

BM5063 Mathematical Physiology and Systems Medicine

Exam 1

Instructions

1. This exam is open notes where you can use any hand-written material. Photocopies/prints/books/electronic devices are not permitted to be used.
2. Questions 1-6 can have **more than one correct** answers. There is a 1 mark for each correct option you choose and -1 for each wrong choice.
3. For questions 7-9, please write your answers clearly. Use your notebook to do rough calculations, if required.
4. You are expected to work on these problems on your own. **Any reasonable signs of 'copying/plagiarism' will attract penalties.**

Questions

1. Which of the following are the fixed points of the system $\dot{x} = -x/(1+x)$
 - (a) $x = 0$
 - (b) $x = -1$
 - (c) $x = +1$
 - (d) There is no fixed point in this system
2. How many stable fixed points does $\dot{x} = -x/(1+x)$ have
 - (a) None
 - (b) 1
 - (c) 2
 - (d) 3
3. Which of the following can result in higher blood glucose levels at steady state
 - (a) A decrease in insulin sensitivity
 - (b) An increase in insulin sensitivity
 - (c) A larger Beta-cell mass
 - (d) An increase in insulin resistance
4. The brain takes up glucose from the blood at an insulin-independent rate. Which of the following can describe the rate of change in glucose levels in the brain
 - (a) $\dot{g} = a(t) - \beta_1 g$
 - (b) $\dot{g} = a(t) - \beta_1 g - \gamma g f_1(I)$ where f_1 is the same function discussed in the class
 - (c) $\dot{g} = a(t) - \beta_1 g m$ where m is the mass of the brain and m_b is some constant
 - (d) $\dot{g} = a(t) - \beta_1 g f_1(I) m$ where m is the mass of the brain and m_b is some constant
5. Identify the odd one
 - (a) TSH:ACTH:MSH:Glucose
 - (b) Thyroid gland:adrenal gland:melanocytes:Beta-cells
 - (c) Thyroid hormone:cortisol:melanin:Insulin
 - (d) None of the above

6. Which of the following is more likely to result in diabetes

- (a) A high rise in blood glucose for 12 hours
- (b) A moderate rise in blood glucose for a month
- (c) A large drop in insulin sensitivity for 12 hours
- (d) A moderate drop in insulin sensitivity for a month

7. Justify your answer to the last question. **(3)**

8. Cells have clocks that track the time of day called circadian clocks. Beta cells secrete more insulin for a given level of glucose during the day rather than during the night. Write down the equations describing the rates of change in glucose and insulin levels considering this effect. *You only have to write the final equations. No analysis is required. Define all the variables in the equations.* **(5)**

9. As discussed in the class, regulation of the thyroid hormone also follows the same mechanism as that of glucose, including the *dynamic compensation* by a change in the size of the thyroid gland. Write down the equations for thyroid hormone regulation, and define all the variables introduced. **(5)**

