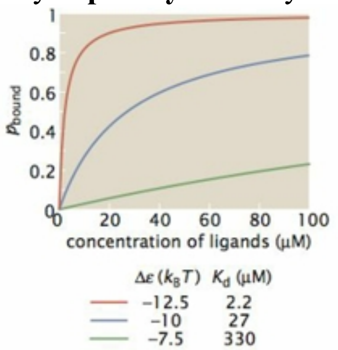
PHYS3511-Biological Physics

Fall 2018, Assignment #6 Due Wednesday November 14, 2018

Read Chapter 6: section 6.1 page 237-248; Section 6.2.2 and 6.2.3 page 262 to 267; Section 6.4.1 and 6.4.2 page 270 to 273. The information on these sections may be used in multiple-choice questions in **quiz 2** and the **final exam**.

Exercise 1) In Figure below, pick at least **two points** from each of the **three** curves, and verify **explicitly** that they are consistent with the $\Delta\epsilon, K_d, c_0$ and the equation for P_{bound}.

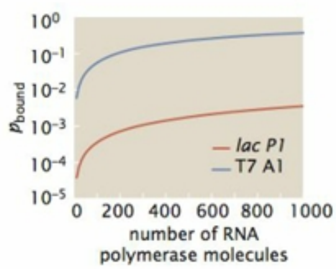


function of ligand concentration. The figure shows the average number of ligands bound as a function of the number of ligands in solution. The plot shows curves for three choices of $\Delta\varepsilon$: −7.5, −10, and −12.5 k_BT, and a standard state $c_0 = 0.6$ M. The binding energies are also translated into the language of equilibrium dissociation constants.

$$p_{bound} = \frac{(c/c_0)e^{-\beta\Delta\varepsilon}}{1+(c/c_0)e^{-\beta\Delta\varepsilon}}.$$

Exercise 2) Chapter 6, Problem 6.3

Exercise 3) Combine the plot below with your results of $\Delta\epsilon_{pd}$ from exercise 2, and the relation of P_{bound}. To estimate the values of N_{NS} for both curves.



occupancy as a function of the number of RNA polymerase molecules. p_{bound} is computed using values for the specific and nonspecific binding of RNA polymerase obtained *in vitro* and corresponding to the *lac* promoter, and the A1 promoter from the phage T7.

$$p_{bound} = \frac{1}{1+\frac{N_{NS}}{P}e^{\beta\Delta\varepsilon_{pd}}},$$

Exercise 4) Chapter 6, Problem 6.5

Exercise 5) Chapter 6, Problem 6.9

6.3 Polymerase binding to the promoter revisited

The probability of promoter occupancy can be computed using both statistical mechanics and thermodynamics (that is, using equilibrium constants). These two perspectives were already exploited for simple ligand–receptor binding in Sections 6.1.1 and 6.4.1.

(a) Write an expression for the probability of finding RNA polymerase bound to the promoter as a function of the equilibrium constants for specific and nonspecific binding.

(b) *In vitro*, the dissociation constant of RNA polymerase binding to nonspecific DNA is approximately 10 μM and the dissociation constants of RNA polymerase to the *lac P1* and T7A1 promoters are 550 nM and 3 nM, respectively. Use these constants and the results from (a) to estimate the *in vivo* binding energies of RNA polymerase to *lac P1* and T7A1 promoters.

6.5 Distinguishable ligands

Derive the probability that a receptor is occupied by a ligand using a model that treats the L ligands in solution as distinguishable particles. Show that the expression is the same as obtained in the text (Equation 6.19), where the ligands were treated as indistinguishable.

6.9 Osmotic pressure of a cell

In Section 6.2.3, we derived the van't Hoff formula for the osmotic pressure and performed an estimate of the osmotic pressure experienced by a bacterium as a result of its impermeability to inorganic ions. Examine the contribution to the osmotic pressure of a bacterium coming from the presence of proteins within the cell.

How does this compare with the contribution to the osmotic pressure from inorganic ions described in the section? See Table 2.1 and Figure 2.4 for the relevant data.