Universe. It is precisely this parallelism in the behaviour of different parts of a system at different times that is at the heart of the second law.

How would one attempt to derive the second law, in the form proposed, from the laws of physics? One could imagine a simple generalization of the usual classical statistical argument in which one considers a system initially in a given macrostate and asks about the macrostate at some later time. If one counts all the phase space trajectories linking the initial macrostate to other macrostates, one is led to associate greater probability to those final macrostates with greater statistical weight. On the other hand, one could consider a system with a specified final macrostate, in which case a similar counting procedure implies that earlier macrostates must have greater statistical weight. This is hardly a satisfactory "proof" of the second law, and indeed there are those who would deny altogether the general validity of the second law, but would prefer to associate the monotonic increase in the entropy of our own system with non-thermodynamic features peculiar to it, such as cosmological expansion[4,7].

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1 Loschmidt, J., *S.B. Akad. Wiss. Wein*, **73**, 139 (1876).
2 Penrose, O., and Percival, I. C., *Proc. Phys. Soc.*, **79**, 606 (1962).
3 Landau, L. D., and Lifshitz, E. M., *Statistical Physics*, 28 (Pergamon Press, Oxford, 1969).
4 Landsberg, P. T., *Studium Generale*, **23**, 1108 (1970).
5 *Proc. Intern. Conf. Thermodynamics, Cardiff, 1970*) (edit. by Landsberg, P. T.) (Butterworths, London, 1970).
6 Reichenbach, H., *The Direction of Time* (Univ. of California Press, Berkeley, 1956).
7 *The Nature of Time* (edit. by Gold, T.) (Cornell Univ. Press, 1967).
8 Boltzmann, L., *Lectures on Gas Theory*, section 90 (Univ. of California Press, 1964).
9 Landsberg, P. T., *Thermodynamics*, 82 (Interscience, New York, 1961).

Consequences of Cycles in East African Climate

Western and Van Praet[1] have convincingly suggested that losses of yellow fever-trees in the Maasi Ambolesi are not due to over-population by cattle or elephants but to a climatic change causing a shift in the salt table. They assume that the change is part of a cycle, though of a much smaller range than has occurred in the past 10,000 yr. Perhaps inadvertently, they seem to suggest that the cycle producing the present vegetation change lasts about a century. Much shorter cycles than this may, however, be usual in the region, as evidence from further south suggests. It is important that this should be appreciated because, as the authors state, investment by governments on developments to accommodate tourists may be wasted if the climate is wrongly forecast.

Western and Van Praet cite evidence for synchronous changes in levels of lakes over a large area of East Africa, especially in those lakes that have no outlet to the sea; Rukwa is one of those lakes[2] and evidence from Lake Rukwa may be appropriate in the Maasi Ambolesi.

Rainfall or lake levels of Lake Rukwa, going back far enough, have not been recorded, so I have to rely on travellers' tales and inferences[3]. My information refers to rather few separate years but covers a century discontinuously. A dry period or a wet period, as indicated by lake levels, lasts several years. For example, Lake Rukwa has been very full from 1963 until today, as it was for years around 1937. Between these two wet periods, the larger northern part of the lake has been so dry that in 1954 we could drive loaded 3-ton lorries across it. In earlier dry periods, when there were no mechanical vehicles to traverse the 30 miles of alkaline dust, the narrower parts of the lake bed could be crossed dry shod or ankle deep. In wet periods, 1,500 mile^2 or more of the northern lake was open to fishing from canoes. Table 1 shows reasonably well authenticated reports suggesting three or four cycles in a century.

Table 1 Available Information on State of Lake Rukwa, over 100 yr

Lake Rukwa	State	Author or authority[3]
1873	Dryish	Livingstone's last journey
1880–2	Very high	Joseph Thomson; Emil Kaiser
1892	Dry	Sir Harry Johnstone; Cross; Wallace
1904	High	Meyer
1920	Dry	Mateo
1933–42	High	Michelmore; Swynnerton; Bredo[4,5]
1954	Quite dry	Gunn[5]
1963–	Very high	Du Plessis; Kühne[5]

I found that upsurges of red locust populations in the Rukwa Valley have been associated with low levels of the lake[3]. Symmons[4] went further and showed a close relation between lake levels and cumulative deviation from average rainfall and a good correlation between locust numbers and previous rainfall; these have been used for forecasting locust numbers in Rukwa more than a year ahead[6]. It may have the salt-table mechanism proposed by Western and Van Praet and the cumulative deviation from average rainfall may also apply to both cases. If it does, sound planning for the Maasi Ambolesi may be facilitated.

On this very large scale, another consequence of climatic cycles is worth recording. During both recent periods of high level in Lake Rukwa, around 1937 and 1967, red locust breeding occurred on a threatening scale in Mocambique; such breeding has never been recorded there in years when Rukwa lake levels were low. Here, too, forecasting is worth attempting and perhaps also in other related matters in East Africa.

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1 Western, D., and van Praet, C., *Nature*, **241**, 104 (1973).
2 Butzer, K. W., Isaac, G. L., Richardson, J. L., and Wasbourn-Kamau, C., *Science*, **175**, 1069 (1972).
3 Gunn, D. L., *Tanganyika Notes and Records*, **42**, 1 (1956).
4 Symmons, P. M., *Bull. Ent. Res.*, **50**, 507 (1959).
5 Annual Reports of the International Red Locust Control Service, Abercorn, Northern Rhodesia (Mbala, Zambia).
6 Gunn, D. L. and Symmons, P. M., *Nature*, **184**, 1425 (1959).

BIOLOGICAL SCIENCES

Movement of Sodium Ions Associated with the Nerve Impulse

HODGKIN AND HUXLEY[1] calculated the extra sodium fluxes in the squid giant axon resulting from the passage of nerve impulses assuming that the time course of the observed currents represented the time course of a change in permeability. The net flux was in rough agreement with experimental data at room temperature but there was more exchange in the axon than in computed predictions. As the calculated fluxes increase by a factor of three when the temperature is reduced 10° it seemed appropriate to test the effect of temperature on the sodium fluxes.

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