I propose to call attention to two facts. First, in accordance with Landsberg, quantum systems which, when placed in a suitable environment, possess the property of reproducing themselves, do exist, and are moreover fairly well known. Secondly, the contentions of Wigner and Landsberg do not in fact justify any statement on the validity of a quantum mechanical description of life.

The first of these statements is easily demonstrated if one considers an atomic nucleus in an environment with a thermal neutron density always different from zero[3]. In such an environment the nucleus enlarges progressively as a result of successive neutron captures and remains stable, so far as the emission of nucleons is concerned, by successive β-disintegrations. At a certain point, however, it reaches the stability limits for nuclear fission and then, following a final neutron capture, it splits into two nuclei of medium atomic weight. Its behaviour is thus wholly analogous to that of a bacterium in a suitable nutrient.

One certainly cannot maintain that this is a rare or contrived quantum system; this example should rather give us grounds for thought whether the capacity to reproduce in a suitable environment is not one common to all matter.

Furthermore, it is clear that an atomic nucleus does not fall, even marginally, within the category of entities which we describe as living. This means that the capacity to reproduce is not wholly peculiar to these entities, and therefore cannot serve as a quality for their definition. This is why Wigner's and Landsberg's contentions have not in fact anything significant to contribute with regard to the applicability of quantum mechanics to a description of life.

The fact that, for each of the functions (reproduction included) which we consider essential for maintaining life, one can find an inorganic model seems then to suggest a rigidly defined set of ideas. This in fact entitles us to suspect that the problem of ensuring this group of functions may have many very different solutions, and that the single solution which we see universally adopted in the world of living organisms, the cell, is after all only one solution, which has effectively displaced all the others, either through historical events, or more probably because it can ensure a much faster reproductive cycle. In this context, it is interesting to note that the period of duplication of an atomic nucleus exposed to a flux of slow neutrons like that produced by cosmic rays in the atmosphere is of the order of 10^{18} years, and in a nuclear reactor this period would be reduced to 10^5 years.

Thus it seems, more generally, that a catalogue of functions is not adequate to define what we call a living being: at least a partial description of the structure of the organism seems essential for an effective definition.

There are in addition many facts which confirm the fundamental nature of the concept of structure (by which we mean the nature and arrangement of the parts constituting the system) as regards both definition and maintenance of life. The most striking of these is the effect of ionizing radiations on living organisms. We know that the permanent changes caused by such radiations in the irradiated material consist almost entirely of the breaking of molecular bonds, which may possibly be followed by the reconstruction of other bonds of the same type. What is thus changed is the arrangement of the particles constituting the cell, and it is clear that this change in the order, that is in the structure of the organism, when it involves certain large molecules of fundamental biological importance, causes a change in the functions which these molecules are intended to perform and thus, triggering a sort of relay amplification process, determines the observable macroscopic damage.

Structure is thus seen, in biology, to be an absolutely basic concept, of which functions are nothing other than dynamic aspects.

But when we remember that the structures we are considering are in point of fact molecular, that is, made of atoms, it is difficult to see why they could not be described by quantum mechanics.

M. AGENO

Physics Laboratory,
Istituto Superiore di Sanità,
Rome.

[1] Landsberg, P. T., *Nature*, **203**, 928 (1964).
[2] Wigner, E. P., *The Logic of Personal Knowledge, Essays Presented to Michael Polanyi* (Routledge and Kegan Paul, London, 1961).
[3] Ageno, M., *Le radiazioni e i loro effetti*, chap. I (Boringieri, Torino, 1962). Ageno, M., *La fisica al servizio della medicina*, Rapporti dei Laboratori di Fisica dell'Ist. Sup. Sanità, *ISS* 64/32 (1964).

PROF. AGENO is correct in quoting inorganic examples of self-duplicating states. Living objects can certainly not be defined by this property alone and this was not our intention. Self-reproduction is, however, one of the properties which has to be discussed from the point of view of quantum mechanics in connexion with living objects. Such a discussion seems to be of interest[1], even though it can only be very speculative (as pointed out in our publications), since a living system is always large by quantum mechanical standards. We were, therefore, interested in dealing with methods of analysing this problem and in developing assumptions which might reasonably be made in this connexion. As our understanding of these questions increases, one may hope that other features of living matter can be introduced into the argument to make it more specific.

Perhaps it is worth while to point also to a concrete error in Prof. Ageno's argument. Neutron multiplication is not a process of extremely small probability according to quantum mechanics, because the state of the neutrons which are emitted is not a highly specialized one. In contrast, if we asked for the probability that a neutron with a definite energy incident on a uranium nucleus should emit two neutrons with the same energy, the probability would turn out to be very small. The essential point which Prof. Ageno disregards is that the living state is a very uncommon state of the matter of which it is composed, that is, that the same matter can be present in many, many other states which are not living.

E. P. WIGNER

Princeton University,
Princeton, New Jersey.

P. T. LANDSBERG

University College of South Wales and Monmouthshire,
Cardiff.

[1] Commonor, B., in *Horizons in Biochemistry*, edit. by Kasha, M., and Pullman, B. (Academic Press, New York, 1962). Mora, P. T., *Nature*, **199**, 212 (1963).

RADIATION CHEMISTRY

Detection in Denmark of the Sinkiang Nuclear Detonation

MEASUREMENTS of fission products in air at ground level are made regularly in Copenhagen using a high-volume air sampler and a 100-channel γ-spectrometer.

A filter exposed during the period October 23–26, 1964, gave the first reliable indication of new fission-products by the appearance of the 1,596-keV line of lanthanum-140. The sample was a compressed filter containing dust from about 150,000 m³ air. The measurement position of the filter is close to a 3-in sodium iodide (Tl) crystal. The concentration of lanthanum-140 was estimated as 5×10^{-5} pc./m³. Filters sampled on October 28 and October 30 show concentrations which are approximately 10 and 100 times greater.

To show the presence of lanthanum-140 clearly in the last-mentioned filter $\gamma - \gamma$ coincidence measurement with the 1,596-keV line was made and the 815-, 487- and 329-keV lanthanum lines appeared clearly as shown in Fig. 1.