Homework Problem 1 – 10 points

- Consider the basic model of in-host infection with the virus loss term AND an eclipse stage split into 2 parts
- Draw a flow diagram
- Describe model variables and parameters
- Derive the basic reproduction number
- Find the model equilibria (fixed points)
- Show that the infected equilibrium can only exist if the basic reproduction number is greater than 1

$$\frac{dx}{dt} = \lambda - d_x x - \beta x v$$

$$\frac{de_1}{dt} = \beta x v - d_e e_1 - \alpha e_1, \qquad \frac{de_2}{dt} = \alpha e_1 - d_e e_2 - \alpha e_2$$

$$\frac{dy}{dt} = \alpha e_2 - d_y y$$

$$\frac{dv}{dt} = k y - \beta x v - d_v v$$

Homework Problem 2 – 8 points

- Again, consider the basic model of in-host infection with the virus loss term AND an eclipse stage split into 2 parts (see Homework Problem 1)
- Rewrite the model to take into consideration infectious and non-infectious virus particles. Justify the structure that you chose.
- Add an equation for antibodies. Add in the neutralization for virus particles by antibodies. Justify why you added antibodies in the structure that you chose.
- Add an equation for cytotoxic T-cells. Add in the killing of infected cells. Justify why you added CTL in the format that you chose.
- Add an equation for Interferon and add in terms that represent the effects of interferon into the model. Justify your choices.

Homework Problem 3 – 4 points

- Read
  - Heffernan, J. M., and M. J. Keeling. "An in-host model of acute infection: Measles as a case study." *Theoretical population biology* 73.1 (2008): 134-147.
  - Heffernan, J. M., and M. J. Keeling. "Implications of vaccination and waning immunity." *Proceedings of the Royal Society B: Biological Sciences* 276.1664 (2009): 2071-2080
- Comment on the utility of embedding in-host information into epidemiological models (1 page)