# Understanding the importance of kinetics through complex systems and drug design – Alia Zander

## Purpose

This lesson challenges students to analyze a complex system with the goal of ultimately manipulating the system to produce the outcome that they desire. Students will practice studying rates and appreciate the importance of knowing a rate of a reaction when determining final concentrations and designing a drug to alter a given system. All of this will be accomplished through an example involving the production of proteins after turning on a gene so that students are exposed to the research being done in science and engineering labs at Northwestern University.

## Overview

The lesson begins with students familiarizing themselves with our system of genes and proteins by going through a worksheet that asks questions highlighting the important details of the system. The teacher will go over rates in general, ways to increase the final product, and stress the importance of knowing the rates of reactions. Students will then analyze a graph and conclude that for 100% survival after being infected with the flu, a certain amount of product is required from our complex system. Students will then spend time designing a drug that ensures enough product is produced after 30 minutes and they can present their ideas to the class.

## Student Outcomes

- SWBAT undestand how genes and proteins are regulated in a complex system by looking at a model.
- SWBAT design a drug to manipulate a complex system and make predictions about their system under different conditions.
- SWBAT draw a model to represent how their drug is incorporated into the complex system.
- SWBAT explain why blocking/degrading/adding proteins and using catalysts would affect the rate of a reaction.

## Time

This activity was completed in two 70-minute class periods, but students could easily spend longer designing their drug and presenting the mechanism of their drug.

## Level

This lesson was taught in a 10$^{th}$ grade Chemistry class, but it could also be taught in a biology class.

## Materials and Tools

Handouts and powerpoints for the lesson are included as separate documents:

- Worksheet_Day1

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- Worksheet_Day2
- Powerpoint_Day1
- Powerpoint_Day2

For the drug design process students will be in groups of 4 and each group will need a white board and markers.

## Preparation

Teachers should have gone through the worksheets themselves and be able to design a drug using several different methods.

## Prerequisites

None.

## Background

Today we will be doing a lesson to learn what it's like being a PhD student in computational biology by breaking down complex systems and manipulating them for our advantage. This skill isn't just important for computational biology, but for problem solving skills in general and challenging yourselves. Once you put in the work to get an idea of how the genes and proteins in our system are working together, we can spend time designing drugs to improve people's health after influenza infection.

## Teaching Notes

Day 1:

1. Introduction to set up next two days.
   Show students an actual complex system to begin and describe the way proteins can bind to genes and turn them on or off (PowerPoint slides). Knowing the rates is important for us to be able to model these systems to make predictions and answer questions about flu infection and other illnesses and diseases. Then talk about our system of proteins/genes and tell students that protein C is important for fighting the flu. Have students work on the worksheet that has an example system so they can see what Northwestern University research is like and learn about rates.

2. Worksheet_Day1 questions 1-3.

3. Give a talk about different mechanisms protein A is using to slow down the production of protein C.
   Draw picture of protein B that has a region to bind to the gene. The region on the C gene is occupied if A is there so B has difficulty binding to the gene. Alternatively, A could be binding to B and then B cannot bind to gene C because there are less of them to collide with the gene.

4. Discuss how the kinetics of the reaction can change if there is more of a protein available
   If there are more collisions, more binding, then more protein will be produced. If you have more time, the reaction can keep happening and you can produce more protein.

5. Worksheet_Day2 questions 4-7.

Day 2:
1. Do now at the top of Worksheet_Day2. Go through a couple examples and then give students time to finish the questions.

2. Recap what we learned on day 1 and then give the background on the graph that they will do claim, evidence, reasoning for. Students analyze graph in Worksheet_Day2

3. Go over strategies for designing drugs in powerpoint slide so that students can work to create their own drug and draw a model to show how it works. Stress that creativity is encouraged.

4. Have groups explain their drug and present their model on small marker boards.

**Assessment**
Teachers can patrol the classroom while students are working on their day 1 worksheets and talk to groups to assess their understanding. There will also be time in class to go over the correct answers and have students explain the process they used and the reasoning behind their answers. On day 2, the class will go over answers to the do now and the claim/evidence/reasoning for the graph they analyzed. Additionally, students will present their model and the describe how their drug works and walk the class through their design process.