An Introduction to Mathematical Modeling in the Life Sciences

Final Project Idea (V0.0)

Zhen-Yu Liu (刘振宇) Yuanpei College 1700017853

Subject:

Mathematical modeling of the glucose-insulin homeostatic control system

Reason:

The glucose-insulin system is one of the clearest and simplest examples of homeostatic control in the organism. Many researchers have investigated the physiological mechanisms of the feedback regulation of blood glucose level and insulin secretion. However, due to the increasing importance of identifying insulin resistance, there is a strong need to have a reliable mathematical model for this system. Besides providing clinical protocols to compute insulin sensitivity of the patient, mathematical models the system may also generally allowing a more accurate knowledge of the regulatory mechanisms underlying glucose–insulin homeostasis.

Since the research in our laboratory focuses on the development and homeostasis of mammalian pancreas, especially the islet, we frequently conduct experiments about glucose tolerance and insulin sensitivity. Our researches always adopt the traditional biological perspective. I think it would be very helpful if we try to analyze the blood glucose-insulin homeostasis using mathematical modeling.

Anticipations:

I think this system could be modeling by a simple two-dimension toy model: blood glucose level (G) and insulin level (I). And the relation of these two state variables could be restricted by ordinary differential equations (ODEs), where glucose stimulates the secretion of insulin and insulin decreases the glucose level. A way to improve the toy model might be introducing another state variable X, representing the intake of glucose into somatic cells, since insulin functions mainly through enhancing the absorbing and consuming of blood glucose. Using this 3-dimension model, we might be able to represent the dynamics of blood glucose level and insulin level, both in physiology state or after a well-defined glucose tolerance test.

Actually, there have been some mathematical models for this system, the *Minimal Model* (MM model) in the late seventies[1], the *DDE model* [2] in 2000 with significant improvement of the MM model, and the *Single Delay Model* [3] (SDM) in 2007. We might try several of previously published models and make some reasonable modifications to generate a model for this system, and try to research the properties of this homeostasis basing on the model.

Reference:

[1] R.N. Bergman, Y.Z. Ider, C.R. Bowden, C. Cobelli, Quantitative estimation of insulin sensitivity, Am. J. Physiol. 236 (1979) E667.

[2] A. De Gaetano, O. Arino, Mathematical modelling of the intravenous glucose tolerance test, J. Math. Biol. 40 (2000) 136.

[3] S. Panunzi, P. Palumbo, A. De Gaetano, A discrete single delay model for the intra-venous glucose tolerance test, Theor. Biol. Med. Model. 4 (2007).