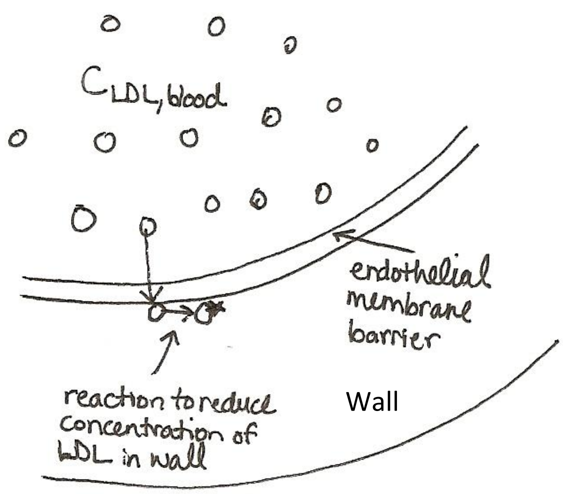
Homework Set 8

BE-382, Winter '08-'09, Dr. C. S. Tritt (conceived by Dr. LaMack)

Due on something a ballerina would wear.

1. The inner lining of arteries (the endothelium) acts as a membrane barrier to the transport of LDL ("bad cholesterol") from the blood into the vessel wall, as shown in the diagram. The concentration of LDL in the blood of a patient ($C_{LDL,blood}$) is 100 mg/dl (or 1.00 mg/cm^3). The LDL permeates through the endothelium into the vessel wall, where it is rapidly modified, keeping the concentration of LDL in the wall near zero. The permeability of LDL through the endothelium is 1.00×10^{-8} cm/s. Calculate how much LDL (in mg) will cross the barrier in an arterial segment with a diameter of 0.500 cm and a length of 2.00 cm over a 24 hour period. Assume that convective transport of LDL across the barrier is negligible.



If you were told that the presence of modified LDL in the arterial wall promotes atherosclerosis, which leads to heart attacks and strokes, name 2 risk factors that you have heard associated with heart attacks and strokes, and explain why you think they might increase risk, *based on the transport process described in this problem*.

2. Different cells are capable of generating different resting membrane potentials, which are essential to secondary active transport mechanisms, excitability, and generation of action potentials. The resting membrane potential of a cell is determined by which ions it actively pumps across the membrane (and in which direction) and to what extent the ions are allowed to "leak" back across the membrane down their electrochemical potential gradient. Suppose a muscle cell has a resting membrane potential that is primarily determined by the transport of K^+, Na^+, and Cl^-. The cell actively pumps Na^+ and Cl^- out and pumps K^+ in. Passive leakage (permeability) of Na^+ across the membrane is very low, while the permeability of K^+ is about 10 times that of Na^+.

The following are the concentrations of these ions inside and outside of the cell:

Ion	Extracellular Fluid (mM)	Cytoplasm (mM)
$[Na^+]$	122	9
$[K^+]$	2.5	140
$[Cl^-]$	122	2

a) The resting membrane potential for this cell at 37°C is experimentally found to be −86 mV. Calculate the permeability of Cl^- of the cell relative to that of Na^+. For your reference, at this temperature, the quantity RT/F is equal to 26.72 mV.

b) In addition to “leak” channels that allow ions to very slowly travel back down their electrochemical potential gradient, cells have gated ion channels that respond to chemical and electrical signals by opening and selectively allowing ions to pass across the membrane. This causes a rapid increase in the permeability for the ion, although the sudden transport of the ion across the membrane only negligibly affects the chemically relevant concentration of the ion inside and outside the cell. Opening and closing of channels in this manner causes huge swings in the membrane potential, called depolarizations and repolarizations. Calculate the membrane potential following a sudden opening of gated Na^+ channels that causes the permeability of Na^+ to become many orders of magnitude larger than those of K^+ and Cl^-. Repeat for the individual openings of K^+ and Cl^- channels.