Numbers, lists and tuples

Genome 559: Introduction to Statistical and Computational Genomics

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Numbers

- Python defines various types of numbers:
  - Integer (1234)
  - Floating point number (12.34)
  - Octal and hexadecimal number (0177, 0x9gff)
  - Complex number (3.0+4.1j)
- You will likely only need the first two.

Conversions

```
>>> 6/2
3
>>> 3/4
0
>>> 3.0/4.0
0.75
>>> 3/4.0
0.75
>>> 3*4
12
>>> 3*4.0
12.0
```

truncated rather than rounded

- The result of a mathematical operation on two numbers of the same type is a number of that type.
- The result of an operation on two numbers of different types is a number of the more complex type.

integer → float

Formatting numbers

- The % operator formats a number.
- The syntax is `<format> % <number>`

```
>>> "%f" % 3
'3.000000'
>>> "%.2f" % 3
'3.00'
>>> "%5.2f" % 3
' 3.00'
```

Formatting codes

- %d = integer (d as in digit)
- %f = float value (decimal number)
- %e = scientific notation
- %g = easily readable notation (i.e., use decimal notation unless there are too many zeroes, then switch to scientific notation)

More complex formats

%[flags][width][.precision][code]

Left justify ("-")
Include numeric sign ("+")
Fill in with zeroes ("0")

Total width of output

Number of digits after decimal

d, f, e, g

Examples

```
>>> x = 7718
>>> "%d" % x
'7718'
>>> "%-6d" % x
'7718  '
>>> "%06d" % x
'007718'
>>> x = 1.23456789
>>> "%d" % x
'1'
>>> "%f" % x
'1.234568'
>>> "%e" % x
'1.234568e+00'
>>> "%g" % x
'1.23457'
>>> "%g" % (x * 10000000)
'1.23457e+07'
```

Read as "use the preceding code to format the following number"

Don't worry if this all looks like Greek – you can figure out how to do these when you need them in your programs.

Ιτ συρε λοοκσ λικε Γρεεκ το με.

Lists

- A list is an ordered set of objects

```
>>> myString = “Hillary”
>>> myList = [“Hillary”, “Barack”, “John”]
```

- Lists are
  - ordered left to right
  - indexed like strings (from 0)
  - mutable
  - possibly heterogeneous

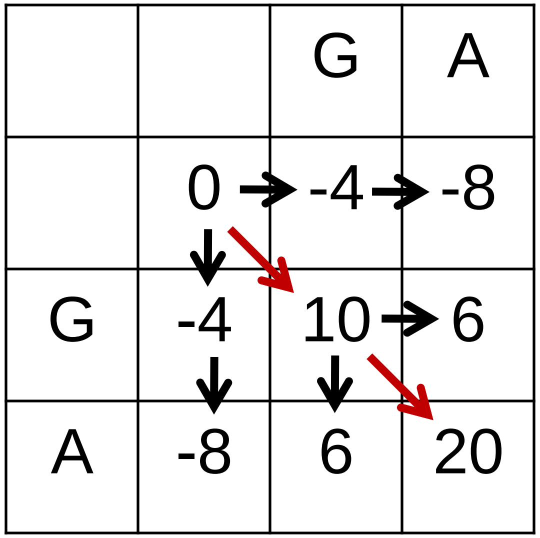
```
>>> list1 = [0, 1, 2]
>>> list2 = [‘A’, ‘B’, ‘C’]
>>> list3 = [‘D’, ‘E’, 3, 4]
>>> list4 = [list1, list2, list3]
>>> list4
[[0, 1, 2], [‘A’, ‘B’, ‘C’], [‘D’, ‘E’, 3, 4]]
```

Lists and dynamic programming

```
# program to print scores in a matrix
dpm = [ [0,-4,-8], [-4,10,6], [-8,6,20] ]
print dpm[0][0], dpm[0][1], dpm[0][2]
print dpm[1][0], dpm[1][1], dpm[1][2]
print dpm[2][0], dpm[2][1], dpm[2][2]
```

```
> python print_dpm.py
0 -4 -8
-4 10 6
-8 6 20
```

this is called a 2-dimensional list
(or a matrix, or a 2-dimensional array)



More readable output

```
# program to print scores in a matrix
dpm = [ [0,-4,-8], [-4,10,6], [-8,6,20] ]
print "%3d" % dpm[0][0], "%3d" % dpm[0][1], "%3d" % dpm[0][2]
print "%3d" % dpm[1][0], "%3d" % dpm[1][1], "%3d" % dpm[1][2]
print "%3d" % dpm[2][0], "%3d" % dpm[2][1], "%3d" % dpm[2][2]

> python print_dpm.py
   0  -4  -8
  -4  10   6
  -8   6  20
```

print integers with 3 characters each

Lists and strings are similar

Strings

```
>>> s = 'A'+'T'+'C'+'G'

>>> s = "ATCG"

>>> print s[0]
A
>>> print s[-1]
G
>>> print s[2:]
CG
>>> s * 3
'ATCGATCGATCG'
>>> s[9]
Traceback (most recent call last):
    File "<stdin>", line 1, in ?
    IndexError: string index out of
    range
```

Lists

```
>>> L = ["adenine", "thymine"] +
    ["cytosine", "guanine"]
>>> L = ["adenine", "thymine",
    "cytosine", "guanine"]
>>> print L[0]
adenine
>>> print L[-1]
guanine
>>> print L[2:]
['cytosine', 'guanine']
>>> L * 3
['adenine', 'thymine', 'cytosine',
    'guanine', 'adenine', 'thymine',
    'cytosine', 'guanine', 'adenine',
    'thymine', 'cytosine', 'guanine']
>>> L[9]
Traceback (most recent call last):
  File "<stdin>", line 1, in ?
IndexError: list index out of range
```

(you can think of a string as an immutable list of characters)

Lists can be changed; strings are immutable.

Strings

```
>>> s = "ATCG"

>>> print s
ATCG
>>> s[1] = "U"
Traceback (most recent call last):
  File "<stdin>", line 1, in ?
TypeError: object doesn't support
   item assignment

>>> s.reverse()
Traceback (most recent call last):
  File "<stdin>", line 1, in ?
AttributeError: 'str' object has no
   attribute 'reverse'
```

Lists

```
>>> L = ["adenine", "thymine",
   "cytosine", "guanine"]
>>> print L
['adenine', 'thymine', 'cytosine',
   'guanine']
>>> L[1] = "uracil"
>>> print L
['adenine', 'uracil', 'cytosine',
   'guanine']

>>> L.reverse()

>>> print L
['guanine', 'cytosine', 'uracil',
   'adenine']
>>> del L[0]
>>> print L
['cytosine', 'uracil', 'adenine']
```

More list operations and methods

```
>>> L = ["thymine", "cytosine", "guanine"]
>>> L.insert(0, "adenine")
>>> print L
['adenine', 'thymine', 'cytosine', 'guanine']
>>> L.insert(2, "uracil")
>>> print L
['adenine', 'thymine', 'uracil', 'cytosine', 'guanine']
>>> print L[:2]
['adenine', 'thymine']
>>> L[:2] = ["A", "T"]
>>> print L
['A', 'T', 'uracil', 'cytosine', 'guanine']
>>> L[:2] = []
>>> print L
['uracil', 'cytosine', 'guanine']
>>> L = [‘A’, ‘T’, ‘C’, ‘G’]
>>> L.index('C')
2
>>> L.remove('C')
>>> print L
['A', 'T', 'G']
>>> last = L.pop()
>>> print last
'G'
>>> print L
['A', 'T']
```

Methods for expanding lists

```
>>> data = []                           # make an empty list
>>> print data
[]
>>> data.append("Hello!")               # append means "add to the end"
>>> print data
['Hello!']
>>> data.append(5)
>>> print data
['Hello!', 5]
>>> data.append([9, 8, 7])              # append a list to end of the list
>>> print data
['Hello!', 5, [9, 8, 7]]
>>> data.extend([4, 5, 6])              # extend means append each element
>>> print data
['Hello!', 5, [9, 8, 7], 4, 5, 6]
>>> print data[2]
[9, 8, 7]
>>> print data[2][0]
9
```

Turn a string into a list

`string.split(x)` or `list(S)`

```
>>> protein = "ALA PRO ILE CYS"
>>> residues = protein.split()  # split() uses whitespace
>>> print residues
['ALA', 'PRO', 'ILE', 'CYS']
>>> list(protein)                # list explodes each char
['A', 'L', 'A', ' ', 'P', 'R', 'O', ' ', 'I', 'L',
  'E', ' ', 'C', 'Y', 'S']
>>> print protein.split()
['ALA', 'PRO', 'ILE', 'CYS']
>>> protein2 = "HIS-GLU-PHE-ASP"
>>> protein2.split("-")          # split at every “-” character
['HIS', 'GLU', 'PHE', 'ASP']
```

Turn a list into a string

`join` is the opposite of `split`:

`<delimiter>.join(L)`

```
>>> L1 = ["Asp", "Gly", "Gln", "Pro", "Val"]
>>> print "-".join(L1)
Asp-Gly-Gln-Pro-Val
>>> print "**".join(L1)
Asp**Gly**Gln**Pro**Val
>>> L2 = "\n".join(L1)
>>> L2
'Asp\nGly\nGln\nPro\nVal'
>>> print L2
Asp
Gly
Gln
Pro
Val
```

the order is confusing.
- string to join with is first.
- list to be joined is second.

Tuples: immutable lists

Tuples are immutable.
    Why? Sometimes you want to guarantee that a list won't change.
Tuples support operations but not methods.

```
>>> T = (1,2,3,4)
>>> T*4
(1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4)
>>> T + T
(1, 2, 3, 4, 1, 2, 3, 4)
>>> T
(1, 2, 3, 4)
>>> T[1] = 4
Traceback (most recent call last):
  File "<stdin>", line 1, in ?
TypeError: object doesn't support item assignment
>>> x = (T[0], 5, "eight")
>>> print x
(1, 5, 'eight')
>>> y = list(x)                    # converts a tuple to a list
>>> print y.reverse()
('eight', '5', '1')
>>> z = tuple(y)                   # converts a list to a tuple
```

Basic list operations:

```
L = ['dna','rna','protein']     # list assignment
L2 = [1,2,'dogma',L]            # list hold different objects
L2[2] = 'central'               # change an element (mutable)
L2[0:2] = 'ACGT'                # replace a slice
del L[0:1] = 'nucs'             # delete a slice
L2 + L                          # concatenate
L2*3                            # repeat list
L[x:y]                          # define the range of a list
len(L)                          # length of list
''.join(L)                      # convert a list to string
S.split(x)                      # convert string to list- x delimited
list(S)                         # convert string to list - explode
list(T)                         # converts a tuple to list
```

Methods:

```
L.append(x)                     # add to the end
L.extend(x)                     # append each element from x to list
L.count(x)                      # count the occurrences of x
L.index(x)                      # give element location of x
L.insert(i,x)                   # insert at element x at element i
L.remove(x)                     # delete first occurrence of x
L.pop(i)                        # extract element I
L.reverse()                     # reverse list in place
L.sort()                        # sort list in place
```

Sample problem #1

- Write a program called dna-composition.py that takes a DNA sequence as the first command line argument and prints the number of A's, C's, G's and T's.

```
> python dna-composition.py ACGTGCGTTAC
2 A's
3 C's
3 G's
3 T's
```

Solution #1

```
import sys
sequence = sys.argv[1].upper()
print sequence.count('A'), "A's"
print sequence.count('C'), "C's"
print sequence.count('G'), "G's"
print sequence.count('T'), "T's"
```

Sample problem #2

- The melting temperature of a primer sequence can be estimated as:

  T = 2 * (# of A or T nucleotides) + 4 * (# of G or C nucleotides)

- Write a program melting-temperature.py that computes the melting temperature of a given DNA sequence.

```
> python melting-temperature.py ACGGTCA
22
```

Solution #2

```
import sys
sequence = sys.argv[1].upper()
numAs = sequence.count('A')
numCs = sequence.count('C')
numGs = sequence.count('G')
numTs = sequence.count('T')
temp = (2 * (numAs + numTs)) + (4 * (numGs + numCs))
print temp
```

Sample problem #3 (optional)

- The object **`sys.argv`** is a list of strings.
- Write a program reverse-args.py that removes the program name from the beginning of this list and then prints the remaining command line arguments in reverse order with asterisks in between.

```
> python reverse-args.py 1 2 3
3*2*1
```

Solution #3

```
import sys
args = sys.argv[1:]
args.reverse()
print "*".join(args)
```

Reading

- Chapters 10 and 12 of *Python for Software Design* by Downey.