LETTER TO THE EDITOR

Caloric Catastrophe Reconsidered

Dear Sir:

I write belatedly concerning Minkoff and Damadian's "Caloric Catastrophe," which claimed that the energy available from bacterial ATP is insufficient for the active transport of solutes by means of classical membrane-situated "pumps" (1). This claim, which was promptly criticized (2–4), has recently again been the subject of a series of exchanges (5–7). In these various critiques attention was directed mainly at the accuracy of determination of the energy available from metabolism of cellular ATP. I should like to point out difficulties in the evaluation of the energy required to maintain transport.

This quantity was calculated from the relation: P(calories per minute) = $\Delta\tilde{\mu}$(calories per mole) × Φ(moles per minute), where $\Delta\tilde{\mu}$ is the electrochemical potential difference of the transported species between the cellular and extracellular compartments, and Φ is its "steady-state flux" (1). This equation is appropriate, provided that Φ refers to *net* flux (i.e. influx minus efflux) by way of an *active* pathway. In fact, however, Φ was evaluated from the unidirectional flux, calculated from the initial rate of tracer accumulation in the presence of steady-state distributions of nonradioactive solute. This measurement evaluates influx, not net flux. Such influx might occur via either an active and/or passive pathway. In either pathway, if there were appreciable efflux, the influx would significantly exceed the net flux. Calculation of the extent to which the unidirectional flux overestimates the net active flux requires knowledge of both $\Delta\tilde{\mu}$ and the relative resistance to tracer exchange in the active and passive pathways; the discrepancy could conceivably be large (8).

For these reasons the fluxes cited in Minkoff and Damadian's Table I cannot be identified with rates of net active transport. Hence they cannot be used to evaluate the energy required for the operation of membrane pumps, and do not permit a test of the membrane theory.

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