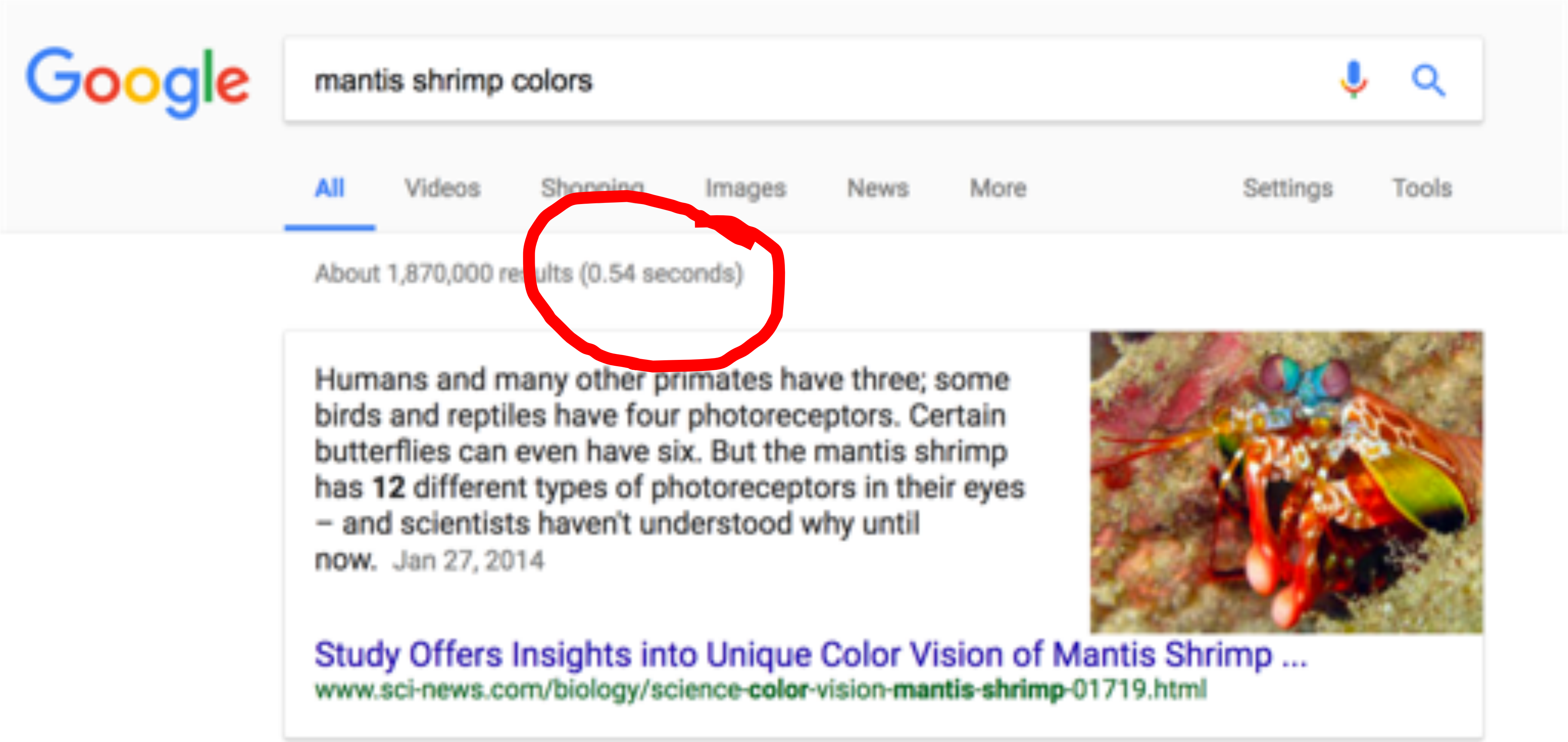
Nestled Structures

Mehran Sahami and Chris Piech
CS106A, Stanford University

Housekeeping

- Assignment 5 goes out today!

Why is this so fast?



mantis shrimp colors

About 1,870,000 results (0.54 seconds)

Humans and many other primates have three; some birds and reptiles have four photoreceptors. Certain butterflies can even have six. But the mantis shrimp has **12** different types of photoreceptors in their eyes – and scientists haven't understood why until now. Jan 27, 2014

Study Offers Insights into Unique Color Vision of Mantis Shrimp ...

www.sci-news.com/biology/science-**color**-vision-**mantis**-**shrimp**-01719.html

Review

Core Datastructures

The standard is called "JSON"

All datasets can be represented by:

Dictionaries,
Lists,
strings,
floats,
integers
booleans,
None,
blob

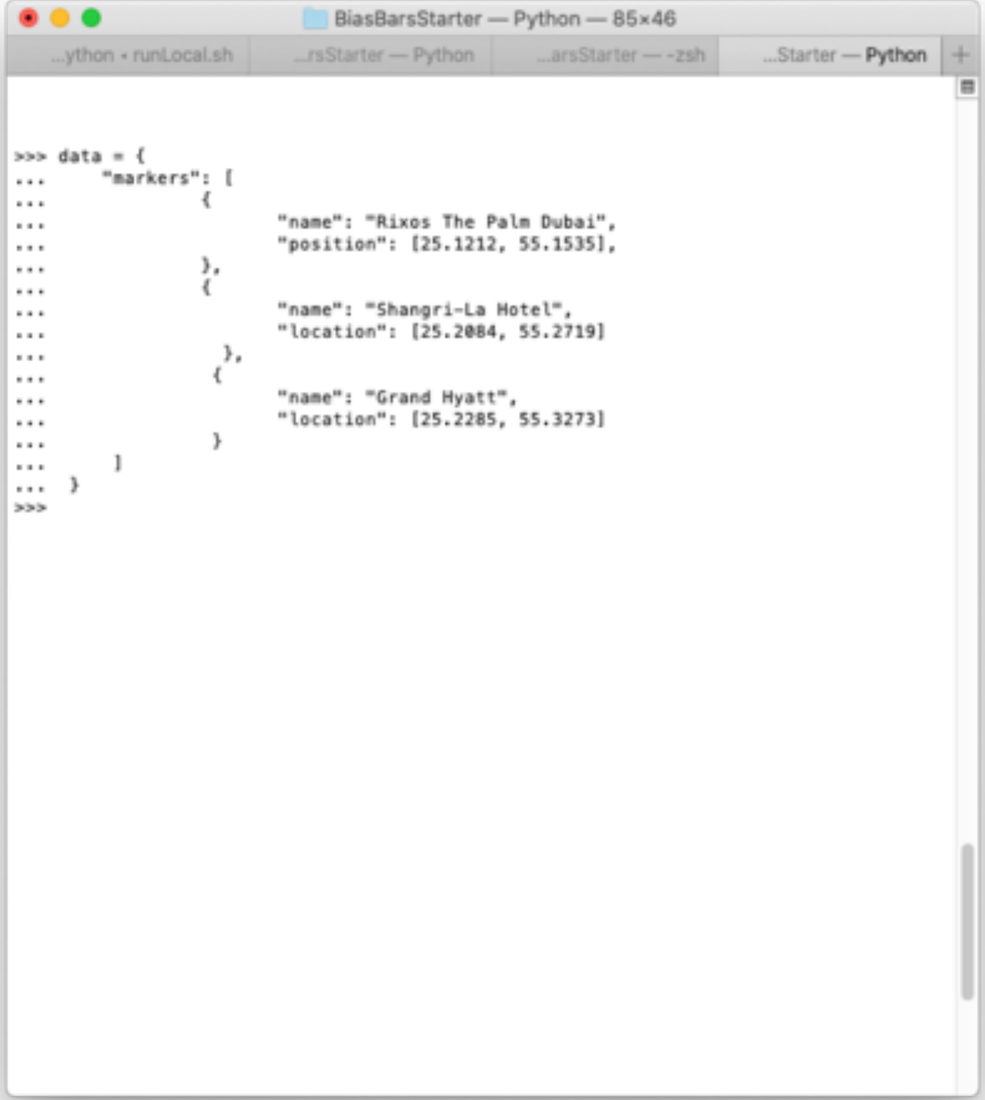
Blob is not covered in cs106a. Basically a binary list. Used for things like images

Example Google Maps Query Result

```
{
    "markers": [
        {
            "name": "Rixos The Palm Dubai",
            "position": [25.1212, 55.1535],
         },
         {
            "name": "Shangri-La Hotel",
            "location": [25.2084, 55.2719]
          },
         {
            "name": "Grand Hyatt",
            "location": [25.2285, 55.3273]
         }
    ]
 }
```

Welcome to the wild west of data

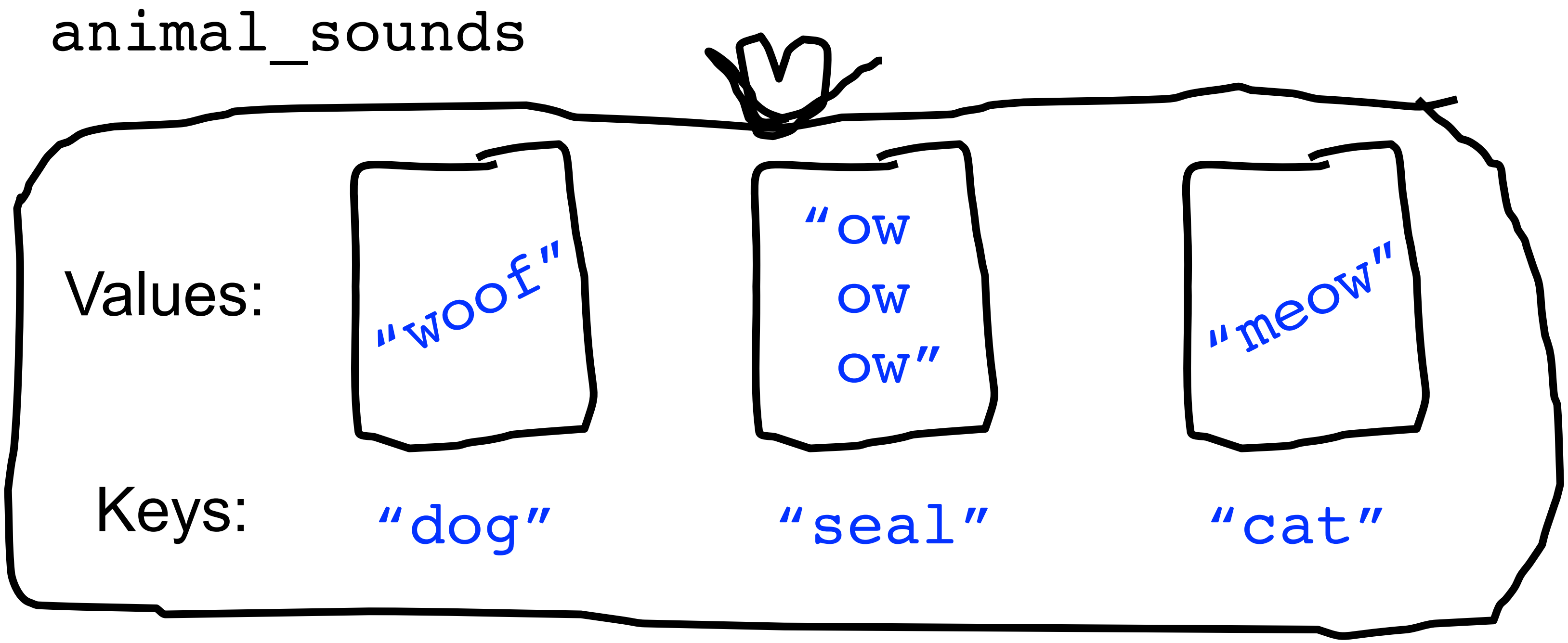
Example Google Maps Query Result



```
>>> data = {
...     "markers": [
...              {
...                     "name": "Rixos The Palm Dubai",
...                     "position": [25.1212, 55.1535],
...              },
...              {
...                     "name": "Shangri-La Hotel",
...                     "location": [25.2084, 55.2719]
...                },
...               {
...                     "name": "Grand Hyatt",
...                     "location": [25.2285, 55.3273]
...               }
...      ]
...  }
>>>
```

Welcome to the wild west of data

Dict Review



animal_sounds

Values: “woof” “ow ow ow” “meow”

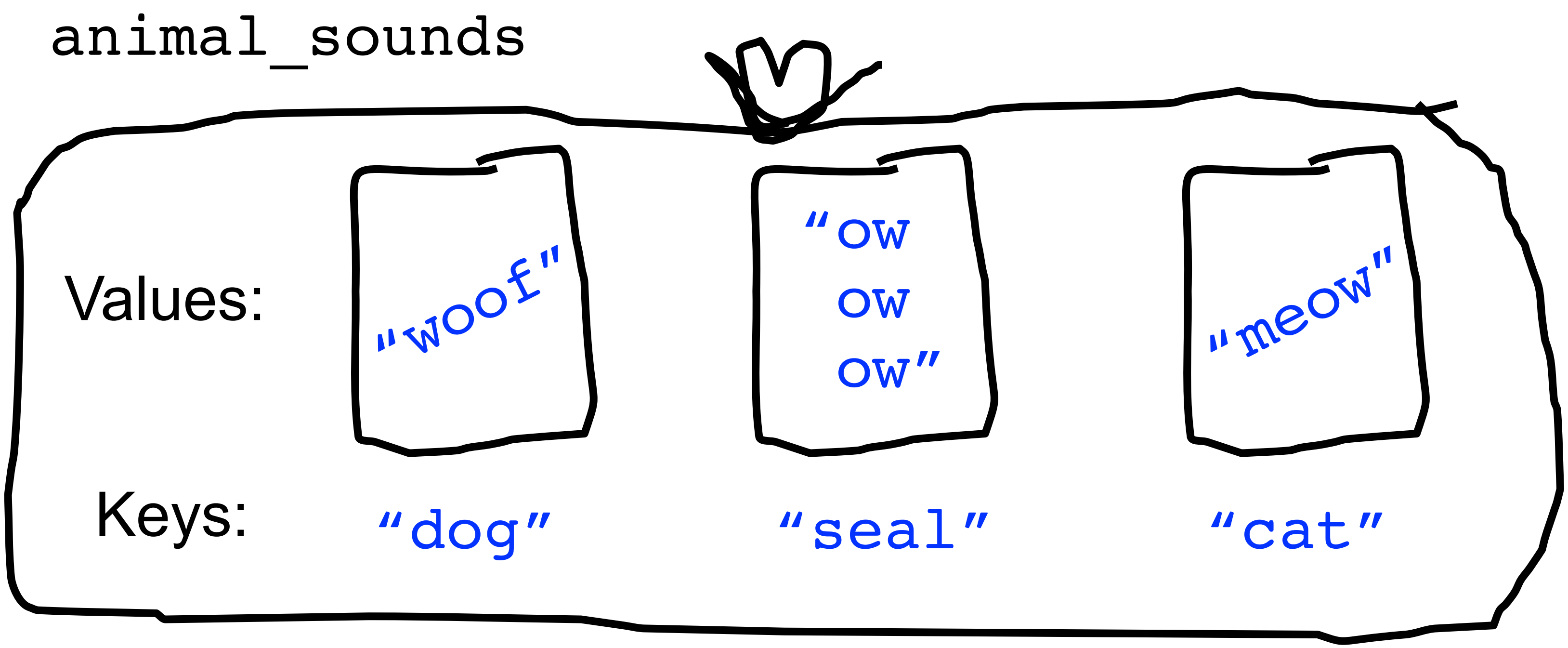
Keys: “dog” “seal” “cat”

```
# 1. Make a new Dict
animal_sounds = {}

# 2. Put things into the Dict
animal_sounds["dog”] = "woof"
animal_sounds["cat”] = "meow"
animal_sounds["seal”] = "ow ow ow"

# 3. Get things out of the Dict
dog_sound = animal_sounds["dog”] # "woof”
```

Dict Review



animal_sounds

Values: “woof” “ow ow ow” “meow”

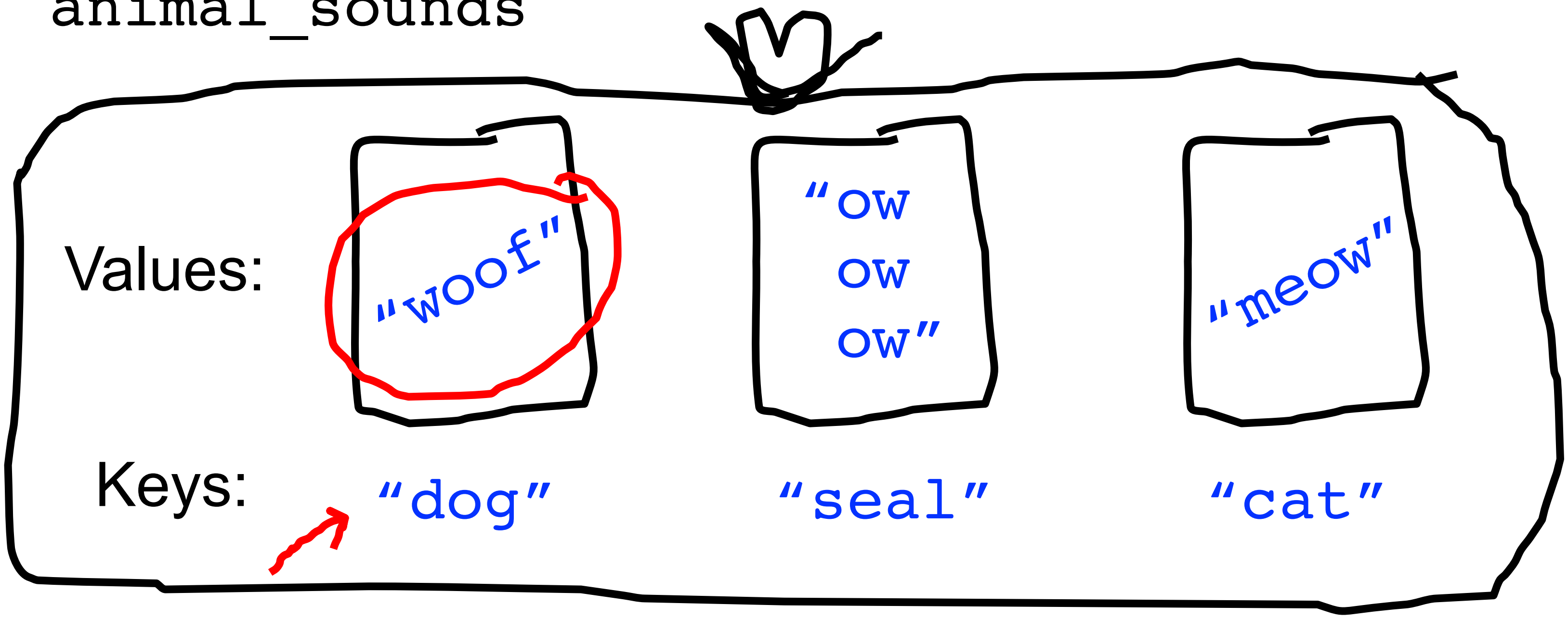
Keys: “dog” “seal” “cat”

```
# 1. Make a new Dict
animal_sounds = {}

# 2. Put things into the Dict
animal_sounds["dog”] = "woof"
animal_sounds["cat”] = "meow"
animal_sounds["seal”] = "ow ow ow"

# 3. Get things out of the Dict
dog_sound = animal_sounds["dog”] # "woof”
```

Dict Review



animal_sounds

Values: “woof” “ow ow ow” “meow”

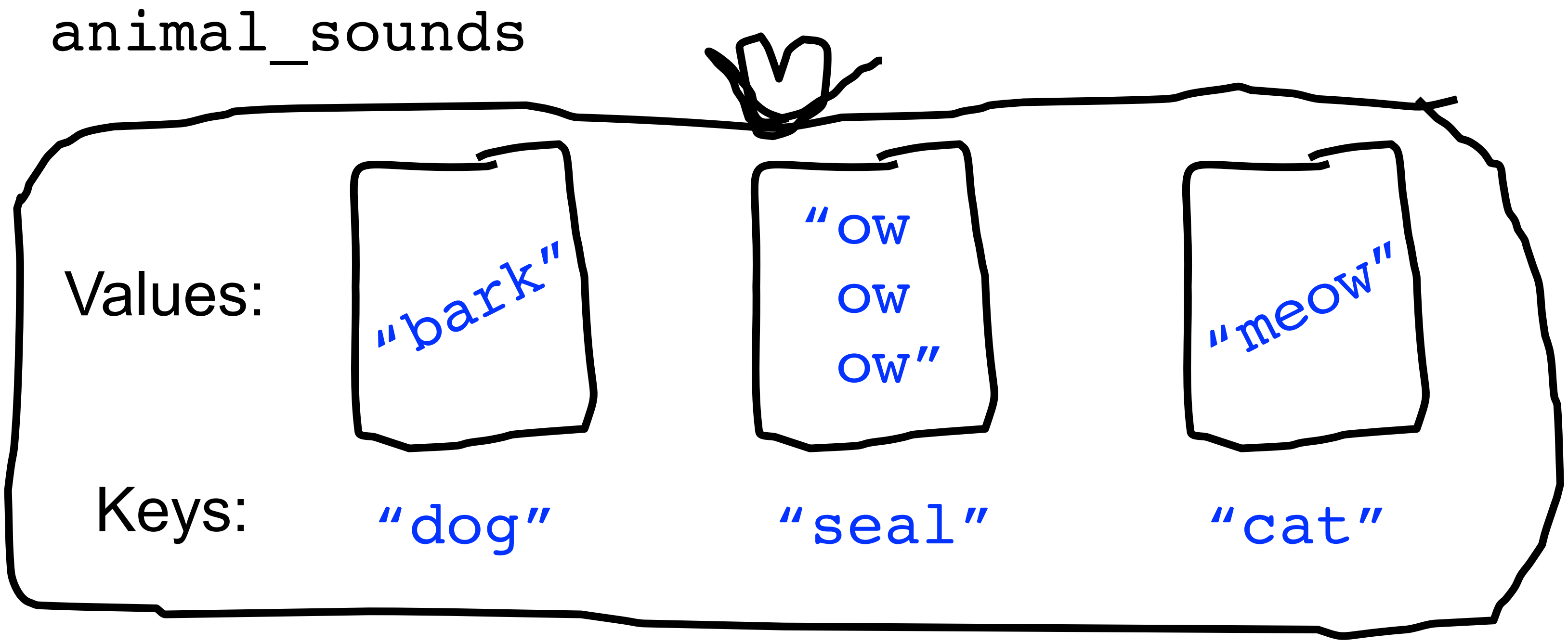
Keys: “dog” “seal” “cat”

```
# 1. Make a new Dict
animal_sounds = {}

# 2. Put things into the Dict
animal_sounds["dog”] = "woof"
animal_sounds["cat”] = "meow"
animal_sounds["seal”] = "ow ow ow"

# 3. Get things out of the Dict
dog_sound = animal_sounds["dog”] # "woof”
```

Dict Review



animal_sounds

Values: “bark” “ow ow ow” “meow”

Keys: “dog” “seal” “cat”

```
# 1. Make a new Dict
animal_sounds = {}

# 2. Put things into the Dict
animal_sounds["dog”] = "woof"
animal_sounds["cat”] = "meow"
animal_sounds["seal”] = "ow ow ow"

# 3. Get things out of the Dict
dog_sound = animal_sounds["dog"] # "woof”
fox_sound = animal_sounds["fox"] # KeyError: 'fox'
```

brothers Vegard
and Bård Ylvisåker

Circa 2013

Pi Ylvis – “The Fox”. Permission asked. Pending.

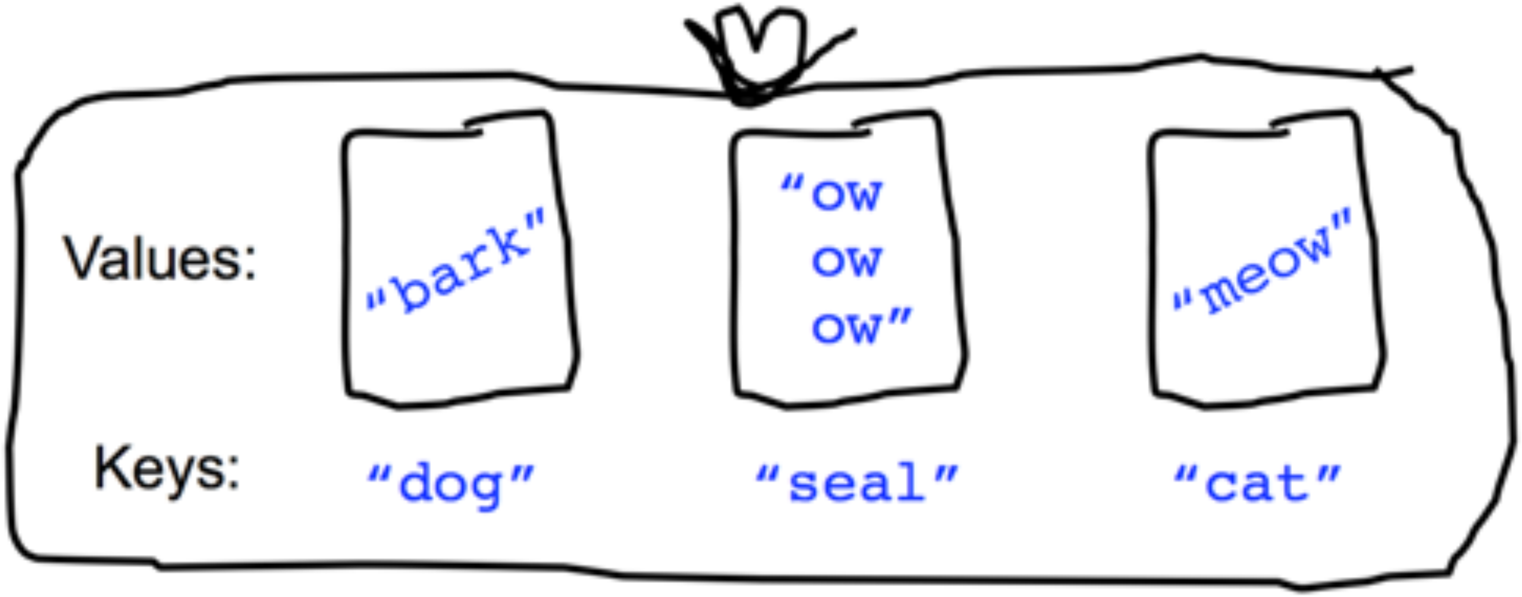
Dictionary Recap

`key` → **`value`**

Dictionary Recap

key → **value**

(string) animal → (string) animal sound

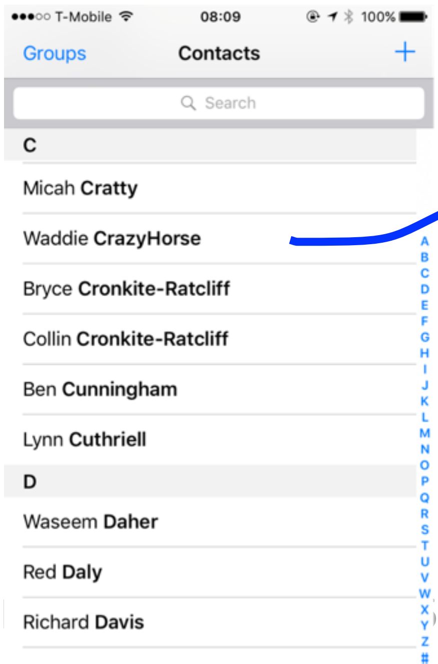


Dictionary Recap

key → **value**

(string) animal → (string) animal sound

(string) name → (int) phone number



●●●○○ T-Mobile 08:09 100%

Groups Contacts +

Search

C

Micah Cratty

Waddie CrazyHorse

Bryce Cronkite-Ratcliff

Collin Cronkite-Ratcliff

Ben Cunningham

Lynn Cuthriell

D

Waseem Daher

Red Daly

Richard Davis

6701678

Dictionarys on one slide

1. Make a Dictionary

```
my_dict = {}
```

2. Put and get values into a Dict

```
my_dict[key] = new_value
my_dict[key] # returns the corresponding value
```

3. Some useful other methods

```
size = len(my_dict)
key in my_dict    # returns true or false if key is in Dict
```

4. Iterate using a foreach loop

```
for key in my_dict:
   value = my_dict[key]  # look up the corresponding value
```

Dictionaries are one way!

In dictionaries you can only look up values by keys.
You can't look up keys by value.

```
animal_sounds['meow']  →  KeyError: 'meow'
```

Each key gets has only one value!

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

```
animal_sounds[‘dog’] = ‘bark’
animal_sounds[‘dog’] = ‘woof’
```

↓

```
animal_sounds = {‘dog’:’woof’}
```

Common Bug

You can use variables as keys! Becareful of quotes

```
animal_sounds = {
   'dog':'woof',
   'cat':'meow'
}
```

A

```
animal = input('? ')
print(animal_sounds["animal"])
```

B

```
animal = input('? ')
print(animal_sounds[animal])
```

Common Bug

Key lookups can be literals or variables. Don't confuse the two

```
animal_sounds = {
   'dog':'woof',
   'cat':'meow'
}
```

A

```
animal = input('? ')
print(animal_sounds["animal"])
```

B ✓

```
animal = input('? ')
print(animal_sounds[animal])
```

Learned about Collections

List

index -> value

Dictionary

key -> value

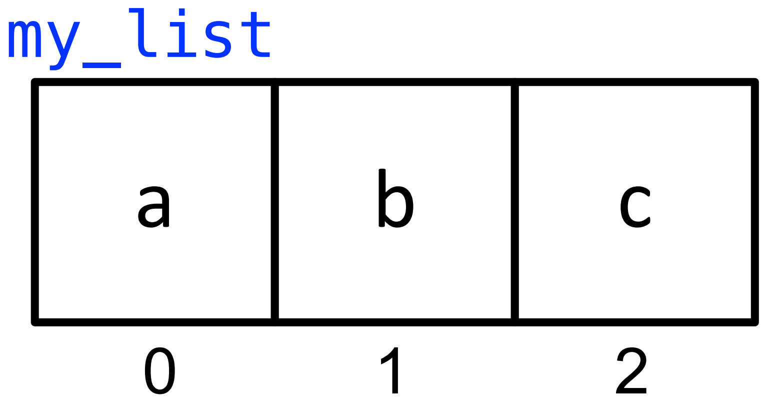
List

```
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

a	b	c
0	1	2

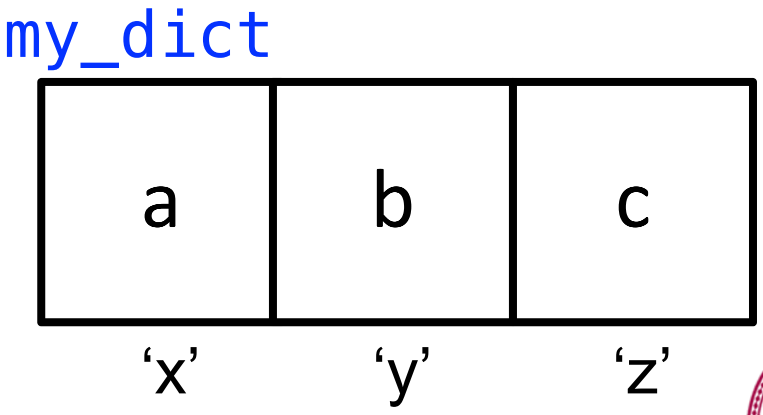
indices

Dictionary

```
my_dict = {
   ‘x’:’a’,
   ‘y’:’b,
   ‘c’:’c’
]

print(my_list[‘y’])

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



my_dict

a	b	c
‘x’	‘y’	‘z’

keys

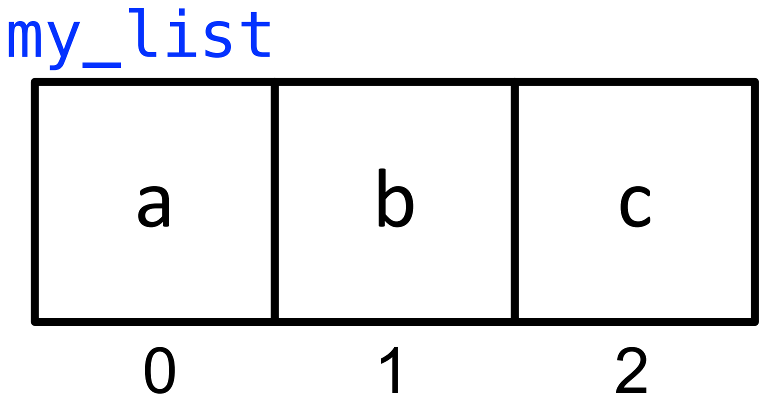
List

```
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



a	b	c
0	1	2

indices

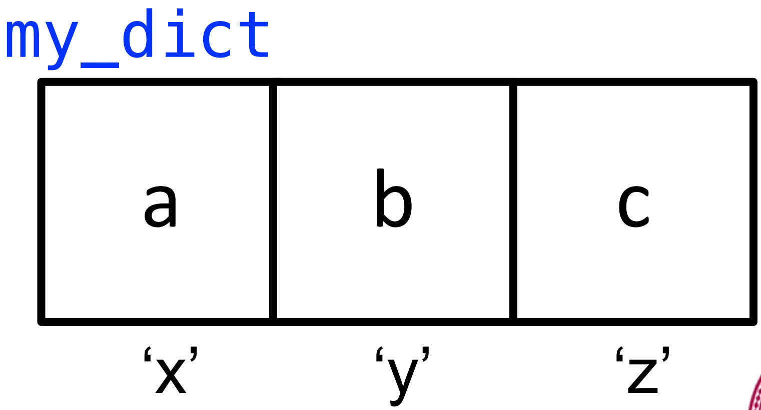
Dictionary

```
my_dict = {
    ‘x’:’a’,
    ‘y’:’b,
    ‘c’:’c’
]

print(my_list[‘y’])

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

my_dict



a	b	c
‘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

a	b	c
0	1	2

indices

Dictionary

```
my_dict = {
   ‘x’:’a’,
   ‘y’:’b,
   ‘c’:’c’
]

print(my_list[‘y’])

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

my_dict

a	b	c
‘x’	‘y’	‘z’

keys

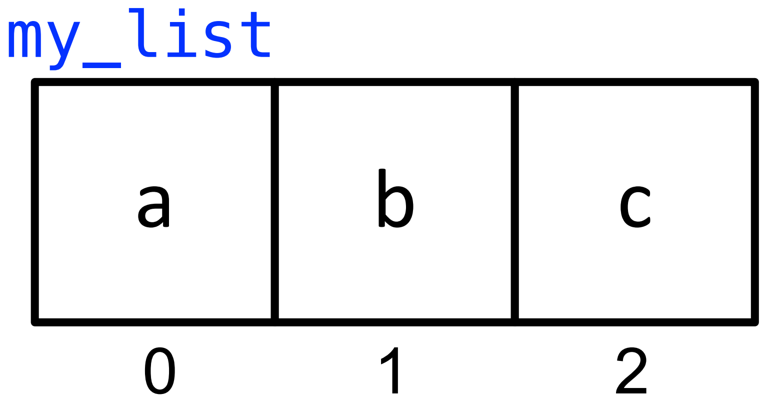
List

```
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

a	b	c
0	1	2

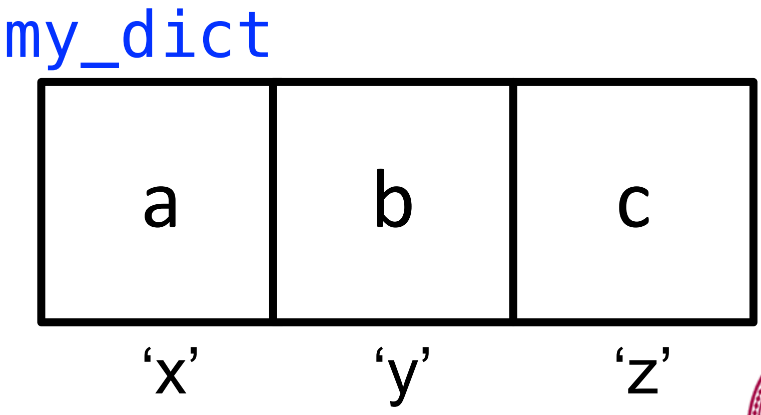
indices

Dictionary

```
my_dict = {
   ‘x’:’a’,
   ‘y’:’b,
   ‘c’:’c’
]

print(my_list[‘y’])

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



my_dict

a	b	c
‘x’	‘y’	‘z’

keys

List

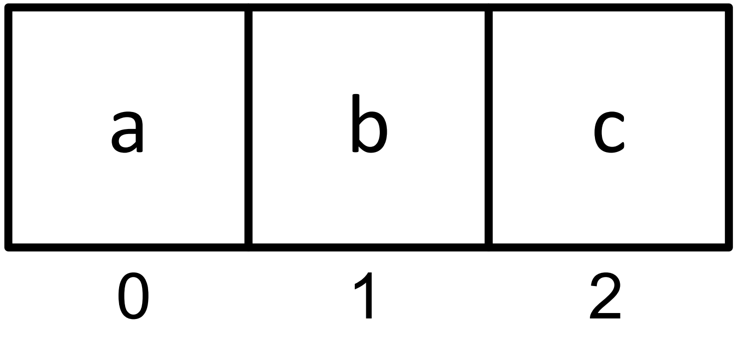
```
my_list = [‘a’, ‘b’, ‘c’]




print(my_list[1])

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

my_list



a	b	c
0	1	2

indices

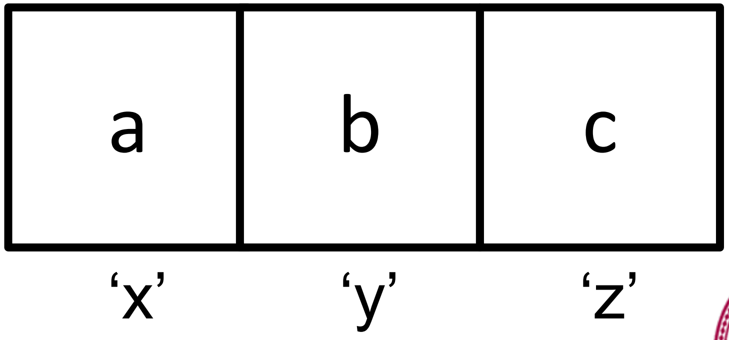
Dictionary

```
my_dict = {
   ‘x’:’a’,
   ‘y’:’b,
   ‘c’:’c’
]

print(my_list[‘y’])

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

my_dict



a	b	c
‘x’	‘y’	‘z’

keys

End Review

Are you ready?

For…

The ULTIMATE cs106a question?

Ultimate CS106A: Reverse a Dict

Normal Dict:

Key -> Value

Reversed Dict:

Value -> Keys

Claim: understanding this single example is most indicative of mastery in CS106A

Ultimate CS106A: Reverse a Dict

```
ages = {
    'Mehran':50,
    'Gary':70,
    'Chris':32,
    Juliette':23,
    'Adele':32,
    'Lionel':32,
    'Rihanna':32,
    'Stephen':32
}
```

```
reversed = {
    50:['Mehran'],
    70:['Gary'],
    32:['Chris', 'Adele', 'Lionel', 'Rihanna', 'Stephen’],
    23:['Juliette']
}
```

To the code!!!

Ultimate CS106A: Reverse a Dict

Gary -> 70

```
reversed = {





 }
```

Ultimate CS106A: Reverse a Dict

Gary -> 70

```
reversed = {
        70 : ['Gary'],



 }
```

Ultimate CS106A: Reverse a Dict

Chris -> 32

```
reversed = {
        70 : [‘Gary’],


        32 : [‘Chris’],


 }
```

Ultimate CS106A: Reverse a Dict

Mehran -> 50

```
reversed = {
        70 : [‘Gary’],


        32 : [‘Chris’],


 }
```

Ultimate CS106A: Reverse a Dict

Mehran -> 50

```
reversed = {
          70 : [‘Gary’],
          50 : [‘Mehran’],
          32 : [‘Chris’],


 }
```

Ultimate CS106A: Reverse a Dict

Rihanna -> 32

```
reversed = {
        70 : [‘Gary’],
        50 : [‘Mehran’],
        32 : [‘Chris’],


 }
```

Ultimate CS106A: Reverse a Dict

Rihanna -> 32

```
reversed = {
          70 : [‘Gary’],
          50 : [‘Mehran’],
          32 : [‘Chris’, “Rihanna”],


 }
```

Ultimate CS106A: Reverse a Dict

```
reversed = {
        70 : [‘Gary’],
        50 : [‘Mehran’],
        32 : [‘Chris’, “Rihanna”, ‘Stephen’, … ]
        23 : [‘Juliette’]
 }
```

something awesome

*idea credits to Keith

The XKCD Color Survey

The XKCD Color Survey

- Volunteers (online) were shown a randomly-chosen color and asked to name the color.
- The result is (after filtering) about 2.8 million RGB triplets and their names.
- What do people think the colors are?

The File Format

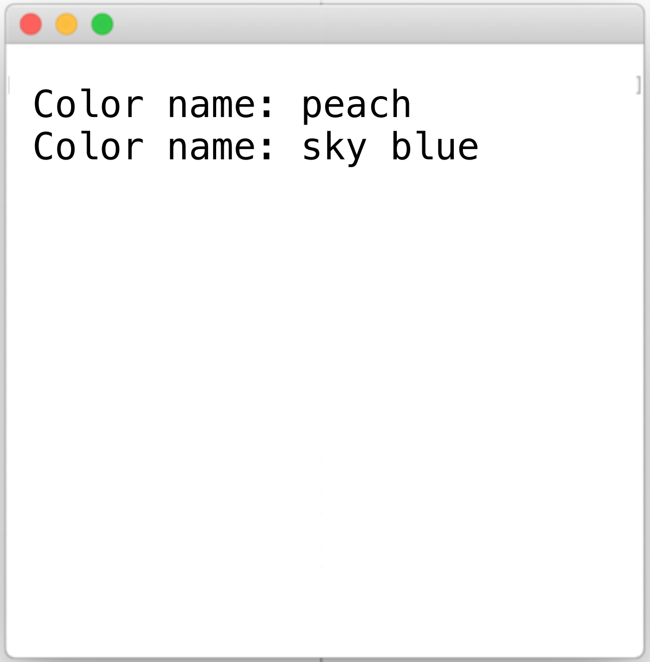
color-name, red, green, blue

```
navy blue,27,34,98
blue,41,201,234
lime green,99,212,32
red brown,160,89,66
orange,204,117,64
teal,12,208,219
blue,73,97,236
dark tan,209,202,95
moss green,77,147,83
magenta,136,30,75
blue,33,115,229
goldenrod,232,171,51
purplish blue,99,46,219
gray,212,209,208
green,56,188,125
mustard,197,164,25
red,242,9,26
pale green,221,240,210
cyan,199,254,247
carrot,240,80,16
purple,186,117,237
pale rose,197,68,63
fuchsia,210,13,137
pea green,198,247,15
forest green,17,106,39
tan,173,163,123
dark blue,27,7,117
teal,41,182,127
aqua,36,219,173
dark green,17,110,73
pale lime,189,244,125
light green,115,235,119
bright blue,17,155,238
hot pink,247,3,229
lighter green,98,253,147
brown,138,112,77
purple,116,50,76
red,245,42,54
green,7,173,31
bluish gray,82,110,127
blue,124,164,176
blue,120,158,209
sand,235,175,100
forest green,32,144,58
purple,145,37,226
dirty green,87,130,64
dirty green,125,136,42
brown,132,116,30
pink,252,68,255
blueberry,71,55,114
yellow brown,179,163,23
purple,199,64,183
deep purple,95,21,87
dirty yellow,221,198,107
light purple,185,110,194
sea blue,24,250,209
navy blue,16,32,75
bluish green,62,208,104
dark blue,2,0,50
blue,107,148,220
dark blue,101,68,175
sky blue,7,152,170
teal,81,166,152
green,19,246,59
green,20,252,59
aquamarine,65,206,163
```

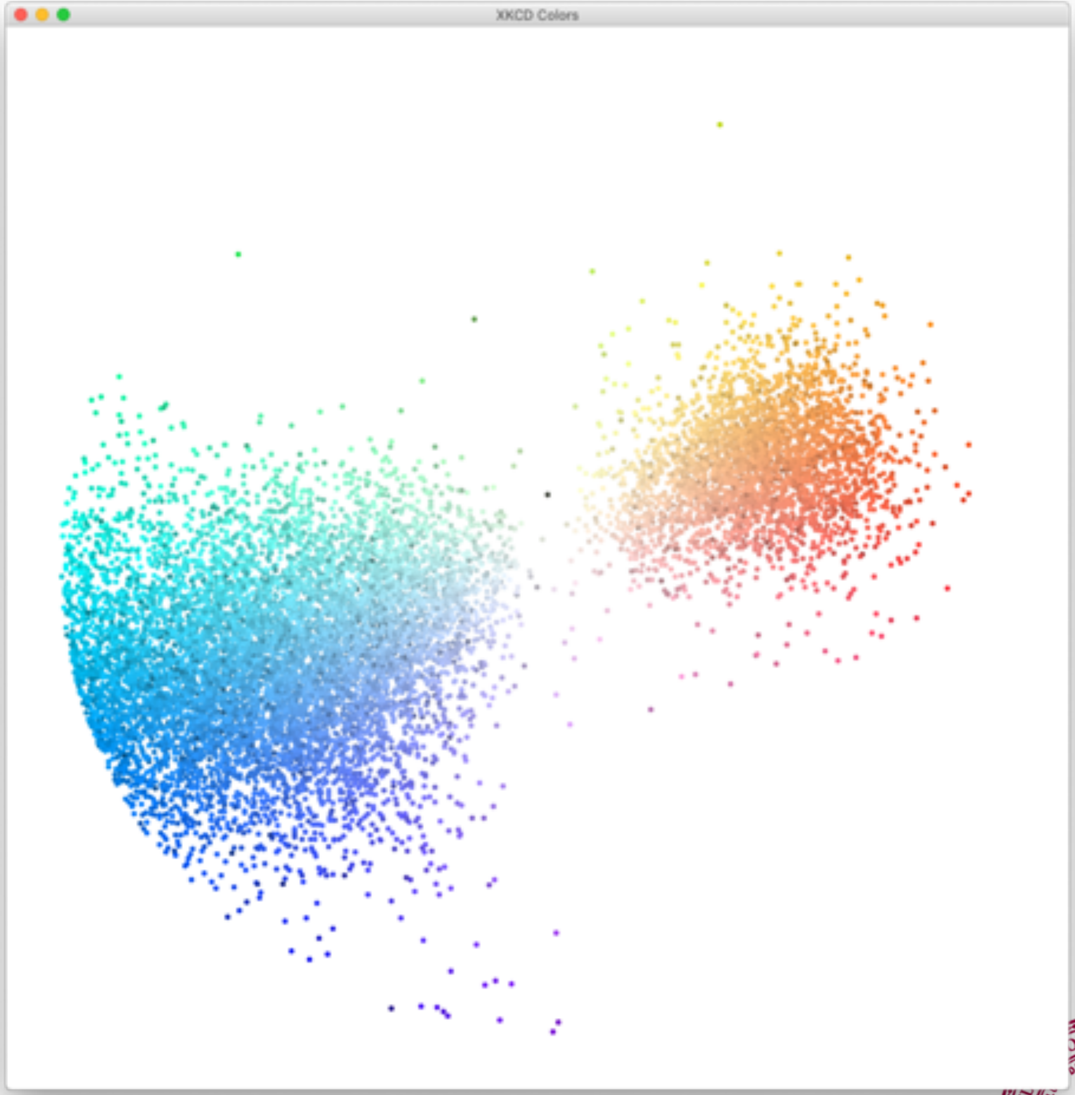
How to Structure Data?

I give this to you so you can focus on data

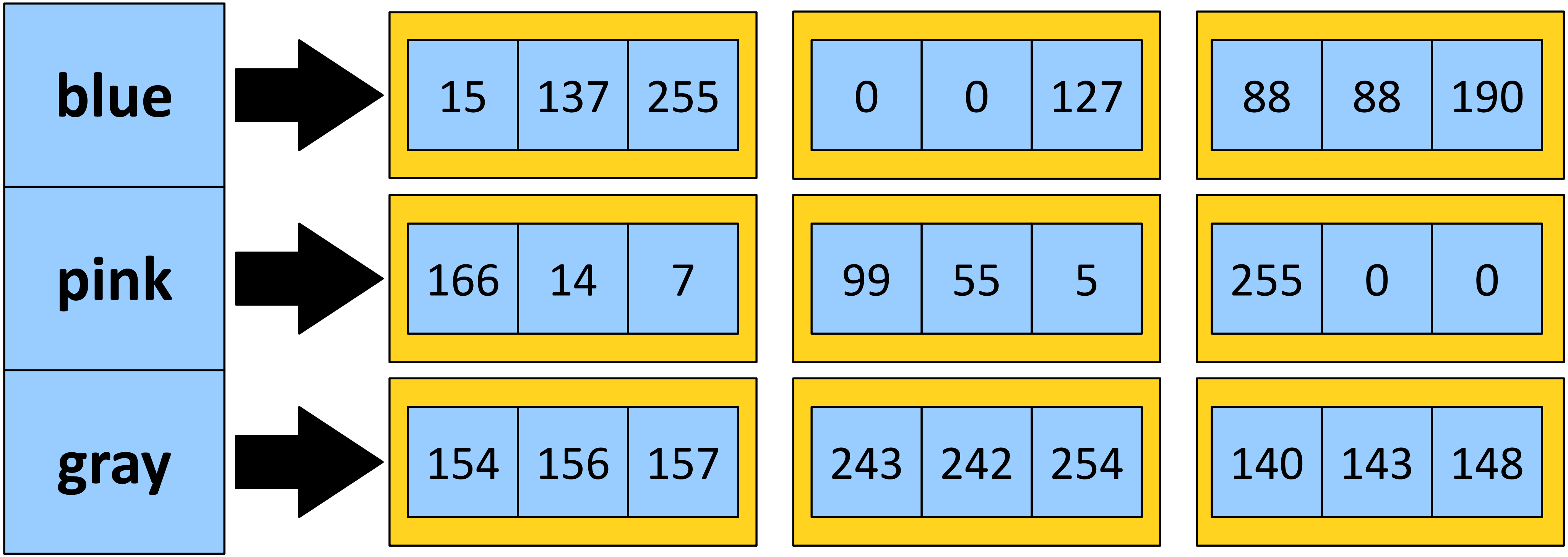
```
def plot_color(canvas, r, g, b):
```



```
Color name: peach
Color name: sky blue
```



How to Structure Data



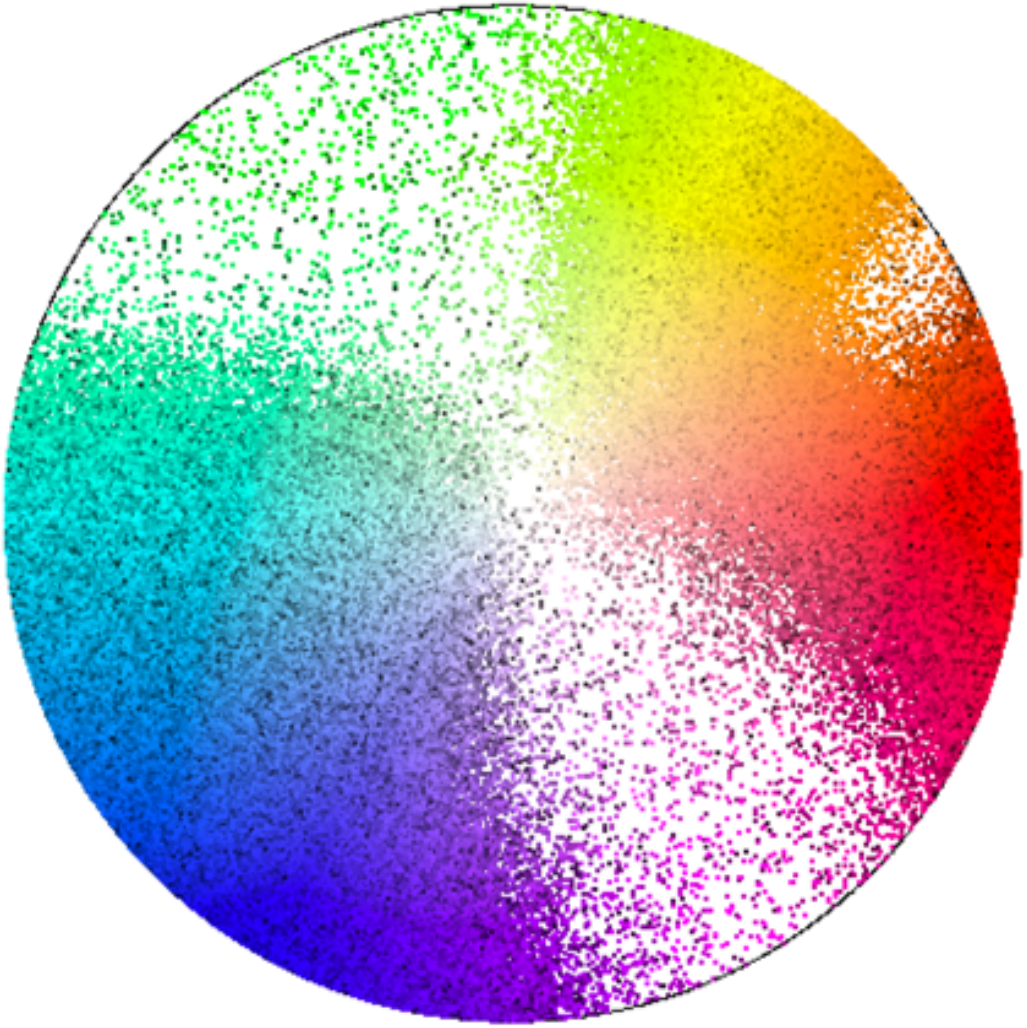
blue	15	137	255	0	0	127	88	88	190
pink	166	14	7	99	55	5	255	0	0
gray	154	156	157	243	242	254	140	143	148

associate each color name with a list of colors

How to Structure Data

```
{
    "clover green": [[100, 216, 135], [72, 218, 111],
      [57, 109, 40], [9, 190, 78], [4, 217, 90], [36,
      164, 33], [85, 195, 120], [137, 207, 101], [155,
      213, 167], [41, 141, 12], [35, 195, 118], [63,
      169, 115], [2, 184, 86], [49, 189, 100], [147,
      200, 8], [63, 160, 43], [87, 121, 8], [49, 183,
      44], [61, 190, 119]],
    "sal": [[184, 207, 244], [48, 199, 109], [247, 4,
      25], [6, 101, 127], [196, 124, 36], [148, 30, 23],
      [106, 51, 249], [186, 63, 96], [209, 234, 226],
      [115, 18, 254], [59, 251, 10], [209, 84, 209],
      [254, 164, 39], [154, 165, 137], [82, 196, 178],
      [120, 250, 248], [175, 59, 33], [67, 52, 126],
      [224, 211, 50], [9, 255, 249], [138, 43, 154],
      [218, 158, 7], [213, 79, 90]],
    "marzipan": [[202, 197, 102], [34, 80, 112], [127,
      162, 51], [90, 171, 24], [134, 198, 156], [163,
      138, 126], [212, 248, 154], [133, 25, 118], [75,
      143, 86], [46, 108, 0], [9, 242, 107], [29, 120,
      25], [237, 209, 155], [215, 82, 187], [200, 79,
      52], [12, 78, 60], [18, 52, 183], [186, 61, 232],
      [169, 201, 232], [173, 216, 142]]
}
```

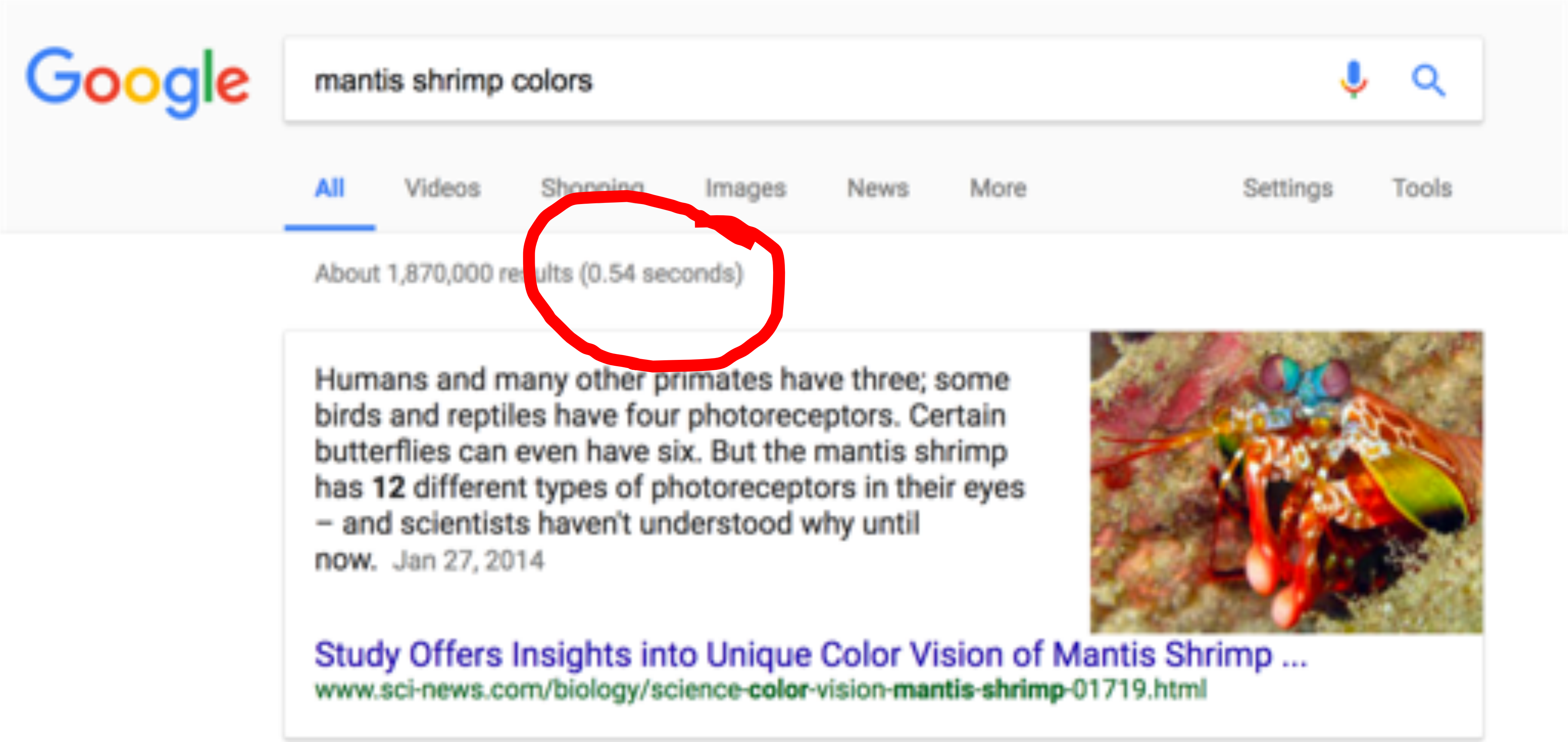
Displaying Colors



Further Reading

- http:#blog.xkcd.com/2010/05/03/color-survey-results/

Why is this so fast?



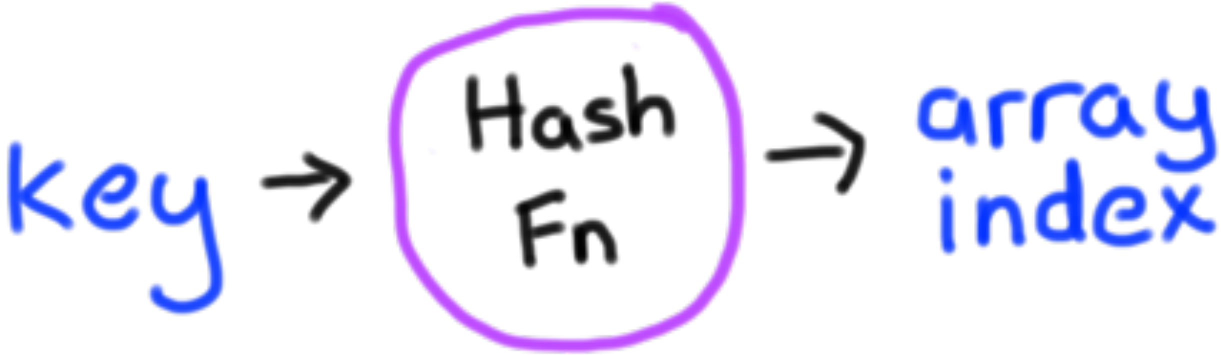
mantis shrimp colors

About 1,870,000 results (0.54 seconds)

Humans and many other primates have three; some birds and reptiles have four photoreceptors. Certain butterflies can even have six. But the mantis shrimp has **12** different types of photoreceptors in their eyes – and scientists haven't understood why until now. Jan 27, 2014

Study Offers Insights into Unique Color Vision of Mantis Shrimp ...
www.sci-news.com/biology/science-**color**-vision-**mantis**-**shrimp**-01719.html

Why is this so fast?



```
hash_int = hash(key);
```

* Learn more in CS106B