

# Exam Computational Biology 2011-12

02-02-2012 10-13hr

*You can answer the questions in English or Dutch;*

*Please type them right below the question  
For graphs and sketches use a piece of paper*

Name:

Student Number

## Question 1. Debugging of models and experiments

The Lac is operon considered as a prototype of a bistable switch.

This is based on (1) experiments (2) minimodels and (3) large scale models, and intuitively on the basis of the structure of the operon.

On the basis of an evolutionary model we concluded it is NOT.

a. The model was an extension of an existing large scale model of the Lac operon.

What was added /modified to make it an evolutionary model?

b. The evolutionary model showed evolution AWAY from bistability.

Mention 2 model results and 1 experimental result which strongly support this model outcome.

c. Discuss how/why previous (and current!) studies could get it so wrong .

## Question 2: Evolutionary dynamics

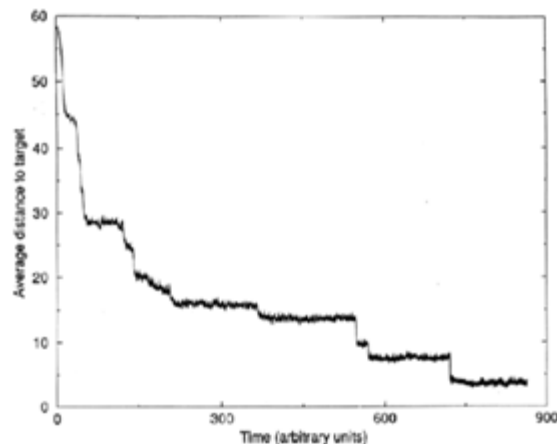
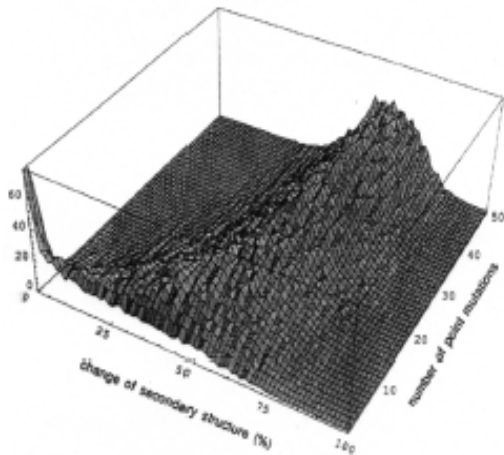


Fig 1a (left) depicts an RNA phenotype landscape.

- a. Explain this representation of the inherently high dimensional landscape.
- b. Which aspects of the landscape are not represented, and how do these aspects impact on the evolutionary dynamics?

Fig 1b (right) shows the fitness (expressed as distance to the target) over time. It shows so called punctuated equilibria.

- c. Is this dynamics compatible with the concept 'molecular clock' as used in e.g. Phylogenetic reconstruction?
- d. RNA has been called "an ideal evolvable molecule", where evolvable refers to the possibility to evolve a certain function from an arbitrary sequence. Why?

### Question 3 Eco-evolutionary dynamics

*... with the newly highlighted realization that evolution can occur over ecological time scales: —eco-evolutionary dynamics— this is invigorating both ecologists and evolutionists and blurring the distinction between them." (Science 2011).*

- a. Is this the case because of high mutation rates? Why?

Consequences for ecology:

- b. Maintenance of species diversity of ecosystems is not well understood because many ecological models predict extinction of species due to competition and predation. Explain two models which show that looking at eco-evolutionary dynamics instead of ecological dynamics may be the answer to this long standing problem (point out differences and similarities in the dynamics of the models which you discuss).

Consequences for evolution:

In eco-evolutionary dynamics "survival of the fittest" is not necessarily true.

- c. Explain 2 mechanisms why this is the case.

### Question 4 Chemotaxis and diffusion

- a. Explain why it is difficult to model chemotaxis in a *classical CA* in which the chemotactic entity is represented as a state of a CA-cell.

- b. Write down pseudocode for modeling chemotaxis in 2 qualitative different models in which the chemotactic entity is represented differently.

- c. A neutral gene spreads through a (spatial embedded) population in a diffusion-like way. Model this process (write down pseudocode!) and discuss the expected behavior.

### Question 5 Evolvability and evolutionary signatures.

Traditionally only immediate benefits were accepted in evolutionary explanations. We have seen long term information integration in evolution.

a. Explain why this was not seen in traditional models, i.e. What are the requirements of models to potentially show this phenomenon.

b. Explain how long term information integration can lead to evolution of evolvability (and give an example).

The complexity of present day organisms may be because such complexity is needed for proper (optimal) functioning. It may also be caused by the fact that they have evolved.

c. Give one biological example of the former case and two examples of the latter case. For each of the cases discuss how modeling has elucidated the underlying reason for the observed complexity.

6. Bottom line

Tell a friend (with a similar scientific background as yours) the (a) bottom line of the course using at least one model in some detail (avoid using only models you used before in this exam).