

Physiological role of Ca^{2+} transport by mitochondria

SIR—We cannot but whole heartedly agree with D.J. Miller¹ that the systems which transfer calcium across the inner membrane of mitochondria are of physiological importance. However, we are very surprised that he completely ignores the strong evidence²⁻⁸ which indicates that the major role of these systems is to regulate the concentration of Ca^{2+} within the mitochondrial matrix rather than, as Miller suggests, the concentration of Ca^{2+} in the cytoplasm. When extramitochondrial Ca^{2+} is raised within the physiological range, a parallel increase in intramitochondrial Ca^{2+} will occur and this may activate three important dehydrogenases which occupy key regulatory sites in oxidative metabolism, namely pyruvate dehydrogenase, NAD-isocitrate dehydrogenase and 2-oxoglutarate dehydrogenase. In this way, the formation of reducing power for oxidative phosphorylation can be accelerated under the very conditions where there is likely to be an increased requirement for ATP. Increases in cytoplasmic Ca^{2+} generally stimulate energy-requiring processes such as muscle contraction, secretion or ion-pumping. It is worth emphasizing that these key dehydrogenases have so far only been found to be sensitive to activation by Ca^{2+} in vertebrate tissues⁹ and only mitochondria from vertebrate tissues appear to take up Ca^{2+} at an appreciable rate at μMolar concentrations.

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1. Miller, D.J. *Nature* 313, 638 (1985).
2. Denton, R.M. & McCormack, J.G. *FEBS Lett.* 119, 1-8 (1980).
3. Hansford, R.G. & Castro, F. *Biochem. J.* 198, 525-533 (1981).
4. Crompton, M., Kessar, P. & Al-Nasser, I. *Biochem. J.* 216, 333-342 (1983).
5. Baumgarten, E., Brand, M.D. & Pozzan, T. *Biochem. J.* 216, 359-367 (1983).
6. Fuller, S.J. & Randle, P.J. *Biochem. J.* 219, 635-646 (1984).
7. McCormack, J.G. & Denton, R.M. *Biochem. J.* 218, 235-247 (1984).
8. McCormack, J.G. *FEBS Lett.* 180, 259-264 (1985).
9. McCormack, J.G. & Denton, R.M. *Biochem. J.* 196, 619-624 (1981).

The electrostatic charge really is on the surface

SIR—A. A. Berezin recently discussed the question: "What will be a minimum energy configuration of a system of N equal point charges q placed inside a circle?" (see *Nature* 315, 104; 1985). He considers two configurations, one (A) with all N charges equally spaced around the circumference and the other (B) with one

charge at the centre and the remaining $N-1$ equally spaced around the circumference. Assuming a three-dimensional Coulomb potential q^2/r between pairs of charges, he finds numerically that $W(A) < W(B)$ for $N \leq 11$ but that for $N \geq 12$ (up to at least $N=400$) $W(A) > W(B)$, where W represents the total electrostatic energy of the system. Whilst this answer to the question posed is doubtless true and has some curiosity value, the subsequent suggestion that these results provide an example where charges in a conductor at equilibrium will not reside on its surface is quite wrong.

The fallacy lies in the use of three-dimensional electrostatics for a two-dimensional system. Berezin's circle should properly be regarded as a thin disk and then the charge at the centre of the circle in B is actually at the centre of one of the flat surfaces of the disk. Thus, in the correct three-dimensional interpretation, all of the charges are on the surface of a thin conducting disk for both configurations A and B. (When N is very large, most of the charges will, at equilibrium, reside on the flat surfaces.)

It is of some interest to consider whether any anomalous behaviour arises in the solution of the above problem when it is regarded as strictly two-dimensional. The relevant Coulomb potential is now $-q^2 \ln(r/L)$, where L is an arbitrary length determining the zero of the potential. It is convenient to choose for L the radius of the circle. Then a straightforward analytic calculation shows that $W(B) - W(A) = (q^2/2)[N \ln N - (N-1) \ln(N-1)] > 0$ for all $N \geq 3$. Thus, in the strictly two-dimensional problem the 'obvious' result is correct and our faith in classical electrostatics is restored.

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The complexity and stability of ecosystems

SIR—I read Pimm's¹ article on stability and complexity within ecosystems with great interest. I would not, as an old-fashioned geologist-palaeontologist, pretend that I understood all of the logic involved, nor that I had been able to follow all of the mathematics employed in the May² and MacArthur papers to which Pimm refers. There is completely independent evidence from the fossil record supporting Pimm, as well as the earlier work by May² to which Pimm refers. Ecologically complex structures such as reef complexes appear historically to have been less stable than level bottom communities. If one concludes that the global marine ecosystem has been subjected to stress sufficient to generate large-scale extinction events, such as oc-

curred at the end of the Permian, then it follows that a comparison can be made between the resultant behaviour of the more simple level bottom communities and faunas as contrasted with the trophically far more complex reef community complexes. The nature of the stress(es) is (are) unknown, but it is reasonable to conclude that the trophically different community types reacted differently. Should one or the other, or at least elements of one or the other, survive such a major environmental perturbation it could be concluded that the surviving items were more stable.

There are five major intervals during the Phanerozoic when reef community complexes were in existence—including the present (Fig. 3 in ref. 3). In the Lower Cambrian some of the archaeocyathids occur in what many feel are reef community complexes. Such complexes disappear totally at the end of the Lower Cambrian concurrent with an important extinction event, whereas some level bottom taxa, particularly among the trilobites, survive to later radiate in the Middle Cambrian. The second interval of reef community complex is present in the Middle and Upper Ordovician. It disappears totally in the major, terminal Ordovician extinction event, together with much, but by no means all, of the level bottom fauna grouped into many communities. A third reef community complex, with antecedents differing from those of the Middle and Upper Ordovician, appears about one-third of the way through the Upper Silurian and persists until the middle of the Upper Devonian. The major mid-Upper Devonian extinction totally wipes out the reef community complex together with the majority of the level bottom taxa and many of the communities. A fourth reef community complex occurs in the Upper Carboniferous and Permian, derived from totally different antecedents (presumably, as always, level bottom taxa). The terminal Permian extinction event eliminates the Permo-Carboniferous reef community complex, and the bulk of the level bottom taxa and communities. The level bottom survivors ultimately provide the material for a re-radiation which is responsible for the different reef community taxa of the later Triassic.

There are significant taxonomic differences between the Triassic reef taxa and those of the Jurassic-Cretaceous, which suggests that the terminal Triassic extinction event was involved here. At the end of the Cretaceous the tropical-subtropical reef community complex was almost totally wiped out, and it does not reappear in any abundance until the Eocene. The reef community complex then persists until the present, although there are some major changes, such as the addition of the algal ridge complex in the Miocene. Large numbers of coeval