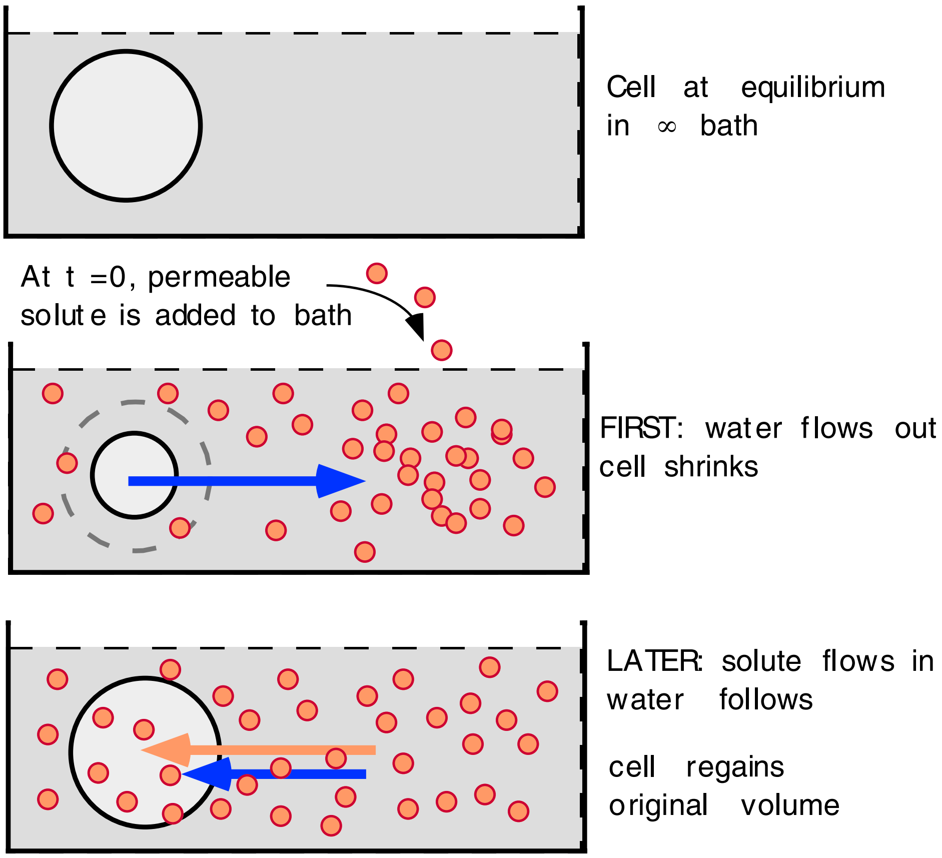
CELL PERMEABILITY - CURVE FITTING EMPIRICAL DATA

Features:

- Importing empirical (numerical) data
- Curve fitting model parameters to the data.

Description of the model:

Experimental data was obtained by measuring how cell volume, v, responds to the sudden introduction of a permeable solute into the bathing medium. The problem is to extract both the water permeability (Pw) and the solute permeability (Ps) from the data. The experiment is illustrated in the figure. The model assumes that all movements are rate limited by moving across the membrane barrier; it takes account of osmotic water flow coupled to solute diffusion through the membrane. Equations are described below.



Follow these steps:

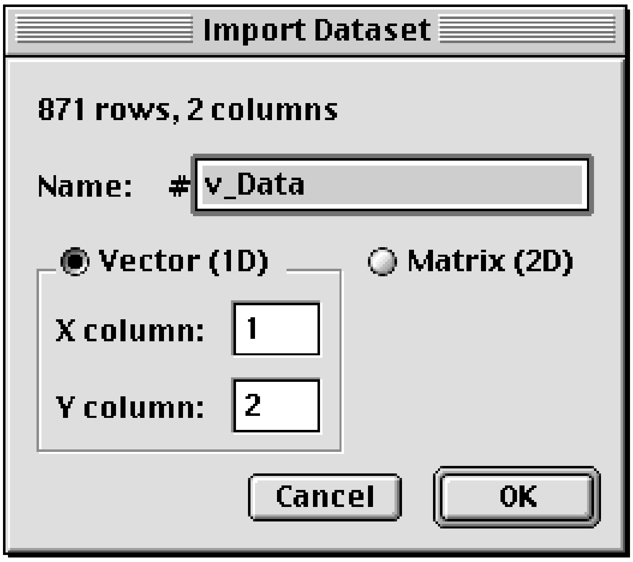
1. Run the model. Curve fitting requires an initial guess of all unknown parameters. In our case we guess Pw = 0.002 and Ps =0.001. These are entered in the model as though they were known (see Equation Window). Running the model shows the results of our guess verifies that the solution shows first a volume, v, shrinkage and then a swelling back towards normal.

2. Import data

a. Select Import Dataset from the File menu. The standard Open dialog will appear

b. Open the enclosed data file entitled "v_Data". This is a simple 2 column text file (Data can be text or spread sheet files with an unlimited number of columns). The dialog shown below will appear. It describes the data file, allows you to rename it, and allows you to choose which column represents the independent (x axis) variable and which represents y. Numerical data files in Berkeley Madonna are referred by by a # prefix. The default name is shown below.

c. Click OK



Notice the large discrepancy between the data and the model run with the guessed parameters (note change in scale).

3. Curve fit

a. Click Curve fit in the Parameters menu. The dialog shown below (truncated on the right side) appears.

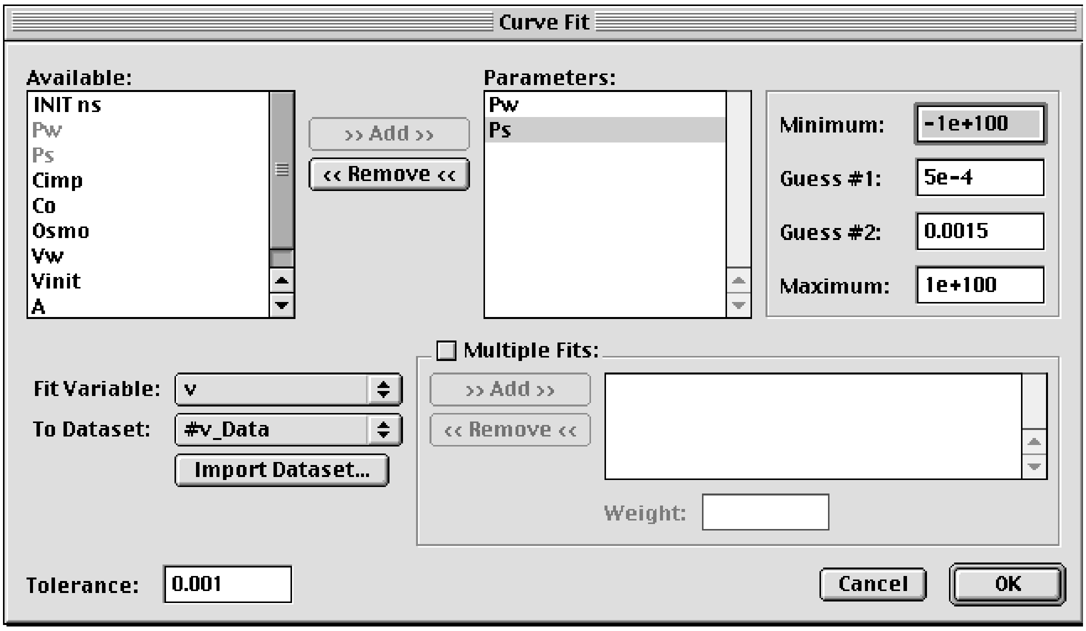
b. Double click on the unknown parameters Pw and Ps.

c. Use the FIt Variable pulldown menu to select v.

d. Check that #v_Data is entered in To Dataset .

e. Click OK. You are finished!

Parameter values used in the plotted curve fit can be found in the current Parameter window. (See the Users manual for more options on curve fitting. For example, the right hand side of the dialog can be used to limit the permissible parameter values.)



Model Equations

The model is described by two coupled differential equations:

d/dt(nw) = Pw*A*(Osmi-Osmo)

d/dt(ns) = Ps*A*(Co - Ci)

where:

nw = number of moles of water inside the cell

Pw = molar water permeability of cell

A = area of cell

Osmi = osmolarity inside cell

Osmo = osmolarity outside cell

ns = number of moles of permeable solute inside the cell

Ps = solute permeability

Co = permable solute concentration outside

Ci = permable solute concentration inside

The data was obtained from red blood cells made into "ghosts" where the internal solutes were replaced by saline making the cell volume virtually equal to the internal water volume. It follows that

Vol = nw* Vw

Vol = cell volume in cm^3

Vw = molar volume of water

v = Vol*1.0e12 = cell volume in μ^3

The rest of the model consists of initial conditions, definitions, and conservation relations. The size of the model could be reduced through algebraic substitutions; but why bother? Let Madonna figure it out!

EQUATIONS

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METHOD RK4
STARTTIME = 0
STOPTIME = 5
DT = 0.02

d/dt(nw) = Pw*A*(Osmi-Osmo)
d/dt(ns) = Ps*A*(Co - Ci)
Vol = nw* Vw{ Vol = cell volume, Vw = molar volume of water}
v = Vol*1e12            { change units from cm^3 to μ^3}

Ci = ns/Vol
init nw = Vinit/Vw
init ns = 0
Pw = .002       {initial guess (water Perm) to be resolved by curve fitter}
Ps = 0.001      {initial guess (solute Perm)to be resolved by curve fitter}

Osmi = (ns+nimp)/Vol    { nimp = number moles of internal impermeable solute}
nimp = Cimp*Vinit       {Cimp = external conc of impermaeable solute}
Cimp = .0003            {300 mOsm = .0003 Osm/cm^3}
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Co = .0003

Osmo = .0003 +.0003

Vw=18

Vinit=87e-12

A = 140e-8