BB 101: Physical Biology

TUTORIAL 3

1. In chromosomes, DNA molecules are wrapped tightly around protein molecules called histones, whose radius is 45 Å. Given bending stiffness k_b=300 Å kcal mol^{-1}, Calculate the energy required to bend a DNA molecule into a semi-circle?

2. The concentration profile c(r) of molecules (with diffusion constant D) as a function of distance r away from the center of an absorbing surface of radius b is given by $c(r) = a[1-(b/r)]$, where a is concentration of molecules at $r = \infty$. An absorbing boundary means that when a molecule contacts/collides with the surface, it is absorbed, dissipated or transformed.

(i) Obtain an expression for the number of molecules colliding with the surface of sphere per unit time. What is the meaning of minus sign in the expression you have obtained?

(ii) Obtain an expression for number of molecules colliding with the surface of sphere between time T_1 and T_2 (Given $T_2 > T_1$)

3. Suppose that drug molecules diffuse out of a tablet (which is modelled as a thin plane wall) into a solution. In addition to diffusion, the drug molecules also undergo a chemical reaction which causes drug to deplete with time in proportion to its present concentration. The constant rate of the chemical reaction which depletes the drug molecules with time is k and D is the diffusion constant of the drug. Find out the concentration profile for the drug as a function of distance x away from the tablet wall in the solution in the steady state i.e. when concentration doesn't change with time. Show that drug will be drawn out of the tablet rapidly if it has high diffusion constant or has a high reaction rate in solution. (*Hint: Add one extra term to diffusion equation to include the effect of depletion of drug due to chemical reaction*)

4. Suppose a drug is encapsulated between two planes at x=0 and x=h. Suppose that drug depletes out of both planes at constant rate R

(i) Write down the corresponding diffusion equation (*Hint*: In this case $\frac{\partial c}{\partial t} = -R$)
(ii) Solve for c(x) inside the tablet, subject to boundary condition c(0)=c(h)=0, that is, the drug is used up the instant it is released
(iii) Compute the flux of the drug out of the tablet