Lab 1

Discovery

Sup'Biotech 3

Python

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Preamble

Document Property

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1 Introduction

In this first lab, we will manipulate the notions of value, expression type and variables. In almost all the questions, we will interact with Python using the command line interpreter. In this mode, Python indicates using the symbol `>>>` that it awaits for a new command. After entering such command, Python perform the computations and displays the result on the line below (if there is any result to be displayed).

2 Arithmetic Expressions

Compute in you head (or on a piece of paper) the following commands and compare with the result obtained in Python.

1. `1 + 2*3`
2. `1 + 2*4/2`
3. `1 + 2**4/2`
4. `1 + 2**4*2`
5. `1/3`
6. `1//3`
7. `2//3`
8. `1.0/3`
9. `2.0/3`
10. `1.0//3`
11. `2.0//3`
12. `5/0`

3 Arithmetic Expressions - 2

1. `5%2`
2. `36%23`
3. `36%23+1`
4. `36%23*2`
5. `36%23**2`
6. `36+2%23`
7. `36*2%23`
8. `36**2%23`
9. `(36+2)%23`

4 Comparing two expressions

In the following we consider that a variable a has been defined.

1. `5 < 3`
2. `5 < 3+2`
3. `5 < 3*2`
4. `5 < 3**2`
5. `5 + 8 < 3**2`
6. `33%2 == 0`
7. Translate $3 \leq a \leq 5$
8. Translate a is either negative or greater than 10.
9. Translate a is different than 0.
10. Translate a is a multiple of 3.
11. For all numbers between 0 and 10, ask Python if it is a multiple of 3.
12. For all numbers between 0 and 10, ask Python if it is a multiple of 3 OR a multiple of 5 and even.

5 Logical Expressions

1. `True and False`
2. `True and (False or True)`
3. `True or not False`
4. `not not True`
5. `True and not False or True`
6. `True and not True or False`
7. `not (True and False)`
8. `not (True or False)`
9. `not not a`
10. `not (a and b)`
11. `not (a or b)`
12. `not (not a or b)`

6 Types

Evaluate the following expression and give the type of the resulting value:

- `2 - 2`
- `2.5 - 2`
- `3 < 4`
- `3*5 < 2*2`
- `(3*5 < 2*2)+1`
- `(3*5 < 5*5)+1`
- `2.5 - True`
- `5/5`
- `5/2`
- `5//2`
- `5.5 % 4.5`
- `10**2`
- `10**-2`

7 Variables

Fill the missing results represented by a "?":

1.
```
>>> a = 1
>>> b = 2
>>> a + b
?
```

2.
```
>>> a = 1
>>> b = 2
>>> a = a + b
>>> a
?
>>> b
?
```

3.
```
>>> a = 3
>>> b = 5
>>> c = a % b
>>> c = c **2
>>> a = a - b + c//3
>>> b = a * (a+1)
>>> a
?
>>> b
```

```
?
>>> c
?
```

8 Problem 1: bacteria party

Let us consider the problem of estimating the number of bacteria from a colony at a given time and in a given medium.

9 Fission

Bacteria divide through a mechanism called fission in which a bacterium is able to divide into two bacteria. The number of division with respect to a given origin bacteria is called the number of generation. Such type of division leads to an exponential process: starting from one bacterium at generation 1, there are 2^k bacteria at generation k. The time for a bacterium to divide is called the generation time and can be estimated given a bacterium strain and a medium. The following table presents the generation time of two bacteria:

Variable name	Specie	Duration	Medium
tau_ec	*E. Coli*	17 min	Glucose + salts
tau_bm	*Bacillus megaterium*	25 min	Glucose + salts

In the following all the times are given in minutes with $t_0 = 0$ is the time at which the first bacteria is added to the medium.

9.1 Questions

Write Python codes to answer the following questions.

How many bacteria in the medium are there at time t for:

1. An *E.Coli* strain ?
2. A *Bacillus megaterium* strain ?
3. If we have 2 *E. coli* bacteria at t_0 ?
4. If we have n *E. coli* bacteria at t_0 ?

10 Real Life Is Hard

Actually, bacterial growth is more complicated than the previous simplified model. When observing the quantity of bacteria in a culture as a function of the time, one can distinguish 4 different phases:

- Lag phase: No growth, the bacteria adapts to its environment and direct its metabolism toward growth.
- Exponential (growth) phase: fast increase of the number of bacteria (fission $\Rightarrow$ growth in 2^k);
- Stationary phase: The bacteria consumed all the substrates available on the medium (there's nothing to eat anymore :( ). Modification of the metabolism toward survival.

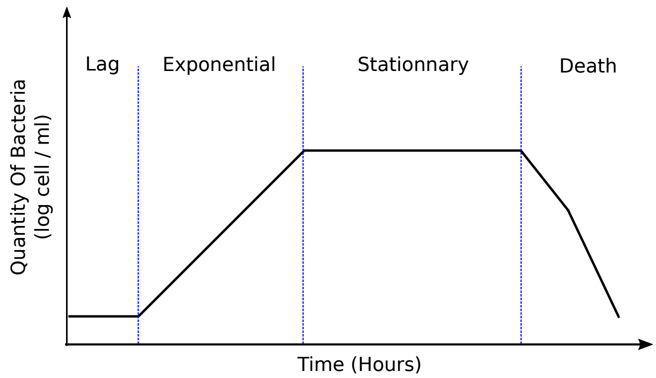

Figure 1: Typical growth profile of a culture of bacteria. The ordinate axis is in log scale, hence the exponential growth phase appears linear.

- Death phase: Decrease of the number of bacteria dying of starving.

Figure 1 presents a typical growth profile for a bacteria. The duration of each phase depends on the medium and of the specific strain.

The following questions guide you through the writing of a Python code that is able to answer the following question:

At a given time t (in minutes), knowing the medium and strain parameters, what is the quantity of bacteria in the medium ?

Lag Phase

Let us take into account the existence of a lag phase. For each question, give a Python code that is able to answer it.

How many bacteria are there at time t for:

- *E. coli* with a lag phase of `tl` minutes ?

Stationary Phase

We now add the stationary phase. Provide a Python code to answer the questions.

How many bacteria are there a time t for:

- *E. coli* with a lag phase of `tl` minutes and an exponential phase of `te` minutes ($t > tl + te$) ?

Death Phase

Finally, we take into account the death phase. Write a Python code to answer the following questions.

How many bacteria are there at time t for:

- *E. coli* with a lag phase of tl minutes, an exponential phase of te minutes and stationary phase of ts minutes ? ($t > tl + ts + te$). In the death phase, the bacterial population is divided by 2 every `tau_die` minutes until there remain no bacteria.

10.1 Altogether

Write a Python code that given the following variables:

- Generation time *tau_g* (min);
- Lag phase duration *tl* (min);
- Exponential phase duration *te* (min);
- Stationary phase duration *ts* (min);
- Death rate *td* (bacteria.min^{-1});

and a time t computes the number of bacteria in the medium in the following cases:

1. At t_0 there is 1 bacterium;
2. At t_0 there are n bacteria.

Be careful that the number of bacteria in the medium cannot be negative.