
# Writing code that makes decisions: `for` and `while` loops

Lesson 3 – 8/1/18

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(Please sign-in)

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# Lab 2 Common Mistakes

- **print (not (b or a))**
- **print (x=2)**
- **Write code that "flips a coin" 10 times**

In [28]:
```
x = "C"
if x == "A" or "B":
    print ("yes")
else:
    print ("no")
```

In [1]:
```
if "So" in Sophie:
    print ("Hey Sophie!")
else:
    print ("Where's Sophie?")
```

# Today's topics

1. Intro to loops
2. `for` loops
3. `while` loops
4. Application of loops: file reading

# 1. Intro to loops

# What is a loop?

- Loops simply let you execute a piece of code multiple times
- For example, if you wanted to generate 10 random numbers: instead of copying and pasting `random.randint(0,1)` ten times, you can simply put it in a loop that is set to loop ten times.

# Example

## Instead of:

```
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
```

## You can write:

```
for i in range(10):
    print random.randint(0,1)
```

## Or :

```
count = 0
while count < 10:
    print random.randint(0,1)
    count = count + 1
```

# Example

## Instead of:

```
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
```

## You can write:

```
for i in range(10):
    print random.randint(0,1)
```

## Or :

```
count = 0
while count < 10:
    print random.randint(0,1)
    count = count + 1
```

# 2. `for` loops

# The `for` loop

**Purpose:** execute a block of code a specific number of times.

Syntax:

```
for var in iterable:
    do this
```

Examples:

```
for i in range(5):
    print i

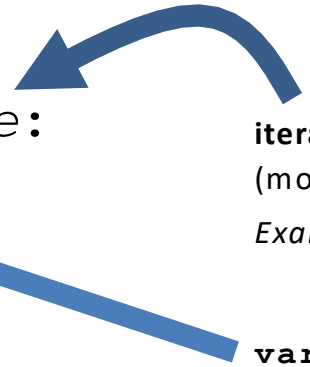
for letter in "ATGCG":
    print letter
```

# The `for` loop

**Purpose:** execute a block of code a specific number of times.

Syntax:

```
for var in iterable:
    do this
```



**iterable** = anything that you can iterate over (most "sequence-like" objects)

*Examples: lists, strings, files, dictionaries*

**`var`** takes on each value in the iterable, one at a time.

When there are no more things in the iterable, the loop ends.

Examples:

```
for i in range(5):
    print i

for letter in "ATGCG":
    print letter
```

# Ways of using the `for` loop

The simplest way to create a loop that loops a certain number of times is to use `range()`:

Example:

```
for i in range(5):
    print "hi"
```

Result:

```
hi
hi
hi
hi
hi
```

`range(5)` will loop 5 times
`range(6)` will loop 6 times
...and so on.

# Ways of using the `for` loop

What `range(x)` actually does is create a list of numbers from 0 to x-1. A list is an iterable, so we can use it in the loop. The variable after `for` (here, `i`) will be assigned to each value in the iterable, one at a time.

Example:

```
for i in range(5):
    print i
```

Result:

```
0
1
2
3
4
```

# Ways of using the `for` loop

A string is also an iterable, and so we can use a `for` loop to iterate over each individual character in the string, one at a time:

Example:

```
for letter in "Hello!":
    print letter
```

Result:

```
H
e
l
l
o
!
```

*Important to note:*

You can name the variable after for anything you want, and you do NOT need to define it before using it in the for loop.

# Practice with `for`

What will the following code print?

```
for i in range(4):
    print i
```

# Practice with `for`

What will the following code print?

```
for i in range(4):
    print i
```

Result:

```
0
1
2
3
```

# Practice with `for`

What will the following code print?

```
for i in range(4):
    print i * 2
```

# Practice with `for`

What will the following code print?

```
for i in range(4):
    print i * 2
```

Result:

```
0
2
4
6
```

# Practice with `for`

What will the following code print?

```
count = 0
for i in range(4):
    count = count + 1
print count
```

# Practice with `for`

What will the following code print?

```
count = 0
for i in range(4):
    count = count + 1
print count
```

Result:

```
4
```

# Practice with `for`

What will the following code print?

```
count = 0
for i in range(4):
    count = count + i
print count
```

# Practice with `for`

What will the following code print?

```
count = 0
for i in range(4):
    count = count + i
print count
```

Result:

```
6
```

*Important to note:*

This is similar to a counter, but instead of adding 1 each time, we're adding up various numbers.

This is sometimes called an *accumulator*, and it's useful in many situations, so remember it!

# Practice with `for`

What will the following code print?

```
for nt in "ATGAT":
    print nt
```

# Practice with `for`

What will the following code print?

```
for nt in "ATGAT":
    print nt
```

Result:

```
A
T
G
A
T
```

# Practice with `for`

What will the following code print?

```
count = 0
for nt in "ATGAT":
    if nt == "A":
        count = count + 1
print count
```

# Practice with `for`

What will the following code print?

```
count = 0
for nt in "ATGAT":
    if nt == "A":
        count = count + 1
print count
```

Result:

```
2
```

# Practice with `for`

What will the following code print?

```
newSeq = ""
for nt in "ATG":
    newSeq = newSeq + nt + "*"
print newSeq
```

# Practice with `for`

What will the following code print?

```
newSeq = ""
for nt in "ATG":
    newSeq = newSeq + nt + "*"
print newSeq
```

Result:

```
A*T*G*
```

*Important to note:*

This is sort of like an accumulator for strings. We can build up a string in a loop by repeatedly concatenating characters to an existing string.

Don't concatenate onto the original string as you iterate over it. This is bad form and could cause weird results. Just create a new string.

# More about `range()`

**Purpose:** Creates a **list** with the indicated range. If only one parameter *n* is given, will automatically create a list from 0 to *n*-1.

Syntax:

```
range(start, stop, interval)
```

Examples (in interpreter):

```
>>> range(5)
[0, 1, 2, 3, 4]
>>> range(1, 6)
[1, 2, 3, 4, 5]
>>> range(0, 11, 2)
[0, 2, 4, 6, 8, 10]
```

Notice that this function does different things depending on how many parameters you give it. This is true of many functions in Python.

If you're unsure of what parameters to use, just google "python functionname" to bring up the Python docs, or type "`help(functionname)`" in the python interpreter.

# Practice with `range()`

What will the following code print?

```
print range(4)
```

# Practice with `range()`

What will the following code print?

```
print range(4)
```

Result:

```
[0, 1, 2, 3]
```

# Practice with `range()`

What will the following code print?

```
print range(4, 8)
```

# Practice with `range()`

What will the following code print?

```
print range(4, 8)
```

Result:

```
[4, 5, 6, 7]
```

# Practice with `range()`

What will the following code print?

```
print range(0, 50, 10)
```

# Practice with `range()`

What will the following code print?

```
print range(0, 50, 10)
```

Result:

```
[0, 10, 20, 30, 40]
```

# 3. `while` loops

# Example

## Instead of:

```
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
print random.randint(0,1)
```

## You can write:

```
for i in range(10):
    print random.randint(0,1)
```

## Or :

```
count = 0
while count < 10:
    print random.randint(0,1)
    count = count + 1
```

# The while loop

**Purpose:** execute code until the conditional statement becomes `False`.

Syntax:

```
while conditional:
    indented code will execute until the
    conditional becomes false
```

Example:

```
x = 0
while x < 4:
    x = x + 1
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    print "hi"
    x = x + 1
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    print "hi"
    x = x + 1
```

Result:

```
hi
hi
hi
hi
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    print x
    x = x + 1
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    print x
    x = x + 1
```

Result:

```
0
1
2
3
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    x = x + 1
    print x
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    x = x + 1
    print x
```

Result:

```
1
2
3
4
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    x = x + 1
print x
```

# Practice with `while`

What will the following code print?

```
x = 0
while x < 4:
    x = x + 1
print x
```

Result:

```
4
```

# A more useful example: Number guessing game

```
secretNumber = 56
notGuessed = True

while (notGuessed):
   guess = int(raw_input("What number am I thinking of? "))
   if (guess == secretNumber):
        print "Wow, you got it!"
        notGuessed = False
   else:
        print "Wrong, guess again."
```

# A more useful example: Number guessing game

```
secretNumber = 56
notGuessed = True

while (notGuessed):
    guess = int(raw_input("What number am I thinking of? "))
    if (guess == secretNumber):
        print "Wow, you got it!"
        notGuessed = False
    else:
        print "Wrong, guess again."
```

this is initially `True`, so we enter the loop...

if the user guesses correctly, we simply set `notGuessed` to `False`. This makes the while loop condition `False`, and we therefore exit the loop.

if the user guesses wrong, we leave `notGuessed` as `True`, and therefore repeat the loop.

By using a `while` loop, we give the user unlimited chances to guess.

# Beware: endless loops

## Code:

```
count = 1
while (count <= 10):
    print count
```

Since we never increment count within the loop, it always remains 1, and therefore the `while` condition is always `True`.

## Output:

```
1
1
1
1
1
... (never ending)
```

# Endless loops

Always watch out for possible endless loops! If you're not sure, temporarily add a print statement somewhere in the loop so you can monitor how many times the loop runs.

If you find your code is taking an unexpectedly long time to run, check for an endless loop.

Stopping a program that is stuck in an endless loop: **Ctrl + c**

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count < 10):
    print count
    count = count + 1
```

# More practice with `while` loops

Endless loop or not?

```
count = 0
while (count < 10):
    print count
    count = count + 1
```

Answer: **no**

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count > 5):
    print count
    count = count + 1
```

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count > 5):
    print count
    count = count + 1
```

## Answer: **no**

(this won't print anything, actually, since the condition `count > 5` is never `True`)

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count != 5):
    print count
    count = count + 1
```

# More practice with `while` loops

Endless loop or not?

```
count = 0
while (count != 5):
    print count
    count = count + 1
```

Answer: **no**

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count != 5):
    print count
count = count + 1
```

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count != 5):
    print count
count = count + 1
```

## Answer: **yes**

Why? We never increment `count` *within* the loop, so it never becomes equal to 5.

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count != 5):
    print count
    count = count + 2
```

# More practice with `while` loops

## Endless loop or not?

```
count = 0
while (count != 5):
    print count
    count = count + 2
```

## Answer: **yes**

Why? Since we're incrementing count by 2 each time, `count` takes the values 0, 2, 4, 6, 8, etc. `count` never equals 5, so the condition `count != 5` never becomes `False`, and we keep looping forever.

# Which kind of loop should I use?

In general:

- Use a `for` loop when:
  - You know exactly how many times you need to loop
  - You want to process each line of a file (as we'll see soon) or item in a list (as we'll see next time)
- Use a `while` loop when:
  - You need to loop until some condition is fulfilled, but you don't know when that will happen

# 4. Application of loops: file reading

# File reading

- File reading (and writing) is something you'll probably be doing **a lot** in your work
- Luckily, Python makes it super easy!
- Today we'll cover file reading

# File reading

The 3 basic steps of file **reading**:

1. Open the input file
2. Read in data line by line, do some processing
3. Close the input file

File **writing** is very similar, but we'll save it for the next lesson.

# Example of simple file reading

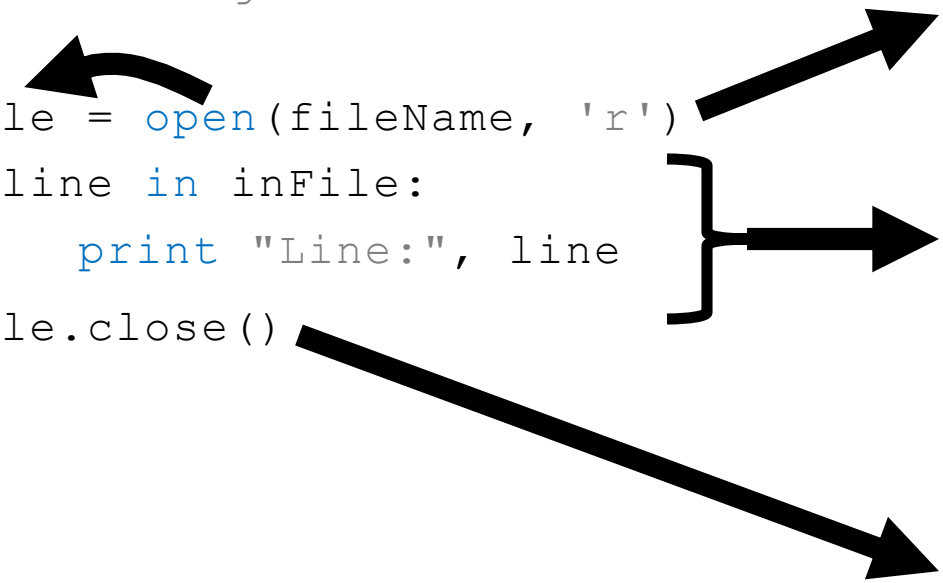
```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        print "Line:", line
inFile.close()
```

# Example of simple file reading

```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        print "Line:", line
inFile.close()
```



`open()` returns a link to the indicated file. We store this link in a variable so that we can use it to read from the file. The `'r'` indicates that we want to open this file in **r**ead mode (as opposed to **w**rite mode).

A file is considered an iterable object by Python, so we can loop over it directly.

The unit of iteration in files is the line, so each time we loop, a single line is assigned to the loop variable.

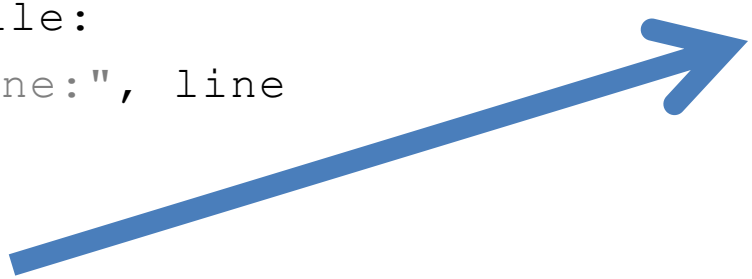
We can then do some processing of that line before we move on to the next one.

This closes the link to the file. It is considered good programming practice to always close files when you are done with them.

# Example of simple file reading

```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        print "Line:", line
inFile.close()
```



genes.txt:

```
uc007afd.1
uc007aln.1
uc007afr.1
uc007atn.1
uc007bcd.1
uc007bmh.1
uc007byr.1
```

If this is genes.txt, what will this script output?

# Example of simple file reading

```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        print "Line:", line
inFile.close()
```

genes.txt:

```
uc007afd.1
uc007aln.1
uc007afr.1
uc007atn.1
uc007bcd.1
uc007bmh.1
uc007byr.1
```

## Output:

```
Line: uc007afd.1

Line: uc007aln.1

Line: uc007afr.1

Line: uc007atn.1

Line: uc007bcd.1

Line: uc007bmh.1

Line: uc007byr.1
```

# Example of simple file reading

```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        print "Line:", line
inFile.close()
```

genes.txt:

```
uc007afd.1
uc007aln.1
uc007afr.1
uc007atn.1
uc007bcd.1
uc007bmh.1
uc007byr.1
```

## Output:

```
Line: uc007afd.1

Line: uc007aln.1

Line: uc007afr.1

Line: uc007atn.1

Line: uc007bcd.1

Line: uc007bmh.1

Line: uc007byr.1
```

**Why are there extra spaces?**

Because of invisible `\n` characters!

When we read each line of the file, there is actually a `\n` on the end of each line. This gets read in as part of the string. Then `print` adds another `\n` on the end when it prints the string (as it always does). This is what causes the double spacing – we technically have `\n\n` on the end of each string.

# Side note: Newline (`\n`)

- Whenever you hit "enter" or "return", you're actually inserting a newline character, which is invisible when you view the file in a text editor
- This "character" is `\n`, and you can manually insert it into your strings when you're printing to create newlines wherever you want.

For example:

```
print "Hello\nWorld"
```

Ouput:

```
Hello
World
```

# Simple file reading, with \n removal

```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        line = line.rstrip('\n')
        print "Line:", line
inFile.close()
```

# Simple file reading, with \n removal

```
# Read and print genes.txt
fileName = "genes.txt"

inFile = open(fileName, 'r')
for line in inFile:
        line = line.rstrip('\n')
        print "Line:", line
inFile.close()
```

`.rstrip()` removes the indicated character from the **end** of the string, if it is there. If the indicated character is not there, does nothing.

There are many cases when the \n will interfere with what you want to do, so it's good to get in the habit of including this line of code.

# File reading functions

- When you open a file, you're actually creating what's called a "File object" – this is what gets assigned to the variable.
- You can think of the File object as simply an interface to the file you're working with.
- File objects come with a set of special methods related to reading and writing files:
  - `.read()` - reads in the entire file at once
  - `.readline()` - reads one line at a time
  - `.readlines()` - reads all lines in file into a list
  - `.write()` - write a string to a file
  - `.close()` - close the file

# File reading functions

Examples:

```
inFile = open("genes.txt", 'r')  #create file object

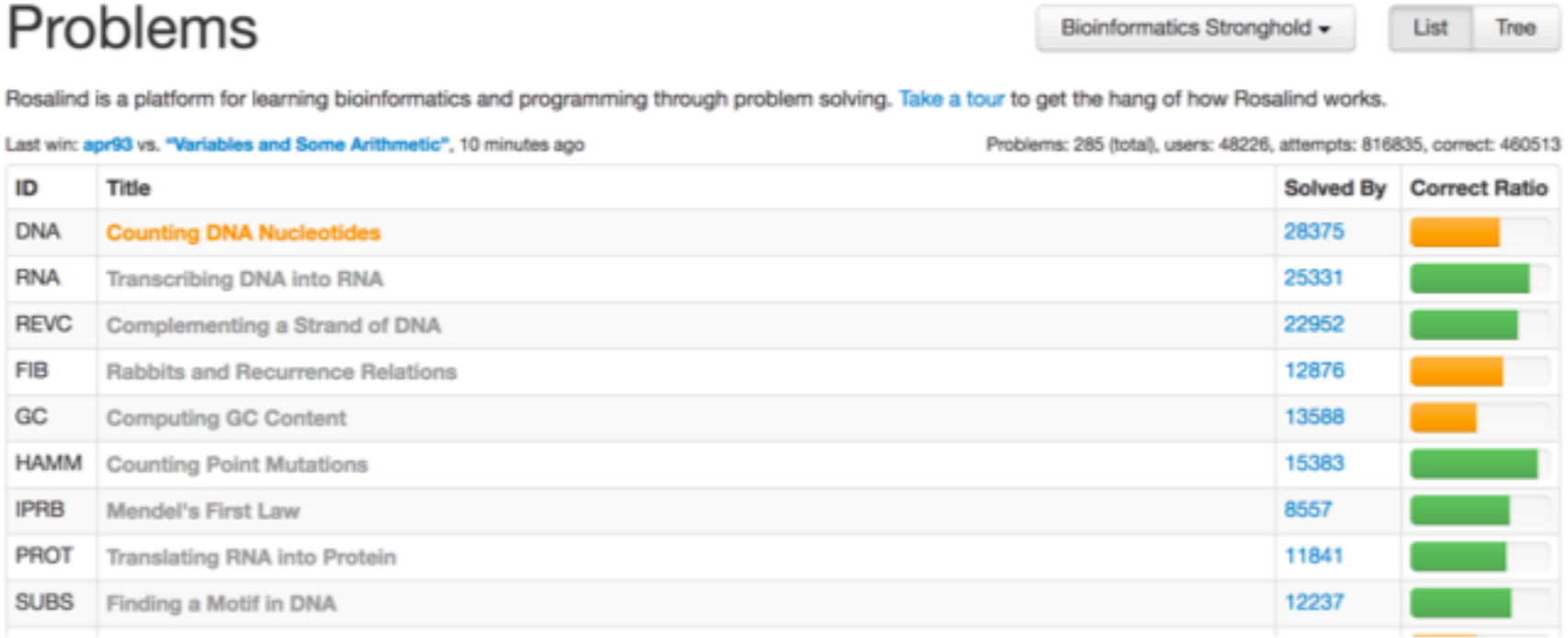
header = inFile.readline()       #read first line of file
line = inFile.readline()         #read second line of file
restOfLines = inFile.readlines() #read rest into list

inFile.close()                   #clean up after ourselves
```

# Tips about Programming

- Practice a problem everyday.
- Think of a data task in your lab that you can speed up by using code and program it.
- Rosalind:
  - Practice programming specifically for bioinformatics
  - Unlock new levels and earn badges (gaming!)
- http://rosalind.info/problems/locations/

# Rosalind Example



Problems

Bioinformatics Stronghold ▾ | List | Tree

Rosalind is a platform for learning bioinformatics and programming through problem solving. Take a tour to get the hang of how Rosalind works.

Last win: apr93 vs. "Variables and Some Arithmetic", 10 minutes ago

Problems: 285 (total), users: 48226, attempts: 816835, correct: 460513

| ID | Title | Solved By | Correct Ratio |
|---|---|---|---|
| DNA | Counting DNA Nucleotides | 28375 | |
| RNA | Transcribing DNA into RNA | 25331 | |
| REVC | Complementing a Strand of DNA | 22952 | |
| FIB | Rabbits and Recurrence Relations | 12876 | |
| GC | Computing GC Content | 13588 | |
| HAMM | Counting Point Mutations | 15383 | |
| IPRB | Mendel's First Law | 8557 | |
| PROT | Translating RNA into Protein | 11841 | |
| SUBS | Finding a Motif in DNA | 12237 | |

http://rosalind.info/problems/list-view/

# Problem 1

## A Rapid Introduction to Molecular Biology click to expand

### Problem

A **string** is simply an ordered collection of symbols selected from some **alphabet** and formed into a word; the **length** of a string is the number of symbols that it contains.

An example of a length 21 **DNA string** (whose alphabet contains the symbols 'A', 'C', 'G', and 'T') is "ATGCTTCAGAAAGGTCTTACG."

**Given:** A DNA string $s$ of length at most 1000 nt.

**Return:** Four integers (separated by spaces) counting the respective number of times that the symbols 'A', 'C', 'G', and 'T' occur in $s$.

### Sample Dataset

```
AGCTTTTCATTCTGACTGCAACGGGCAATATGTCTCTGTGTGGATTAAAAAAAGAGTGTCTGATAGCAGC
```

### Sample Output

```
20 12 17 21
```

# Problem 2

## The Second Nucleic Acid click to expand

### Problem

An **RNA string** is a string formed from the alphabet containing 'A', 'C', 'G', and 'U'.

Given a DNA string $t$ corresponding to a coding strand, its transcribed RNA string $u$ is formed by replacing all occurrences of 'T' in $t$ with 'U' in $u$.

**Given:** A DNA string $t$ having length at most 1000 nt.

**Return:** The transcribed RNA string of $t$.

### Sample Dataset

```
GATGGAACTTGACTACGTAAATT
```

### Sample Output

```
GAUGGAACUUGACUACGUAAAUU
```

# Problem 3

## Problem

The GC-content of a DNA string is given by the percentage of symbols in the string that are 'C' or 'G'. For example, the GC-content of "AGCTATAG" is 37.5%. Note that the reverse complement of any DNA string has the same GC-content.

DNA strings must be labeled when they are consolidated into a database. A commonly used method of string labeling is called **FASTA format**. In this format, the string is introduced by a line that begins with '>', followed by some labeling information. Subsequent lines contain the string itself; the first line to begin with '>' indicates the label of the next string.

In Rosalind's implementation, a string in FASTA format will be labeled by the ID "Rosalind_xxxx", where "xxxx" denotes a four-digit code between 0000 and 9999.

**Given:** At most 10 DNA strings in FASTA format (of length at most 1 kbp each).

**Return:** The ID of the string having the highest GC-content, followed by the GC-content of that string. Rosalind allows for a default error of 0.001 in all decimal answers unless otherwise stated; please see the note on **absolute error** below.

## Sample Dataset

```
>Rosalind_6404
CCTGCGGAAGATCGGCACTAGAATAGCCAGAACCGTTTCTCTGAGGCTTCCGGCCTTCCC
TCCCACTAATAATTCTGAGG
>Rosalind_5959
CCATCGGTAGCGCATCCTTAGTCCAATTAAGTCCCTATCCAGGCGCTCCGCCGAAGGTCT
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>Rosalind_0808
CCACCCTCGTGGTATGGCTAGGCATTCAGGAACCGGAGAACGCTTCAGACCAGCCCGGAC
TGGGAACCTGCGGGCAGTAGGTGGAAT
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