Python Tutorial

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Acknowledgement

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Outline

- **Fundamentals**
- **Introduction to Data Structures**
- **Programming Structure and Functions**
- **Python Standard Library**
- **Advanced Topics**
- **Projects**

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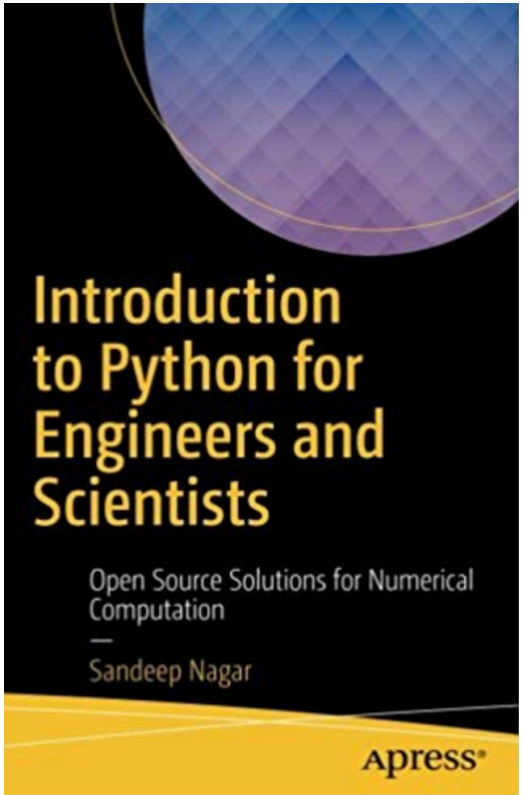
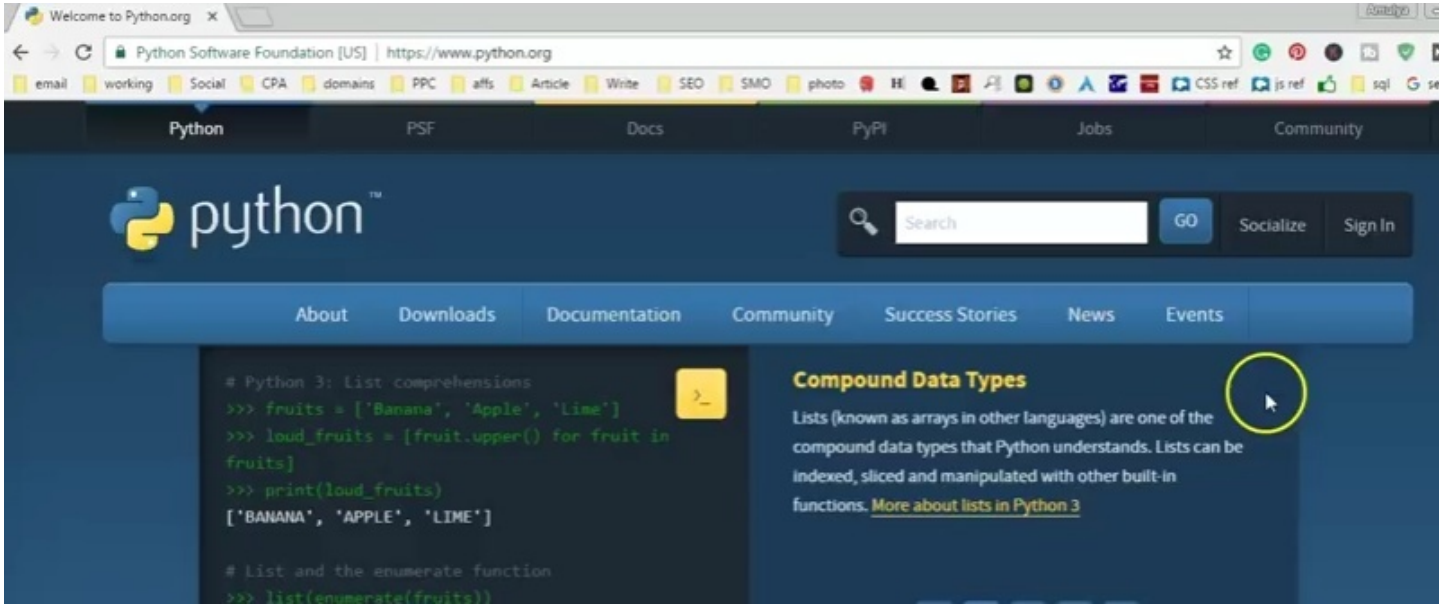
Why Python?

- **Python is a powerful, multi-paradigm, interpreted language popular.**



Installation

- **Windows**

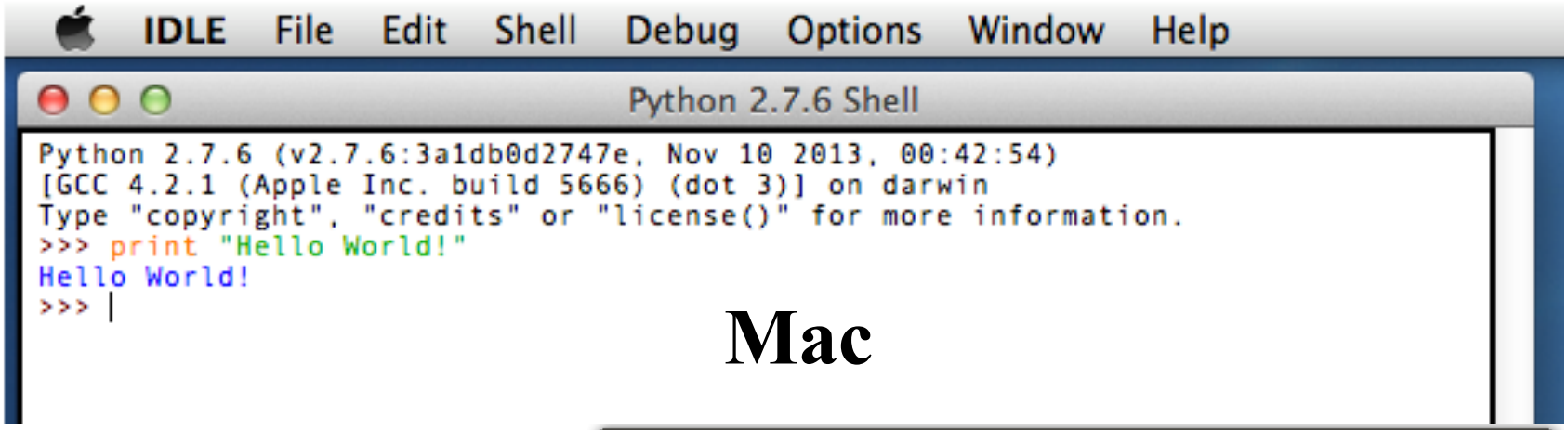


https://www.youtube.com/watch?v=oHOiqFs_x8Y

- **How to install Python on Windows (https://www.howtogeek.com/197947/how-to-install-python-on-windows/)**

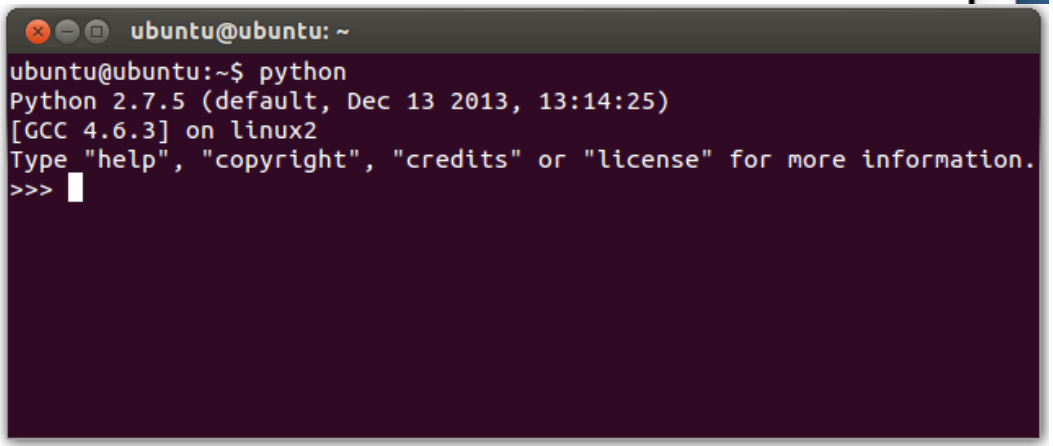
Installation

- **Mac & Linux (Ubuntu)**
  - **Prepackaged Python 2**



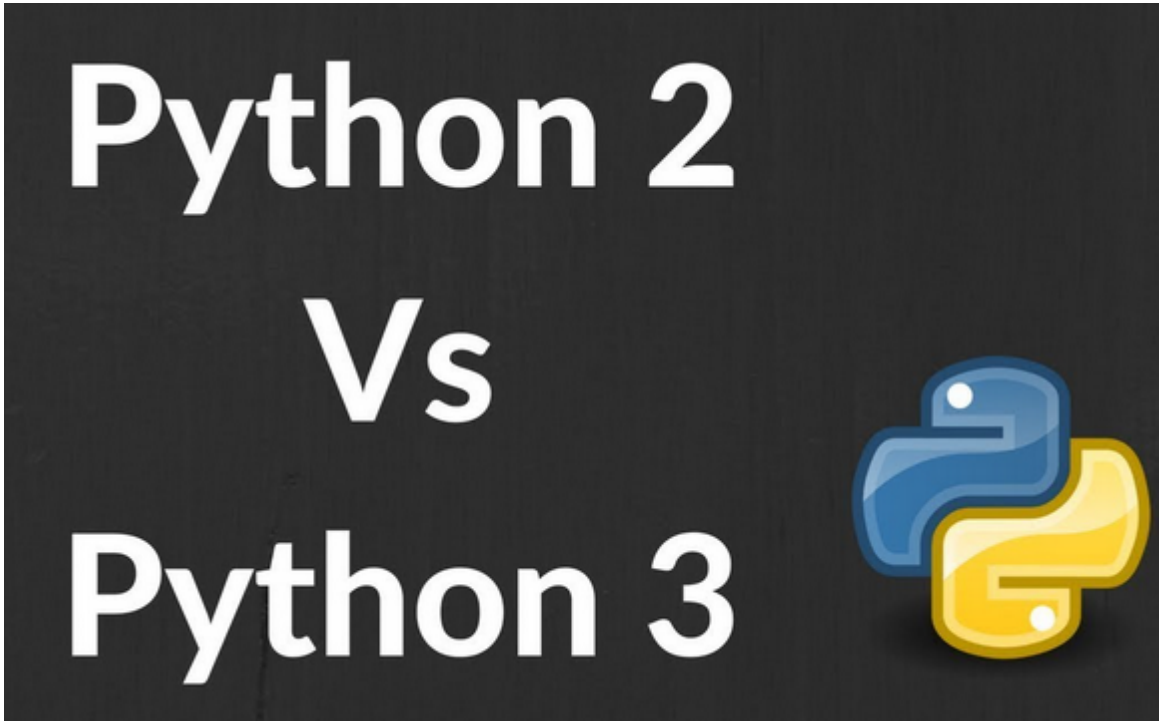
Mac

Linux (Ubuntu)



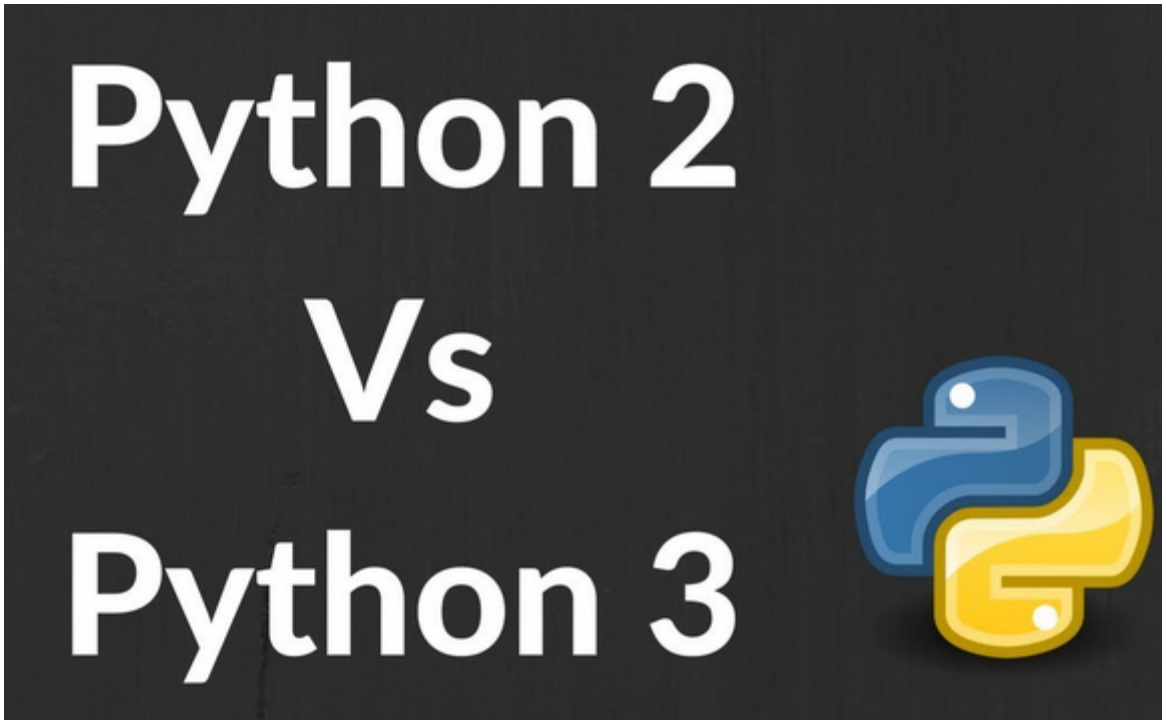
Python 2 *vs* Python 3

- **For beginners there is no real difference between Python 2 & 3. The basics are the same.**



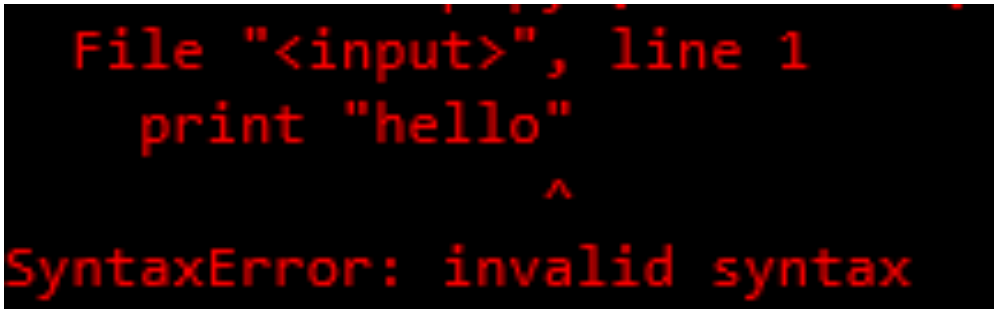
Python 2 *vs* Python 3

- **Examples are written for Python2.**
- **Python2 will be maintained until 2020.**



Python 2 *vs* Python 3

- **Python 2**
  - **>> print (“hello world”)**
  - **>> print “hello world”**
- **Python 3**
  - **>> print (“hello”)**
  - **>> print “hello”**



Python 3 HELLO WORLD

- ***print*** **is no longer a statement, but a FUNCTION**

```
print("hello world")
```

From Script

- **Make a file hello.py with**

  print "hello world"

- **Run with:**

  python hello.py

Python syntax

Python

```
x = 5
y = x + 7
z = 3.14

name = “Rishi”


1 == 1 # => True
5 > 10 # => False

True and False # => False
not False # => True
```

Variables are not statically typed!

Java/C++

```
int x = 5;
int y = x + 7;
double z = 3.14;

String name = “Rishi”; // Java
string name(“Rishi”);  // C++

1 == 1 # => true
5 > 10 # => false

true && false # => false
!(false) # => true
```

Variables

```
a = 4              # Integer
b = 5.6            # Float
c = "hello"        # String
a = "4"          # rebound to String
```

Naming

- **Lowercase**
- **Underscore_between_words**
- **Don't start with numbers**

Math

- **+, -, *, /, ** (power), % (modulo)**
- **Careful with integer division**

```
>>> 3/4
0
>>> 3/4.
0.75
```

Data Type

- **Long**

```
>>> 10**100
1000000000000000000000000000000000
0000000000000000000000000000000000
0000000000000000000000000000000000
00000L
```

```
>>> import sys
>>> sys.maxint
9223372036854775807
>>> sys.maxint + 1
9223372036854775808L
```

Strings

```
name = 'matt'
with_quote = "I ain't gonna"
longer = """This string has
multiple lines
in it"""
```

String escaping

- **Escape with **

```
>>> print 'He said, "I\'m sorry"'
He said, "I'm sorry"
>>> print '''He said, "I'm sorry"'''
He said, "I'm sorry"
>>> print """He said, "I'm sorry\"""""
He said, "I'm sorry"
```

String escaping

Escape Sequence	Output
`\\`	Backslash
`\'`	Single quote
`\"`	Double quote
`\b`	ASCII Backspace
`\n`	Newline
`\t`	Tab

String methods

`s.endswith(sub)`

Returns True if endswith `sub`

`s.find(sub)`

Returns index of `sub` or `-1`

Comments

- **Comments follow a #**
- **No multi-line comments**

```
#hello world
print("hello")
```

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- Advanced Topics
- Projects

Data Structures

- **Lists**
- **Dictionaries**
- **Iteration**
- **List Comprehensions**

Lists

- **Hold sequences.**
- **How would we find out documentation for a method?**

`help` function:

```
>>> help([].append)
Help on built-in function append:

append(...)
    L.append(object) -- append object to end
```

List methods

`l.append(x)`

Insert `x` at end of list

`l.extend(l2)`

Add `l2` items to list

`l.sort()`

In place sort

List methods

`l.reverse()`

Reverse list in place

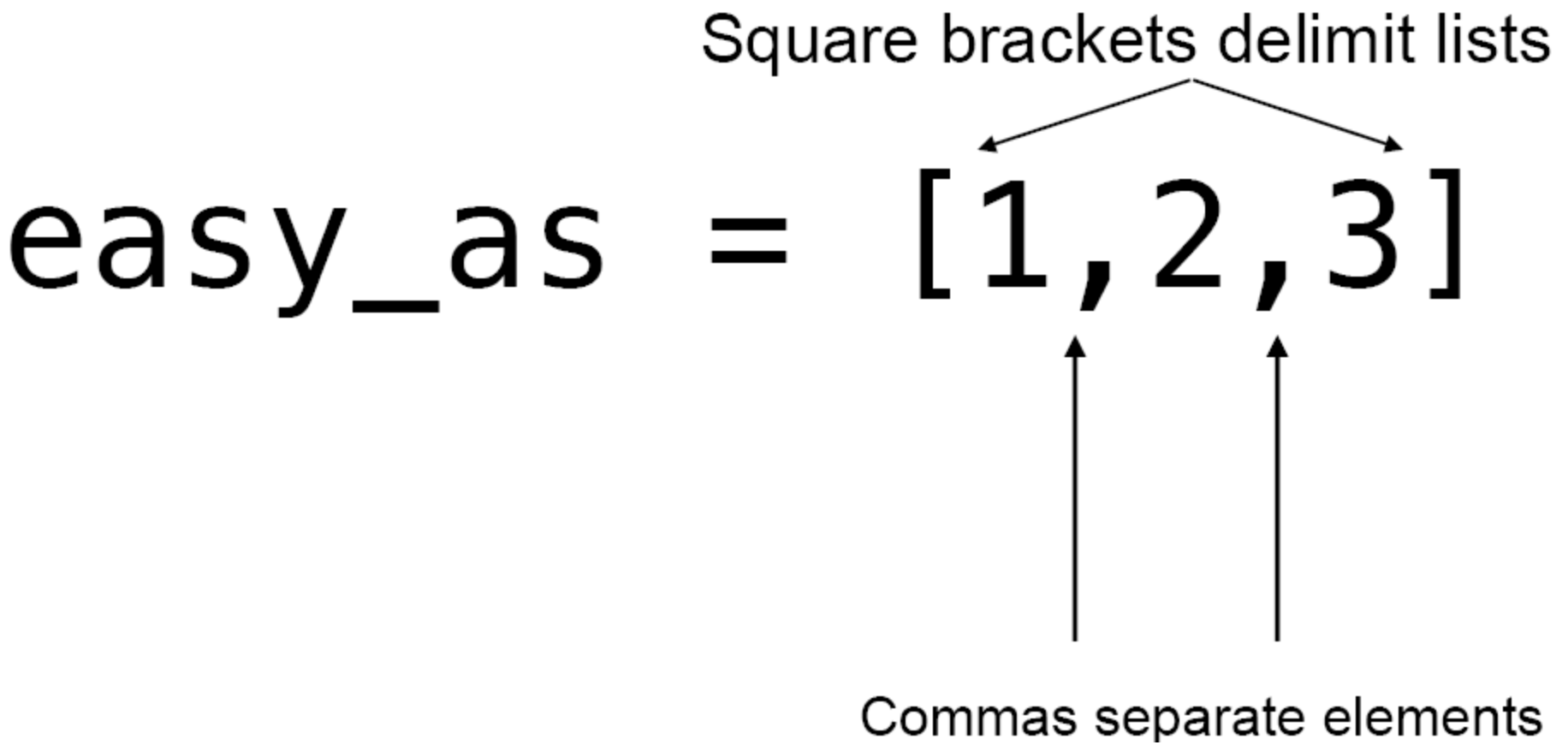
`l.remove(item)`

Remove first `item` found

`l.pop()`

Remove/return item at end of list

Lists


Square brackets delimit lists
easy_as = [1,2,3]
Commas separate elements

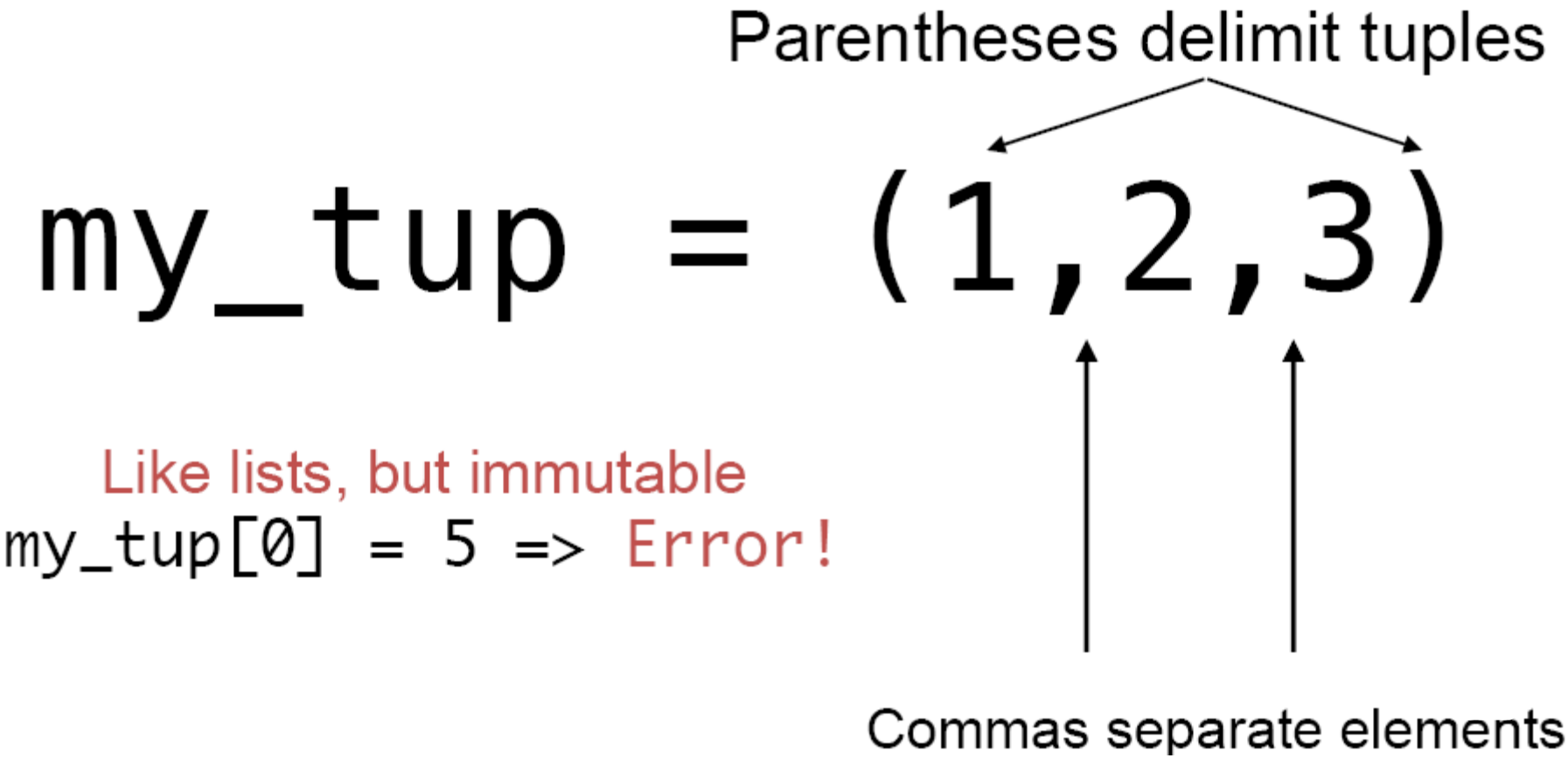
Lists

```
# Create a new list
empty = []
letters = ['a', 'b', 'c', 'd']
numbers = [2, 3, 5]

# Lists can contain elements of different types
mixed = [4, 5, "seconds"]

# Append elements to the end of a list
numbers.append(7)   # numbers == [2, 3, 5, 7]
numbers.append(11)  # numbers == [2, 3, 5, 7, 11]
```

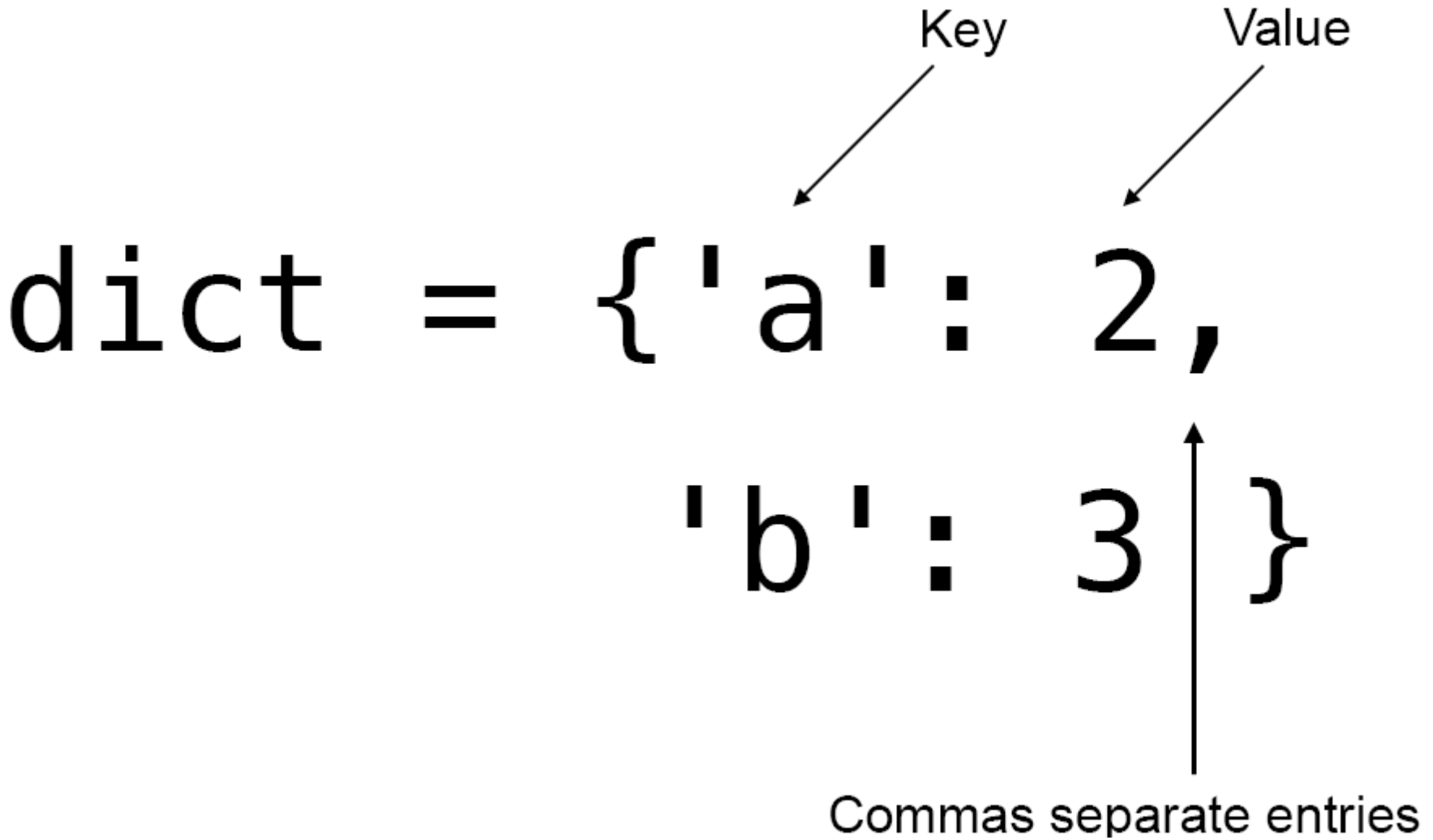
Lists

```
# Access elements at a particular index
numbers[0]  # => 2
numbers[-1]  # => 11

# You can also slice lists - the same rules apply
letters[:3]  # => ['a', 'b', 'c']
numbers[1:-1]  # => [3, 5, 7]

# Lists really can contain anything - even other lists!
x = [letters, numbers]
x  # => [['a', 'b', 'c', 'd'], [2, 3, 5, 7, 11]]
x[0]  # => ['a', 'b', 'c', 'd']
x[0][1]  # => 'b'
x[1][2:]  # => [5, 7, 11]
```

Tuples


Parentheses delimit tuples
my_tup = (1,2,3)
Like lists, but immutable
my_tup[0] = 5 => Error!
Commas separate elements

Dictionaries



Dictionaries

- **Also called hashmap or associative array elsewhere**

```
>>> age = {}
>>> age['george'] = 10
>>> age['fred'] = 12
>>> age['henry'] = 10
>>> print age['george']
10
```

Dictionaries

- **Find out if 'matt' in age**

```
>>> 'matt' in age
False
```

- **.get method**

```
>>> print age['charles']
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'charles'
>>> print age.get('charles', 'Not found')
Not found
```

Deleting Keys

- **Removing 'charles' from age**

```
>>> del age['charles']
```

Dictionaries

```
d = {"one": 1, "two": 2, "three": 3}

len(d.keys())  # => 3

print d['one']   # => 1
print d['five']  # => ERROR!

d['five'] = 5    # => OK, creates new key

d.keys()        # iterator over k
d.values()      # iterator over v
d.items()       # iterator over (k, v) pairs
```

Iteration

- **Most data structures can be iterated over in the same way:**

```
mylist = ['a', 'b', 'c']
for item in mylist:
    print item
```

```
dict = {'a': 10, 'b': 15}
for key in dict:
    print key, dict[key]
```

When iterating over a dictionary like this, we iterate over the keys.

```
mytuple = ('a', 'b', 'c')
for item in mytuple:
    print item
```

Note we don't need the index of the element to access it.

Iteration

- **We can also iterate over indices:**

```
for i in range(4):
    print i,                                    # 0 1 2 3

for i in range(1, 10, 2):
    print i,                                    # 1 3 5 7 9

mylist = ['a', 'b', 'c']                        #  0 'a'
for i in range(len(mylist):                     #  1 'b'
    print i, mylist[i]                          #  2 'c'


mylist = ['a', 'b', 'c']                        #  0 'a'
for idx, item in enumerate(mylist):             #  1 'b'
    print idx, item                             #  2 'c'
```

List Comprehensions

Input: `nums = [1, 2, 3, 4, 5]`

Goal: `sq_nums = [1, 4, 9, 16, 25]`

Here's how we could already do this:

```
sq_nums = []
for n in nums:
    sq_nums.append(n**2)
```

Or... we could use a comprehension:

square brackets show we're making a list

```
sq_nums = [n ** 2 for n in nums]
```

apply some operation to the loop variable

loop over the specified iterable

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Programming Structure

- **Conditionals**

```
if grade > 90:
    print "A"
elif grade > 80:
    print "B"
elif grade > 70:
    print "C"
else:
    print "D"
```

Comparison Operators

- **Supports (>, >=, <, <=, ==, !=)**

```
>>> 5 > 9
False
>>> 'matt' != 'fred'
True
```

Logical operators

- **and, or, not (for logical)**

```
>>> x = 5
>>> x < -4 or x > 4
True
```

Iteration (Loop)

```
for number in [1,2,3,4,5,6]:
    print number

for number in range(1, 7):
    print number
```

Range note

- Python tends to follow half-open interval ([start,end)) with range and slices.
  - end - start = length
  - easy to concat ranges w/o overlap

Iteration (2)

- **Java/C-esque style of object in array access (BAD):**

```
animals = ["cat", "dog", "bird"]
for index in range(len(animals)):
    print index, animals[index]
```

- **If you need indices, use enumerate If you need indices, use enumerate**

```
animals = ["cat", "dog", "bird"]
for index, value in enumerate(animals):
    print index, value
```

break

- **Can break out of nearest loop Can break out of nearest loop**

```
for item in sequence:
    # process until first negative
    if item < 0:
        break
    # process item
```

continue

- Can continue to skip over items

```
for item in sequence:
    if item < 0:
        continue
    # process all positive items
```

Iteration (3)

- **Can loop over lists, strings, iterators, dictionaries ... sequence like things:**

```
my_dict = { "name": "matt", "cash": 5.45}
for key in my_dict.keys():
  # process key

for value in my_dict.values():
  # process value

for key, value in my_dict.items():
  # process items
```

Null Operation

- ***pass*** **is a null operation**

```
for i in range(10):
    # do nothing 10 times
    pass
```

Functions

```
def fn_name(param1, param2):
    value = do_something()
    return value
```

```
def isEven(num):
    return (num % 2 == 0)

myNum = 100
if isEven(myNum):
    print str(myNum) + " is even"
```

- def starts a function definition
- return is optional
  - if either return or its value are omitted, implicitly returns None
- Parameters have no explicit types

Functions

- **def**

  function name

  (parameters)

  : + indent

  optional documentation

  body

  return

Whitespace

- **Instead of { use a : and indent. consistently (4 spaces)**

```
def add_2(num):
    """ return 2
    more than num
    """
    return num + 2
```

Default parameters

```
def add_n(num, n=3):
    """default to
    adding 3"""
    return num + n

five = add_n(2)
ten = add_n(15, -5)
```

__doc__

- **Functions have docstrings. Accessible via .__doc__ or help via .__doc__ or help**

```
>>> def echo(txt):
...     "echo back txt"
...     return txt
>>> help(echo)
Help on function echo in module __main__:
<BLANKLINE>
echo(txt)
    echo back txt
<BLANKLINE>
```

Putting Functions and List Comprehensions Together

- **Goal: given a list of numbers, generate a list that contains True for every even number and False for every odd number**

```
def isEven(num):
    return (num % 2 == 0)

numbers  = [5, 18, 7, 9, 2, 4, 0]
isEvens  = [isEven(num) for num in numbers]

## isEvens = [False, True, False, False, True, True, True]
```

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Importing Modules

```
from math import exp
from random import random
```

Imports only the selected function(s) from the module; in this case, exp from math and random from random

Can now do:

exp(0.5) to compute $e^{0.5}$

random() to generate uniform random number over [0,1]

But if we had imported the whole modules, like this…	Then we would call the functions like this:
`import math`	`math.exp(0.5)`
`import random`	`random.random()`

Numeric Computing using NumPy

- **Python's built-in datatypes are very flexible**
- **They aren't optimized for fast numerical calculations, especially on large multidimensional matrices**
- **NumPy is a widely-used 3rd part package which adds such support to Python**
- **Sister library for scientific computing: SciPy**

NumPy

```
>>> import numpy as np
>>> mat = np.ones((3,3))
>>> print mat
[[ 1.  1.  1.]
 [ 1.  1.  1.]
 [ 1.  1.  1.]]
>>> mat[1,1] = 5
>>> print mat
[[ 1.  1.  1.]
 [ 1.  5.  1.]
 [ 1.  1.  1.]]
>>> vec = np.array([1, 2, 3])
>>> np.dot(mat, vec)
array([  6.,  14.,   6.])
```

I can rename my module when I import it for convenience

It looks a lot like a list of lists!

Create arrays using `np.array`

Support for various linear algebra operations like dot products

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Advanced Topics

- **File IO**
- **Class**

File Input

- **Open a file to read from it:**

```
fin = open("foo.txt")
for line in fin:
    # manipulate line

fin.close()
```

File Output

- **Open a file using 'w' to write to a file:**

```
fout = open("bar.txt", "w")
fout.write("hello world")
fout.close()
```

File IO

Always remember to close your files!

Class

```
class Animal(object):
    def __init__(self, name):
        self.name = name

    def talk(self):
        print "Generic Animal Sound"

animal = Animal("thing")
animal.talk()
```

Classes (2)

- **notes:**
  - **object (base class) (fixed in 3.X)**
  - **Default init (constructor)**
  - **All methods take self as first parameter**

Subclass

```
class Cat(Animal):
    def talk(self):
        print '%s says, "Meow!"' % (self.name)

cat = Cat("Groucho")
cat.talk() # invoke method
```

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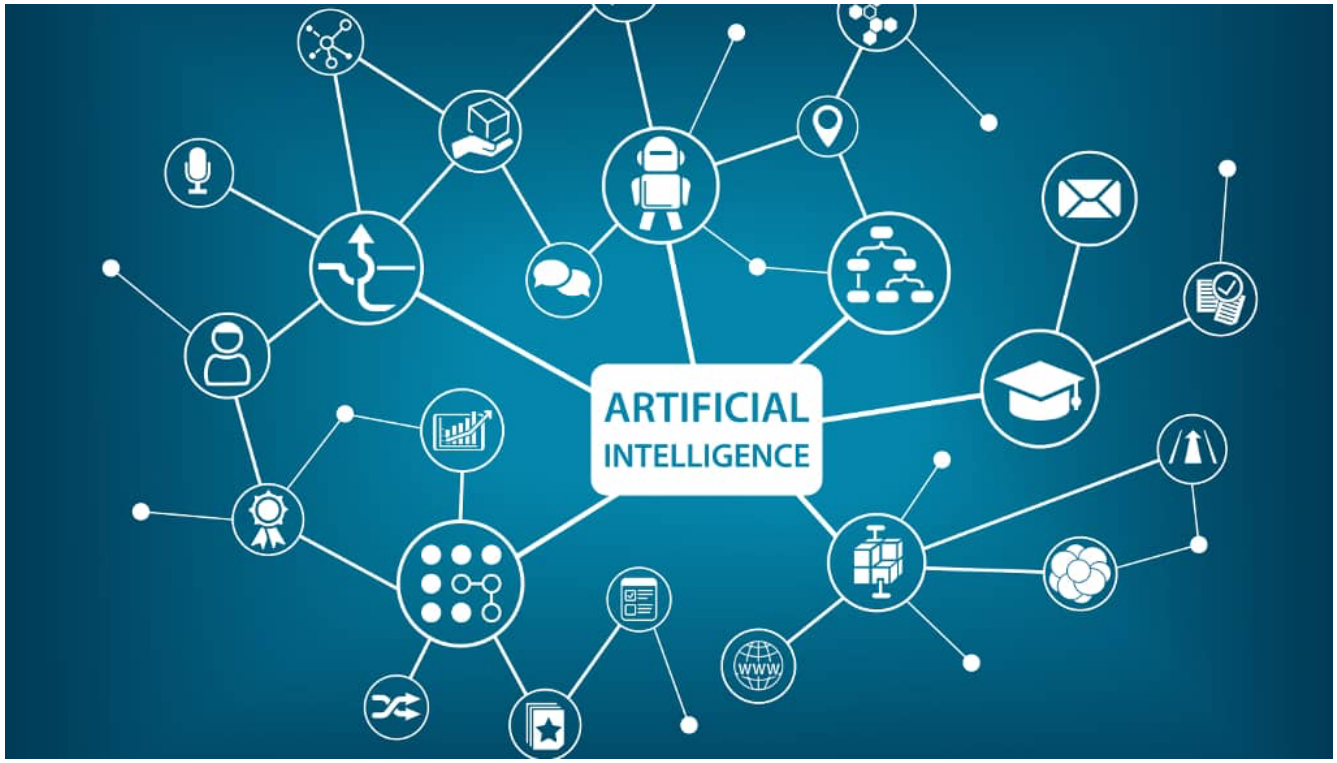
Project

- **Automatic Diagnosis on Diabetes**

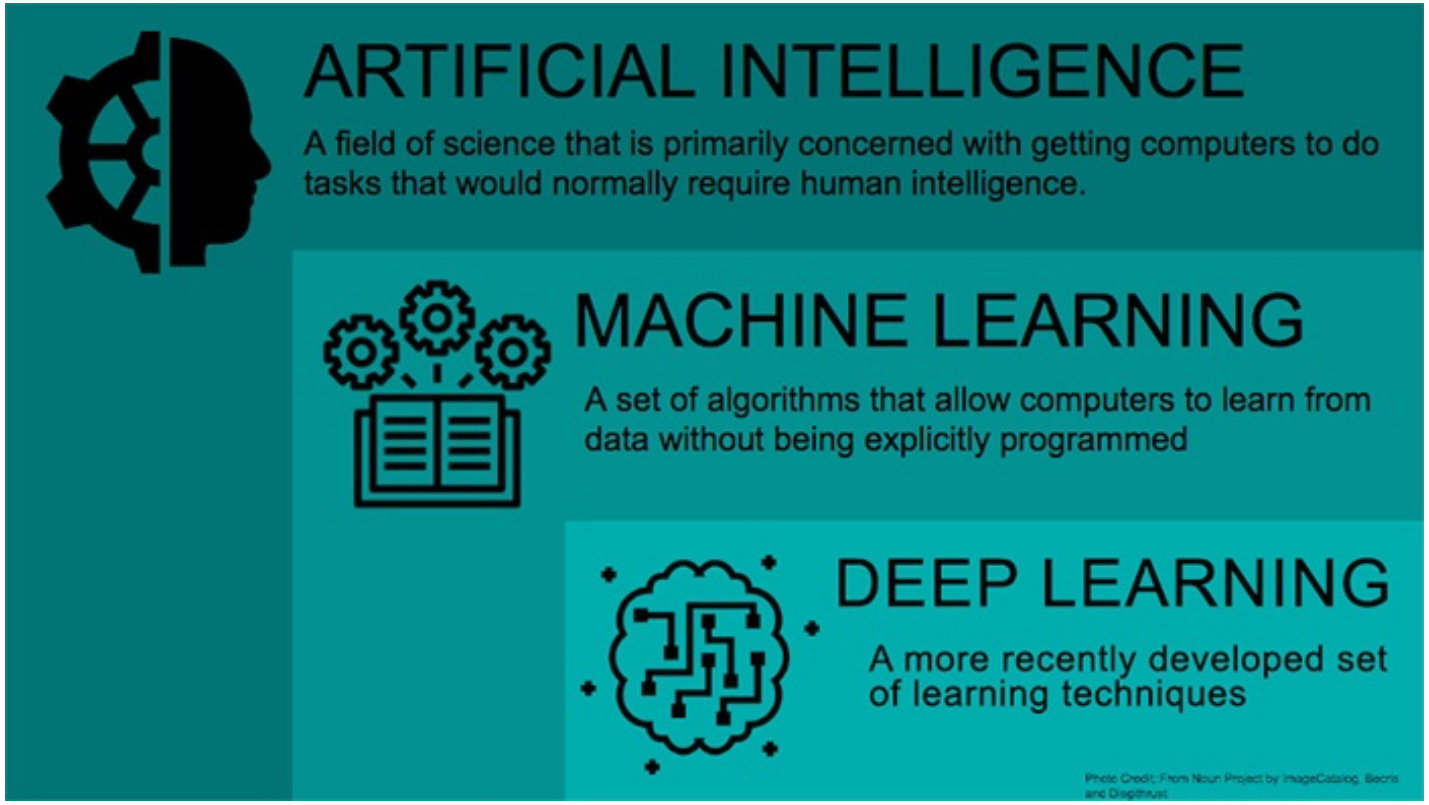
http://theindianpractitioner.com/2019/07/01/nasscom-and-nathealth-collaborate-to-boost-indias-digital-health/

Artificial Intelligence



https://www.gettingsmart.com/2018/12/the-future-is-here-artificial-intelligence-what-it-means-for-our-kids-2/

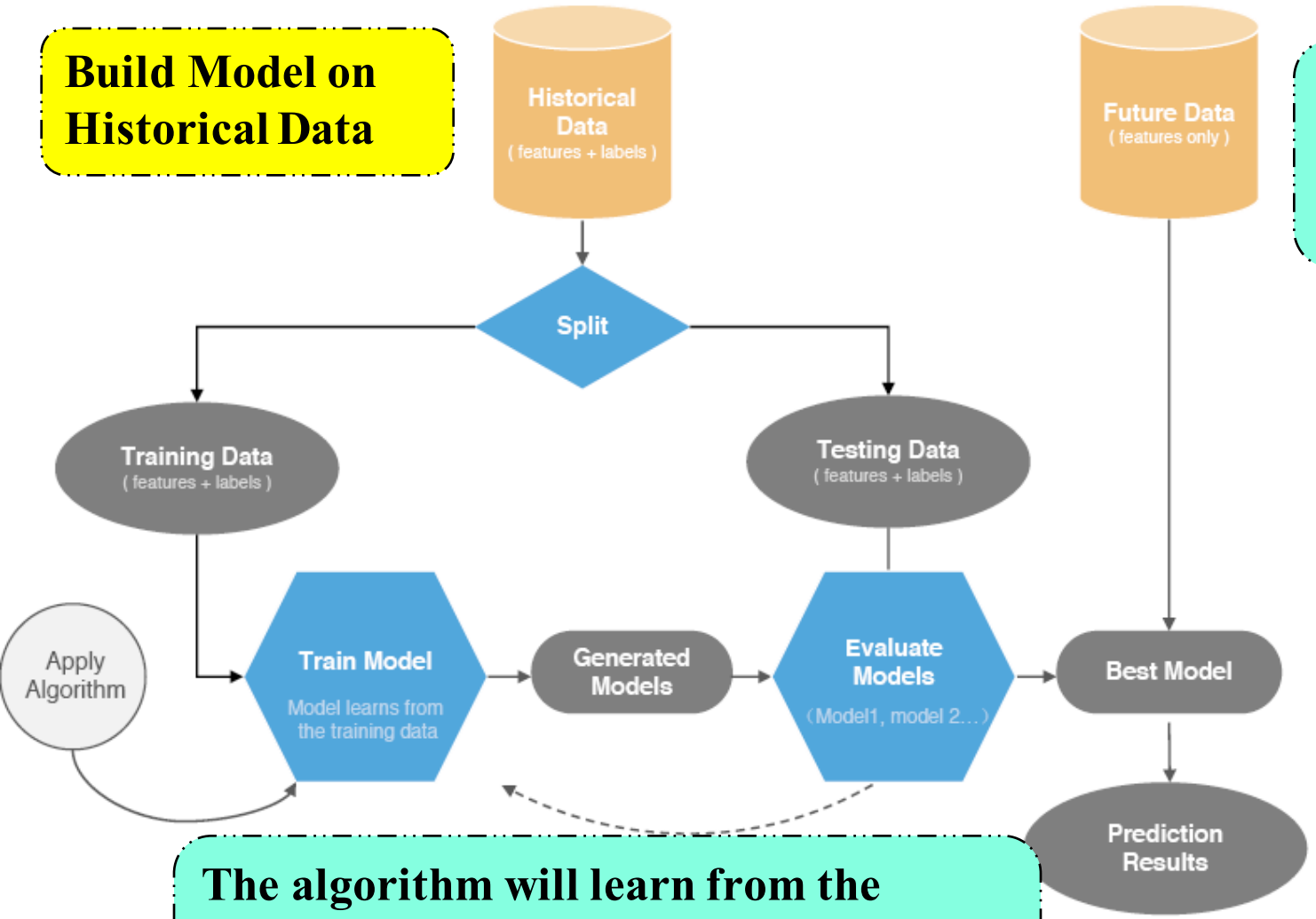
Machine Learning



https://connect.bim360.autodesk.com/what-is-machine-learning-in-construction

Flow

Build Model on Historical Data

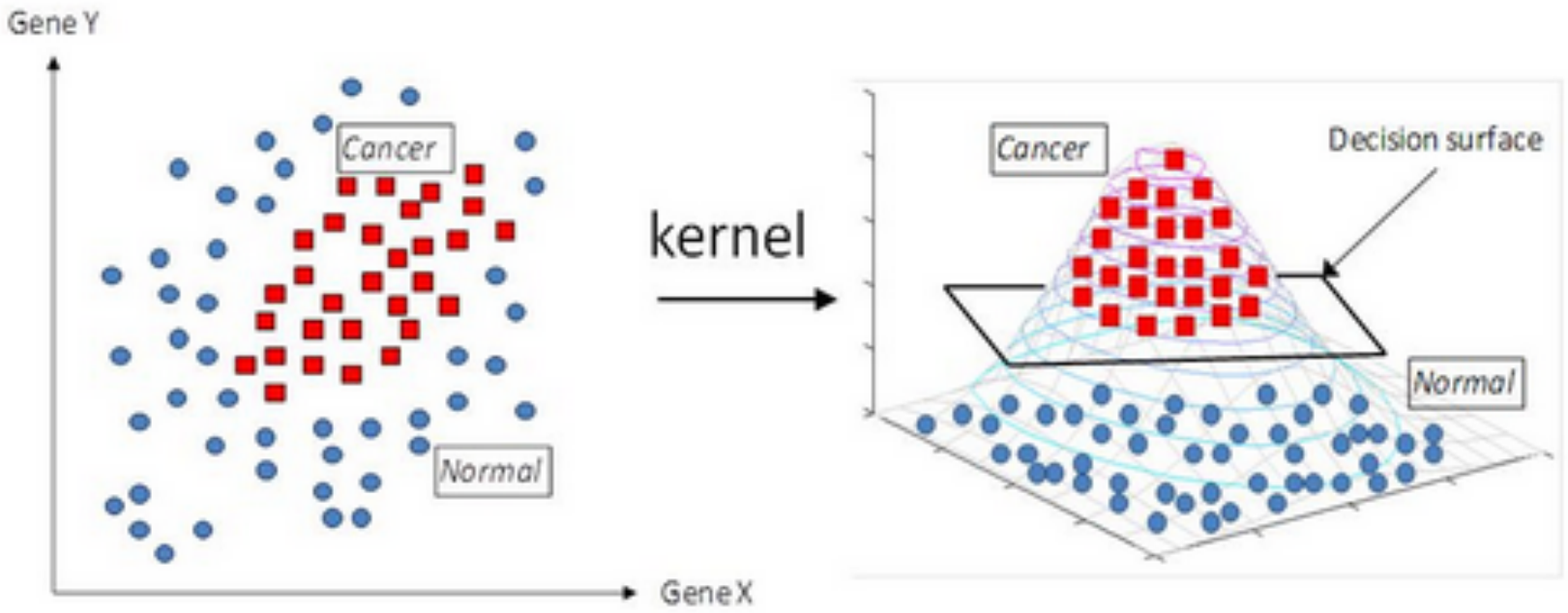


Apply the model on New data to Solve problems

The algorithm will learn from the training data patterns and output a model that captures these relationships

Support Vector Machine (SVM)

- **Supervised learning**
- **Mapping from low-dimensional space to high-dimensional space with kernel function**



Python for Machine Learning

- **Data Preparation**
  - **Preprocessing missing value**
- **Feature Engineering**
  - **Feature Selection**

Data

- **Pima Indians Diabetes Dataset (https://www.andreagrandi.it/2018/04/14/machine-learning-pima-indians-diabetes/)**
  - **768 observations with 8 input variables and 1 output variable**
  - **This dataset is known to have missing values.**

Python Tutorial

Q & A