Biological Physics II: Dynamics in Biological Systems

I. Deterministic dynamics

1. Qualitative analysis of dynamical systems *Strogatz, Chapter 2; Murray I, Section 1.1*

1.1 Dynamical systems

1.2 Logistic growth

1.3 Flows on the line

1.4 Bifurcations *Strogatz, Chapter 3; Murray I, Section 1.6*

1.5 Higher-dimensional flows

2. Dynamics of interacting populations

2.1 Predator-prey dynamics *Murray I, Sections 3.1 and 3.3; Hofbauer & Sigmund, Chapter 2*

2.2 Competetive exclusion *Murray I, Section 3.5; Hofbauer & Sigmund, Chapter 3*

2.3 Epidemic modeling *Murray I, Section 10.2*

3. Nonlinear dynamics in gene regulation
Molecular mechanisms of gene regulation; genetic switches and genetic oscillators

4. Chaos in biological systems
Characteristics of chaotic dynamics; logistic map; chaos in microbial communities

II. Stochastic dynamics

5. Elementary stochastic processes
Poisson distribution and Poisson process; birth-death processes; branching processes; Markov chains; Langevin equations

6. Noise in gene expression
Bursty expression dynamics; Fano factor and statistical kinetics; functional significance of expression noise: bet hedging

7. Exclusion models of cellular transport
The asymmetric simple exclusion process; exlusion models of translation and transscription; pore transport; transport by motor proteins

III. Spatiotemporal dynamics

8. Biological waves
Fisher waves; velocity selection; pulled and pushed fronts; effects of noise

9. Principles of pattern formation
Reaction-diffusion equations; linear stability and nonlinear evolution; Turing patterns

Books (*) available as e-books

M. Cross and H. Greenside: Pattern formation and dynamics in nonequilibrium systems. Cambridge University Press 2009 (*)

J.H. Hofbauer and K. Sigmund: Evolutionary Games and Replicator Dynamics. Cambridge University Press 1998 (*)

J.D. Murray: Mathematical Biology I: An Introduction. Springer 2002

J.D. Murray Mathematical Biology II: Spatial models and biomedical applications. Springer 2002

A. Schadschneider, D. Chowdhury and K. Nishinari: Stochastic transport in complex systems : from molecules to vehicles. Elsevier 2011 (*)

K. Sneppen: Models of Life. Cambridge University Press 2014 (*)

S.H. Strogatz: Nonlinear dynamics and chaos. CRC Press 2018 (*)

N. van Kampen: Stochastic Processes in Physics and Chemistry. North Holland 2007 (*)