

# Recitation 7

10/3/06

**Exercise ex1.6.8.** Consider the simple, symmetric, four-state carrier model. For each of the following conditions, find  $\mathcal{N}_E^i$ ,  $\mathcal{N}_E^o$ ,  $\mathcal{N}_{ES}^i$ ,  $\mathcal{N}_{ES}^o$ , and  $\phi_S$ . Explain the physical significance of each of your answers.

- $\alpha = 0$ .
- $\beta = 0$ .
- $K = 0$ .

**Exercise pr1.6.3.** The unidirectional transport of sugar molecules into red blood cells of badgers,  $\bar{\phi}_s$ , is measured by means of radioactive tracers as a function of the external concentration of the sugar molecules,  $c_s^o$ . The results for 4 different types of sugar molecules are plotted in Figure 6. It

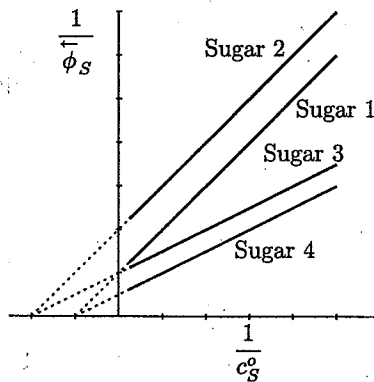


Figure 1: Flux versus concentration in reciprocal coordinates. The straight lines were fit to the measurements (not shown).

is known that the transport of 10 types of sugar molecules through badger red-cell membranes can be described by a simple, symmetric, four-state carrier model. The values for the parameters  $K$  and  $(\bar{\phi}_s)_{max}$  for these sugars are given in Table 1 including the value for Sugar 1. Determine the identity of the three measured sugars (2,3 and 4) among those (A-I) in the table.

Sugar Species	$K$ (mmol/L)	$(\bar{\phi}_s)_{max}$ ( $\mu\text{mol}/\text{cm}^2 \cdot \text{s}$ )
A	20	20
B	20	80
C	40	40
D	40	80
E	40	40
F	20	10
G	10	40
H	20	5
I	10	20
1	20	40

**Exercise ex1.6.9.** Consider the simple, symmetric, four-state carrier model when  $c_s^i = c_s^o = 0$ . Sketch the carrier density in each of its four states as a function of  $\alpha/\beta$ . Give a physical interpretation of your results.

Ex. 1.6.8

Recitation 7

10/3/06

- a. Since  $\alpha$  is zero, none of the enzyme can translocate to face the extracellular solution. Therefore the densities of outward facing enzymes  $\mathcal{N}_{ES}^o$  and  $\mathcal{N}_E^o$  are zero. The inward facing densities partition in proportion to the intracellular concentration of solute and the dissociation constant for the binding reaction. Therefore,

$$\mathcal{N}_{ES}^i = \frac{c_S^i}{c_S^i + K} \mathcal{N}_{ET} \text{ and } \mathcal{N}_E^i = \frac{K}{c_S^i + K} \mathcal{N}_{ET}.$$

Since the enzyme cannot translocate, the flux of solute  $\phi_S$  is also zero.

- b. The case  $\beta = 0$  is similar to the case  $\alpha = 0$  except that the enzyme can not face the intracellular solution. Therefore the densities of inward facing enzymes  $\mathcal{N}_{ES}^i$  and  $\mathcal{N}_E^i$  are zero. The outward facing densities partition in proportion to the extracellular concentration of solute and the dissociation constant for the binding reaction. Therefore,

$$\mathcal{N}_{ES}^o = \frac{c_S^o}{c_S^o + K} \mathcal{N}_{ET} \text{ and } \mathcal{N}_E^o = \frac{K}{c_S^o + K} \mathcal{N}_{ET}.$$

Since the enzyme cannot translocate, the flux of solute  $\phi_S$  is also zero.

- c. If  $K = 0$ , the enzyme cannot dissociate. Therefore, if there is any extracellular or intracellular solute, it will bind to the enzyme and never unbind. Therefore the unbound densities  $\mathcal{N}_E^i$  and  $\mathcal{N}_E^o$  will be zero. The bound densities will partition by the forward and reverse translocation rate constants, so that

$$\mathcal{N}_{ES}^i = \frac{\beta}{\alpha + \beta} \mathcal{N}_{ET} \text{ and } \mathcal{N}_{ES}^o = \frac{\alpha}{\alpha + \beta} \mathcal{N}_{ET}.$$

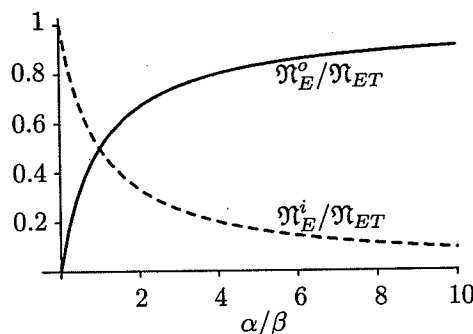
Since the solute cannot unbind, there will be no transport,  $\phi_S$  will be zero.

**Exercise ex1.6.9.** For  $c_S^i = c_S^o = 0$  there is no carrier bound to solute:  $\mathcal{N}_{ES}^i = \mathcal{N}_{ES}^o = 0$ . From Equations 6.56 and 6.58 (weiss1-1996?) it follows that

$$\mathcal{N}_E^i = \frac{\beta}{\alpha + \beta} \mathcal{N}_{ET} = \frac{1}{(\alpha/\beta) + 1} \mathcal{N}_{ET},$$

$$\mathcal{N}_E^o = \frac{\alpha}{\alpha + \beta} \mathcal{N}_{ET} = \frac{(\alpha/\beta)}{(\alpha/\beta) + 1} \mathcal{N}_{ET}.$$

These relations are plotted in Figure 2. If  $\alpha/\beta = 1$  then half the carrier is in the inside configuration and the other half is in the outside configuration. As  $\alpha/\beta$  is increased, more of the carrier is found in the outside configuration, whereas as  $\alpha/\beta$  is decreased, more of the carrier is found in the inside configuration



Recitation 7  
10/3/06

**Exercise pr1.6.3.** For a simple, symmetric, four-state carrier mechanism

$$\frac{1}{\bar{\phi}_s} = \frac{1}{(\phi_s)_{max}} \left( 1 + \frac{K}{c_s^o} \right).$$

The intercept at  $1/c_s^o = 0$  is  $1/(\phi_s)_{max}$ ; the intercept for  $1/\bar{\phi}_s$  is  $-1/K$ . The parameters determined from the graph are given in Table 1.

Sugar	K	$(\phi_s)_{max}$	Sugar
1	20	40	I
2	10	20	I
3	10	40	G
4	20	80	B

**Table 1.** Transport parameters.