seen in Fig. 3 the system considered contains two subsystems which are capable of oscillating, in principle, themselves and are connected (and synchronized) by a diffusion process.

If the activities a_i of the redox components are periodically changing with time at the interfaces ($a_i = a_{i0} + a_{il} \cdot P_i(t)$; $i = A, B$) then the momentary value of the EMF is given by

$$E = \bar{E}_0 + A_0 \cdot \nu_A a_{Al} / A_0 a_{A0} P_A(t) + B_0 \nu_B a_{Bl} / a_{B0} P_B(t) - A_0 \nu_A^* a_{Al}^* / a_{A0}^* P_A(t) - B_0 \nu_B^* a_{Bl}^* / a_{B0}^* P_B(t) \qquad (7)$$

so the EMF fluctuates periodically around the stationary value

$$\bar{E}_0 = E_0 + A_0 \ln a_{A0} / a_{A0}^* + B_0 \ln a_{B0} / a_{B0}^* \qquad (8)$$

Similar expressions can be derived for the current.

As far as the mechanical oscillations are concerned, one has to assume that there is an energy barrier for the ions generated at interface II, and thus these ions can accumulate at the BLM (Fig. 4; see ref. 17) and the electrostatic repulsion among these bounded ions strives to increase the surface area of the BLM. This increase of surface area occurs to the detriment of the Plateau–Gibbs border and lasts as long as the molecular architecture of the BLM begins to change. The architectural change may lead to increasing separation between polar groups and to a decreasing activation energy for leaving the membrane; consequently the bounded iodide ions can stream into the aqueous phase. After depletion the BLM takes on its original shape and the process starts again.

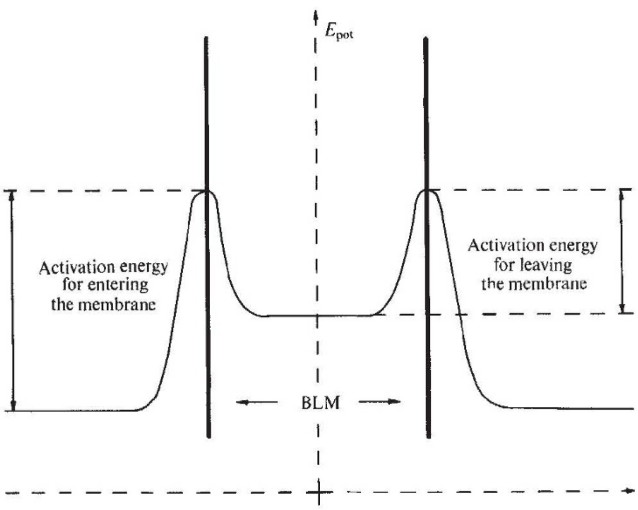

Fig. 4 Energy barrier of the BLM.

Although Pant and Rosenberg found an oscillation of the Plateau–Gibbs border, they did not observe the oscillating bending out of the membrane, in accordance with my assumption. Due to the geometrical circumstances (Pant, personal communication), the BLM behaved like a concave mirror with oscillating curvature. Accordingly, the reflected light beam moved parallel or nearly parallel to the direction of observation and its motion was not observable.

Finally I note that this interpretation supports some suggestions of theoretical and practical importance, namely the iodine-BLM systems are predominantly electronic conductors; the interfaces between the BLM and aqueous phase electronically may behave as semiconductor electrodes; coupled (synchronized) electrochemical electrode reactions occurring at the interfaces are capable of bringing about sustained and temporary processes of regulation and passing of information; electrochemical deposition on and liberation from the membrane surface endow the membrane with dynamic character; the coupled diffusion and phase boundary effects may play an important role in creating biological oscillations.

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1 Pant, H. C., and Rosenberg, B., *Biochim. Biophys. Acta*, **225**, 379 (1971).
2 Mueller, P., and Rudin, D. O., *J. Theoret. Biol.*, **18**, 222 (1968).
3 Mueller, P., and Rudin, D. O., *Nature*, **217**, 713 (1968).
4 Teorell, T., *Exp. Cell Res. Suppl.*, **3**, 339 (1955).
5 Franck, U. F., *Ber. Bunsenges. Phys. Chem.*, **67**, 657 (1963).
6 Boguslavsky, L. I., Bogolepova, F. I., and Lebedev, A. V., *Chem. Phys. Lipids*, **6**, 296 (1971).
7 Boguslavsky, L. I., and Lebedev, A. V., *Experientia Suppl.*, **18**, 163 (1971).
8 Karvaly, B., Rosenberg, B., Pant, H. C., and Kemeny, G., *Biophysik* (in the press).
9 Karvaly, B., *Fourth Int. Congress on Biophysics* (Moscow, 1972).
10 Pant, H. C., Karvaly, B., Rosenberg, B., and Kemeny, G., *Fourth Int. Congress on Biophysics* (Moscow, 1972).
11 Karvaly, B., *Studia Biophysica* (in the press).
12 Beinert, H., and Bonhoeffer, K. F., *Z. Elektrochem.*, **47**, 441 (1941).
13 Beinert, H., and Bonhoeffer, K. F., *Z. Elektrochem.*, **47**, 536 (1941).
14 Bonhoeffer, K. F., *Naturwiss.*, **31**, 270 (1943).
15 Bonhoeffer, K. F., *Z. Elektrochem.*, **52**, 24 (1948).
16 *Gmelins Handbuch der Anorganischen Chemie* (Verlag Chemie, Weiheim, 1955).
17 Peshaev, P. A., and Tsofina, L. M., *Biofizika*, **13**, 360 (1968).

Freely Falling Clocks

SURELY Ellis[1] has not really answered Dingle's question. For the question was: "Which of the two . . ."; not: "Which of all possible . . .". Suppose that neither of the clocks was in free fall.

Incidentally, if that be the answer, am I to suppose that Born was wrong? He answered that Dingle should have asked a different question; presumably that was intended to mean that the original question had no answer.

Also, perhaps I could be told how a theory can deal with free fall, if it does not deal adequately with gravity, which is surely the same thing as free fall considered from another viewpoint. And how can the invocation of free fall provide the solution to a problem in the formulation of which nothing was said about free fall, or any other accelerated motion?

Dingle remarked that everyone who answered his question had a different answer. Maybe the time has come for all of those who want to answer to get together and to come up with one official answer. Otherwise, the plain man, when he hears of this matter, may exercise his right to remark that when the experts disagree they cannot all be right, but they can all be wrong.

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1 Ellis, G. F. R., *Nature*, **242**, 143 (1973).