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The ionic basis of membrane potentials and cellular equilibrium: a computer model for teaching

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The demonstration shows the use of an interactive program for teaching cell physiology. It takes the place of a practical experiment and students treat the program much as they would a real experiment: they change the conditions and properties of a simulated cell, note down new values of cell parameters, plot graphs, etc., and interpret these. In elementary classes the teaching schedule gets students to examine the dependence of the membrane potential on the ionic environment and the membrane permeability of the cell and to look at the effects of poisoning the Na/K pump on the membrane potential, cytoplasmic composition and cell volume.

The program is written in Fortran and implemented on a multi-user mainframe computer system and RML 380Z machines. It performs two main types of calculation. In any specified conditions it can calculate a 'resting' cytoplasmic composition and membrane potential, governed by rules that the cell must end up in Na, K, Cl and H_2O balance. For conditions in which there is insufficient time for the cytoplasmic composition to be altered by a disturbance from resting conditions (e.g. short-lasting permeability changes), a 'transient' membrane potential is calculated, subject to the rule that there be zero net ionic current. Only passive fluxes of Na, K, Cl and active fluxes of Na, K are considered in the model. Goldman flux equations are used for passive fluxes, with pumped Na efflux proportional to $Na_i(1+c/K_o)^{-1}$, where c is a simple Michaelis constant for binding of external K. A fixed average charge (z) on impermeant molecules within the cytoplasm is assumed. The parameters c, z and the ratio of K:Na pumped fluxes are variable for advanced applications.

The model allows students to influence and study the interactions of cell parameters that are not easily measured with elementary techniques. Since the procedure to obtain results is simple, it allows teachers to spend more time discussing the design and interpretation of the simulated experiments.