ON THE SEARCH FOR ARCHETYPAL LIFE FORMS.

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Introduction. One of the main tasks of a martian expedition will be the search for existing or vanished life forms. Mars is a near planet of comparable size in our solar system. So it is not unlikely that life is, or has been, existent there and developed along lines observed on Earth. Against this background I present a new idea, focalized on biological membranes and their properties, for the detection of the evolution of early life on Mars.

Membranes. Analytical ultracentrifugation of isolated biological membranes by my former research group (Netherlands Cancer Institute, Amsterdam) has revealed that these take the form of globular vesicles which only exist in a range of discrete size classes, if not constrained by structural or environmental factors (1). This characteristic appears not to be restricted by experimental conditions of isolation, disruption and spontaneous reassembling in the laboratory. It is seen as well in membranebound bodies in living cells like neurotransmitter and hormone vesicles, cell nuclei and even free moving cells like lymphocytes and oocytes. The architecture of structures like the succession of chambers in the spirals of foraminifera can likewise be explained (2). The common materials of all these objects are the phospholipid molecules which, because of their amphiphilic character, spontaneously constitute the membranes. That laboratory made preparations of liposomes clearly show the differentiation in size classes, proves the assumption that the phospholipids are responsible for this (3).

Serial discreteness. Membranes of different origins may appear in sizes that differ in orders of magnitude but the discontinuous appearance of the size classes is always the same. Proven is that the globular surface, on which the the phospholipid molecules assemble themselves, is in fact the ruling parameter of the phenomenon. The surfaces of successive size classes of vesicles appear to be mutually related as the terms of a geometric series by a simple ratio. This ratio is larger than one (it has approximately the value of 2 for surfaces, and consequently of ca √2 for diameters), which causes the succession of size classes in any range to be an exponentially expanding series (3) The provocative idea behind these observations is that in fact these different size clusters are all part of the same general system, one discontinuous series ranging from the smallest neurotransmitter vesicles (diameter ca 30 nm) to the magnitude of vertebrate egg cells (millimetre size) and possibly beyond.

Quantum behavior. An explanation for the simple mathematical character of this membrane feature was found in the physico-chemical properties of the constituting phospholipid molecules that push them towards a dynamic order in a liquid crystalline (LC) lattice (4). A model of this concept explains the existence of a sequence of molecular configurations for which the entropy – i.e. the number of probable equivalent molecular realizations in the crystal lattice – is maximized depending on the size of that lattice, which in turn determines the size of the membrane vesicle (5). This LC-model also predicts a fundamental uncertainty in the exact position of these maxima on the size scale. They will turn up as the ridges of a probability wave and may be understood as a true manifestation of molecular quantum behaviour.
In close connection with this view we developed a statistical analysis that gives a quantitative (confidence limits) as well as a visual (probability wave) impression of the similarity between the observations and the theoretical model (fig. 1).

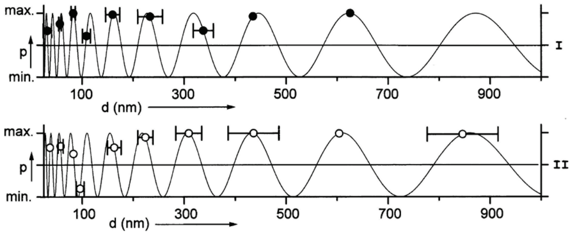

fig1. size distribution of reconstituted nuclear membranes (I) and liposomes (II).
data: Bont et al. (1977).
bars: 95% confidence limits.
lines: theoretical probability density waves.
series ratio's: 1.40 (I) and 1.41 (II)

Fossillized life. Considering these results the question arose whether the quantum behavior of membranes could also be traced in fossil specimen. This was tested on measurements of embryonic chambers of closely related foraminifera from different depths (i.e. geological age). Evolutionary change appeared to be connected with size transitions of these chambers fitting in the geometric series for membrane globules. This observation could be confirmed by a number of different sequences of species in different regions of the world and it opened a window on one of the most spectacular evolutionary events: the origin of life itself.

Origins. One of the oldest life forms on earth is found in early Pre-Cambrium sedimentary rocks in the goldmine region near Barberton, South Africa. The age of these sediments is estimated at more than 3.2×10^9 yr. and one type of fossil life form found here is described as 'spheroidal carbonaceous alga-like microstructures' in the size range (diameters) from ca 10 to100 µm. Because they are supposed to represent life – although this is disputed - they were named accordingly as *Archaeosphaeroides barbertonensis.* Several hundreds of these spheroids from different samples were measured and the results presented in histograms (6). The distribution over the size range is evidently discontinuous and supposed to be polymodal by the authors. When compared to our quantum model of membranes this is confirmed. The size distributions of all samples, for which the data were published, fit significantly with the model, which means that these fossil spherules are undisputably characterized by an enclosing biological membrane (fig. 2).

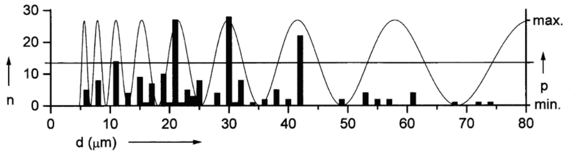

fig. 2. size distribution of an example of *A. barbertonensis* spheroids.
data and histogram: Engel et al. (1968).
line: theoretical probability density wave.
series ratio: 1.40.

Conclusions. The findings summarized here justify the postulate that membranes, because of their amphiphilic architecture and quantum behavior, are a normative factor in the evolution as well as in the development and the functioning of living cells. For the archetypical life forms at the beginning of the evolutionary process this was, and still is, probably even the all-dominating factor, since it is generally assumed that the spontaneous generation of membranes from phospholipid-like materials was undoubtedly realized prior to the more difficult – and still problematic – natural synthesis of proteins and nucleic acids.

This makes clear that the identification of biological membranes may play a key role in the recognition of primitive life forms. However, the availability of facilities and instrumentation for proper research on the spot, whether this is on Mars or any other extraterrestrial body, is a problem. This may only be solved when samples of well-defined soil structures can be brought back to the earth. As long as this is a too distant goal, this study gives some new clues about where and for what to look when tracking early life forms in the field. The description of the geomorphological context of fossil remains of early life forms like *A.barbertonensis* gives an impression of the environment were early life has flourished: streaming water, active erosion and sedimentation of certain types of clay, silt and other silicium compounds (eventually transformed to rock layers of mudstone and chert among others), volcanic activitiy and possibly some specific minerals containing phosphorus, one of the key-elements for the synthesis of phospholipids.

My proposal is to take into consideration the discrete serial character of primitive life forms described here, and their environmental context, when developing a program for searching the soil of Mars.

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JB/06/05/12