BM5063 Systems Medicine

Problem Set 3

Instructions

1. You are not expected to submit answers to these problems

Questions

1. The brain takes up glucose from the blood at an insulin-independent rate.
   (a) Modify the glucose-insulin-Beta cell model to describe this effect.
   (b) Is the steady-state blood glucose level affected by the brain's uptake rate?
2. As discussed in the class, consider the carrying capacity of the Beta cells where their growth cannot go on beyond a limit. You can use logistic growth to model this effect.
   (a) Write down the equations.
   (b) How many fixed points are there in this system? Interpret these fixed points in terms of healthy and diseased states.
   (c) Write `Python` code to simulate this effect and show it can result in pre-diabetes.
3. Many medical situations are treated by drugs that mimic cortisol called corticosteroids (such as dexamethasone or prednisone), to reduce inflammation, swelling, and autoimmune diseases. Millions of people take such drugs at high doses for many weeks.
   (a) Modify the HPA axis model to include the effect of the drug.
   (b) Explore the effect of the drug on steady-state hormone levels. What is the effect on the gland sizes?
   (c) Write down `Python` program to explore HPA dynamics with and without drug intake.
   (d) Suppose there is a brief crisis where the external stimulus (say stress) is increased for a short duration. In another scenario, consider a chronic condition where stress remains high for a very long time. Compare the impacts of these two conditions.