

# Kent Academic Repository

## Full text document (pdf)

### Citation for published version

Chu, Dominique (2013) Replaying the tape of evolution: Evolving parameters for a simple bacterial metabolism. In: IEEE CEC 2013 : IEEE Congress on Evolutionary Computation, 20th - 23rd June, 2013, Cancun, Mexico.

### DOI

### Link to record in KAR

<https://kar.kent.ac.uk/34409/>

### Document Version

Pre-print

#### Copyright & reuse

Content in the Kent Academic Repository is made available for research purposes. Unless otherwise stated all content is protected by copyright and in the absence of an open licence (eg Creative Commons), permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

#### Versions of research

The version in the Kent Academic Repository may differ from the final published version.

Users are advised to check <http://kar.kent.ac.uk> for the status of the paper. **Users should always cite the published version of record.**

#### Enquiries

For any further enquiries regarding the licence status of this document, please contact:

[researchsupport@kent.ac.uk](mailto:researchsupport@kent.ac.uk)

If you believe this document infringes copyright then please contact the KAR admin team with the take-down information provided at <http://kar.kent.ac.uk/contact.html>

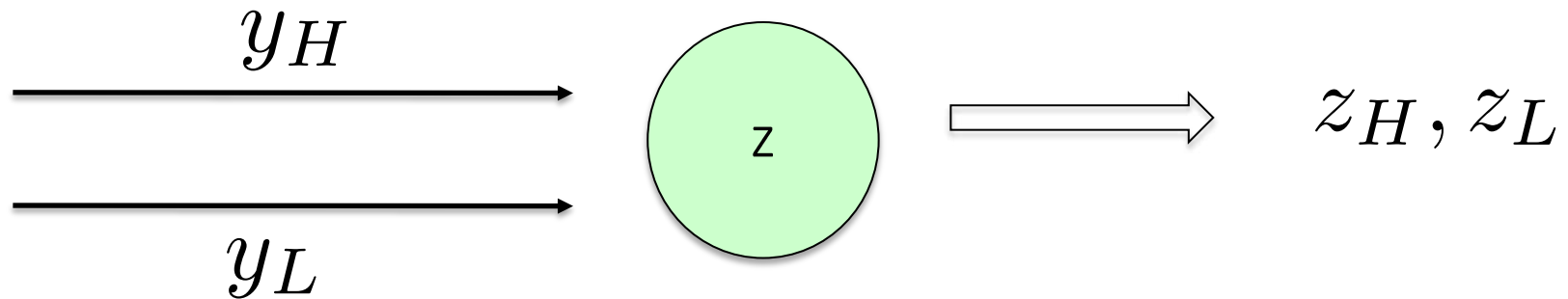
# Evolving parameters for genetic regulatory networks

Dominique Chu  
School of Computing  
University of Kent  
CT2 7NF, Canterbury, UK

# Motivation

- Design principles of living systems.
  - Abstract models of organisation (autopoiesis, (M,R)-systems etc...
  - “Complex systems” approach (network topology)
- A numerical understanding of organisms:
  - Why is a particular reaction rate  $k$ , rather than something else?
  - Why are there  $N$  proteins in the cell, rather than twice as many? Half?

# Simplest possible model system: binary Gene



$$\dot{z} = \beta \frac{y^h}{y^h + K^h} - \mu z$$



Biosystems

Volume 104, Issues 2–3, May–June 2011, Pages 99–108



Optimal parameter settings for information processing in gene  
regulatory networks

Dominique F. Chu<sup>a</sup>, , , Nicolae Radu Zabet<sup>a</sup>, Andrew N.W. Hone<sup>b</sup>

# Noise-time trade-off

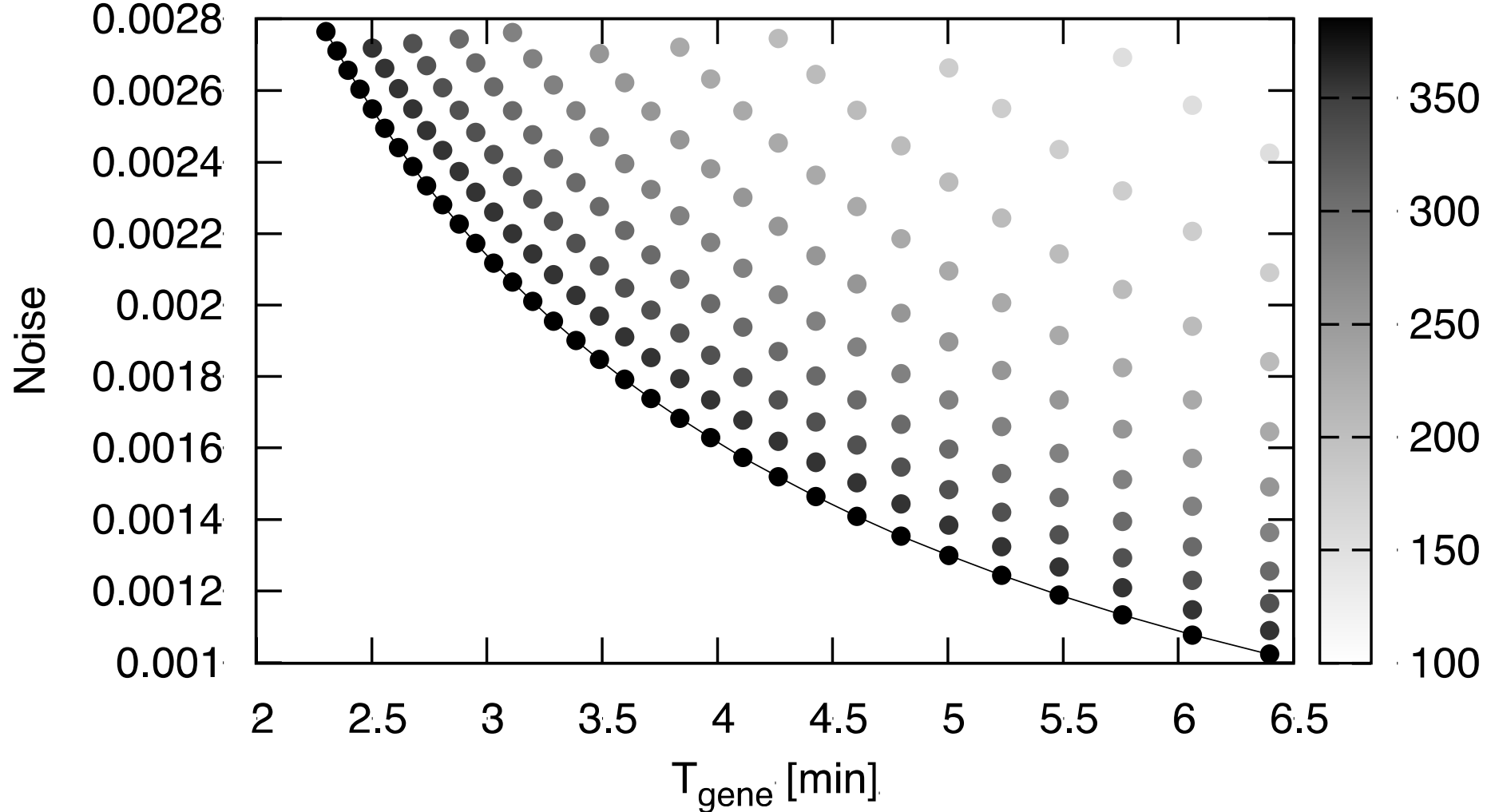
1 gene case:

$$T \sim \frac{1}{\mu} \quad \mathcal{N} \sim \mu$$

- We have ignored cost so far.
- Define as the number of molecules produced per time unit (at maximum).

$$\dot{z} = \beta \frac{y^h}{y^h + K^h} - \mu z$$

# Noise-time-cost trade-off

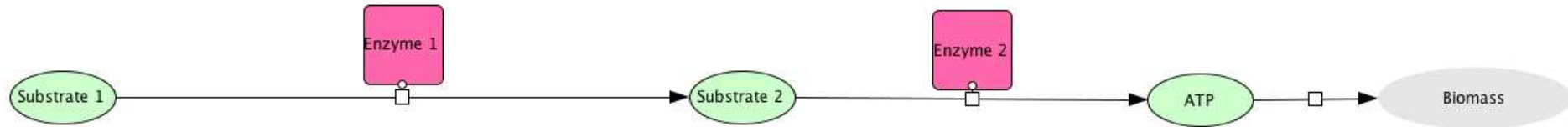


[J R Soc Interface](#). 2010 Jun 6;7(47):945-54. doi: 10.1098/rsif.2009.0474. Epub 2009 Dec 9.

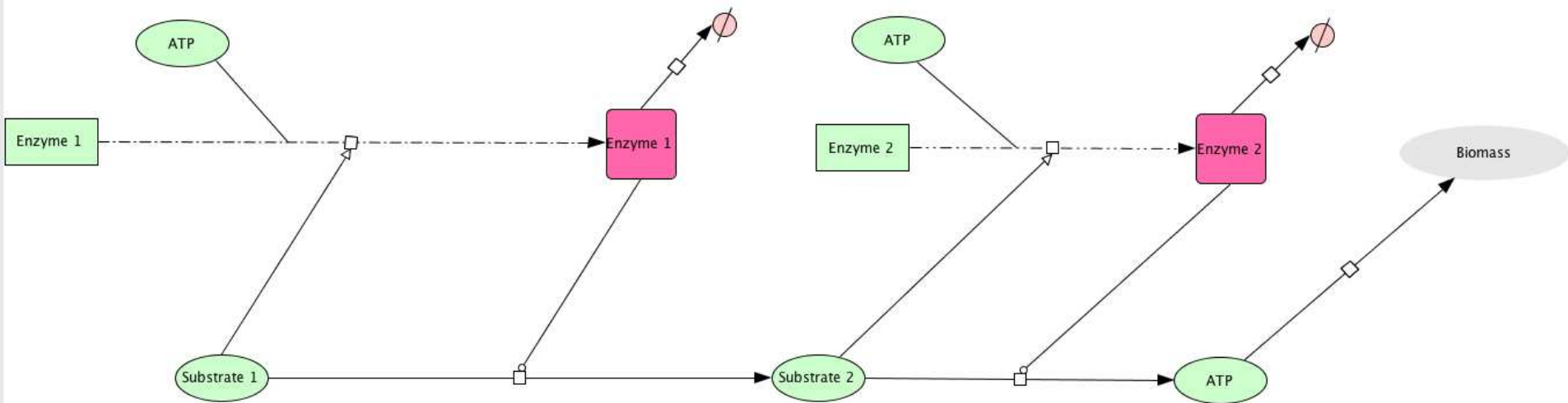
## Computational limits to binary genes.

[Zabet NR](#), [Chu DF](#).

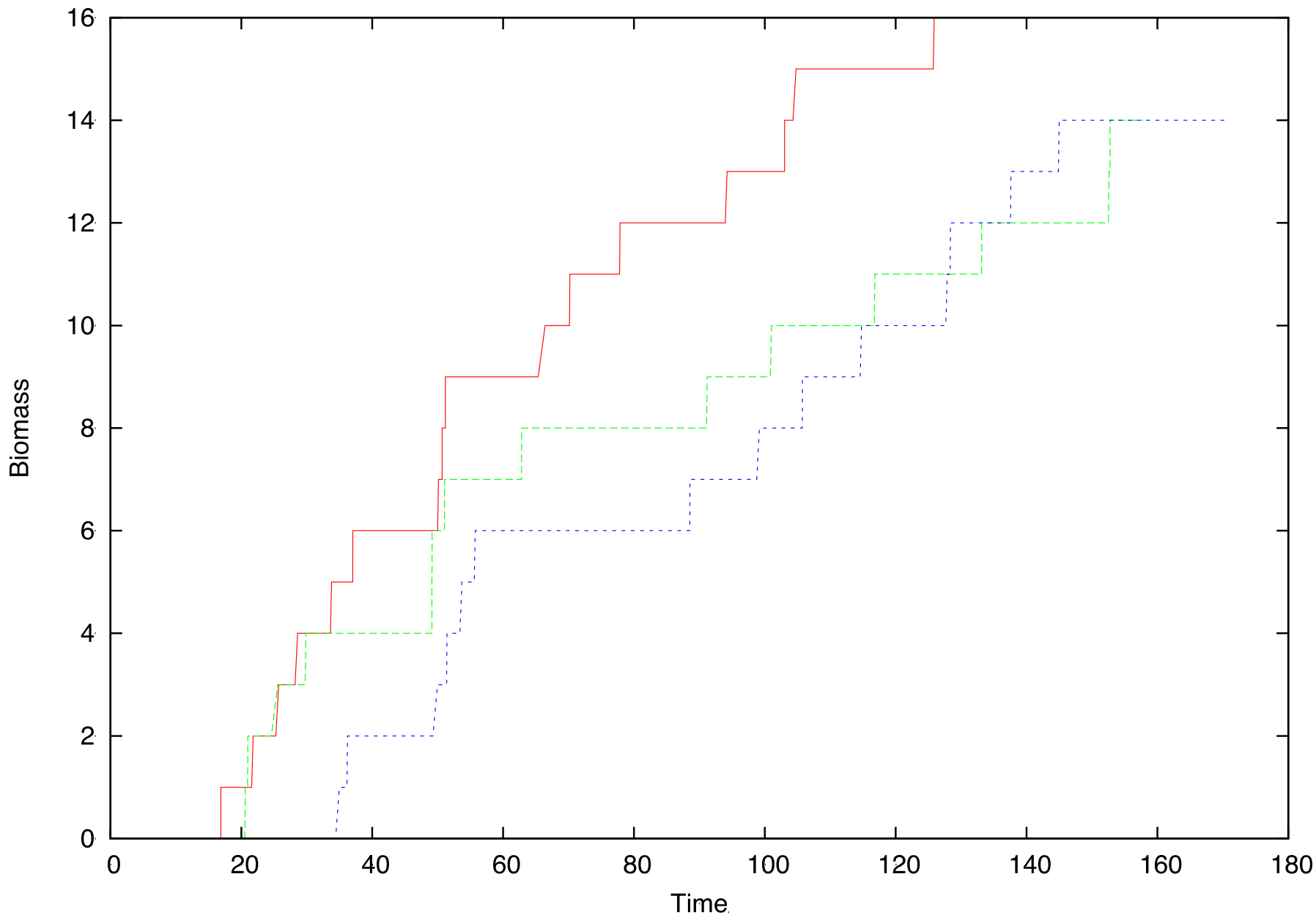
# A very simple example system (simplified representation)



# A very simple example system (full representation)

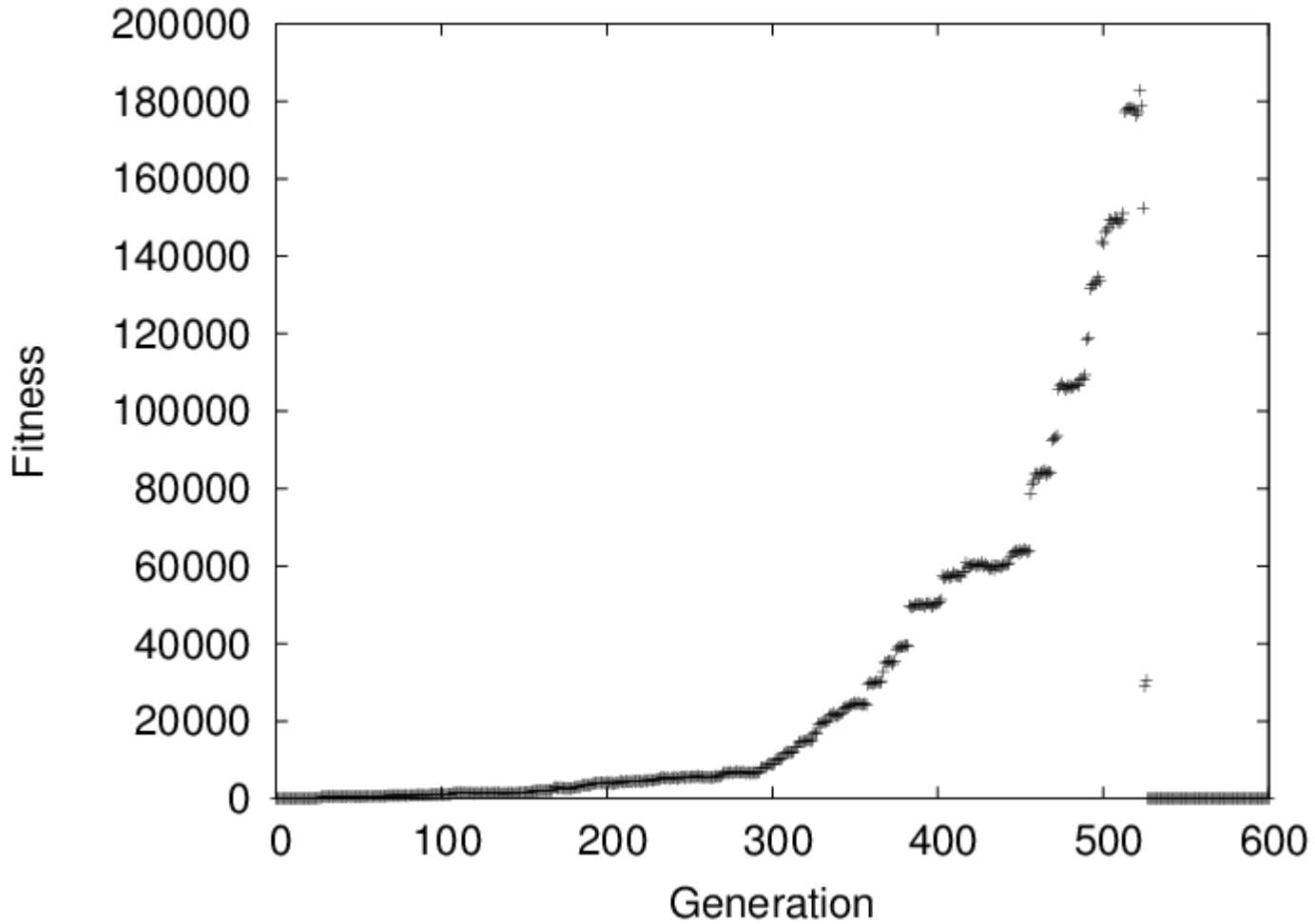






step	subs1	subs2	enz1	enz2	atp	biomass
0	179	0	0	0	10	0
1	179	0	1	0	9	0
2	179	0	2	0	8	0
3	179	0	3	0	7	0
4	179	0	4	0	6	0
5	179	0	5	0	5	0
6	179	0	6	0	4	0
7	178	0	5	0	4	0
8	178	1	6	0	4	0
9	178	1	6	1	3	0
10	178	0	6	0	3	0
11	178	0	6	1	4	0
12	178	0	7	1	3	0
13	178	0	8	1	2	0
14	178	0	9	1	1	0
15	178	0	10	1	0	0
16	177	0	9	1	0	0
17	177	1	10	1	0	0
18	177	0	10	0	0	0
19	177	0	10	1	1	0
20	176	0	9	1	1	0
21	176	1	10	1	1	0
22	176	1	10	2	0	0
23	176	0	10	1	0	0

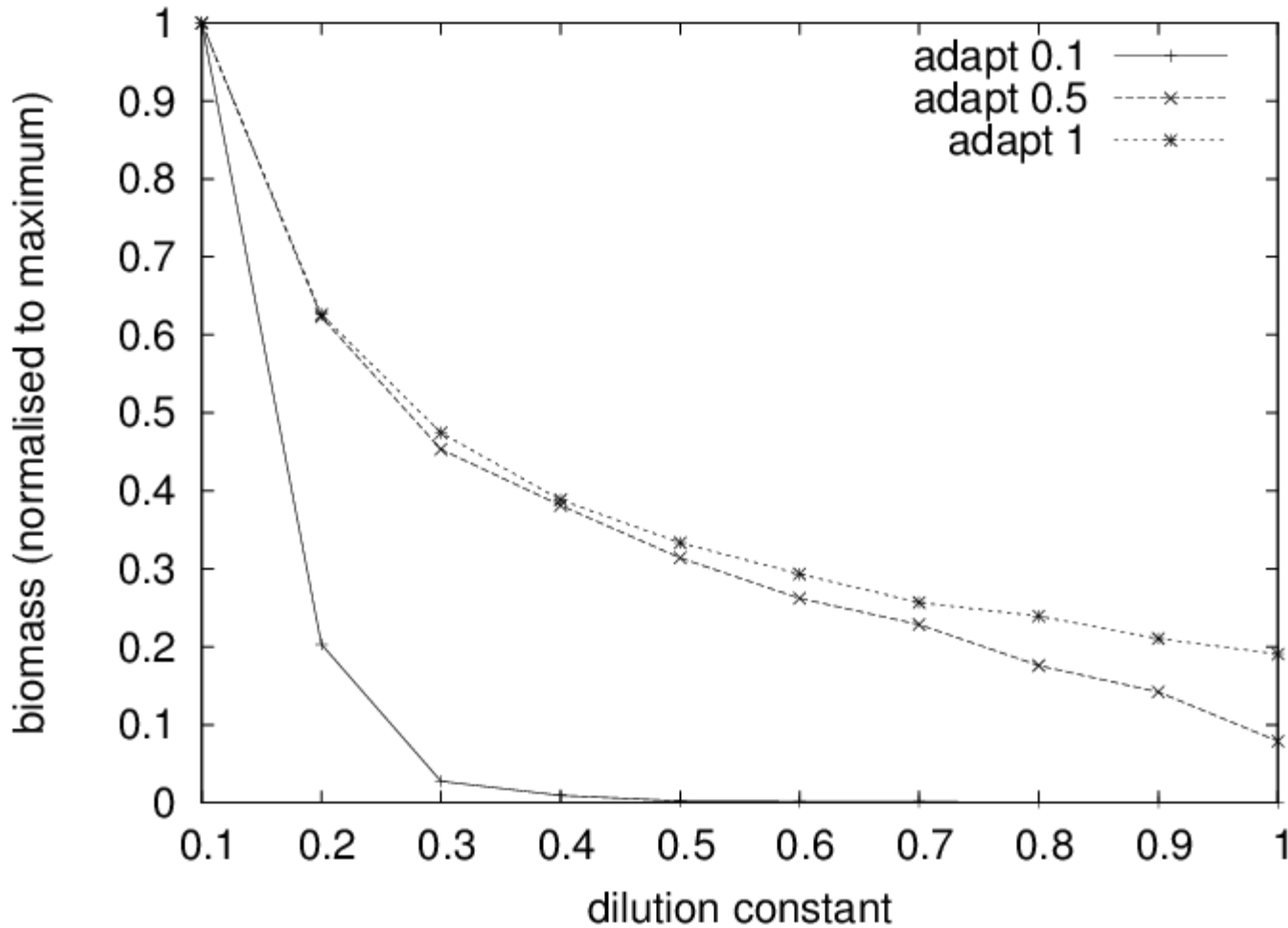
# Running an EA



# Adapting to 3 environmental conditions

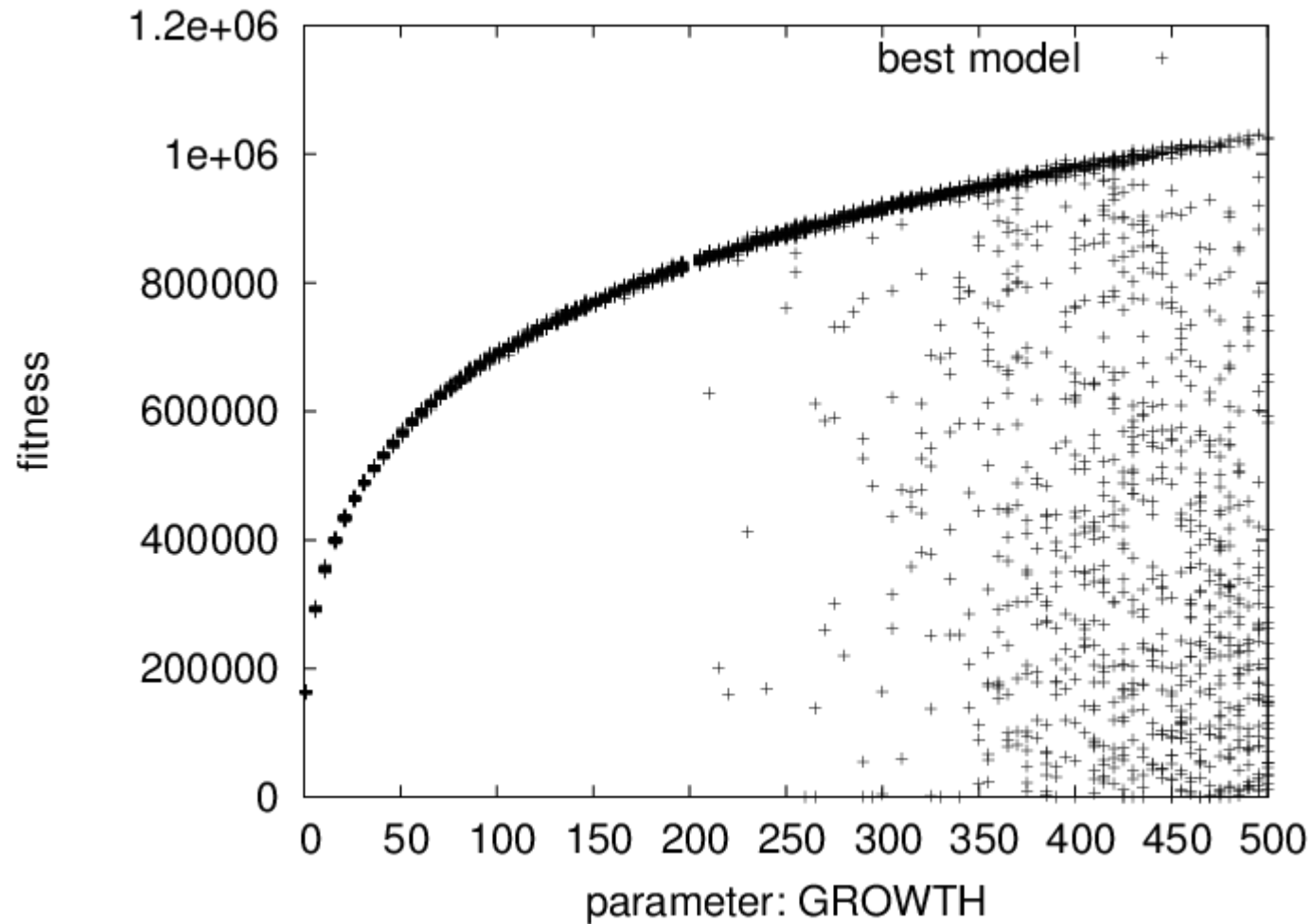
	(i) unlimited		(ii) oscillating		(iii) long break	
Adapted to:	biomass	sd	biomass	sd	biomass	sd
(ii)	221.9	164.898661	48.35	28.8175294	91.85	72.2657923
(ii)	491.65	522.103768	<b>83.75</b>	41.5285254	142.5	49.0375796
(i)	<b>49947</b>	19618.0107	0.25	0.5501196	0.45	0.51041779
(iii)	700.75	589.922464	30.45	25.7078219	135.4	70.6111666
(iii)	493.7	31.8567517	70.85	8.85720046	<b>157.75</b>	10.1560197

# Adaptation to different dilution rates.

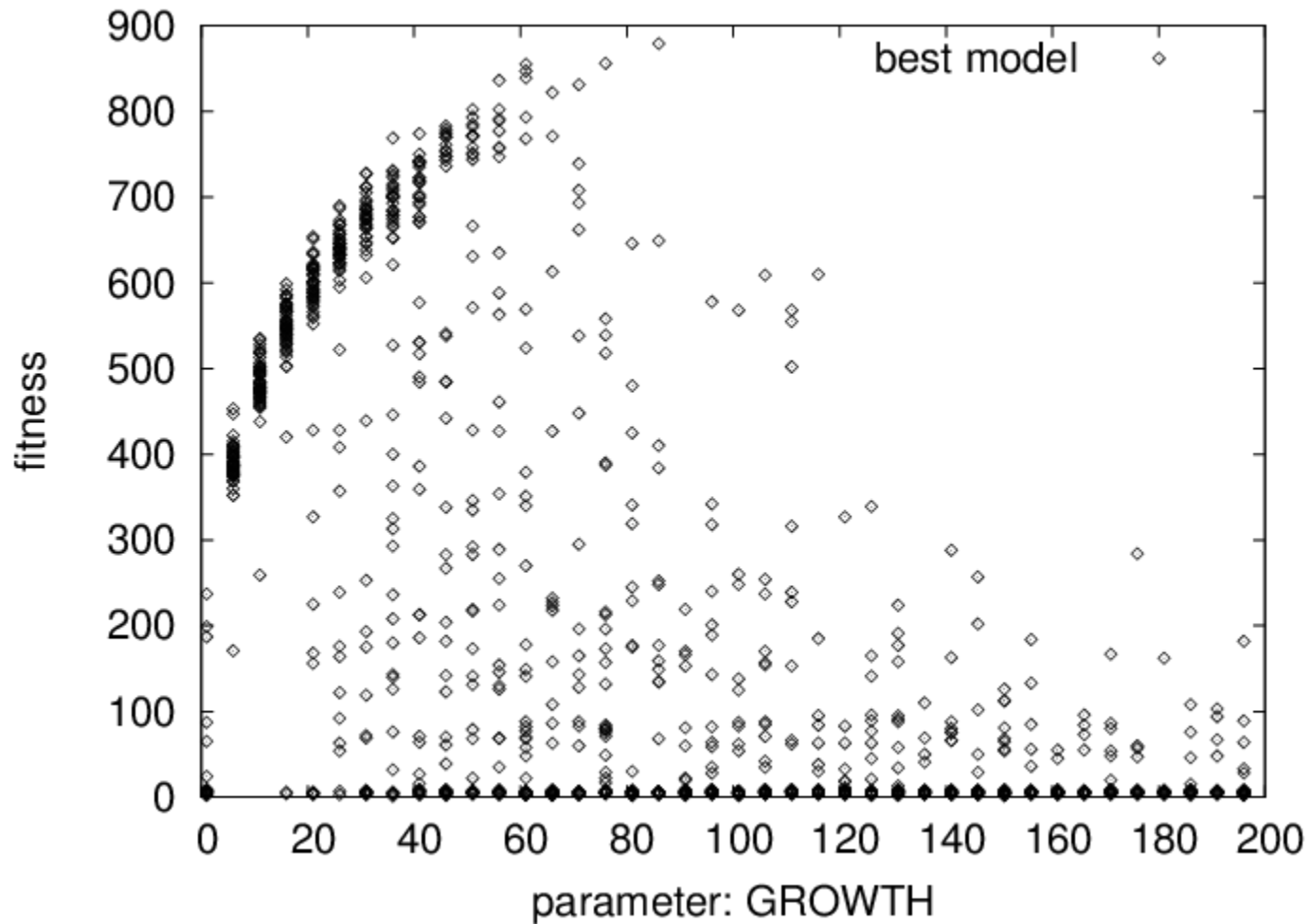


Interesting feature:  
Stochastic fitness function

# Unlimited nutrient supply



# Oscillating nutrient supply





# Summary

- The cost/speed trade-off in biological cells is not yet understood.
- Naturally evolved parameters are likely a an adaptation to optimise switching while controlling costs.
- In realistic systems it is difficult to understand how to think about parameters with respect to computational properties.