CMPBIO210, IB201, IB120
Introduction to Quantitative Methods In Biology

Denis Titov –Lecture 8

Cell Signaling and Cell Cycle model

Overview of Part I of the course Differential equations

- What biological processes can differential equations describe?
- How to convert an idea/model/mechanism into differential equations?
- How to use a computer to easily solve differential equations?
- How to plot/analyze/interpret the solutions?

Most lectures will have a component of writing/discussing/reviewing python code, so you'll learn some python/programming along the way

Overview of Part I of the course Differential equations

Lecture Schedule

Dates	Topic	Instructor
1/19	Introduction	RN
1/21, 1/24, 1/26, 1/28, 1/31, 2/2, 2/4, 2/7	**Lecture 1.** Python Intro **Lecture 2.** Differential Equations Intro **Lecture 3.** Numerical solutions of ODEs using SciPy **Lecture 4.** Graphical methods of analyzing ODEs **Lecture 5.** Analytical solutions of ODEs using SymPy **Lecture 6.** Predator-Prey dynamics ODE models **Lecture 7.** COVID19 dynamics ODE models **Lecture 8.** Cell Signaling dynamics ODE models **Lab 1**: R & Python Basics **Lab 2**: Discrete Time Modeling **Lab 3**: Analytical Solutions to ODEs and Systems of Equations	DT

What should you learn from today's lecture?

- Brief overview of cell cycle regulation
- How to make a model of cell cycle that cycles?
- How to find and analyze the solution to this model?
- Introduction to dynamic systems theory for analysis of dynamic properties of systems of ODEs

Eukaryotic cell cycle

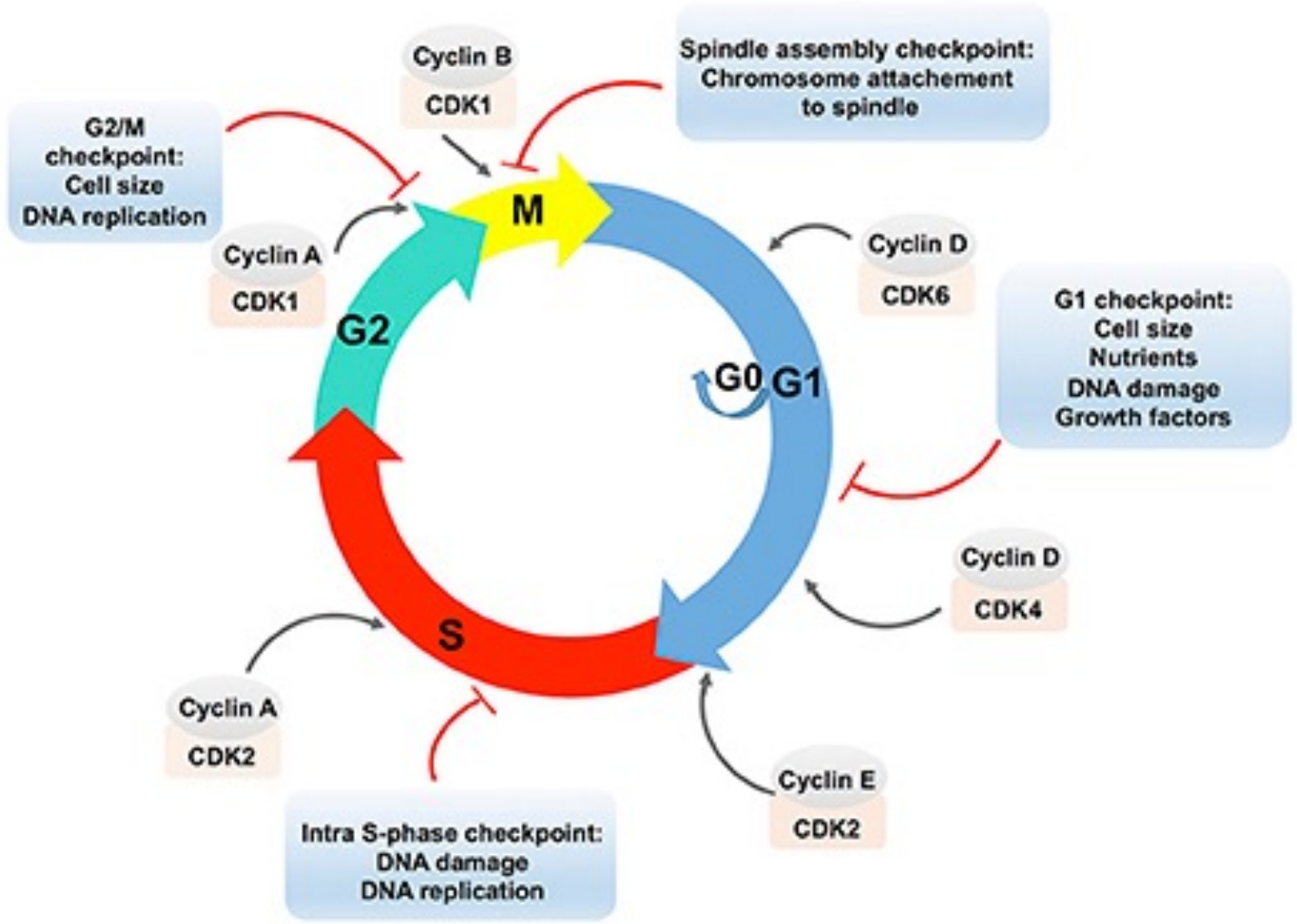


Image credit: https://doi.org/10.3389/fcimb.2017.00208

Cell cycle checkpoints and regulation

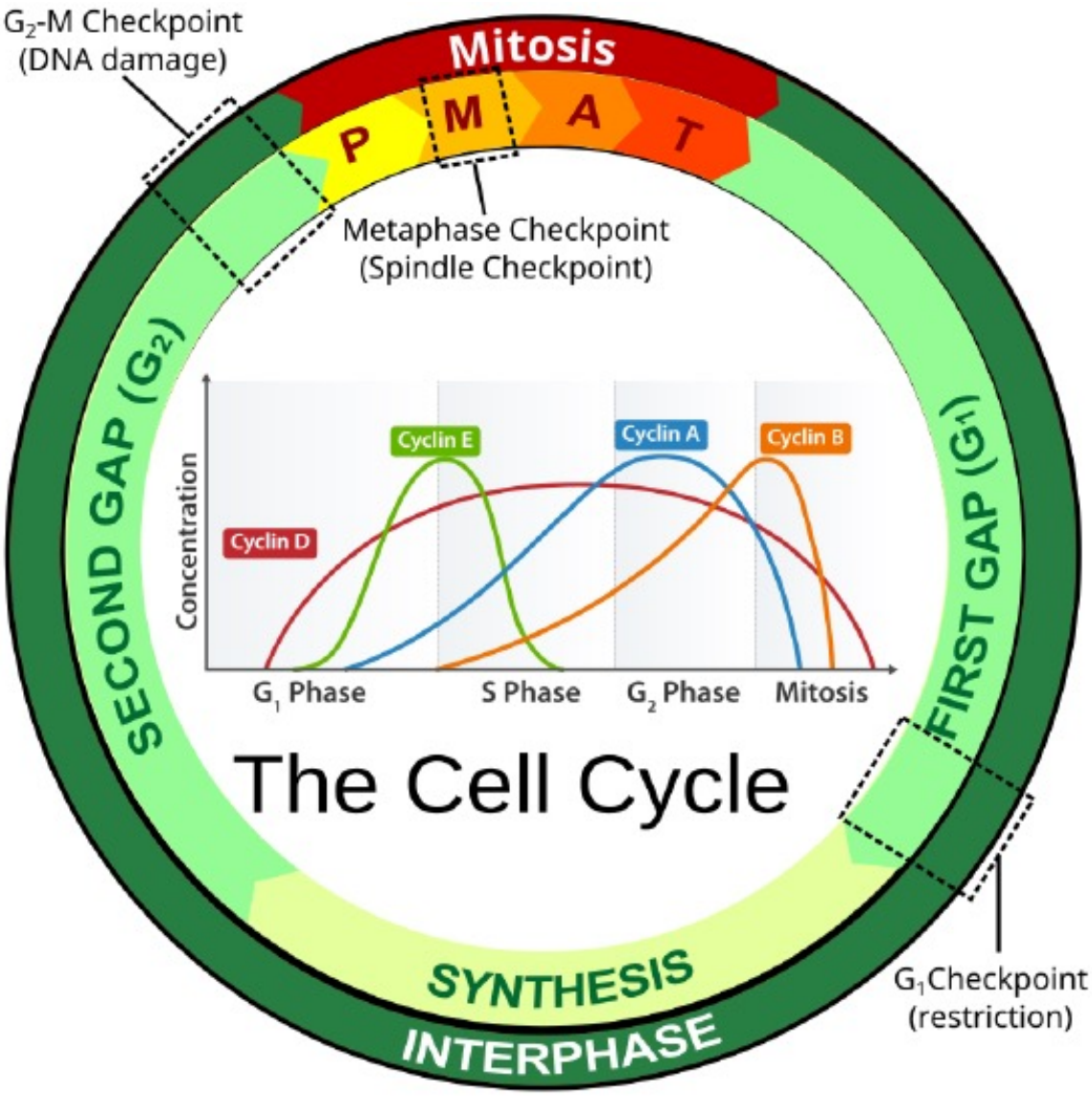
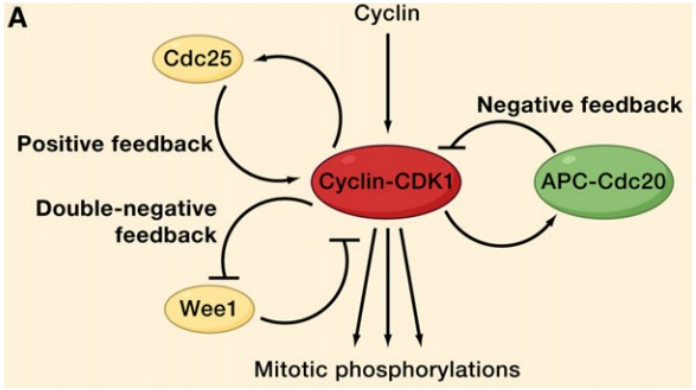


Image credit:
https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/07%3A_Cell_Reproduction/7.2%3A_Cell_Cycle_and_Cell_Division

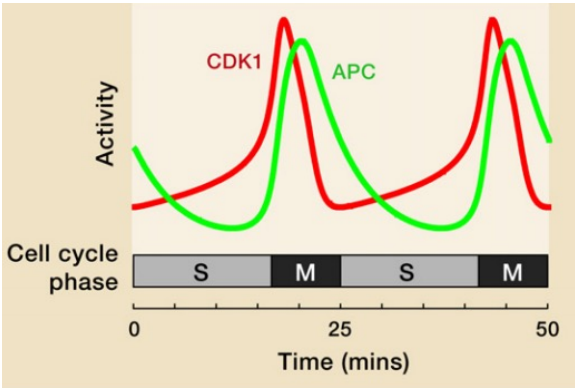
Mechanistic mathematical models



$$\frac{dCDK1^*}{dt} = \alpha_1 - \beta_1 CDK1^* \frac{APC^{*n1}}{K_1^{n1} + APC^{*n1}}$$

$$\frac{dPlk1^*}{dt} = \alpha_2 (1 - Plk1^*) \frac{CDK1^{*n2}}{K_2^{n2} + CDK1^{*n2}} - \beta_2 Plk1^*$$

$$\frac{dAPC^*}{dt} = \alpha_3 (1 - APC^*) \frac{Plk1^{*n3}}{K_3^{n3} + Plk1^{*n3}} - \beta_3 APC^*$$



Figures from https://www.cell.com/action/showPdf?pii=S0092-8674%2811%2900243-1

Optional reading on the topic of value of mechanistic mathematical models in biology:

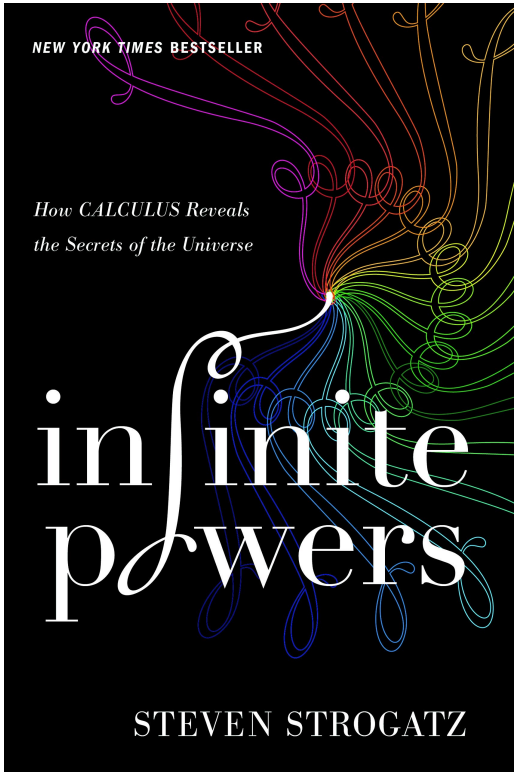
1. J. Gunawardena. Models in biology: 'accurate descriptions of our pathetic thinking'
2. R. Phillips. Theory in Biology: Figure 1 or Figure 7?
3. J. Cohen. Mathematics Is Biology's Next Microscope, Only Better; Biology Is Mathematics' Next Physics, Only Better.

Let’s numerically solve some differential equations with python

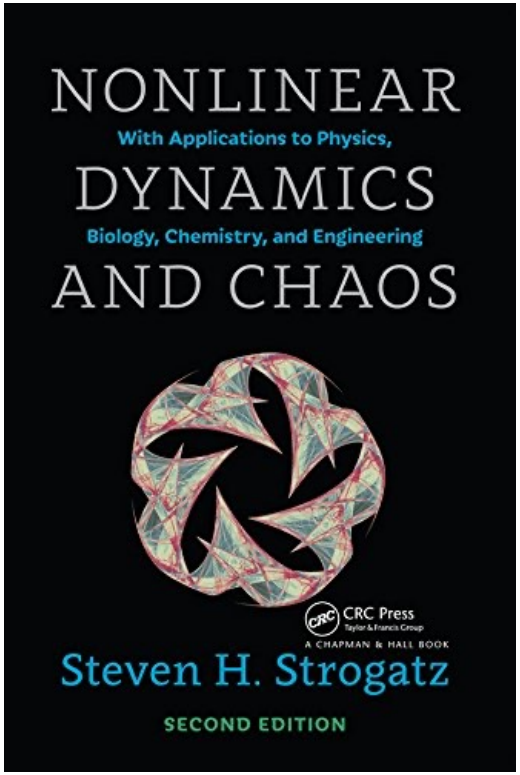
You can open Jupyter Hub that we’ve setup for you at the following link with your CalNet ID:

https://biology.datahub.berkeley.edu/hub/user-redirect/git-pull?repo=https%3A%2F%2Fgithub.com%2FIB120-201-CCB210%2FSpring2022&urlpath=tree%2FSpring2022%2F&branch=master

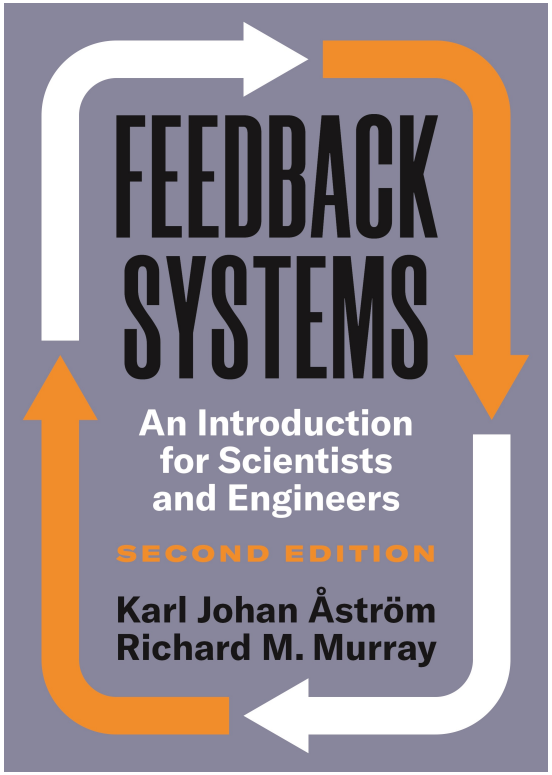
Additional optional reading if you want to learn more about differential equations and modeling



History and overview of calculus for non-scientists



Intro textbook for Nonlinear Dynamics and Chaos



Intro textbook for Dynamical Control