

The amplitude and time course of extracellular potassium concentration changes during potassium flux through brain tissue

By A. R. GARDNER-MEDWIN. *Department of Physiology, University College London, London WC1E 6BT*

In several different situations extracellular potassium ($[K^+]_o$) has been measured during a flux of K^+ through brain tissue. The flux has been caused variously by ionophoretic K^+ injection (Lux & Neher, 1973), raised $[K^+]_i$ in fluid at the surface (Fisher, Pedley & Prince, 1976) and a voltage gradient through the tissue (Gardner-Medwin, 1977; Gardner-Medwin & Nicholson, 1978). In the first two papers the results are interpreted as consistent with K^+ movement occurring mainly through interstitial clefts while the third set of results suggests that K^+ movement occurs largely through cells. This paper describes a model which fits the data obtained with voltage gradients and it discusses the relationship between the different results.

The model includes two routes for K^+ movement: (1) simple diffusion and mobility within the interstitial clefts, and (2) passive transport across the membranes and cytoplasm of cells whose processes have a uniform electrical space constant, *ca.* 0.3 mm. The parameters are such that over large distances approximately four times as much K^+ moves through cells as through clefts and the effective diffusion coefficient for K^+ within the clefts is *ca.* $0.9 \times 10^{-5} \text{ cm}^2 \text{ sec}^{-1}$ (*cf.* $2.5 \times 10^{-5} \text{ cm}^2 \text{ sec}^{-1}$ for aqueous solution). It is assumed that changes of $[K^+]_o$ are accompanied by approximately equal changes of $[K^+]_i$, roughly as expected for a passive Gibbs-Donnan redistribution for cells which are permeable to anions as well as to K^+ (Conway, 1957). Inclusion of a diffusion barrier at the pial surface raises the required K^+ diffusion coefficient, but has little effect on other parameters. A selective barrier at the surface could not itself explain the apparent K^+ selectivity of transport within the brain, since the $[K^+]_o$ changes beneath the surface should then be in the wrong direction.

The relative importance of cleft and transcellular K^+ movement should be similar for gradients of electrical potential and of concentration. Thus the different conclusions described above are surprising. The results of Lux & Neher (1973) refer, however, to $[K^+]_o$ changes at short distances from the source of K^+ (*ca.* 50–100 μm), and over these distances transcellular movement through cells with large space constants should not contribute substantially. Furthermore, in their experiments there should have been larger proportional changes in amplitude than in time course for the observed $[K^+]_i$ rises (compared with results in aqueous fluid) if K^+ did not enter cells at any distance from the source. In the experiments of Fisher *et al.* (1976) there may also have been substantial unmeasured entry of K^+ into cells, which would have led the authors to underestimate the K^+ flux in their experiments. Thus transcellular K^+ movement may be of general importance for the redistribution of K^+ , except over short distances.

REFERENCES

- CONWAY, E. J. (1957). *Physiol. Rev.* **37**, 84–132.
 FISHER, R. S., PEDLEY, T. A. & PRINCE, D. A. (1976). *Brain Res.* **101**, 223–237.
 GARDNER-MEDWIN, A. R. (1977). *J. Physiol.* **269**, 32–33P.
 GARDNER-MEDWIN, A. R. & NICHOLSON, C. (1978). *J. Physiol.* **275**, 66–67P.
 LUX, H. D. & NEHER, E. (1973). *Expl Brain Res.* **17**, 190–205.