# Module 09: Cell Trafficking and Molecular Transport
Assignment
## Total Point Value = 30

Due by midnight on Day 7 of Module 9
This should be submitted to Blackboard as a pdf.

1. Understanding and analyzing molecular transport mechanism is necessary when designing basic cell culture experiments and perfusion of biomaterials using a bioreactor. Oxygen delivery to cells in culture can by modeled using Fick's Law. Transport of oxygen from the gas phase (P_g) to the cell phase (P_c) is driven by the oxygen gradient across the height of the medium. The rate of oxygen uptake by cells however can be modeled with Michaelis-Menten kinetics (what we use for facilitated diffusion) (from P_c into the cell).
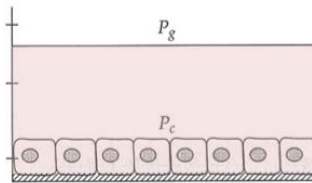

a) In lecture, we graphed dn/dt as a function of dC/dx for simple diffusion. What is the slope of this line? What do increases or decreases in the slope mean biologically?
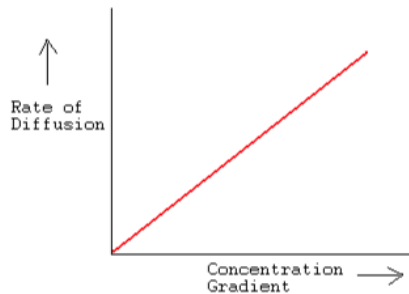
The slope of this line represents how the rate of diffusion depends on the concentration gradient. Biologically this is the relationship between the concentration gradient of the molecule diffusing and the rate at which it diffuses. The slope is equal the area of the membrane, A, times the permeability constant, P, which is a property of the molecule diffusing (based on its size, lipid solubility etc). When the slope increases there is either an increase in the area of membrane across which the molecule is diffusing, or a change in the permeability constant. A higher slope indicating a faster rate of diffusion and a lower slope indicating a slower rate of diffusion (for a set concentration gradient). The slope can also change if dC/dx changes – if the molecule diffusing is more/less abundant or if the source of that molecules has moved closer/further from the membrane.

b) Now assume the concentration gradient is a constant. How does the rate of diffusion (dn/dt) change with the surface area of the cell and the permeability of the diffusing molecule? Graph dn/dt as a function of A or P and describe the physiological function.
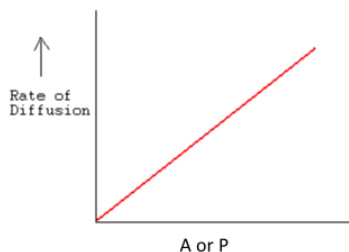
The rate of diffusion is linearly proportional to both the area and the permeability. This function tells us that there are two ways to directly increase the rate of diffusion if we cannot increase the concentration gradient. This is often the case as the gradient is limited by the production rate of the cell and creates a metabolic burden. If the body needs to increase the rate of diffusion of a molecular species it can increase the area for transport or produce

molecules with higher permeability constants. This is in fact something nature does! Think about the capillary bed – this portion of the vasculature has an enormous surface area to aid in diffusion. Also think about the molecules that are most critical for passage – O_2. These molecules have a small diameter and high lipid permeability. So even though we can't change the atmosphere we can maximize our oxygen diffusion rate with A and P. Of course we do change the concentration gradient in medical situations!

2. Describe 3 principles of bioreactor design used in bioreactors for creating functional tissues – one of your three may be from Dr. Grayson's lecture (improved mass transfer or biostimulation), and the other two you will need to independently research. In each description explain what the principle is, why it is important and some ways that bioreactors are being designed to meet that principle.

   There is a long of possibilities for this question – potential answers include:
   - improved mass transfer
   - biostimulation
   - providing the correct balance of nutrients and gases
   - sterility
   - functions reproducibly
   - patient specificity (molding)
   - robust if used for repeated cultures
   - inexpensive if used for single use cultures
   - imaging or monitoring capacity

3. In the paper *Engineered cell homing*, by Sarkar et al. researchers describe a new method to enhance homing of mesenchymal stem cells (MSCs) to inflamed tissue. In 250 words or less please compare this method to adoptive cell therapy. What are the pros and cons of each?
   Points given for the comparison, pros and cons of each.

Assignment Rubric

Question	Component	Total Point Value
1	a	4
	b	4
2		12
3		10

Total Point Value = 30