: ['Pat Jones', 'Jamie Chang']
}
```



To the code!!!

Ultimate CS106A: Reverse a Dict

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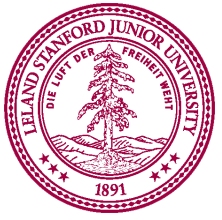
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



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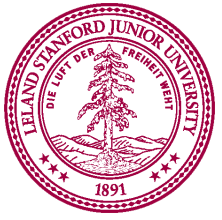

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}
```

key `'Mehran Sahami'`

```
reversed = {}
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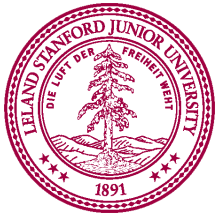

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}
```

key `'Mehran Sahami'`

value `1970`

```
reversed = {}
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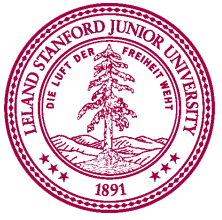

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key `'Mehran Sahami'`

value `1970`

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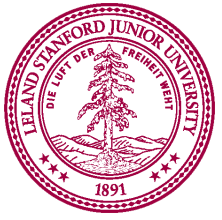

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}
```

key `'Mehran Sahami'`

value `1970`

```
reversed = {
     1970: []
}
```

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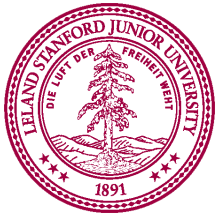

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     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

key `'Mehran Sahami'`

value `1970`

```
reversed = {
     1970: ['Mehran Sahami']
}
```

```
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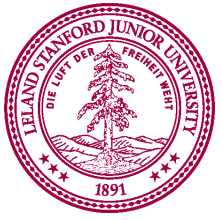

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     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

key `'Chris Piech'`

value `1970`

```
reversed = {
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}
```

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    return reversed
```
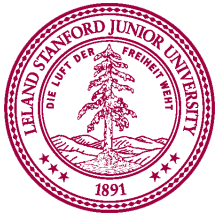
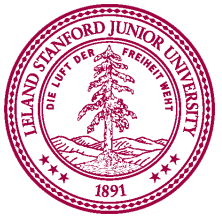



Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}

key   'Chris Piech'

value   1988

reversed = {
     1970: ['Mehran Sahami']
}
```

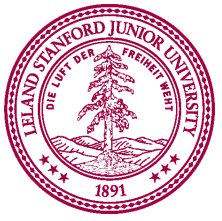
```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}

key   'Chris Piech'

value   1988

reversed = {
     1970: ['Mehran Sahami']
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

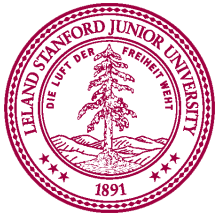
```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

key `'Chris Piech'`

value `1988`

```
reversed = {
     1970: ['Mehran Sahami'],
     1988: []
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

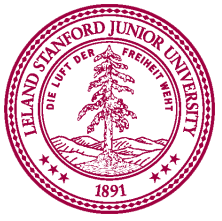
```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

key `'Chris Piech'`

value `1988`

```
reversed = {
     1970: ['Mehran Sahami'],
     1988: ['Chris Piech']
}
```

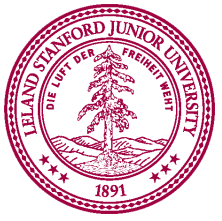
```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}

key   'Queen Latifah'

value   1988

reversed = {
     1970: ['Mehran Sahami'],
     1988: ['Chris Piech']
}
```

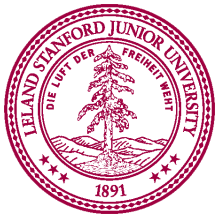
```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}

key   'Queen Latifah'

value   1970

reversed = {
     1970: ['Mehran Sahami'],
     1988: ['Chris Piech']
}
```

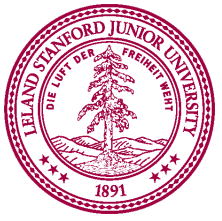
```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}

key   'Queen Latifah'

value   1970

reversed = {
     1970: ['Mehran Sahami'],
     1988: ['Chris Piech']
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



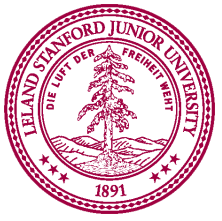
Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
key   'Queen Latifah'
value 1970
```

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah'],
     1988: ['Chris Piech']
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



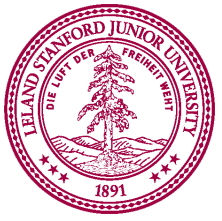
Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
key   'Queen Latifah'
value 1970
```

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah'],
     1988: ['Chris Piech']
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```



Ultimate CS106A: Reverse a Dict

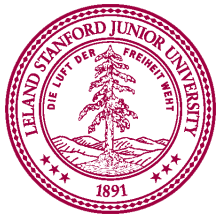
```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```

key `'Jamie Chang'`

value `2003`

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah'],
     1988: ['Chris Piech'],
     2003: ['Jamie Chang']
}
```



Ultimate CS106A: Reverse a Dict

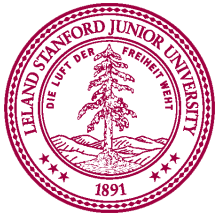
```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```

key `'Jennifer Connelly'`

value `1970`

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah', 'Jennifer Connelly'],
     1988: ['Chris Piech'],
     2003: ['Jamie Chang']
}
```



Ultimate CS106A: Reverse a Dict

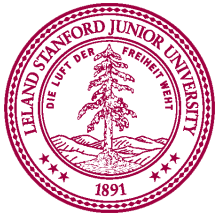
```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
def reverse(original):
    reversed = {}
    for key in original:
        value = original[key]
        if value not in reversed:
            reversed[value] = []

        reversed[value].append(key)

    return reversed
```

key `'Pat Jones'`

value `2003`

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah', 'Jennifer Connelly'],
     1988: ['Chris Piech'],
     2003: ['Jamie Chang', 'Pat Jones']
}
```



Ultimate CS106A: Reverse a Dict

```
birth_year = {
     'Mehran Sahami': 1970,
     'Chris Piech': 1988,
     'Queen Latifah': 1970,
     'Jamie Chang': 2003,
     'Jennifer Connelly': 1970,
     'Pat Jones': 2003
}
```

```
def reverse(original):
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   for key in original:
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      if value not in reversed:
         reversed[value] = []

      reversed[value].append(key)

   return reversed
```
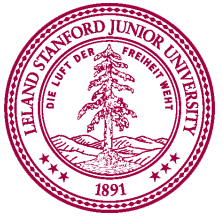

```
reversed = {
     1970: ['Mehran Sahami', 'Queen Latifah', 'Jennifer Connelly'],
     1988: ['Chris Piech'],
     2003: ['Jamie Chang', 'Pat Jones']
}
```

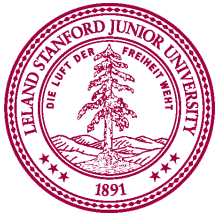


A better phonebook

Multiple Phones Per Person

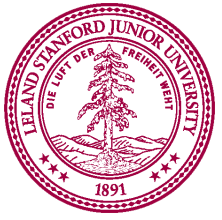
- In a real contact list, you can store multiple phone numbers for the same person
  - Different numbers denoted by different phone types
  - E.g. home, work, mobile, etc.

- How might we design a data structure for this?



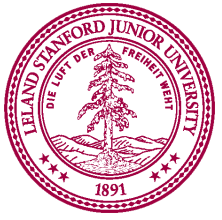
Structuring the Data

```
{
    'Mehran':
        {
         'work': '723-6059',
         'home': '555-1212',
         'mobile': '876-5432'
        },
    'Pat':
        {
         'home': '800-2112'
        },
    'Jamie':
        {
         'mobile': '888-8888',
         'work': '777-7777'
        }
}
```

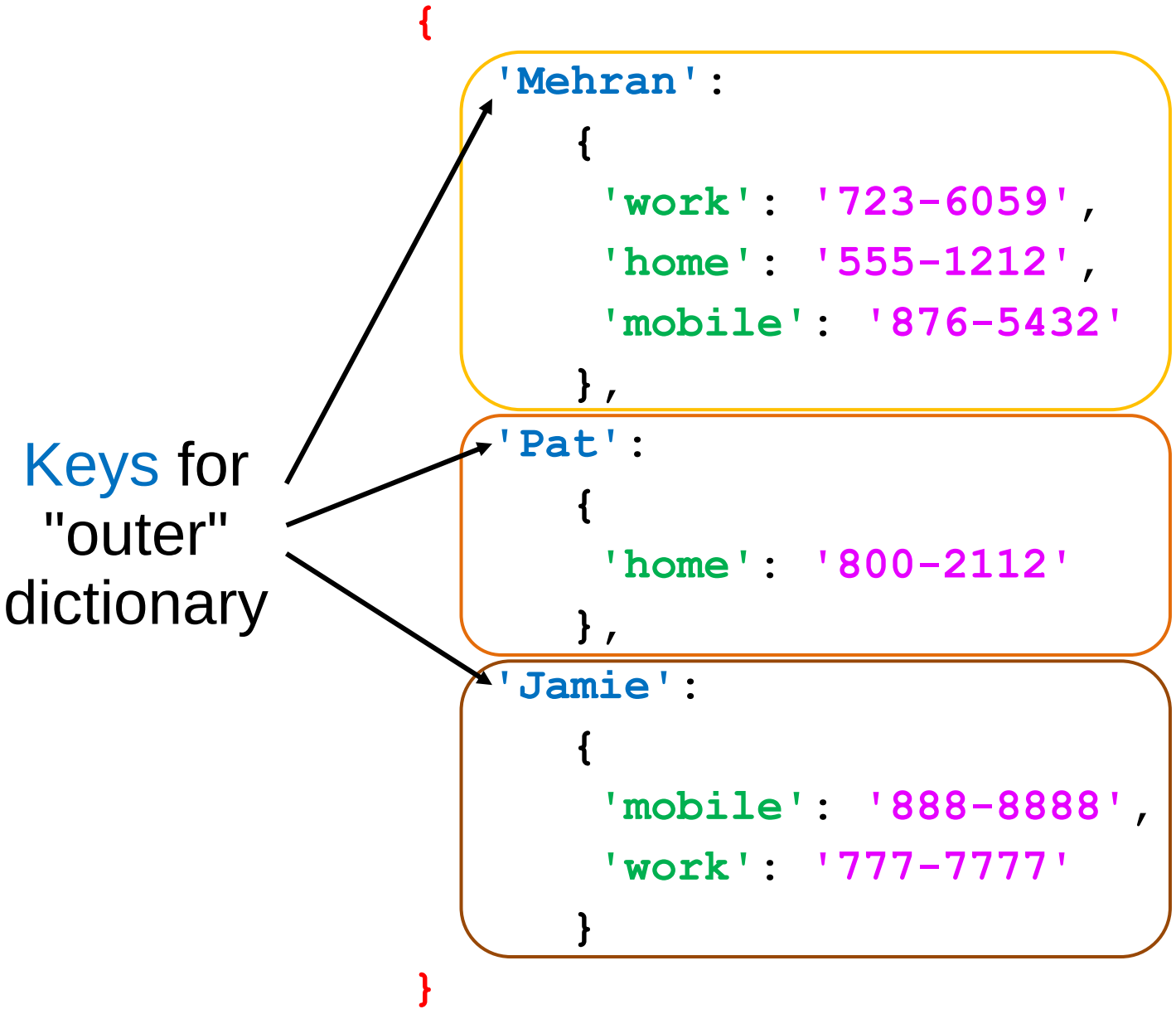


Structuring the Data

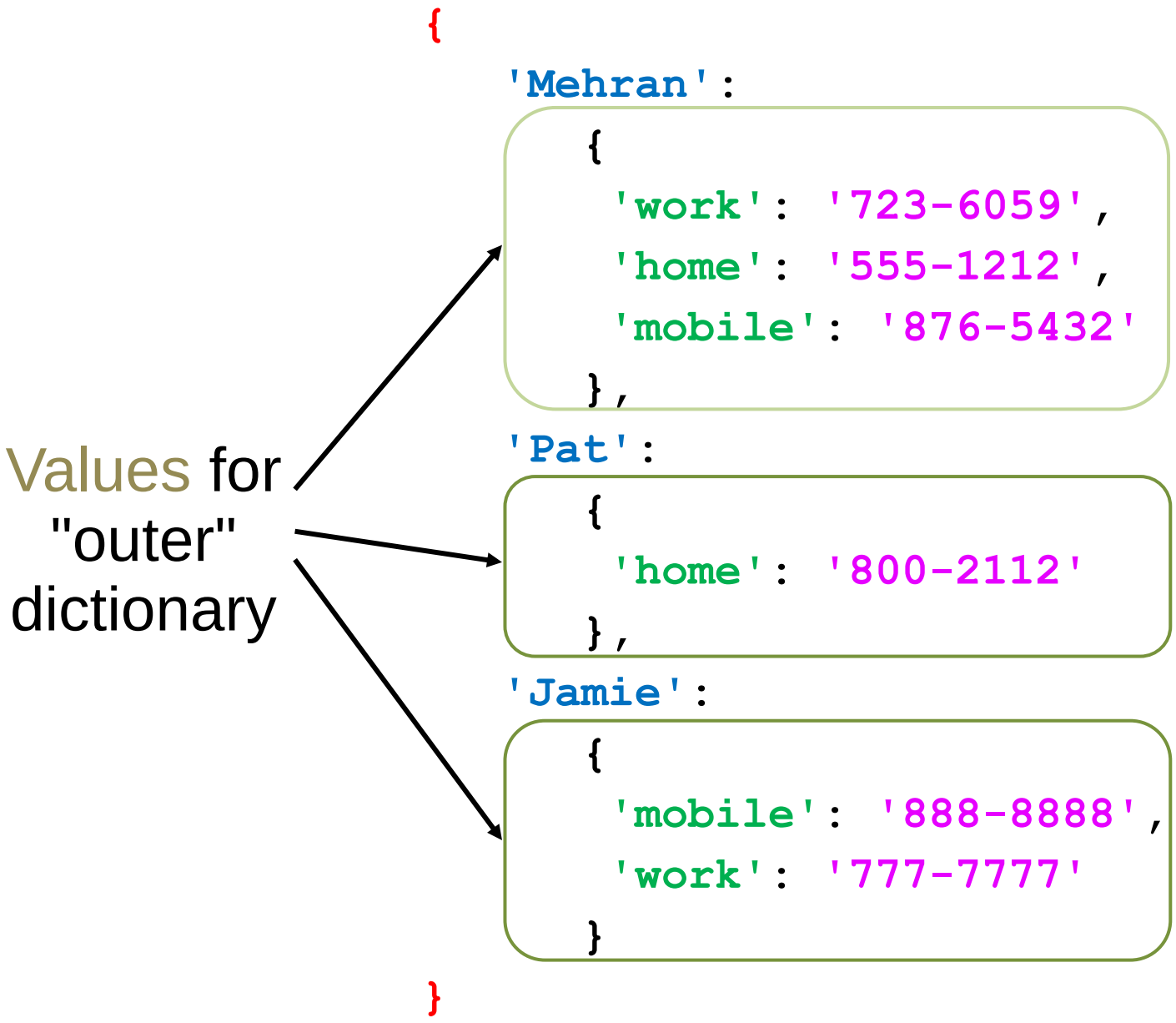
```
{
    'Mehran':
        {
          'work': '723-6059',
          'home': '555-1212',
          'mobile': '876-5432'
        },
    'Pat':
        {
          'home': '800-2112'
        },
    'Jamie':
        {
          'mobile': '888-8888',
          'work': '777-7777'
        }
}
```



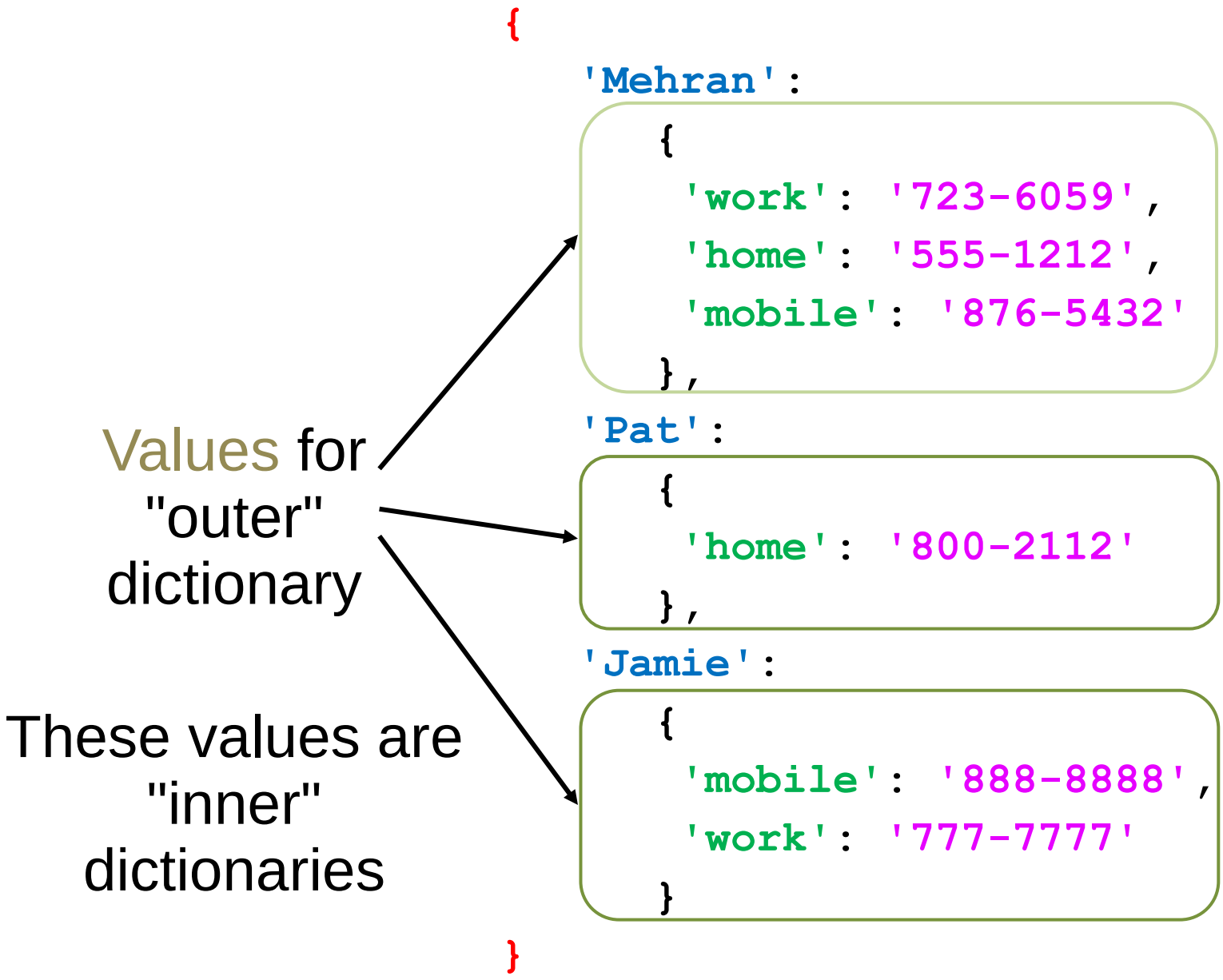
Structuring the Data



Structuring the Data

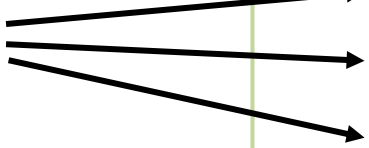


Structuring the Data

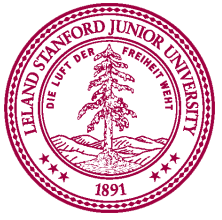


Structuring the Data

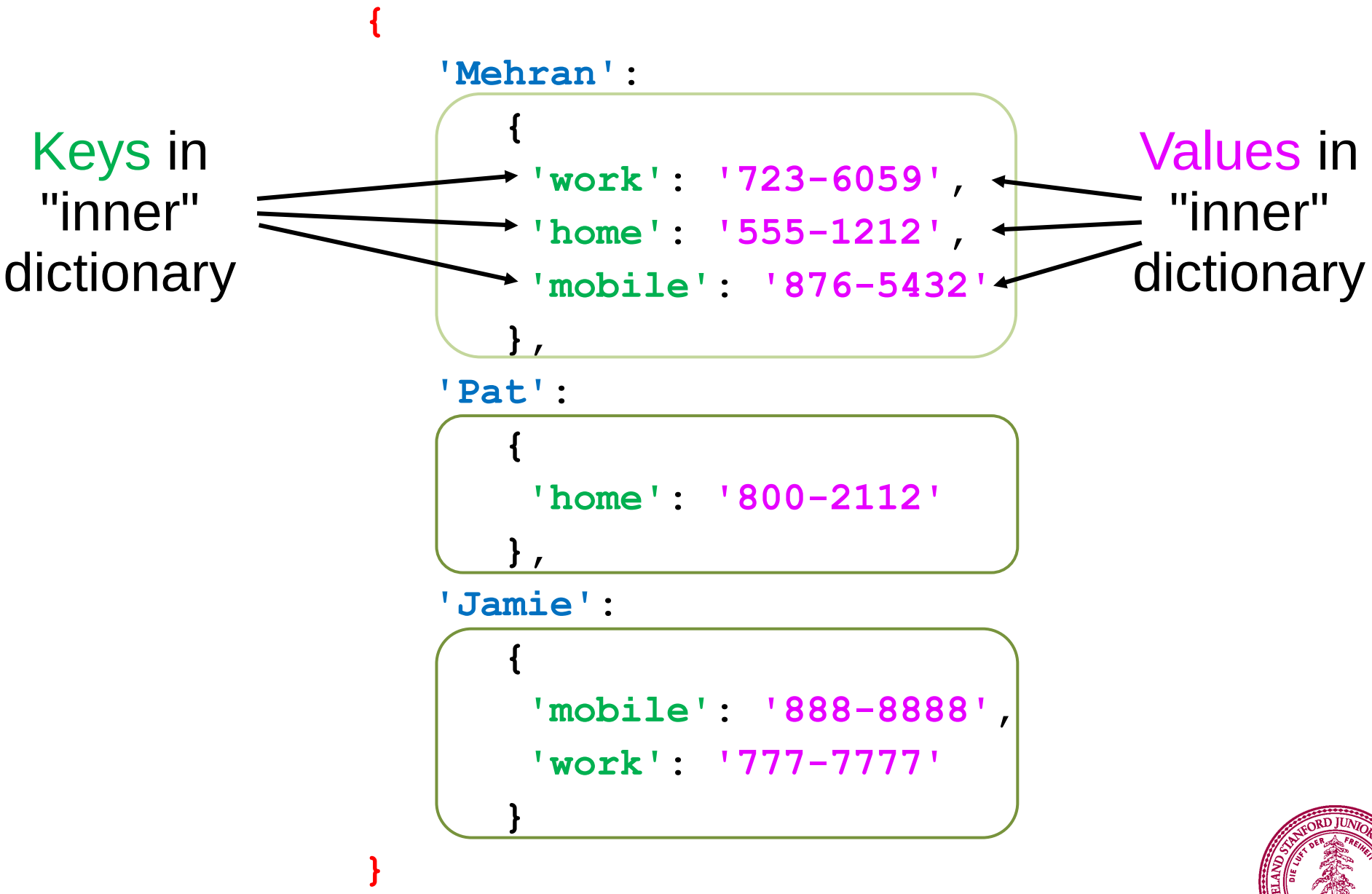
Keys in "inner" dictionary



```
{
    'Mehran':
        {
         'work': '723-6059',
         'home': '555-1212',
         'mobile': '876-5432'
        },
    'Pat':
        {
          'home': '800-2112'
        },
    'Jamie':
        {
          'mobile': '888-8888',
          'work': '777-7777'
        }
}
```



Structuring the Data



Let's take it out for a spin:
betterphonebook.py