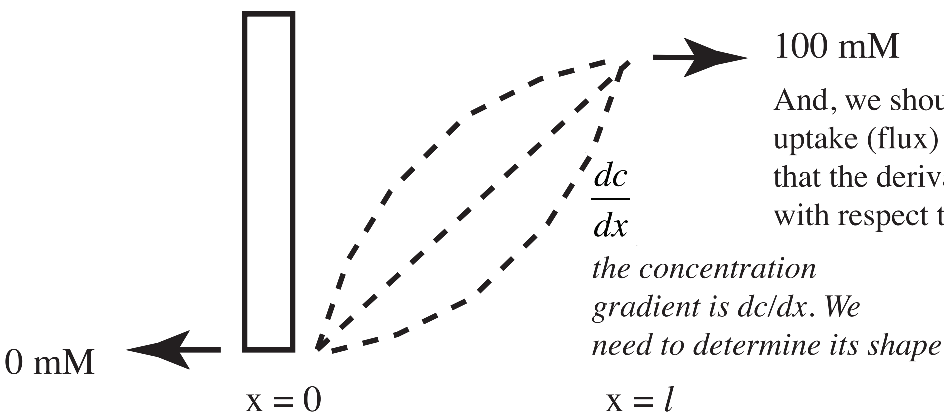
Uptake of glucose by your digestive tract requires that glucose molecules diffuse to the intestinal wall where they are absorbed. Assuming a high glucose content (say, 100 mM) and that the intestinal wall is such an efficient absorber that [glucose] at the wall is zero, what is the flux through the intestinal wall? (HINT: The solution is not elegant)

Assumptions: We should use a planar absorptive surface (it makes the math a lot easier).



And, we should assume 'steady state' uptake (flux) of the glucose. This means that the derivative of concentration with respect to time is zero:

$$\frac{dc}{dt} = 0$$

We also need to know the diffusion coefficient for glucose. Googling yields many values. Here's one (for 30ªC): 7×10^{-10} m^2 s^{-1} or 7×10^{-6} cm^2 s^{-1}.

Now, if dc/dt = 0 (recall that dc/dt = d^{2}c/dx^2 from your course notes), we need to find a solution of the flux equation J = –D(dc/dx) that satisifies the condition –D(d^{2}c/dx^2) = 0. A linear gradient is the solution (dc/dx of c = ax is a —a constant— and d^{2}c/dx^2 of c = ax is zero). Thus the flux equation J = –D(dc/dx) has the solution J = –D[c(x)–c(0)]/l:

$$J = -(7 \times 10^{-6}\ \text{cm}^2\text{s}^{-1})\frac{(0.1 - 0)\ (\text{mole}\ [10^3\text{cm}^3]^{-1})}{l\ (\text{cm})}$$

This is where 'inelegance' appears, what is the value of l (the length)? The length must be related to the width of the intestinal lumen. If we assume l = 1 cm, the calculations are easier, and it's not an unreasonable assumption of the lumen width. So the flux is:

$$J = -(7 \times 10^{-6}\ \text{cm}^2\text{s}^{-1})\frac{(0.1 - 0)\ (\text{mole})}{10^3\ (\text{cm}^4)} = 7 \times 10^{-10}\ \text{mole cm}^{-2}\text{s}^{-1}$$

Don't forget the 1/l dependence of flux. Decreasing the length estimate will increase the flux, something that could have a very significant effect in the biological world.

How long would it take for a glucose molecule to diffuse to the intestinal wall? We can rely on Einstein as described in your course notes.

$$\left\langle x(t)^2 \right\rangle = 2Dt \qquad \frac{\left\langle x(t)^2 \right\rangle}{2D} = t \qquad \frac{1^2\ (\text{cm}^2)}{(2)(7 \times 10^{-6}\ \text{cm}^2\text{s}^{-1})} = 71429\ \text{seconds (19.8 hours)}$$

19.8 hours is a very long time. Clearly diffusion alone is insufficient.