

Mreže in samoorganiziranost v bioloških sistemih

Networks and **self-organization**
in biological systems

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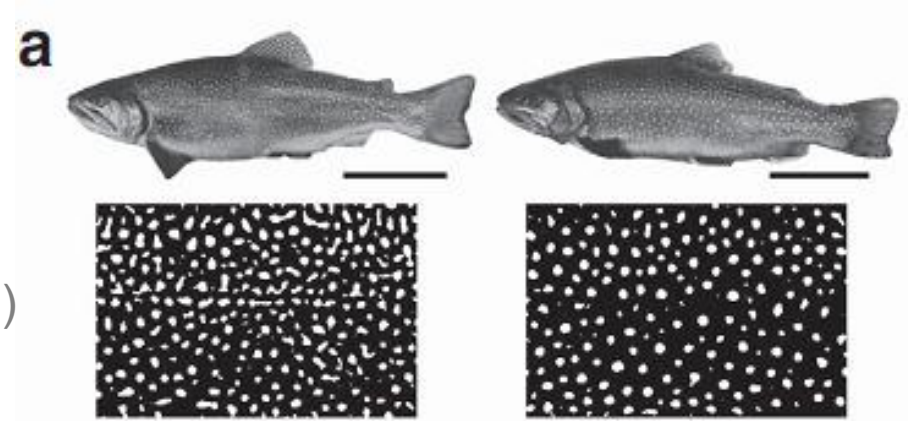
Biolška znanost in družba, Organizmi kot živi sistemi
Ljubljana, 21. in 22. oktober 2010

»And, alas, complexity is uncomfortable,
so we are inclined to ignore it.«

Denis Noble, *The Music of Life*, 2006

“Understanding **pattern** formation is intimately related to understanding the notion of **complexity**.”

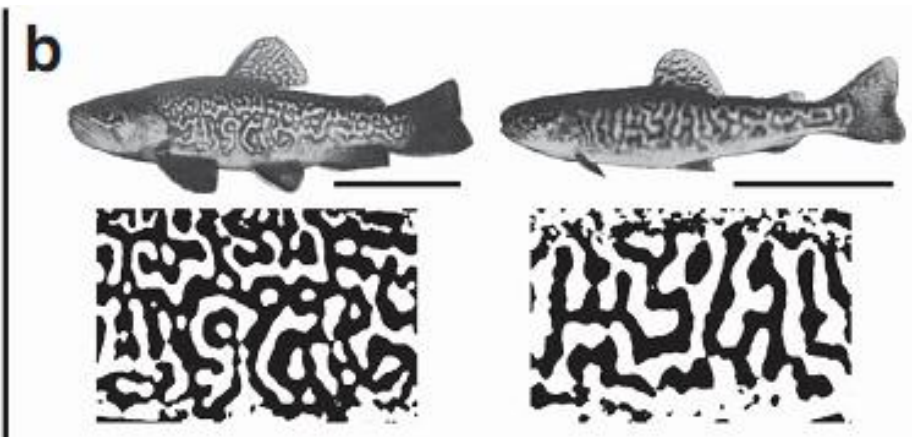
– E. Ben-Jacob and H. Levine, Nature (2001)



S. Miyazawa et al., Nature Communications (2010)

kompleksnost : temeljna značilnost bioloških sistemov

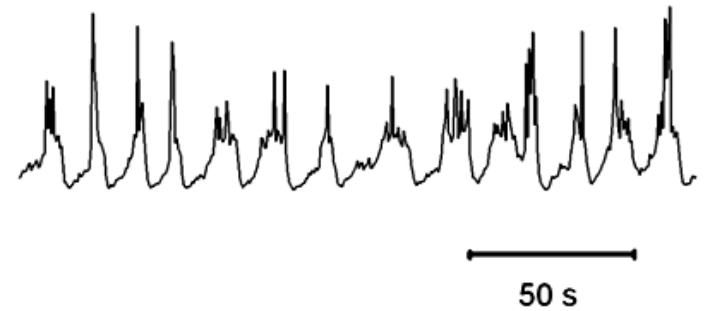
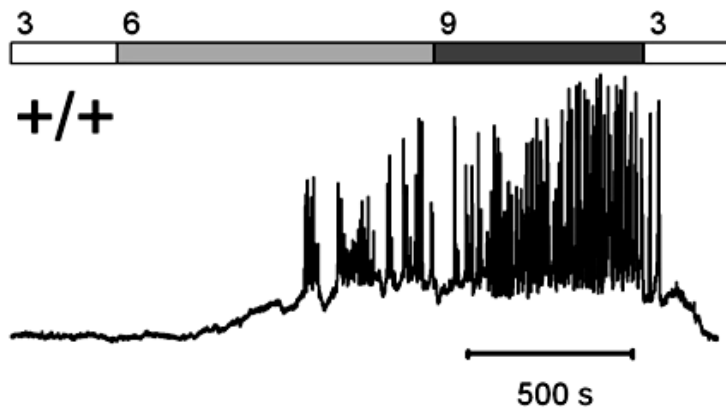
vzorec : strukturna/funkcionalna organiziranost



S. Miyazawa et al., Nature Communications (2010)

kompleksni vzorci “nekje vmes” med urejenostjo in neurejenostjo

vzorci so lahko **prostorski** ...



kompleksni vzorci “nekje vmes” med urejenostjo in neurejenostjo

... časovni

THE CHEMICAL BASIS OF MORPHOGENESIS

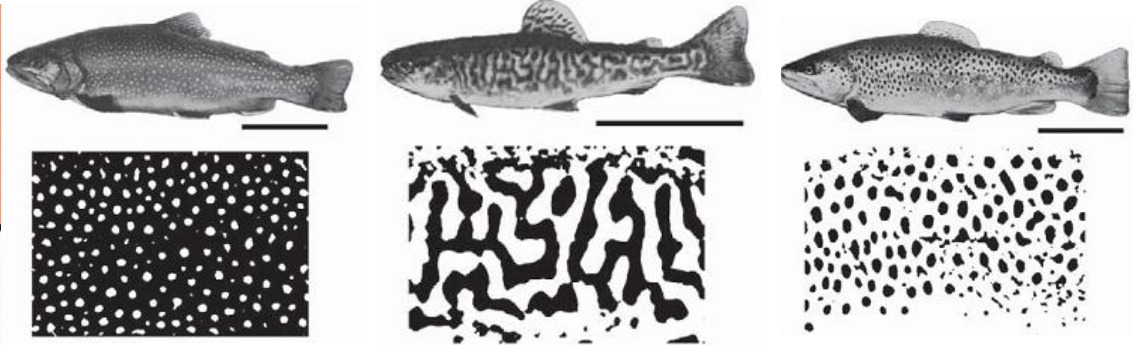
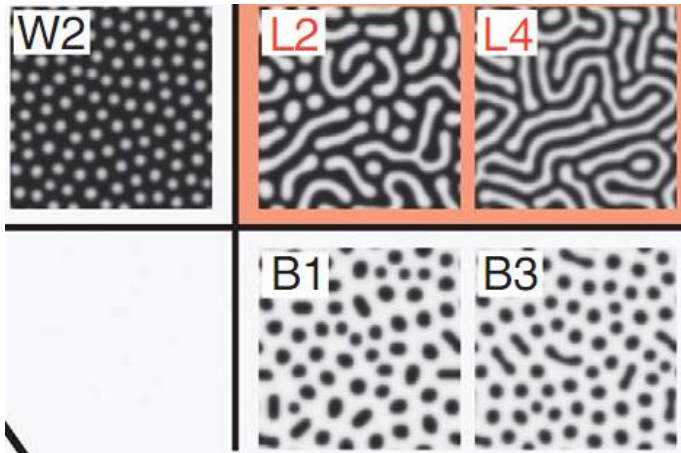
By A. M. TURING, F.R.S. *University of Manchester*

(Received 9 November 1951—Revised 15 March 1952)

It is suggested that a system of chemical substances, called morphogens, reacting together and diffusing through a tissue, is adequate to account for the main phenomena of morphogenesis.

A. M. Turing, Philos T Roy Soc B (1952)

sklopitev kemijskih reakcij in difuzije
kratkodosežni **aktivator** – dolgodosežni **inhibitor**



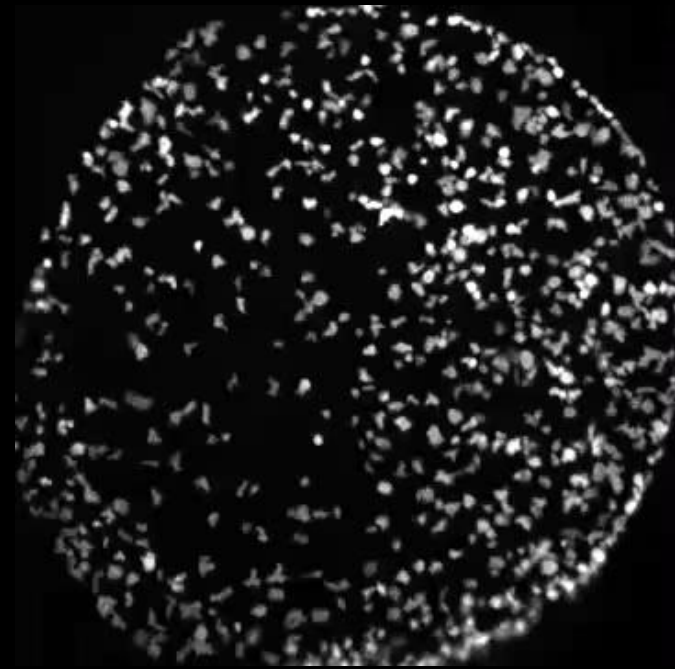
S. Miyazawa et al., Nature Communications (2010)

vzorec je posledica razmerja difuzijskih konstant morfogenov



Starlings on Otmoor

<http://www.youtube.com/watch?v=XH-groCeKbE>



Slime mold formation

<http://www.youtube.com/watch?v=hpHpBHZQvU>

vzorci brez zunanjega usmerjanja: **samoorganizacija**

gibanje škorcev v jatah, agregacija socialnih ameb



Conway's Game of Life

diskretni dinamični sistemi – **celični avtomati**,
stanje celice (0,1)
celice se odzivajo na spremembe v **bližnji okolici**

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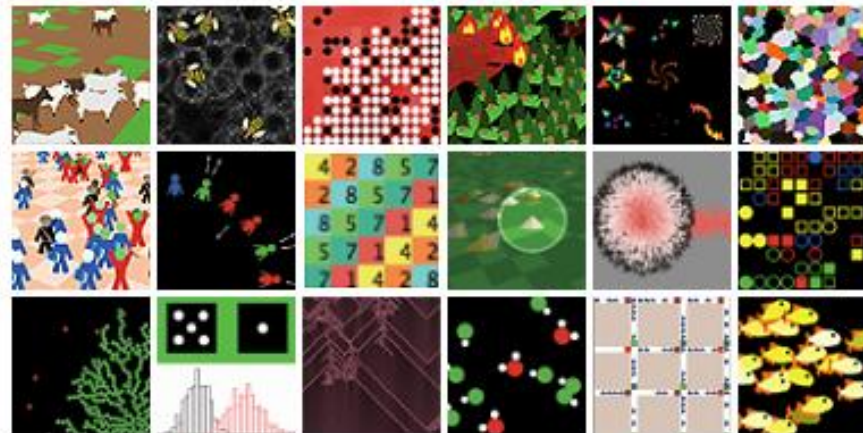
NetLogo is a multi-agent programmable modeling environment. It is used by tens of thousands of students, teachers and researchers worldwide. It also powers [HubNet](#) participatory simulations. It is authored by [Uri Wilensky](#) and developed at the [CCL](#). You can download it free of charge.

What can you do with NetLogo? Read more [here](#).

Join mailing lists [here](#).

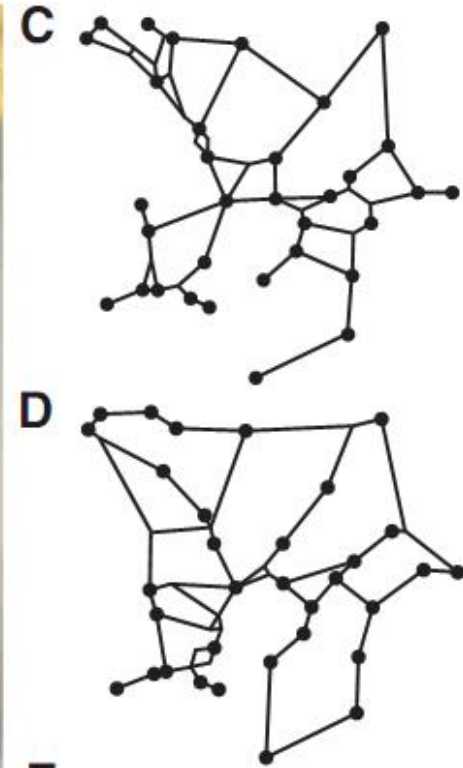


NetLogo comes with a large library of sample models. Click on some examples below.



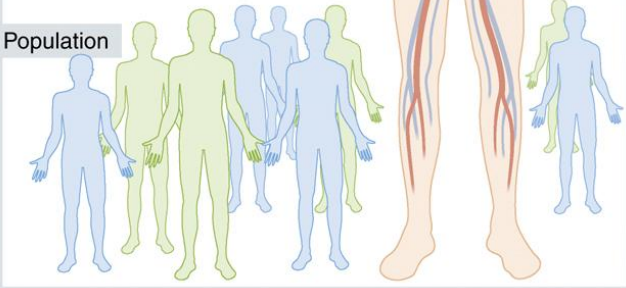
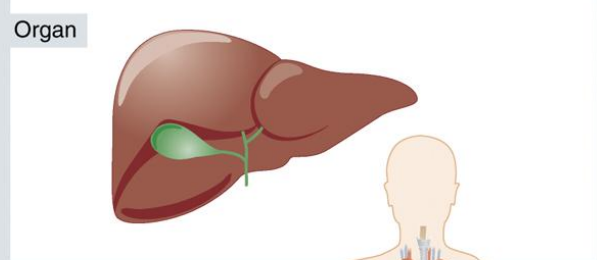
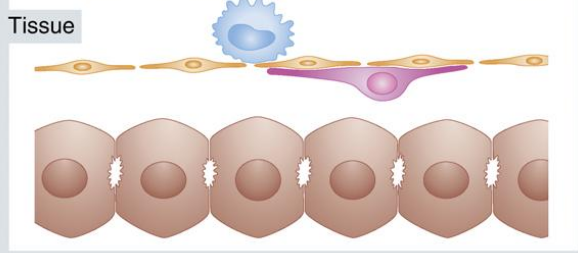
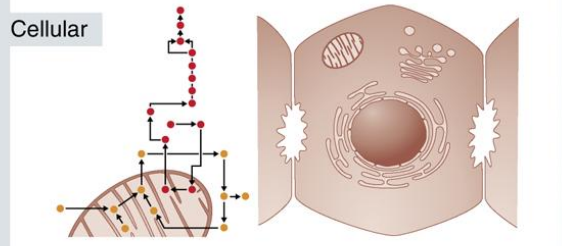


Tokyo rail network designed by Physarum plasmodium
<http://www.youtube.com/watch?v=BZUQQmcR5-g>

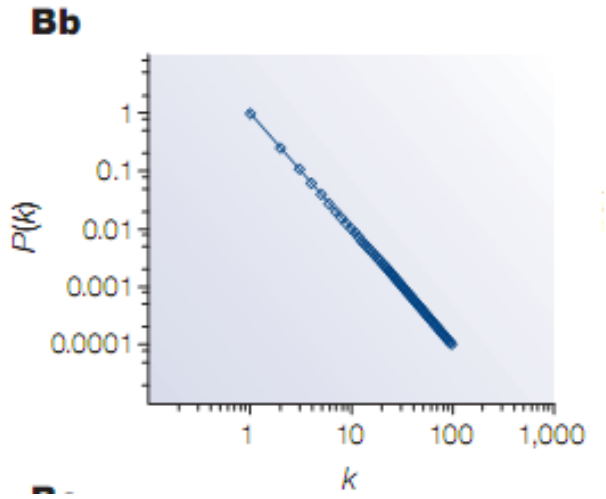
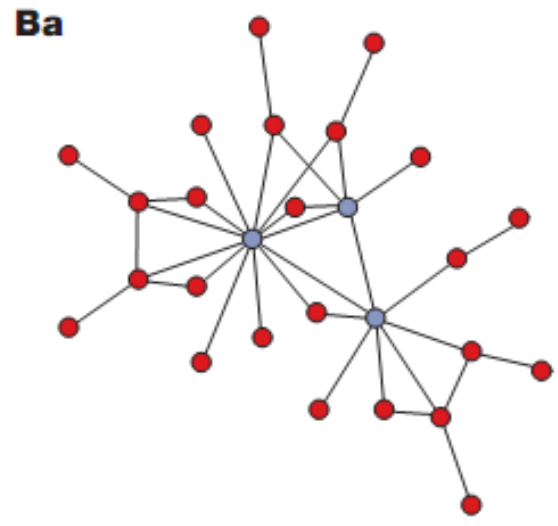


A. Tero et al., Science (2010)

diskretni dinamični sistemi – **celični avtomati**,
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celice se odzivajo na spremembe v **bližnji okolici**

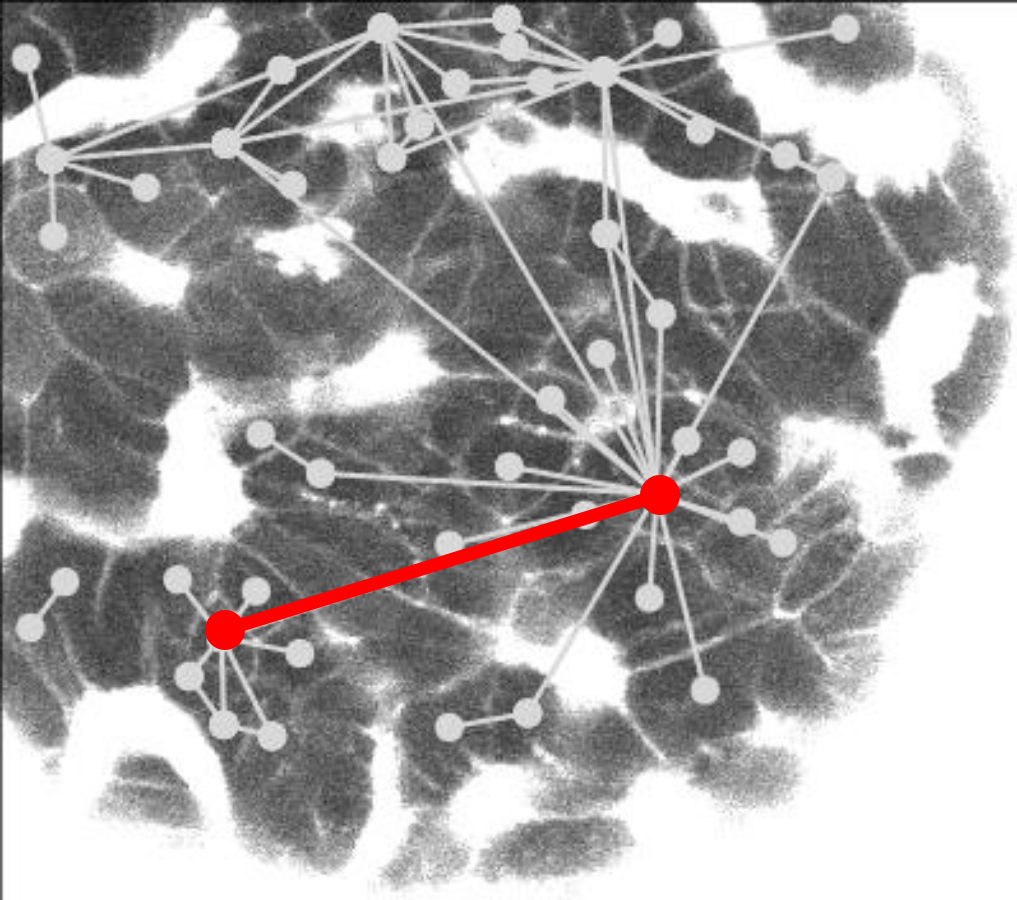


B Scale-free network

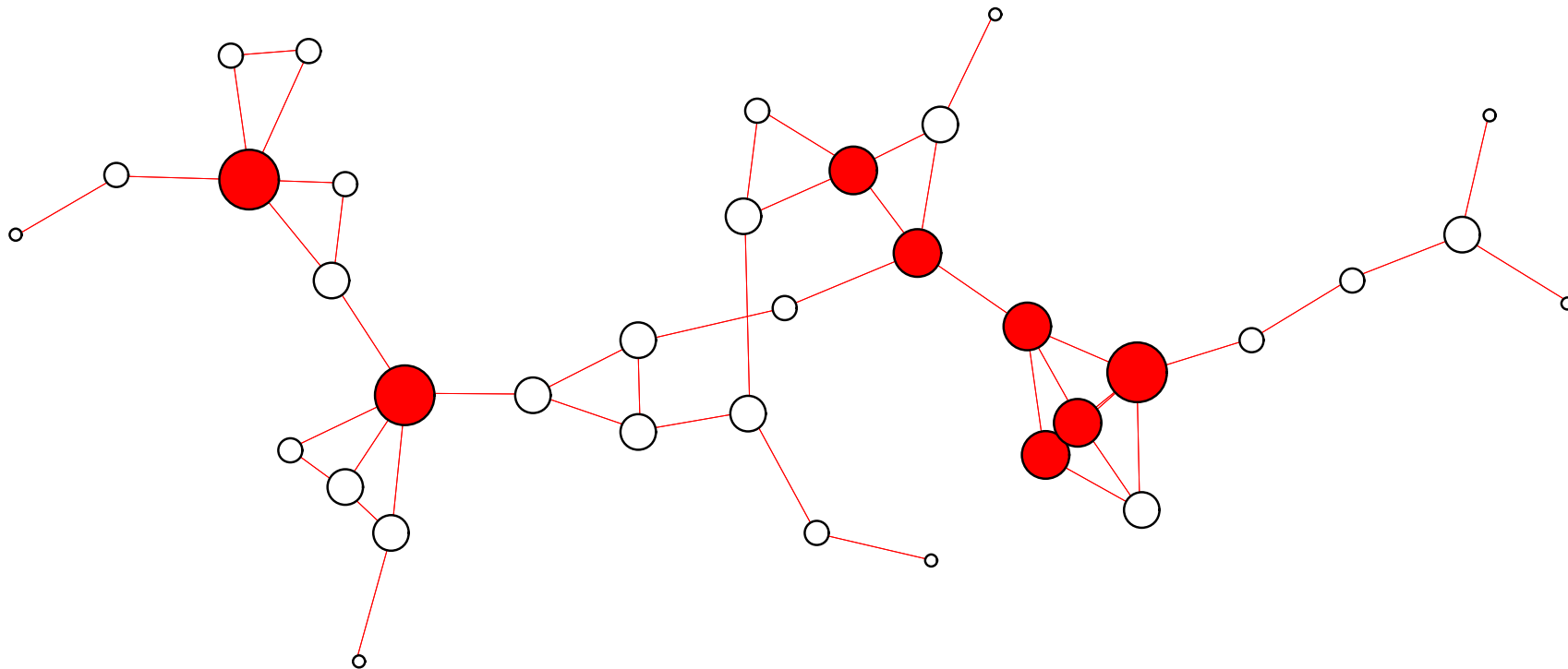


A.-L. Barabasi and Z. N. Oltvai, Nature Rev Gen 2004

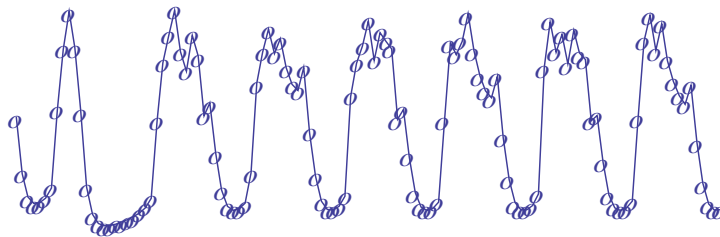
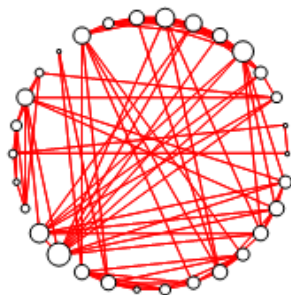
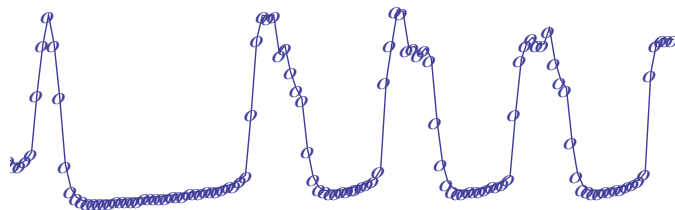
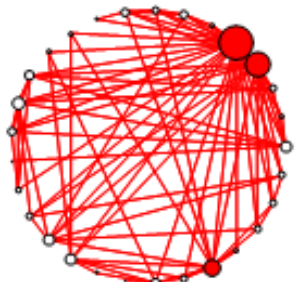
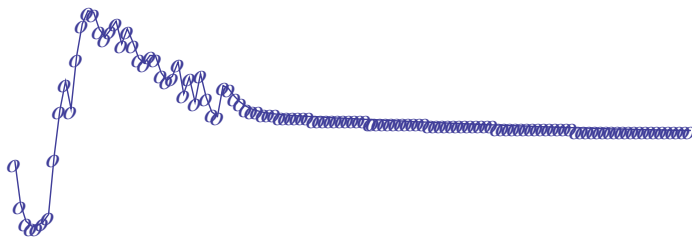
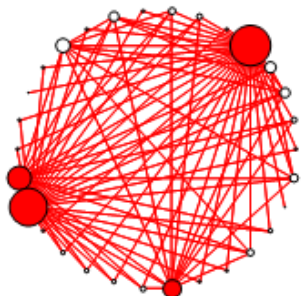
L. Kuepfer, Mol Sys Biol (2010)



povezava med celicama je odvisna
od **položaja celic** v otočku in sposobnosti za **komunikacijo**



struktura **skalno neodvisne mreže** je heterogena
sobivanje **vozlov** z majnim in velikim številom **povezav**



kratkodosežnost **aktivacijska**
dolgodosežnost **inhibitorna?**
optimalna struktura **“nekje vmes”?**

»Nature is inherently messy.«

Denis Noble, *The Music of Life*, 2006

»Nature is inherently messy.«

Denis Noble, The Music of Life, 2006

... and what a beautiful mess it is!