Exam Tuesday, January 18, 2005, 9.00-13.00.

20p in total feasible – roughly 10 p required for pass.

1. The figure above shows a small, undirected network. Calculate the degree distribution and present it in a table or a plot. [2]

2. Assume you have downloaded some network and you want to figure out whether a particular motif, say a feed forward loop, is overrepresented in this network. Describe shortly the main steps you would go through in order to carry out this task. [5]

3. A What is the whole point of the rate equation investigation of the Drosophila segment polarity problem? [1]
   B Describe some key components of this system. How many cells are used in the simulations? [1]
   C Roughly how many components (proteins, protein complexes) and parameters are used in the investigation? [1]
   D How is the system initialized and what fraction of the solutions turn out to be good ones? [1]
   E How does this translate into parameter sensitivity for the variables one by one? [1]

4. In the TGFβ pathway the extracellular TGFβ binds to and activates a cell membrane receptor R. The activated receptor (R∗) works as an enzyme for the phosphorylation of the protein Smad1. The phosphorylated Smad1 (P Smad1) then forms a complex with the protein Smad4, and the complex can also degrade back into P Smad1 and Smad4. Assume a mass action formalism in general and Michaelis–Menten formalism for the phosphorylation of Smad1 with a constant amount of active receptor.
\[ R^* \]
\[ \downarrow \]
\[ \text{Smad1} \rightarrow \text{PSmad1} \]

\[ \text{Psmad1} + \text{Smad4} \Leftrightarrow \text{PSmad1Smad4} \]

A Write down the differential equation for the time evolution of the concentration of PSmad1 (the phosphorylated Smad1 protein).
[2]

B Assume a constant concentration of Smad1, Smad4 and complex (PSmad1Smad4). Make a rough plot of \( \frac{dx}{dt} \) as a function of \( x \) (where \( x \) is the PSmad1 concentration). Describe the dynamics.
[2]

5. **Gene auto-activation**: Assume a protein activating its own production, and a simple degradation proportional to the protein concentration. The activation is governed by the Michaelis–Menten formalism.

A Write down the differential equation for the time evolution of the protein concentration.
[1]

B What happens for the protein concentration equal to zero?
[1]

C Analyse the dynamics.
[2]