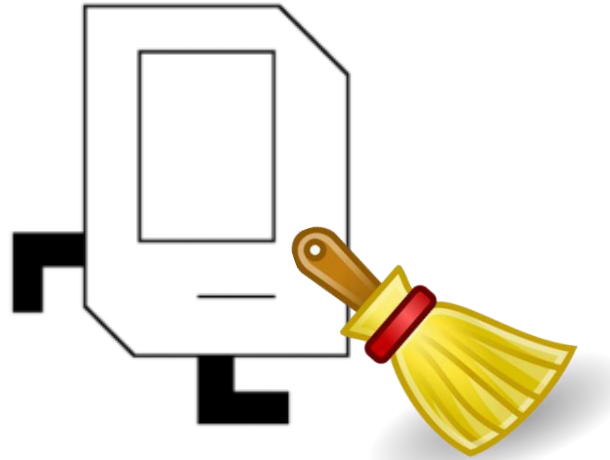




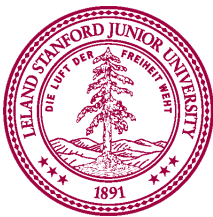
Nested Structures

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?


Google baby yoda

All Images Shopping Videos News More Tools

About 50,600,000 results (0.79 seconds)

Grogu :

Overview Videos Played by Quotes



More images

<https://starwars.fandom.com/wiki/Grogu>

Grogu | Wookieepedia | Fandom

News reports and social media have widely and affectionately referred to Grogu as "Baby Yoda." According to an article from Vanity Fair, fans were desperate ...

Species: Yoda's species Height: 0.34 meters (1 ft, 1 in)
Born: c. 41 BBY Hair color: White

About


Grogu, colloquially referred to as "Baby Yoda," is a fictional character from the Star Wars television series The Mandalorian. He is a member of the same unnamed species as the Wars characters Yoda and Yoda's species. He shares a strong ability in the Force.

Nicknames: The Asset (by Din Djarin), The Kid (by Din Djarin and Grogu)

Age: 50 years (born ca. 41 BBY)

Played by: David Acord

Species: Yoda's species



Core Data Structures



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

dictionaries

lists

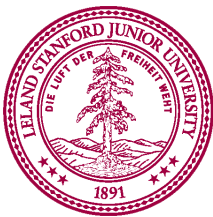
strings

floats

ints

bools

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



dictionary review

Common Use of Dictionary

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

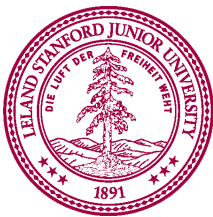
```
phonebook = {}
```

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])
```

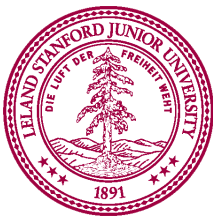


Adding Elements to Dictionary

- Can add pairs to a dictionary:

`phonebook = {}`

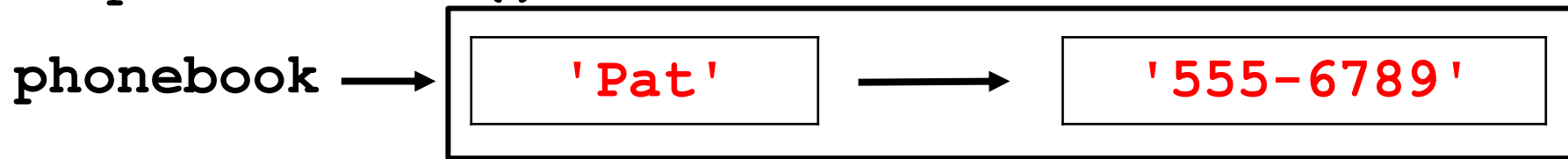
`phonebook` → *Empty dictionary*



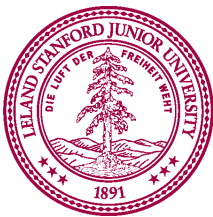
Adding Elements to Dictionary

- Can add pairs to a dictionary:

```
phonebook = {}
```



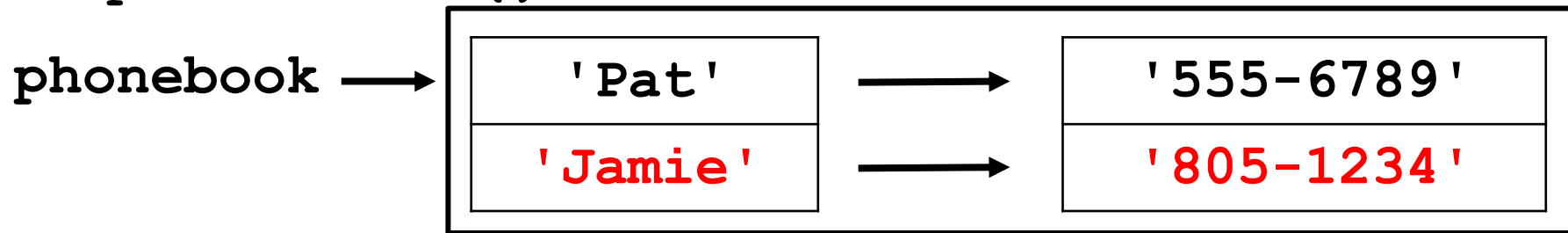
```
phonebook['Pat'] = '555-6789'
```



Adding Elements to Dictionary

- Can add pairs to a dictionary:

```
phonebook = {}
```



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

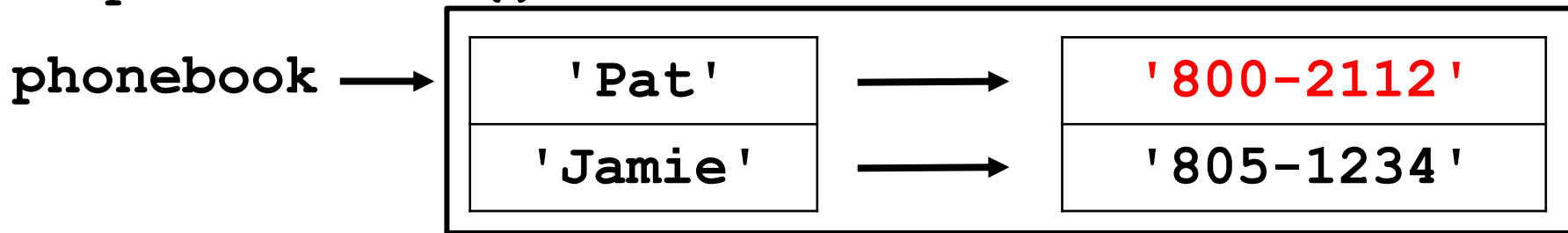
```
phonebook['Jamie'] = '805-1234'
```



Adding Elements to Dictionary

- Can add pairs to a dictionary:

```
phonebook = {}
```



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

```
phonebook['Jamie'] = '805-1234'
```

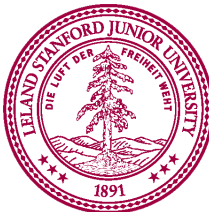
```
phonebook['Pat'] = '800-2112'
```





Each key has only one value!

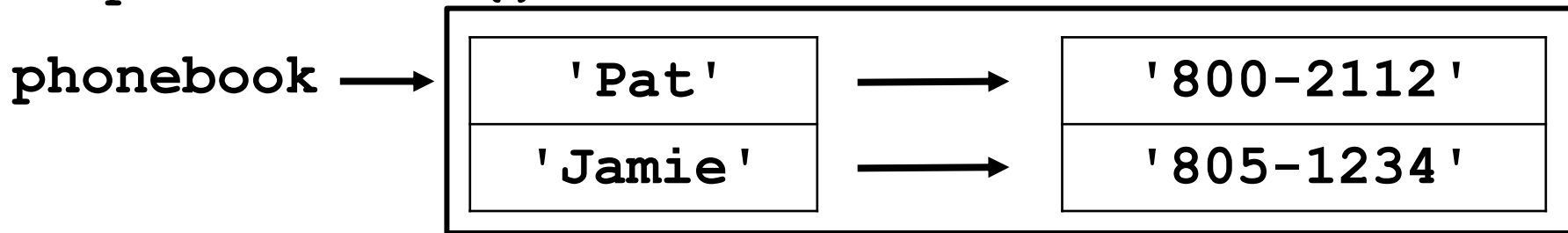
If you put a key in the dictionary twice, it will overwrite old value.



Adding Elements to Dictionary

- Can add pairs to a dictionary:

```
phonebook = {}
```

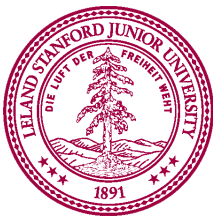


```
phonebook['Pat'] = '555-6789'
```

```
phonebook['Jamie'] = '805-1234'
```

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

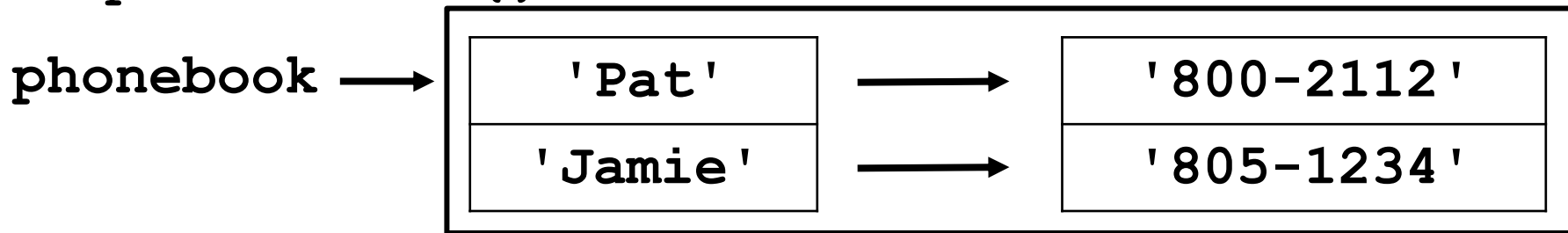
```
print(phonebook['Pat'])
```



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
```





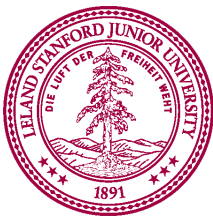
Dictionaries are one way!

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])
```



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])
```



Lists vs. Dictionaries



List

index -> value

Dictionary

key -> value

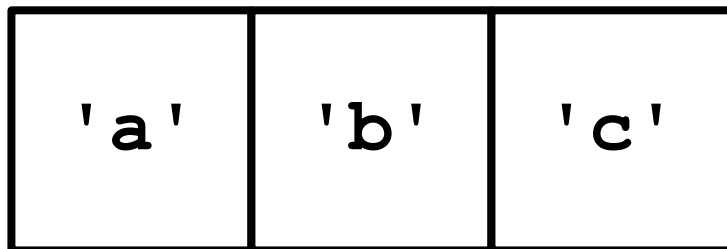
List

```
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



0

1

2

indices

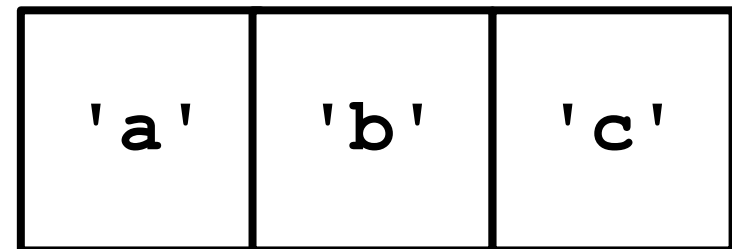
Dictionary

```
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



'x'

'y'

'z'

keys



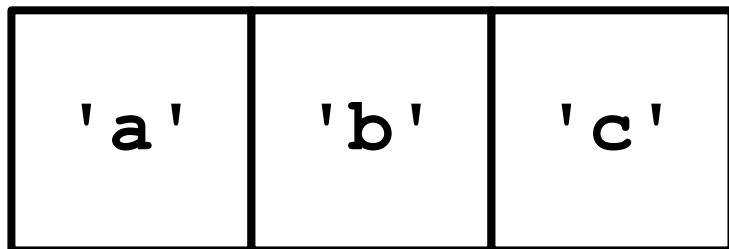
List

```
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



0

1

2

indices

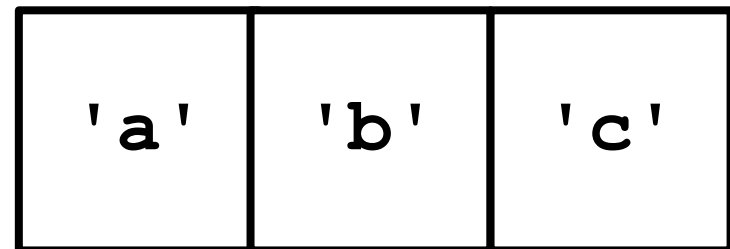
Dictionary

```
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



'x'

'y'

'z'

keys



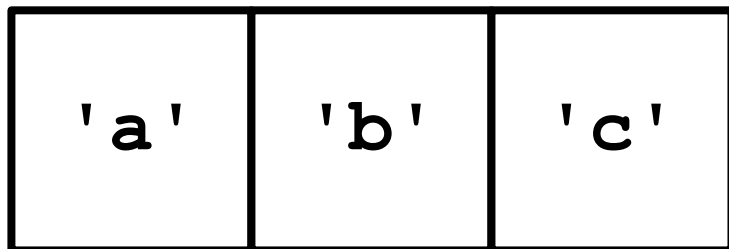
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```

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print(my_list[1])
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for i in range(len(my_list)):  
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    print(i, value)
```

my_list



0

1

2

indices

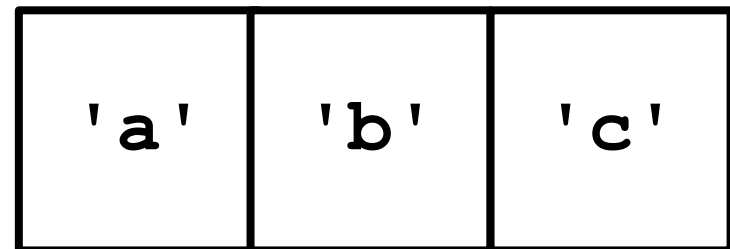
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}
```

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print(my_dict['y'])
```

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

my_dict

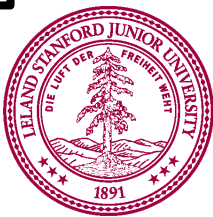


'x'

'y'

'z'

keys



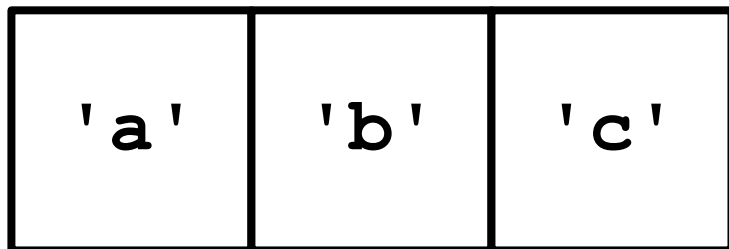
List

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

```
print(my_list[1])
```

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

my_list



0

1

2

indices

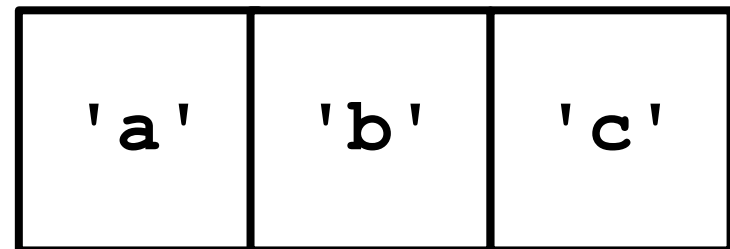
Dictionary

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my_dict = {  
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    'z': 'c'  
}
```

```
print(my_dict['y'])
```

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

my_dict



'x'

'y'

'z'

keys



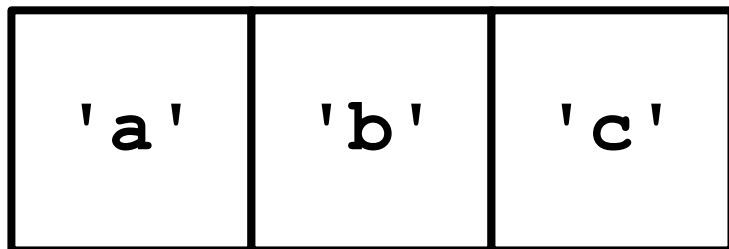
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```

my_list



0

1

2

indices

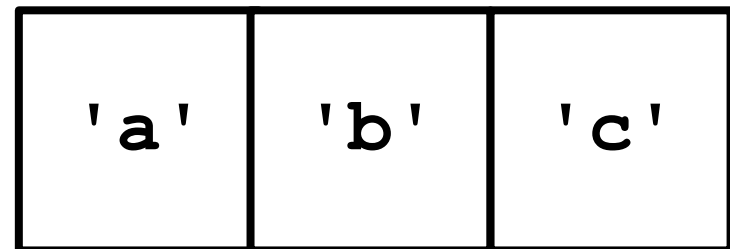
Dictionary

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

my_dict

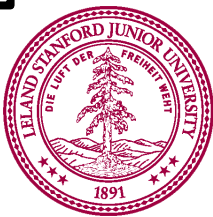


'x'

'y'

'z'

keys



End Review

Are you ready?

For...

The ULTIMATE cs106a question?

Ultimate CS106A: Reverse a Dict



Normal Dict:

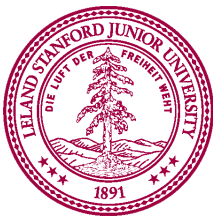
Key \rightarrow Value

Reversed Dict:

Value \rightarrow Keys



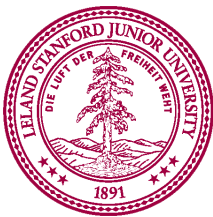
What's the issue?



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

```
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
```



Ultimate CS106A: Reverse a Dict

```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
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        value = original[key]  
        if value not in reversed:  
            reversed[value] = []  
  
        reversed[value].append(key)  
  
    return reversed
```

```
reversed = {}
```



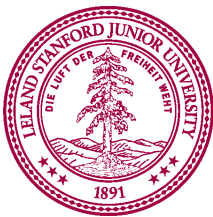
Ultimate CS106A: Reverse a Dict

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

key 'Mehran Sahami'

```
reversed = {}
```

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



Ultimate CS106A: Reverse a Dict

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

key 'Mehran Sahami'

value 1970

```
reversed = {}
```

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



Ultimate CS106A: Reverse a Dict

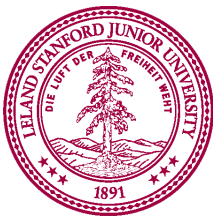
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birth_year = {  
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    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Mehran Sahami'

value 1970

```
reversed = {}
```

```
def reverse(original):  
    reversed = {}  
    for key in original:  
        value = original[key]  
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```



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 'Mehran Sahami'

value 1970

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

```
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

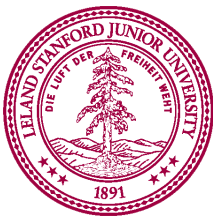
```
birth_year = {  
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    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Mehran Sahami'

value 1970

```
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

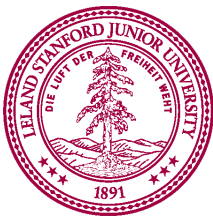
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Chris Piech'

value 1970

```
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

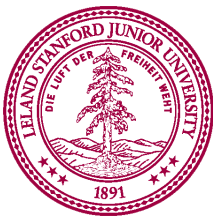
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Chris Piech'

value 1988

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

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



Ultimate CS106A: Reverse a Dict

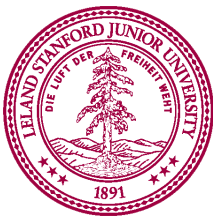
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    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Chris Piech'

value 1988

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

```
def reverse(original):  
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Ultimate CS106A: Reverse a Dict

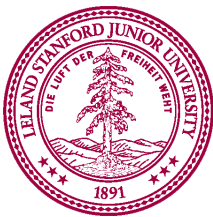
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    'Pat Jones': 2003  
}
```

key 'Chris Piech'

value 1988

```
reversed = {  
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}
```

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        if value not in reversed:  
            reversed[value] = []  
  
        reversed[value].append(key)  
  
    return reversed
```



Ultimate CS106A: Reverse a Dict

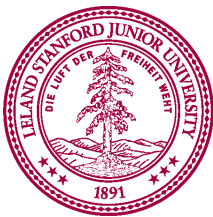
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

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

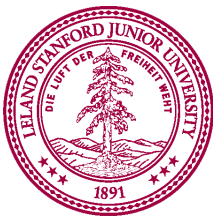
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

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

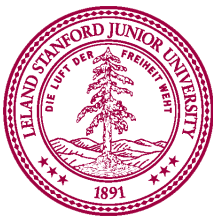
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

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

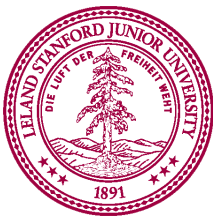
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

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

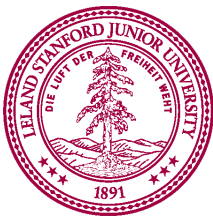
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

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

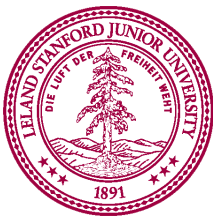
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

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

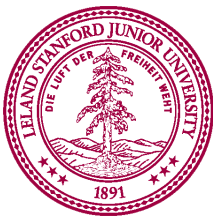
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Jamie Chang'

value 2003

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

```
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

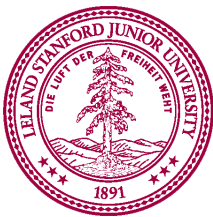
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Jennifer Connelly'

value 1970

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

```
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

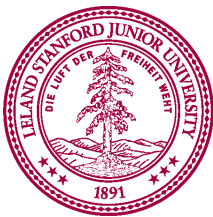
```
birth_year = {  
    'Mehran Sahami': 1970,  
    'Chris Piech': 1988,  
    'Queen Latifah': 1970,  
    'Jamie Chang': 2003,  
    'Jennifer Connelly': 1970,  
    'Pat Jones': 2003  
}
```

key 'Pat Jones'

value 2003

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

```
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
```

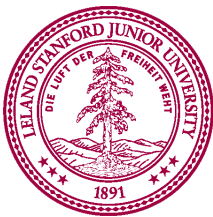
```
reversed = {  
    1970: ['Mehran Sahami', 'Queen Latifah', 'Jennifer Connelly'],  
    1988: ['Chris Piech'],  
    2003: ['Jamie Chang', 'Pat Jones']  
}
```



A better phonebook

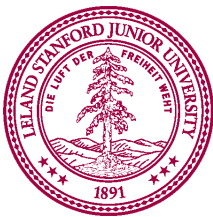
Multiple Phones Per Person

- 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?



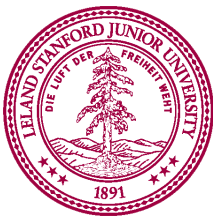
Structuring the Data

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

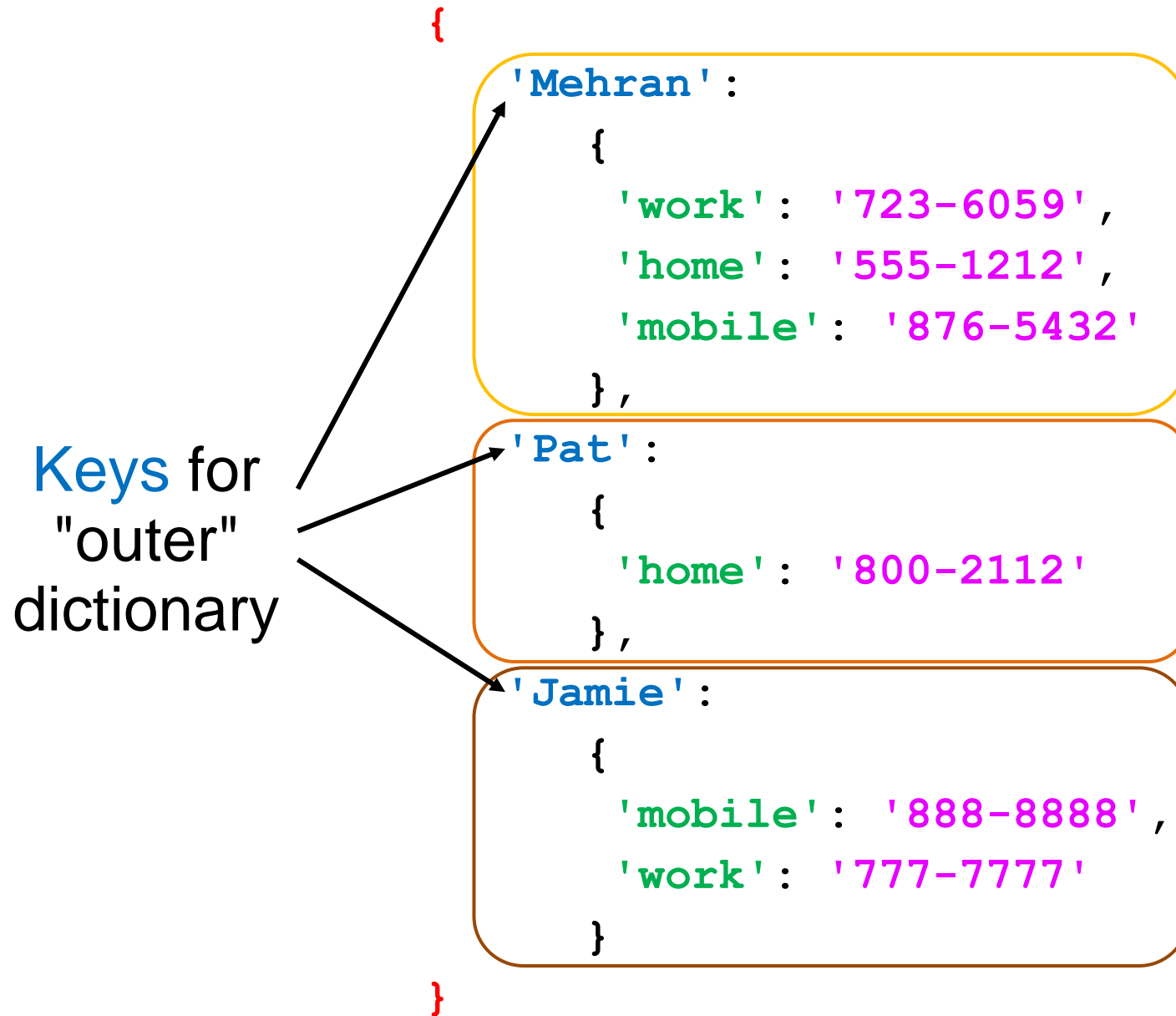


Structuring the Data

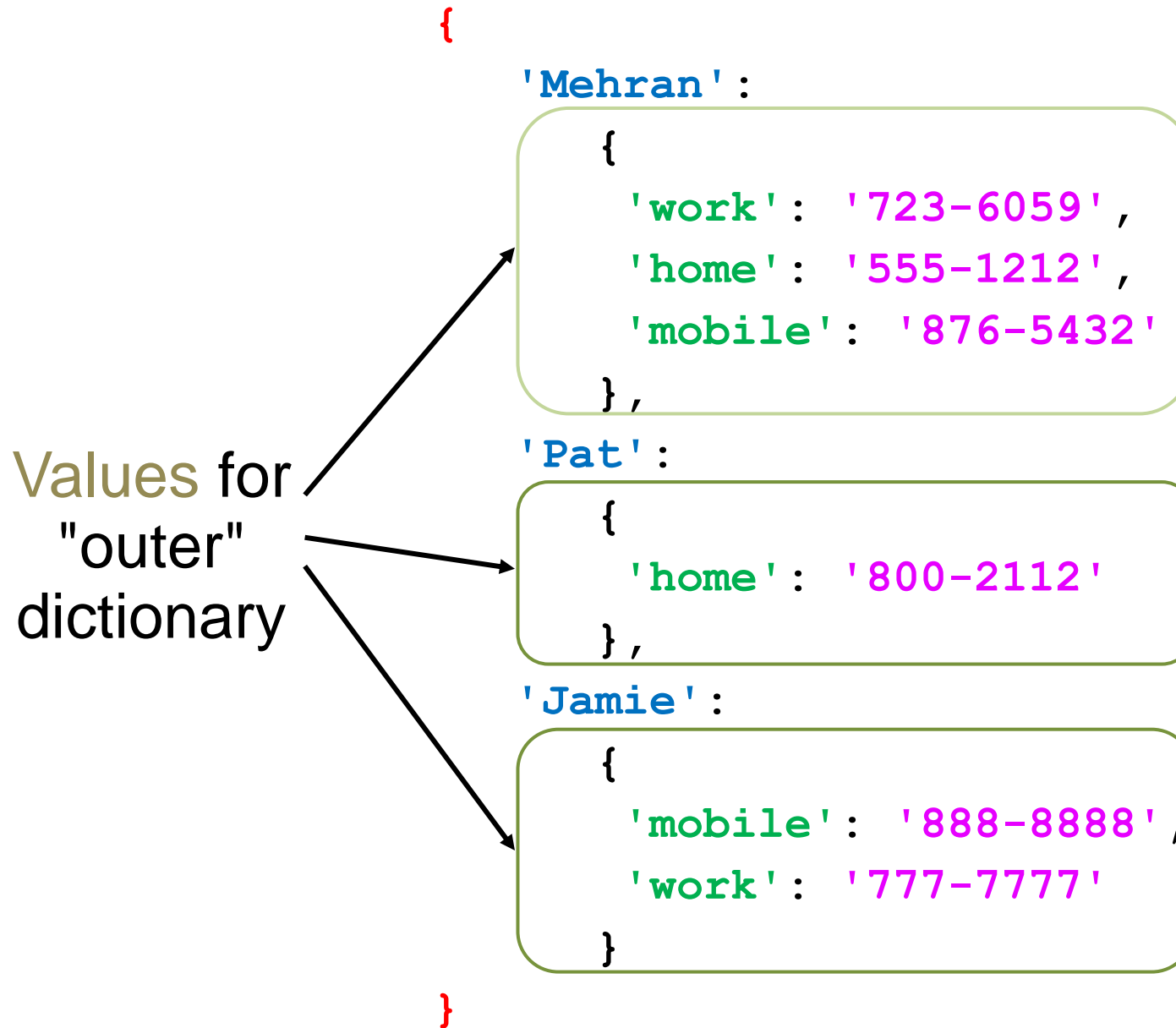
```
{  
  'Mehran':  
    {  
      'work': '723-6059',  
      'home': '555-1212',  
      'mobile': '876-5432'  
    },  
  'Pat':  
    {  
      'home': '800-2112'  
    },  
  'Jamie':  
    {  
      'mobile': '888-8888',  
      'work': '777-7777'  
    }  
}
```



Structuring the Data



Structuring the Data



Structuring the Data

```
{
```

```
'Mehran' :
```

```
{  
  'work' : '723-6059',  
  'home' : '555-1212',  
  'mobile' : '876-5432'  
},
```

```
'Pat' :
```

```
{  
  'home' : '800-2112'  
},
```

```
'Jamie' :
```

```
{  
  'mobile' : '888-8888',  
  'work' : '777-7777'  
}
```

```
}
```

Values for
"outer"
dictionary

These values are
"inner"
dictionaries



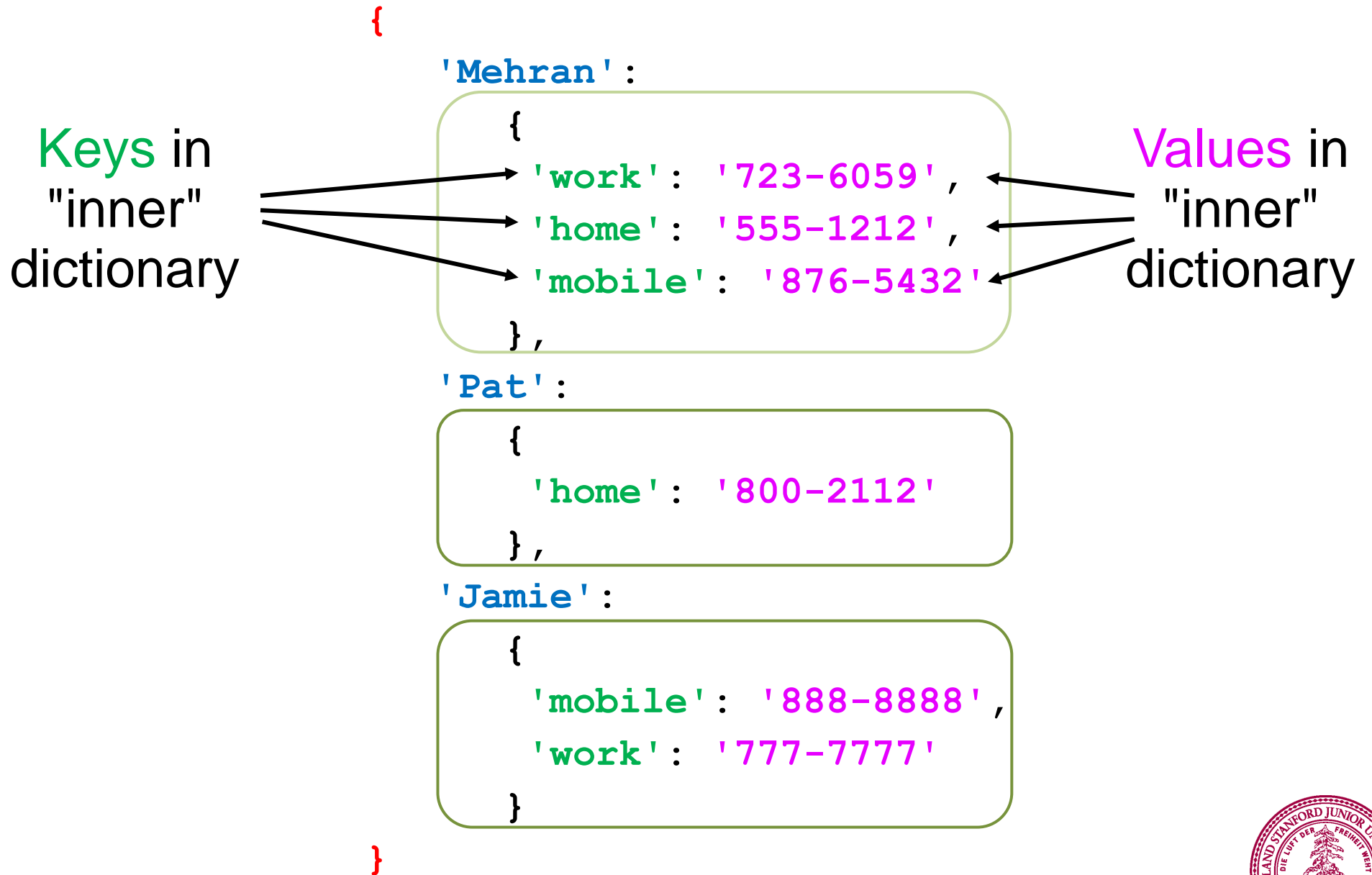
Structuring the Data

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