Rates of Chemical Reactions

The “Rates of Chemical Reactions” piece is about how chemical reactions regularly work. For a complete detailed description read that entire section. So summarize it a little bit:

Chemical reactions happen at a certain rate. A + B -> X + Y in a uni-directional reaction. It will stop once there is not enough fuel (A or B). The rate at which this conversion happens can be calculated. This is depicted in this chapter.

Enzyme Kinetics

Enzymes are catalysts in living systems. They make complex reactions happen at lower temperature and a lot faster. Proteins used as catalyst will first be used and then regenerated with during a multi-step process. Enzyme catalyzed reactions are normally rate-limited by enzyme saturation, meaning their limit depends on how many enzymes you got. Afterwards there is a whole example on how to calculate this rate etc…

Synthetic gene networks

Due to advanced molecular manipulation techniques and more knowledge on genetics we are slowly getting closer to using synthetic networks to manipulate cellular behavior. This chapter is about building genetic networks and its modular genetic components. In many ways these synthetic networks have analogies with electrical circuits. To understand how this synthetic network works we need to understand the components and how they interact.

Transcriptional control operates at the level of mRNA synthesis through the use of inducible transcriptional activators and repressors that are capable of binding naturally occurring or specifically engineered promoters. The majority of systems utilize bacterial response regulators or activators that, upon binding to a target promoter, inhibit or activate transcription respectively. Binding of a specific molecule to the response regulator induces an allosteric change leading to disassociation of the regulator from its cognate promoter.

Bacterial response regulators also form the basis of synthetic eukaryotic gene regulation systems although given transcriptional differences they require adaptation. This has been successfully achieved for many bacterial response regulators by placing the operator for the response regulator adjacent to an eukaryotic compatible promoter. The response regulator thus acts as a heterologous DNA-binding protein (DBP) whose association with the desired promoter can be controlled through addition of an appropriate inducer. If the operator is placed close to an strong constitutive promoter, DBP binding can prevent the initiation of transcription by RNA polymerase II machinery. Alternatively, transcription can be actively repressed by fusing a eukaryotic transcriptional silencer, such as the Kruppel-associated box protein (KRAB), to the DBP. Such systems are referred to as ON-type systems, as the addition of an inducer leads to de-repression of transcription. In an OFF-type configuration, in which addition of inducer leads to transcriptional silencing, a transcriptional activation domain is fused to the DBP. By placing the corresponding operator site adjacent to the minimal promoter, DBP binding activates

transcription from an otherwise silent minimal promoter. Addition of an inducer results in the subsequent deactivation of transcription. Be sure to check out the diagram! (figure 15-1)

The expression output of many cell-based regulatory networks is often a logic response generated by one or more input signals. Due to the sigmoid-shaped dose-response curves, most gene control systems can be seen as the genetic equivalent of an analog-to-digital converter. The output is either ON or OFF based on the inducers concentrations. There is a small space where the difference in concentration is very low between OFF and ON, but apart from this we can easily see the resemblance with logical gates.

Using certain gene control systems responsive to tetracycline, macrolide, streptogramin and butyrolactone we can make all kind of gates, including NAND, INVERTER and NOR. Again see the diagram (figure 15-12).