

1st grade: Ca²⁺ inward flow from the extracellular space and its buffering in the intracellular space

Summary: Calcium ion (Ca²⁺) plays essential role in the signal transduction in cells, especially in neurons. Its concentration is exactly regulated, and it is more than four order of magnitude lower in intracellular space, which is maintained by Ca²⁺-permeable ion channels, its release from ER in the cytoplasm, Ca²⁺ buffers, and so on. Here we focus on the binding of buffer proteins to Ca²⁺ that enters intracellular space through ion channels (Fig.1).

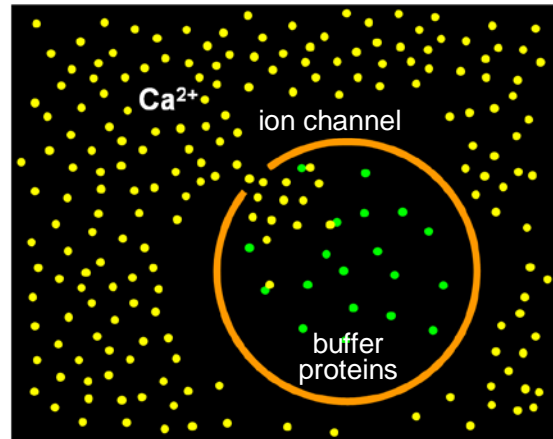


Fig.1 Inward flow of Ca²⁺ and its buffering

Cartoon and A-Cell model: In this simple example, Cartoon and A-Cell model for the buffering is the same as shown in the left and bottom middle panel in Fig.2. Shape model is a 2D disk (right panel in Fig.2), and Ca²⁺ was assumed to flow into the intracellular space through top 5 compartments shown in red. Extracellular Ca²⁺ and its inward flow are modeled by a stimulus with step function allowing constant supply of Ca²⁺. Buffering reaction was embedded to all compartments.

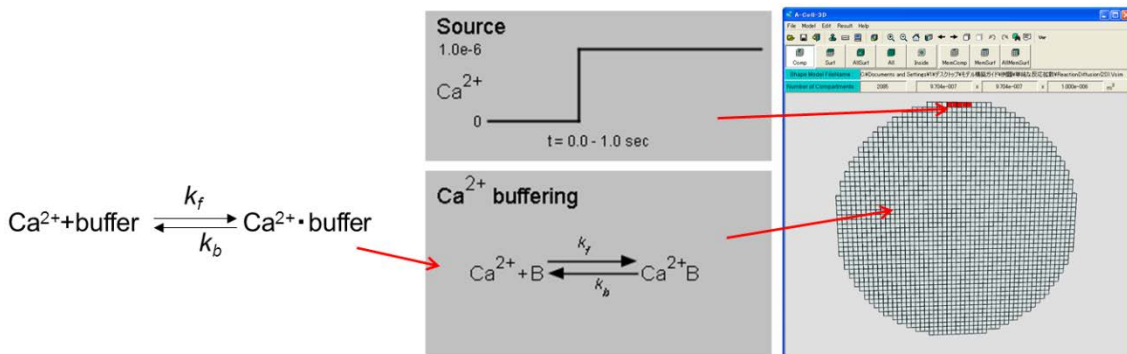


Fig.2 Cartoon and A-Cell

Simulation result with diffusion coefficient of Ca²⁺ of 10⁻¹⁰ m²/s, simulation time of 0-5 ms, calculation step of 1 μs, and output step of 0.1 ms is shown in Fig.3. Buffer protein was not diffusing. It is interesting to compare with a case without buffer proteins or diffusing buffer protein.

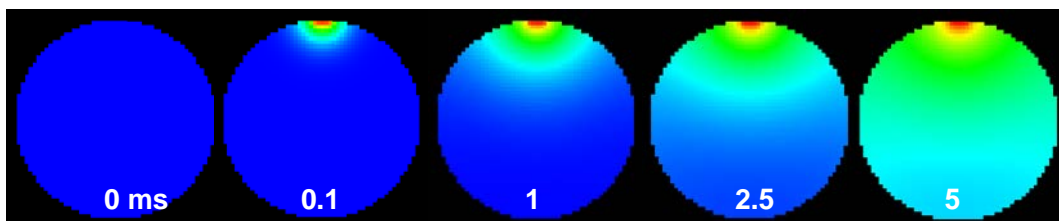


Fig.3 Simulation result for Ca²⁺