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# Brain Tissue Modeled as a Porous Medium with parameters derived from Micro-Iontophoresis Experiments

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The cellular structures of the brain are separated by a narrow fluid-filled extracellular (interstitial) space giving brain tissue properties of a porous medium. The porosity and tortuosity can be measured by releasing tetramethylammonium cations from a micropipette and measuring the time-dependent concentration about 100 µm away using an ion-selective microelectrode (ISM), as shown in Fig. 1 [1].
Fitting the results of experiments to an appropriate solution to the diffusion equation [1, 2] revealed that that the typical porosity is $\phi$ ~ 0.2 and the tortuosity is $\tau$ ~ 1.6, where tortuosity = sqrt(D/D*), D is free diffusivity and D* is effective diffusivity. These results were modeled by regarding the brain as an ensemble of cubic cells of side 2a with cubic voids (expansions of interstitial space) of side b at each corner. Cells were separated by sheets of interstitial space of width 2w and the packed cells formed composite voids of width 2b, as shown in Fig. 2. [4]
Monte Carlo simulations took place in this ensemble using the MCell program [3]. It was found that, to obtain the experimental $\phi$ and $\tau$, the required geometry was a = 0.742 µm, b = 0.379 µm and w = 20 nm [4]. The presence of voids was essential to obtain the measured tortuosity and this feature was consistent with freeze-fixed electron microscopy and super-resolution optical imaging [4].
References
1. J. Odackal, R. Colbourn, N. J. Odackal, L. Tao, C. Nicholson, and S. Hrabetova. Real-time iontophoresis with tetramethylammonium to quantify volume fraction and tortuosity of brain extracellular space, JoVE: e55755 (2017).
2. E. Syková, and C. Nicholson. Diffusion in brain extracellular space, Physiological Reviews, 88 (2008) 1277-1340.
3. J.R. Stiles, and T.M. Bartol. 2001. Monte Carlo methods for simulating realistic synaptic microphysiology using MCell. in E. De Schutter, Editor, Computational Neuroscience: Realistic Modeling for Experimentalists, CRC Press: London; 2001, p 87 - 127.
4. C. Nicholson, Sheet and void porous media models for brain interstitial space, Journal Royal Society Interface, 20 (2023): 20230223.

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