

Hormone circuits

Uri Alon (Spring 2021)

Exercise 1

(Lectures 1+2)

(Due 4/5/21)

1. Use the phase portrait to predict food intake and fat as a function of time in the following cases. The answer should be a schematic plot of u and F as a function of time, and a plot of the dynamics as arrows on the phase portrait:
 - a) after a liposuction operation that removes some of an organism's fat.
 - b) after a gastric bypass operation that reduces the stomach, modeled by reducing the maximal food intake u_{max} .
 - c) after a drop in the rate of leptin clearance (removal) by the kidneys, γ_L .
 - d) During hyperthyroidism, in which metabolic rate increases due to excessive levels of the thyroid hormones that control metabolism. Check your answer qualitatively by googling hyperthyroidism and seeing whether fat and appetite go up or down relative to normal (paste from internet, max 30 words).
 - e) Think of an additional condition that is of interest. Which parameter(s) is affected?

2. Rodents provided with a variety of foods (buffet-style) eat more and gain fat compared to rodents provided with a single food type. Both can eat as much and as often as desired.
 - a) What experiment can determine whether the food-fat conversion parameter α_F is the same in both cases? Explain using the phase portrait.
 - b) Suppose the food-fat conversion parameter α_F is found to be the same in the buffet and single food experiments. What might be going on? (50 words).

3. Simulation of fat dynamics: this is our first taste of numerical simulations, which we will use in the course to understand hormone circuits. We start simple: A simulated animal has fat $F_0 = 1$ at time $t=0$ and then food supply stops so that food intake is $u=0$.
 - a) Write an equation for dF/dt
 - b) Numerically solve the equation, with $\gamma_E = 1$, $\gamma_F = 1$. Plot $F(t)$ versus time.
(Be aware that in this simulation, it is normal for fat to drop below 0, even though in reality of course fat can not be negative)
 - c) What is the value of F_{st} in this case? Show calculation.
 - d) At what time does fat drop to zero? Answer either with the simulation or by an analytic solution of the equation.