

BM5063 Mathematical Physiology and Systems Medicine

Problem Set 3

Instructions

1. You are not expected to submit answers to these problems
2. *How to approach this problem set:* Questions may not have a unique answer here. Try working on them to explore the scenario described by developing a model carefully. Identify the variables and parameters, fast and slow variables, simplifying assumptions, and generalizations.

Questions

1. *Pioglitazone* is an oral antidiabetic medication that increases insulin sensitivity in certain tissues. Suppose a person is prescribed to take two doses of *pioglitazone* per day. Write down the equations describing the dynamics of the insulin-glucose system. What will change if the dose is reduced to one?
2. Read about the role of glucagon in blood glucose level regulation. Extend the model developed in the class to incorporate the role of glucagon function.
3. Write a Python program to simulate the blood glucose dynamics to study the onset of pre-diabetes and its further progression to type-2 diabetes.
4. SGLT2 inhibitors (available in the market as *empagliflozin*, *dapagliflozin*, and *remogliflozin* etc.) are a class of prescription medications used to manage type 2 diabetes by blocking glucose reabsorption in the kidneys, causing excess sugar to be excreted through urine. Develop a model.
5. GLP-1 agonists (one of the popular names is *ozempic*) work by increasing glucose-dependent insulin secretion and suppressing glucagon. Formulate a mathematical model to study the effect.
6. We have introduced several therapeutics for type-2 diabetes. Formulate a mathematical model and use numerical simulation to identify the potential combination therapies.
7. Using numerical simulation of the mathematical model, can you design a diet regimen (a practical one, don't ask them to stop taking sugar) for a person suffering from type-2 diabetes?
8. As seen in the class, cortisol dynamics also follows a similar interaction network as that for glucose. It is also seen that chronic stress increases cortisol, which in turn reduces insulin sensitivity. Develop a mathematical model to study this system.
9. Read about the therapeutics of type-2 diabetes.

