

Purpose:

To illustrate the quantitative interaction between osmotic and hydrostatic convective forces. The model system is a U-tube, the two halves of which are separated by a semi-permeable membrane.

General Information:

Program name = "**starling.rt**" on any of the PowerMac computers in the LRU or "**starling.exe**" on any of the Pentium computers in the LRU or MSL Rm 180. The program can also be downloaded from the course website for use at home.

Directions:

- 1) Double click on the "**starling.rt**" icon to load the program.
- 2) On the left side of the display, the initial volumes and solute concentrations on sides A and B can be adjusted. The characteristics of the membrane (σ , L_p) and the type of solute (which determines ϕ and i) can also be specified.
- 3) Use the mouse to move the analog slide controls up and down (to adjust volumes and concentrations). The mouse changes into a pointing finger when it is moved over the controls. For fine adjustments, click on the small up / down arrows next to the digital displays, or double-click on the number inside the digital display (when the number is highlighted, enter a new number from the keyboard then hit return to enter it).
- 4) To run the model, click on the --> symbol or select "**run**" from the "operate" menu. The program will stop by itself (this will usually take a few seconds) or it can be halted by pressing the "stop" button which appears during execution.
- 5) Under the "**operate**" menu, choose "**reinitialize all to default**". This returns all the variables to their default state, where

$\text{vol.}_A = \text{vol.}_B = 1.0$ liter, $\text{conc.}_A = \text{conc.}_B = 0.15$ M/liter, $\sigma = 1.0$, $L_p = 10$, and solute = NaCl.

Problems:

- 1) Determine how water redistributes when 1 liter solutions of 0.15 M NaCl and 0.20 M NaCl are placed on the two sides of the membrane. To do this, return all variables to their default values, then set $\text{conc.}_B = 0.20$ M/l and run the model.
 - a) What is the magnitude and direction of the hydrostatic pressure gradient in the steady state? Why?
 - b) Given the same initial conditions, how does changing the solute from NaCl to CaCl_2 affect the steady state pressure gradient? Why?
 - c) Given the same initial conditions for CaCl_2 , how does lowering L_p from 10 to 1 alter the steady state pressure gradient? How does it alter the time to reach steady state?
- 2) Return all variables to their default values, set $\text{conc.}_B = 0.20$ M/l and run the model.
 - a) How is the steady state pressure gradient affected by reducing σ from 1.0 to 0.5? from 0.5 to 0.1? Why?

- b) Despite what the model will indicate, what should the final concentrations be on sides A and B if $\sigma = 0$? Why?
- 3) Return all variables to their default values, set $\text{conc.}_A = 0.30 \text{ M/l}$ and run the model. In the steady state:
- Which side has the greater volume?
 - In what direction is net water movement?
 - In what direction is hydraulic water movement?
 - In what direction is osmotic water movement?
 - Which side has a higher concentration of solute particles?
 - Which side has a greater number of solute particles?
- 4) Return all variables to their default values, set $\text{conc.}_A = 0.30 \text{ M/l}$ and run the model. Now experiment with changing the initial volume on side B to see the effect on the steady state volumes (re-run the model each time you change vol._B).
- What initial volume on side B (vol._B) will produce an equilibrium state in which $\text{vol.}_B = \text{vol.}_A$? Why?
 - If hydrostatic forces did not operate, use the van't Hoff Eq. to calculate the pressure gradient that would be generated by the initial concentration difference.