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## Hi, I'm Andy!

I've been programming for nearly 20 years.

I love it.

### Goals Today:

Learn essential syntax.

Write a few programs.

Understand how to learn more.

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## What is Python?

*An interpreted, object-oriented, high-level programming language with dynamic semantics! (Woah! What?!)*

- A formal language.
- Stored in a text file.
- Run by the Python interpreter.

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## Why Python?

### Readability

Lots of code to come.

### Community

Mailing lists, Irc, Wiki, Docs.

### Libraries (20,114 of them)

Numpy, Biopython, Cogent.

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# Running Python: Interactively

## Interactive Prompt

Only good for fooling around.

```
andy@tak ~$ python
Python 2.6.5 (r265:79063, Apr 16 2010, 13:57:41)
[GCC 4.4.3] on linux2
Type "help", "copyright", "credits"
or "license" for more information.
>>> print "type your commands here"
type your commands here
>>> 2+2
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```

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# Running Python: Scripts

## Script Files

are specially formatted text files.

say\_hello.py

```
#!/usr/bin/env python # hashbang (this is a python file)
question = "What is your name?\n" # assign a variable
name = raw_input(question) # assign a variable (via user input)
print "Hello " + name + "!" # print output.
```

shell

```
andy@tak ~$ gedit say_hello.py
andy@tak ~$ chmod +x say_hello.py
andy@tak ~$ ./say_hello.py
What is your name?
Andy<ENTER>
Hello Andy!
```

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# Syntax

- Comments
- Assignment
- Data Types
- Logical Operators
- Tests / Loops
- Functions

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# Syntax: Comments

```
# This is a comment.
# Any line that starts with a '#' is.
# They are for your benefit.
# They are ignored by the interpreter.

# When should I use them?
# * At the top of the file describing the goal.
# * At the beginning of a method, or long process.
# * Any time the code isn't obvious,
#   but don't repeat the logic of the code.
```

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## Syntax: Assignment

```
# Name your data.
# Use meaningful names!

# constants are usually all caps,
# and at the top of the file.
PHI = 1.61803399
SECONDS_PER_DAY = 24*60*60

# regular variables are lower case
# with underscores instead of spaces.
first_name = 'Guido'
last_name = 'van Rossum'

# rules:
#   start with a letter
#   contain only letters, numbers and underscores '_'.
#   cannot be a reserved word (listed later).
```

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## Syntax: Basic Data Types

```
# String, either "" or ''
course_name = "python"
description = """
a basic introduction
to syntax and scripting
in the python language.
"""

# Integer
lecture_length = 1

# Float (aka fractions)
exercise_length = 0.999

# List (aka array)
topics = ["syntax",
          "scripts",
          "help"]

# Dictionary (aka hash)
glossary = {
    'key': 'value',
    'python': 'type of snake',
    'five': 5
}
```

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## Syntax: Logical Operators

equality tests:

```
a == b # equals
a != b # not equals
```

greater/lesser tests

```
>, <, >=, <=
```

composing multiple tests (use parens for clarity)

```
(a == b) && (b == c) # and
(a == b) || (a == c) # or
```

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## Syntax: Flow Control

```
# if/else control
n = 13
if n % 2 == 1:
    print "Odd Number"
else:
    print "Even Number"
# => "Odd Number"

# for loop
# count from 5 to 10
for n in range(5,11):
    print n

# while loop
# count from 10 to 1
n = 10
while n > 0:
    print n
    n = n - 1
```

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# Functions

## Built-In

- 80 functions
- available everywhere
- provided by Python

```
abs(-1) # => 1
len([1,2,3]) # => 3
min([2,4,6]) # => 2
max([1,3,5]) # => 5
```

## see:

[docs.python.org/library/functions.html](https://docs.python.org/library/functions.html)

## Library

- Standard libraries
- Community libraries
- (thousands and growing)

```
math.cos(theta)
scipy.std(numbers)
```

## see:

[docs.python.org/library](https://docs.python.org/library)  
[pypi.python.org/pypi](https://pypi.python.org/pypi)

## Object

- Provided by the object

```
"String".upper()
"String".find("ring")
[1,2,3].append(4)
```

# Functions for Numbers

## Operators

```
1 + 1 # => 2
1 - 1 # => 0
3 * 2 # => 6
3 / 2 # => 1 (int math)
3.0 / 2 # => 1.5 (phew!)
3 % 2 # => 1 (modulous)
2**8 # => 256 (exponent)
```

## Functions

```
# changing between types
float(1) # => 1.0
int(1.7) # => 1 # floors!
str(5) # => '5'
chr(65) # => 'A'

round(1.5) # => 2.0
abs(-1) # => 1
pow(2,8) # => 256
```

# Functions for Lists

```
# lists, sorted, indexed
first_5 = range(1,6) # => [1,2,3,4,5]
2 in first_5 # => True
[1,2] + [3,4] # => [1,2,3,4]
list("str") # => ['s','t','r']

min(first_5) # => 1
max(first_5) # => 5
len(first_5) # => 5
```

# Functions for Lists (indexing)

```
residues = list('GTCA') # => ['G','T','C','A']
# indexes start at 0, e.g. 0 1 2 3

# residues[start:stop:step]
# start - defaults to 0
# stop - blank means the end of the string
# step - defaults to 1 (use -1 to go backwards)
residues[0] # 'G' first char
residues[0:2] # 'GT' first two chars
residues[:3] # 'GTC' first three
residues[2:] # 'CA' last two chars
residues[::-1] # 'ACTG', reverse of the string
```

## Functions for Strings

```
string = 'Go to work\n'
string = string.replace('work','the park')
        # => 'Go to the park\n'

string.lower() # => 'go to the park\n'
string.upper() # => 'GO TO THE PARK\n'
string.count('t') # => 2
string.index('p') # => 10
string.rstrip('\n') # => 'Go to the park'

# Strings can also be treated as lists.
# So all the List indexes work.
string[10,4] # => 'park'
```

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## Functions for Dictionaries

```
# WARNING: Bad variable names! Don't do this.
d = {'A':1, 'B':2}
d['A'] # => 1
d.keys() # => ['A','B']
d.values() # => [1,2]
d['C'] = 3

# keys are not sorted
print d # => {'A': 1, 'C': 3, 'B': 2}
```

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## Functions for you!

```
def is_odd(n):
    # check if n is odd
    return n % 2 == 1

is_odd(5) # => True

def is_even(n):
    return not is_odd(n)

is_even(2) # => True
```

### Whitespace & Colons

- Whitespace is used for grouping blocks.  
4 spaces, or a tab (be consistent)
- Colons end all lines that begin indented blocks.
- **def**, **if**, **elif**, **for**, **while**, and **class** are the keywords that begin new blocks.

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## Libraries

- Standard
- Community
- Usage

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# Libraries: Standard

do more, write less

## Standard Libraries

**String Services:** string, re, struct, difflib, StringIO, cStringIO, textwrap, codecs, unicodedata, stringprep, fformat

**Data Types:** datetime, calendar, collections, heapq, bisect, array, sets, sched, mutex, Queue, weakref, UserDict, UserList, UserString, types, new, copy, pprint, repr

**Numeric and Mathematical Modules:** numbers, math, cmath, decimal, fractions, random, itertools, functools, operator

**File and Directory Access:** os.path, fileinput, stat, statvfs, filecmp, tempfile, glob, fnmatch, linecache, shutil, dircache, macpath

**Data Persistence:** pickle, cPickle, copy\_reg, shelve, marshal, anydbm, whichdb, dbm, gdbm, dbhash, bsddb, dumbdbm, sqlite3

**Data Compression and Archiving:** zlib, gzip, bz2, zipfile, tarfile

**File Formats:** csv, ConfigParser, robotparser, netrc, xdrlib, plistlib, Cryptographic Services, hashlib, hmac, md5, sha

**Generic Operating System Services:** os, io, time, argparse, optparse, getopt, logging, logging.config, logging.handlers, getpass, curses, curses.textpad, curses.ascii, curses.panel, platform, errno, ctypes

**Optional Operating System Services:** select, threading, thread, dummy\_threading, dummy\_thread, multiprocessing, mmap, readline, rlcompleter

**Interprocess Communication and Networking:** subprocess, socket, ssl, signal, popen2, asyncore, asyncchat

**Internet Data Handling:** email, json, mailcap, mailbox, mllib, mimetools, mimetypes, MimeWriter, mimify, multifile, rfc822, base64, binhex, binascii, quopri, uu

**Structured Markup Processing Tools:** HTMLParser, sgmlib, htmllib, htllib, htllibentitydefs, xml.parsers.expat, xml.dom, xml.dom.minidom, xml.dom.pulldom, xml.sax, xml.sax.handler, xml.sax.saxutils, xml.sax.xmlreader, xml.etree.ElementTree

**Internet Protocols and Support:** webbrowser, cgi, cgiib, wsgiref, urllib, urllib2, httplib, ftplib, poplib, imaplib, nntplib, smtplib, smtpd, telnetlib, uuid, urlparse, SocketServer, BaseHTTPServer, SimpleHTTPServer, CGIHTTPServer, cookielib, Cookie, xmlrpclib, SimpleXMLRPCServer, DocXMLRPCServer

**Multimedia Services:** audioop, imageop, aifc, sunau, wave, chunk, colorsys, imghdr, sndhdr, ossaudiodev

Details at <http://docs.python.org/library/>

# Libraries: Community

## Community

**SciPy** - Scientific Tools

**Biopython** - Biological Computation Tools

**PyCogent** - Genomic Biology

Among 20,114 available libraries (vs perl's 104,923)

See <http://pypi.python.org/pypi> for more

# Libraries: Usage

- `import library_name`  
makes methods available via the `library_name` prefix

```
import math
math.pi # => 3.141592653589793
```

- `from library_name import function,function,...`  
Makes specified functions available without the prefix

```
from math import cos
cos(math.pi) # => -1.0
```

# Filesystem Input/Output

```
import os
filename = '/tmp/testfile'

# write a file
if not os.path.isfile(filename):
    out = open(filename, 'w')
    out.write("new file contents")
    out.close()

# read a file
if os.path.isfile(filename):
    for line in open(filename):
        print line # => "new file contents"
```

# Composing a script

Let's take what we've learned  
and see it do something

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# DNA Complement

```
#!/usr/bin/env python
import fileinput
# usage: ./dna_complement_manual.py input.fasta
# std. dna complements
reverse = { 'A':'T', 'C':'G', 'G':'C', 'T':'A' }
for line in fileinput.input():
    line = line.rstrip('\n')
    if line: # skip empty lines
        if line[0] == ">": # info lines
            print line
        else: # reverse complement current line
            complement = ""
            for letter in line:
                complement += reverse[letter]
            print complement
```

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# DNA Complement: Results

```
% head -n 3 NC_003279.6.fasta
>gi|193203938:4762885-4772799 Caenorhabditis elegans chromosome I, complete sequence
TCGAAGAATCGCATAACTCCGAACTTTAATTTTTTAAGTTCATTGCCCGAGAGGAGAACACGGCCGA
GAATCTGAAAAATCATTGACGCGGAATTCAAATTAGATCGAGGAAAAGAGTAGTATTTGGAACTTTGT

% python examples/dna_complement_manual.py NC_003279.6.fasta | head -n 3
>gi|193203938:4762885-4772799 Caenorhabditis elegans chromosome I, complete sequence
AGCTTCTTAGCGTATTTGAGGCTTTGAAATTAATAAAAAATTCAGTAACGGGCTCTCCTCTTGTGCCGGCT
CTTAGACTTTTAGTAACGTGCGCCTTAAGTTAATCTAGCTCCTTTTCTCATATAAACCTTGAAACA
```

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# DNA complement: with a library

```
#!/usr/bin/env python
import fileinput
from Bio import SeqIO

for record in SeqIO.parse(fileinput.input(), 'fasta'):
    record.seq = record.seq.complement()
    print record.format('fasta')
```

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## Learning More

- Commandline
- On the Internet
- On paper
- Intermediate Topics

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## Learning More: Commandline

### Pydoc Quick Reference (lookup any term)

```
% pydoc int
Help on class int in module __builtin__:

class int(object)
| int(x[, base]) -> integer
|
| Convert a string or number to an integer, if possible. A floating point
| argument will be truncated towards zero (this does not include a string
| representation of a floating point number!) When converting a string, use
| the optional base. It is an error to supply a base when converting a
| non-string. If base is zero, the proper base is guessed based on the
| string content. If the argument is outside the integer range a
| long object will be returned instead.
|
| Methods defined here:
|
| __abs__(...)
| x.__abs__() <==> abs(x)
|
| __add__(...)
| x.__add__(y) <==> x+y
| ...
```

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## Learning More: Internet

- **The Python Wiki**  
<http://wiki.python.org/moin/>
- **A Gentle Introduction to Programming Using Python**  
MIT Courseware  
<http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-189-a-gentle-introduction-to-programming-using-python-january-iap-2011/index.htm>
- **A Primer on Python for Life Science Researchers**  
by Sebastian Bassi  
<http://www.ploscollections.org/article/info%3Adoi%2F10.1371%2Fjournal.pcbi.0030199>

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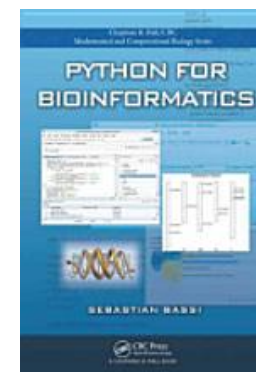
## Learning More: Paper



**Learning Python**  
by Mark Lutz  
ISBN 0596158068



**Programming Python**  
by Mark Lutz  
ISBN 0596158106



**Python for Bioinformaticists**  
By Sebastian Bassi  
ISBN 1584889292

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## Learning More: Intermediate Topics

- **Classes**  
build your own objects
- **Revision Control**  
keep a history of code changes (subversion)
- **Python aware Editor**  
syntax, error help (idle-python, eclipse, etc.)

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## Thank you.

- Next: hands on scripting
  - DNA Reverse Complement
  - FASTQ De-duplication by quality

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## Hands on scripting!

- `ssh -Y username@tak`
- `wget`  
`http://jura/bio/education/hot_topics/Unix_Perl_Python/python_lecture_files.tar.gz`
- `tar xvfz python_lecture_files.tar.gz`
- `cd python_lecture_files/exercise1`
- `idle-python2.6 dna_complement_reverse.py`

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## Appendix: Installing

- Windows:
  - Cygwin [cygwin.com](http://cygwin.com)
- Linux
  - (debian): `sudo apt-get install python2.7`
  - (fedora): `sudo yum install python`
- Mac
  - Comes with an old version
  - Upgrade instructions at [python.org/getit/mac](http://python.org/getit/mac)

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## Appendix: Python Editor

**IDLE-Python knows about python.**

It executes scripts and helps clarify errors.

```
andy@home:~$ ssh user@tak -Y
```

```
andy@tak:~$ idle-python2.6
```

## Appendix: Reserved Words

```
and    assert    break    class    continue
def    del        elif     else     except
exec   finally   for      from     global
if     import    in       is       lambda
not    or         pass     print    raise
return                try      while
```

**Do not try to use these as variable names.**

Also avoid type names, library names and common methods too  
e.g. `Float`, `Int`, `Numeric`, `math`, `range`, `cos`, `pi`, **etc.**