Chapter 37

Quantitative Aside 37.1--The Speed of Water

In 2003 Peter Agre won the Nobel Prize in Chemistry for his work on aquaporins—water transport channels. In plants, these channels, which allow water to freely cross a membrane, are found in both vacuole and plasma membranes. The discovery of aquaporins was fuelled by quantitative thinking.

Diffusion through the lipid bilayer alone made sense until the rate of water movement across membranes was measured. Measuring water flow across a cell membrane takes a bit of creativity. Agre and others have used *Xenopus* oocytes whose membranes have relatively low water permeability. The oocytes are very large for cells, 600 to 1300 m, and it is possible to inject aquaporin encoding RNA into the oocyte, where it is translated into protein and inserted into the membrane. Both control and injected oocytes are then transferred to a hypotonic solution where the control cells barely swell and the injected oocytes quickly explode like popcorn within 2 to 6 minutes. The rate of swelling, prior to bursting, was used to calculate the osmotic water permeability, 0.1×10^{-2} cm/sec without aquaporins compared with 1.0 to 2.0×10^{-2} cm/sec with aquaporins. To count the number of aquaporin channels in the membrane, the cells were frozen in liquid nitrogen and fractured before being examined microscopically so the channels could be visualized. Using the difference in rate of water movement with and without aquaporins and the number of aquaporins it was estimated that a water molecule could move through an aquaporin channel at a rate of $\sim 3 \times 10^9$ water molecules per channel per second—much, much faster than the rate of water movement through a lipid bilayer.

Certainly $\sim 3 \times 10^9$ water molecules per channel per second is a huge number, but how does that translate into the functioning of a whole plant? Over 35 aquaporin genes have been identified in the model plant, *Arabidopsis*, and it is possible to block the expression of one or more of these genes in a plant. Depending on which and how many aquaporins are repressed, the plants either wilt or die; strong evidence for the critical nature of aquaporins in osmosis.

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