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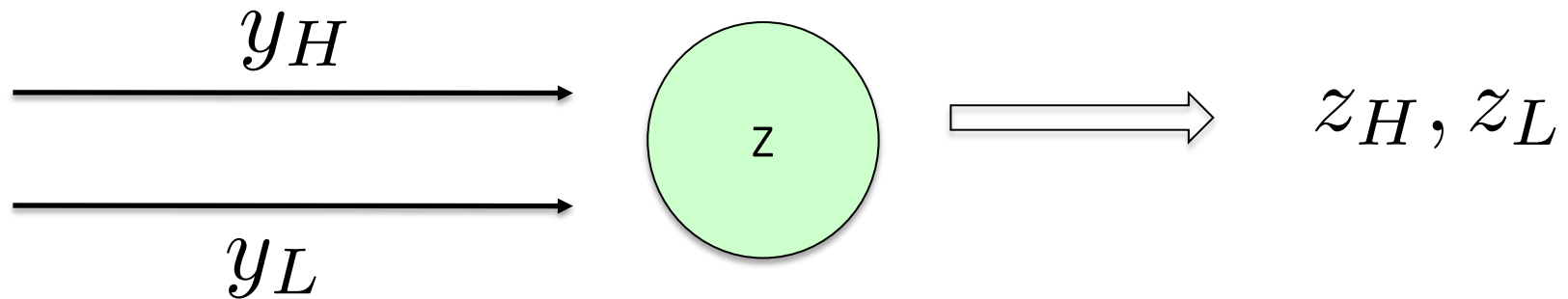
Evolving parameters for genetic regulatory networks

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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^a,  , Nicolae Radu Zabet^a, Andrew N.W. Hone^b

Noise-time trade-off

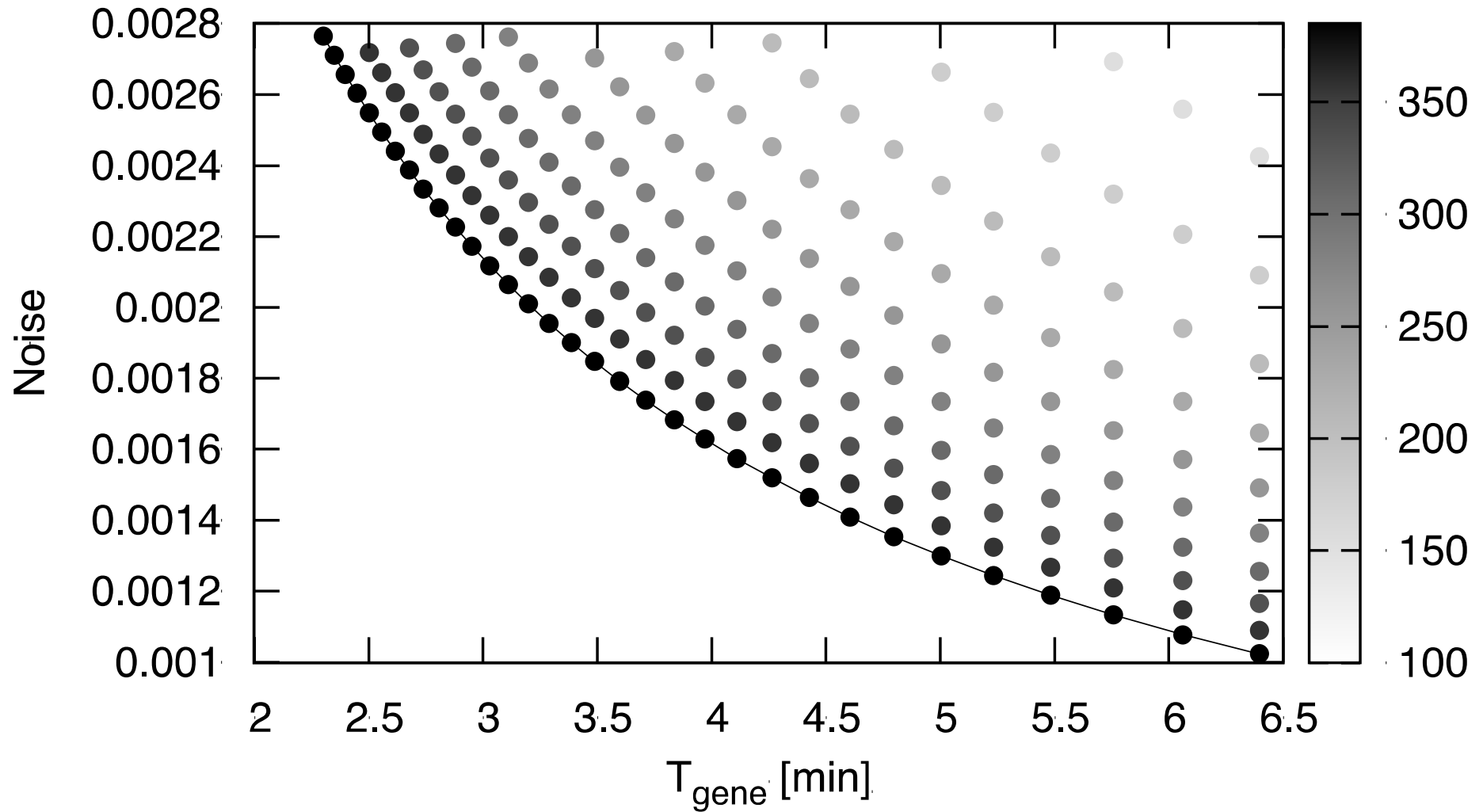
1 gene case:

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

- 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

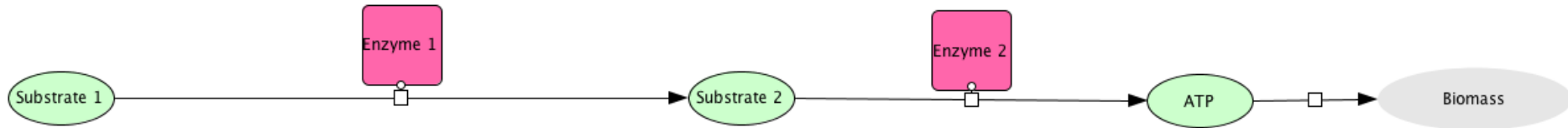


[J R Soc Interface](#). 2010 Jun 6;7(47):945-54. doi: 10.1098/rsif.2009.0474. Epub 2009 Dec 9.

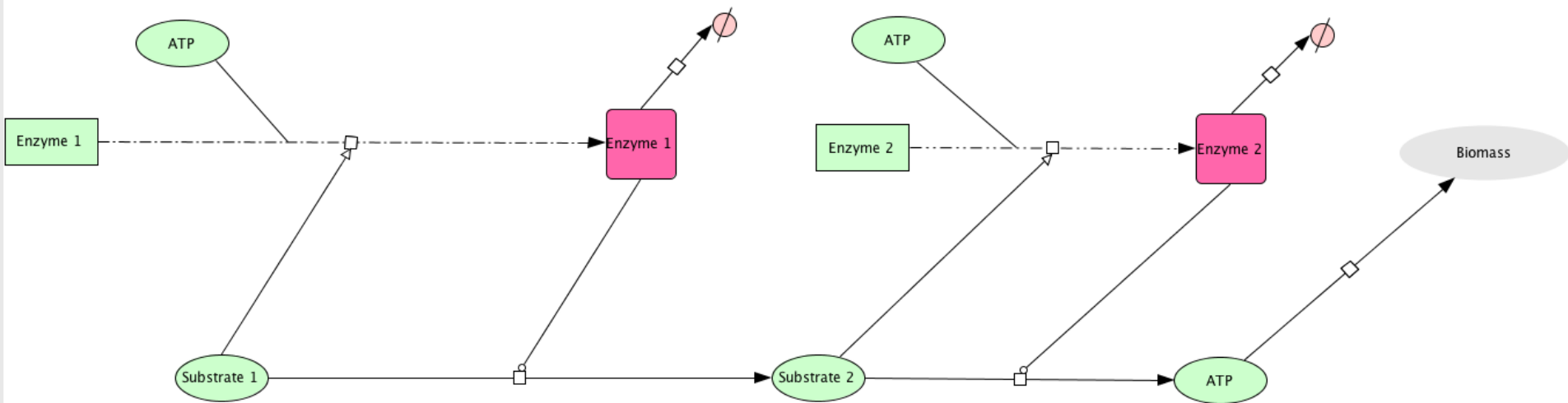
Computational limits to binary genes.

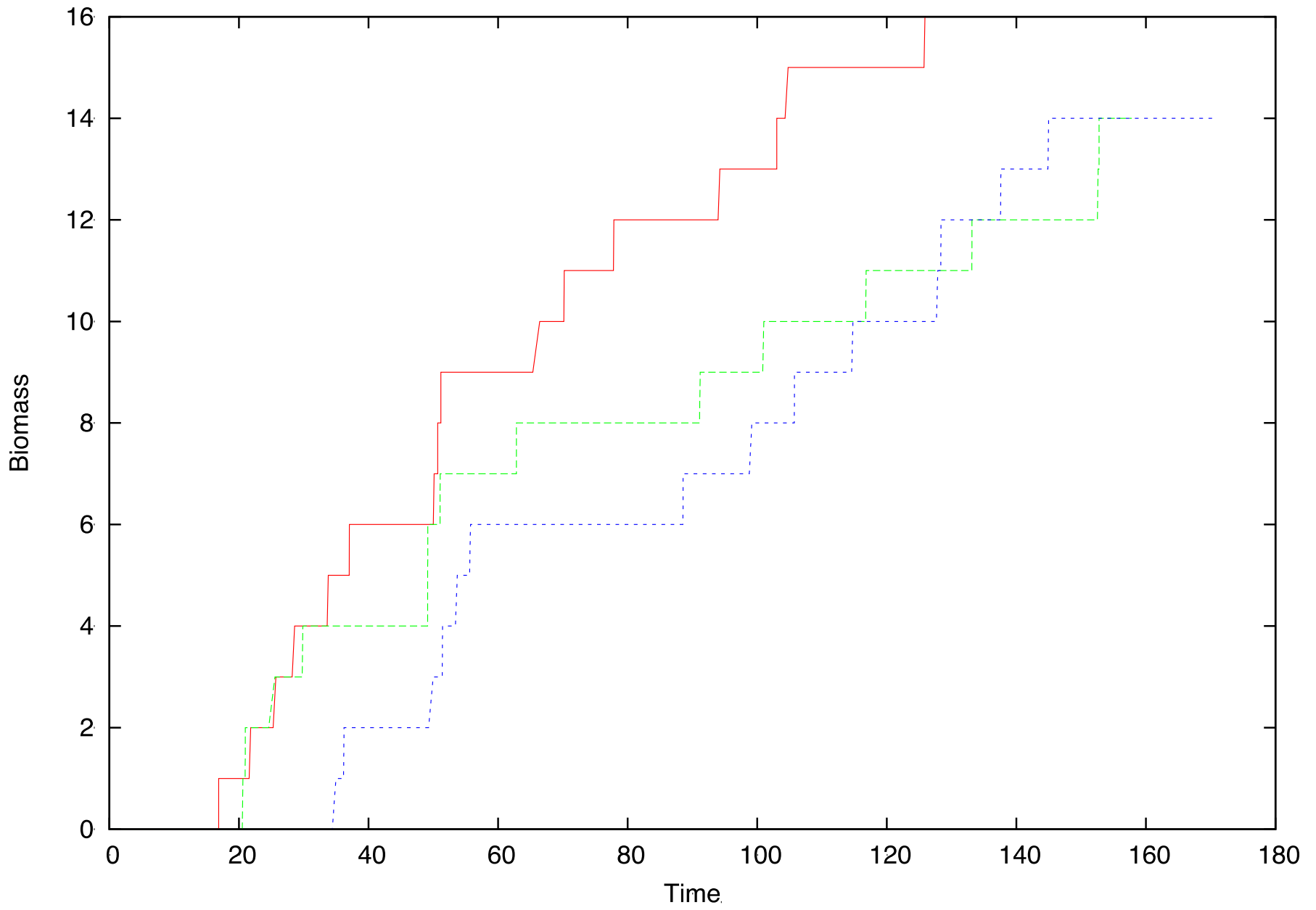
[Zabet NR](#), [Chu DF](#).

A very simple example system (simplified representation)



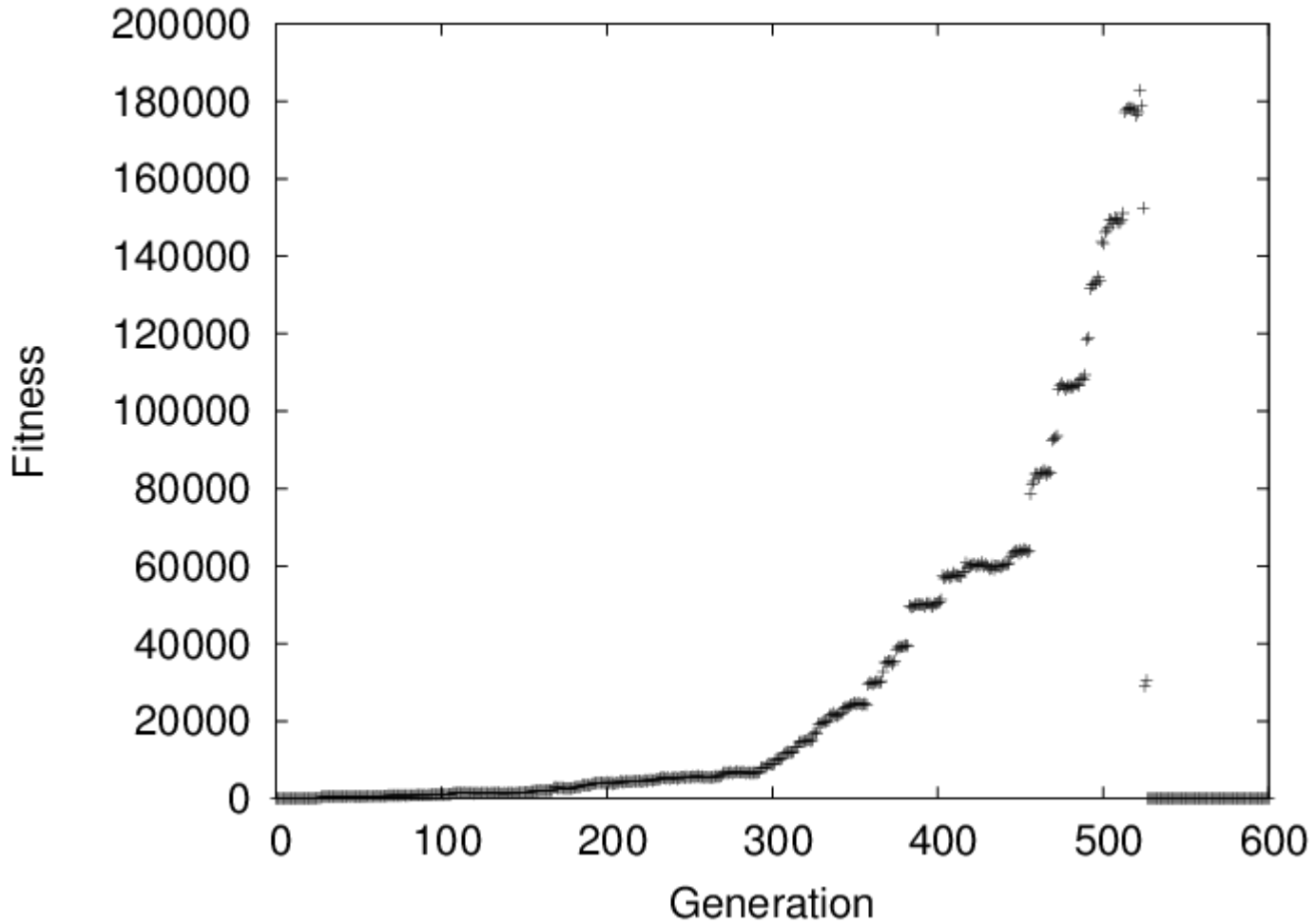
A very simple example system (full representation)





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

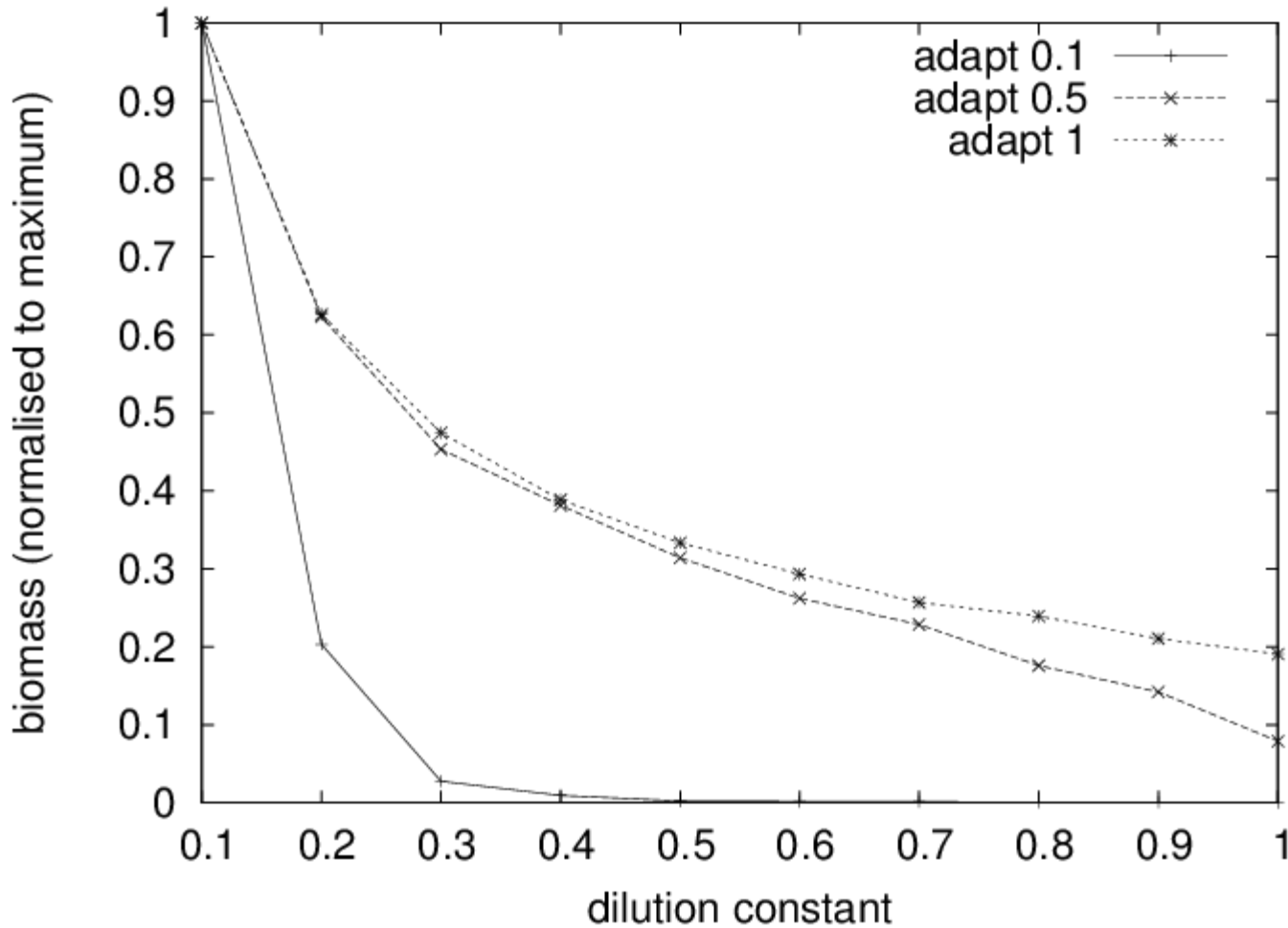
Running an EA



Adapting to 3 environmental conditions

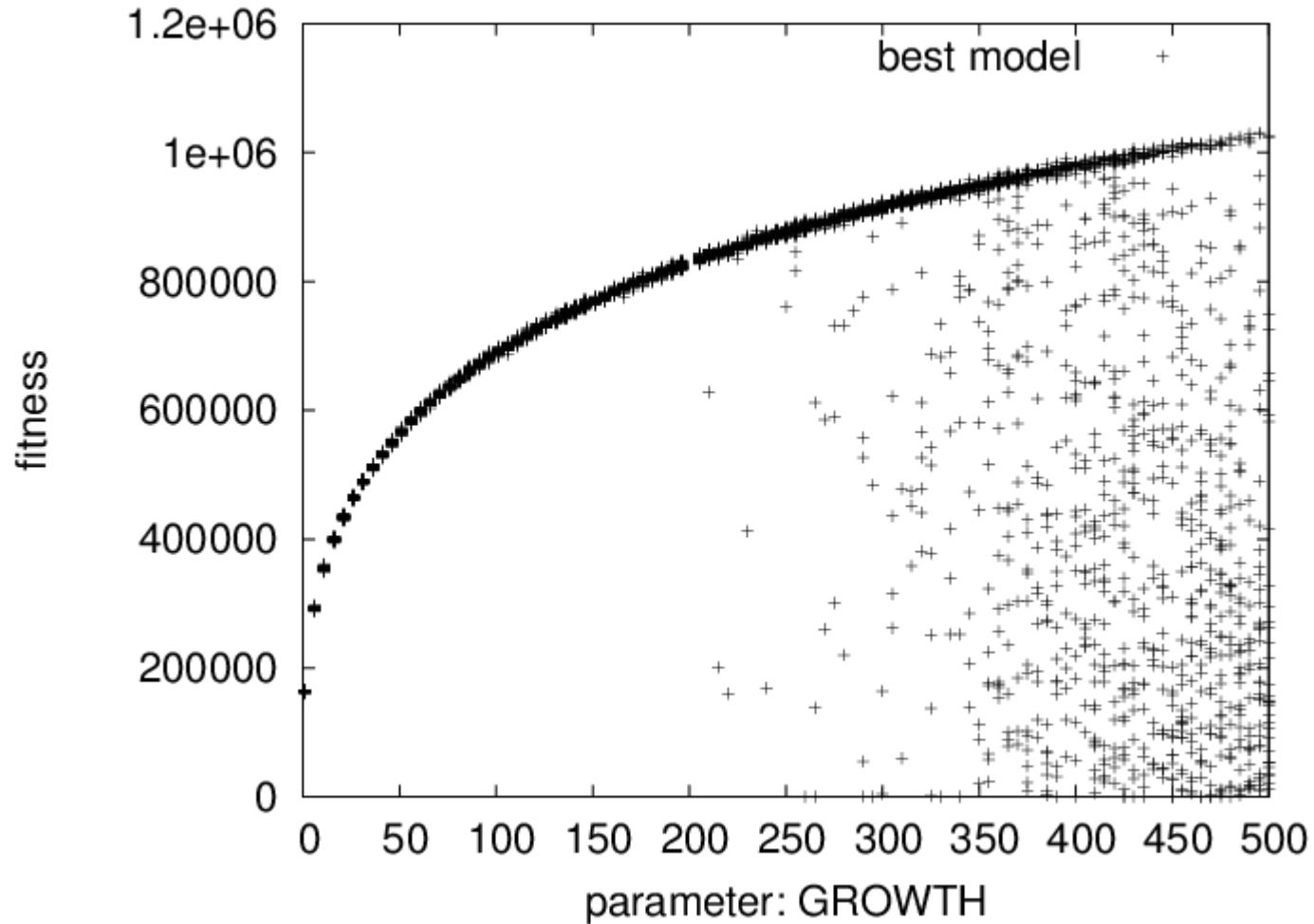
	(i) unlimited		(ii) oscillating		(iii) long break	
Adapted to:	biomass	sd	biomass	sd	biomass	sd
(ii)	221.9	164.898661	48.35	28.8175294	91.85	72.2657923
(ii)	491.65	522.103768	83.75	41.5285254	142.5	49.0375796
(i)	49947	19618.0107	0.25	0.5501196	0.45	0.51041779
(iii)	700.75	589.922464	30.45	25.7078219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

Adaptation to different dilution rates.

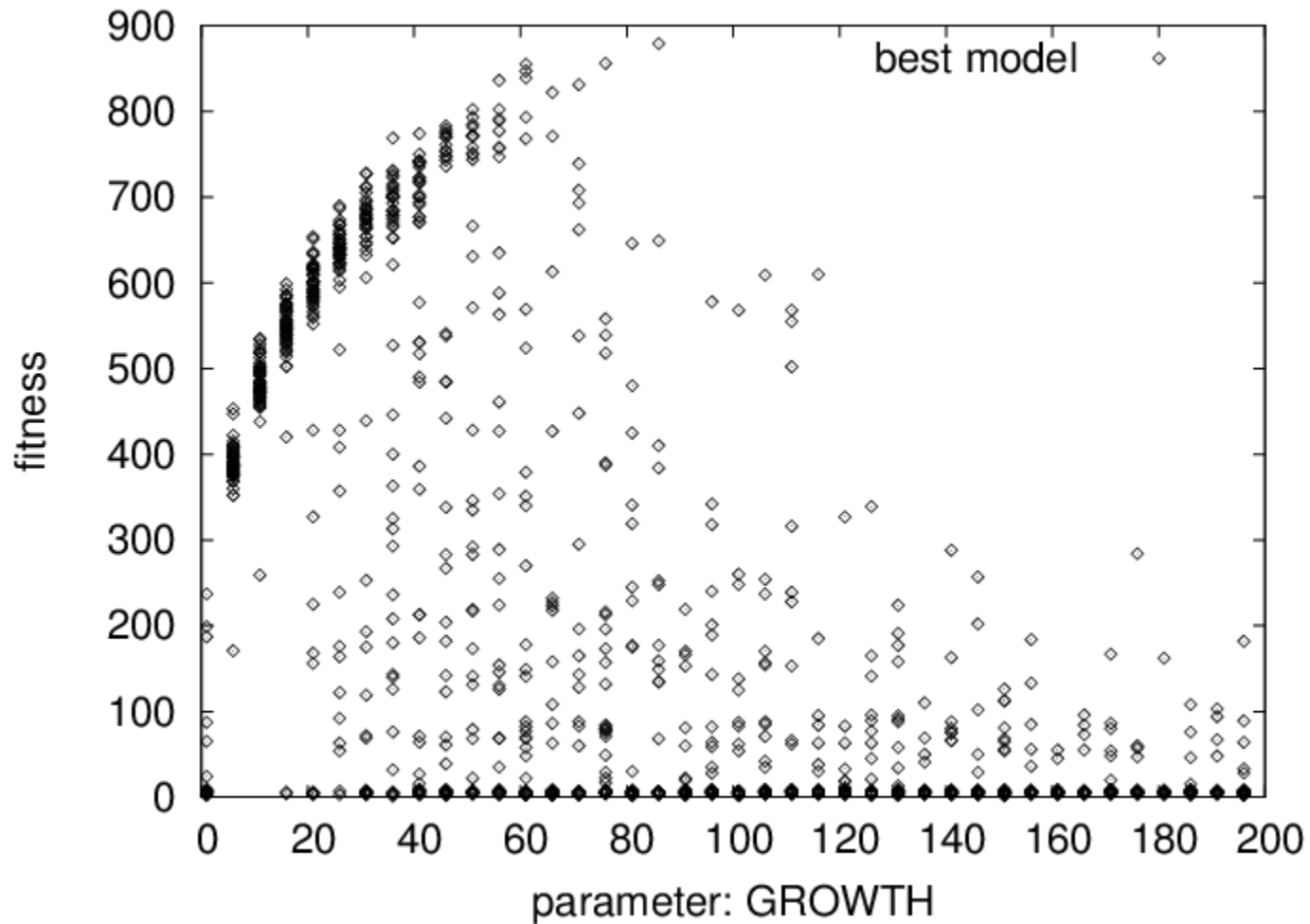


Interesting feature:
Stochastic fitness function

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.