BB-101 Tutorial – 3

Quiz question.
Please write the answer on an A4 sheet and submit it at the end of the Friday class (27/10/2023). Ensure your Roll number and name are on the A4 sheet. You may prepare the answer even before coming to the class.

1. We learned that molecular motors kinesin and dynein can generate force and drag cargo inside our cells. Scientists have purified single kinesin and dynein motor molecules in laboratory and have examined the speed with which they will move when a force f is applied against their movement (like a cargo). It turns out that these two motors show interestingly different force-velocity relations. Dynein velocity is highly sensitive when the applied force varies in the small force range, and insensitive when the force is varied in the large force range. That is, the velocity change is larger when the force is changed by a single unit at low forces. At large forces, the velocity change is smaller when force is changed by a single unit. For kinesin, this is opposite. That is, at small applied forces, the kinesin velocity is less sensitive to force change. At large applied force, the kinesin velocity highly sensitive to force change. Make an approximate sketch of velocity as a function of force both for kinesin and dynein (both should be plotted in the same graph making it easy to compare). Scale the X-axis with the maximum force generated by the respective motor; scale the Y-axis with the maximum velocity at zero force for the respective motor.

   (1+1 Marks)

Tutorial questions: Please answer the tutorial questions below in your notebook and not in the quiz A4 sheet. You do not have to submit them. It is only for your training purpose.

1. In reality, actin monomers can polymerise and depolymerise at both the ends of an actin filament. Consider an actin filament with ATP-bound monomer polymerisation and depolymerisation at both the ends. Let $k_{on}^{+}= k_0^{+}[c]$, k_{off}^{+} be the 'on' and 'off' rates on the positive end, and $k_{on}^{-}= k_0^{-}[c]$, k_{off}^{-} be the 'on' and 'off' rate on the negative end, where [c] is the concentration of ATP-bound actin monomers in the solution. The numerical values of the rates are

$$k_0^{+} = 11.6(\mu M)^{-1}s^{-1}, k_{off}^{+} = 1.4s^{-1}, k_0^{-} = 1.3(\mu M)^{-1}s^{-1}, k_{off}^{+} = 0.8s^{-1} \qquad (1)$$

   Assume that ATP-hydrolysis does not happen (for simplicity).

   (a) What is the concentration at which the plus end is neither growing nor shrinking on an average? That is, rate of polymerisation and the rate of depolymerisation on the plus end will be equal.

(b) What is the concentration at which the minus end is neither growing nor shrinking on an average?

(c) What happens to the polymer when it is at a concentration [c]$= 0.1\mu M$ and [c]$= 0.9\mu M$, respectively?

(d) Find the concentration range at which the actin polymer's plus end will grow and the minus end will shrink.

(e) What happens when [c]=0.3 μM?