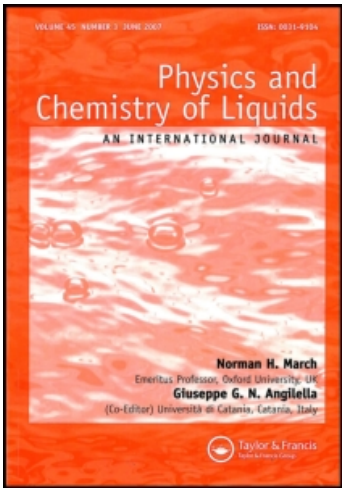

Physics and Chemistry of Liquids
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713646857

Can the Aqueous Solution Inside a Cell Membrane Characterize Normal and Cancerous Forms?

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To cite this Article Hammel, H. T. , March, N. H. and Watson, B. W.(1991) 'Can the Aqueous Solution Inside a Cell Membrane Characterize Normal and Cancerous Forms?', Physics and Chemistry of Liquids, 23: 1, 57 — 59
To link to this Article: DOI: 10.1080/00319109108030633
URL: http://dx.doi.org/10.1080/00319109108030633

Phys. Chem. Liq., 1991, Vol. 23, pp. 57–59
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LETTER
Can the Aqueous Solution Inside a Cell Membrane Characterize Normal and Cancerous Forms?

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(Received 15 August 1990)

A way of characterizing an aqueous solution within a cell surrounded by membrane is discussed. As an example, a preliminary experiment involving supercooling and freezing of water extracellularly is summarized, on normal plant cells. Reasons are given for supposing that such an experiment could, at least in principle, distinguish normal and cancerous cells.

The purpose of this Letter is to propose a possible way of characterizing both normal and cancerous cells via the aqueous solution contained within the membranes of these cells. The line of argument will first be presented and then brief reference will be made to a relevant experiment performed some time ago by one of us (H.T.H.) which has been reported in abstract elsewhere[1].

The DNA within any cell will unravel at a certain rate, which we assume to depend on (i) the ionic content of the aqueous solution within the cell and (ii) additionally on the state of the membrane itself, which is presumably closely related to (i). Now let us assume further that (iii) the rapid unravelling of DNA in a cancerous cell is brought about by the influence on the chemical bonding in the DNA of the dielectric aqueous solution with its ionic solutes. These assumptions (i)–(iii) we feel may also be relevant in understanding why apparently very different physical, chemical and biological perturbations of a cell, eg X-rays, chemical carcinogens and viruses, all lead to the same end effect in a cancerous cell, ie uncontrolled replication.

This is the point to turn to an experiment (see Figure 1) carried out earlier on a plant membrane[1]. It is relevant here to stress a salient difference between plant and

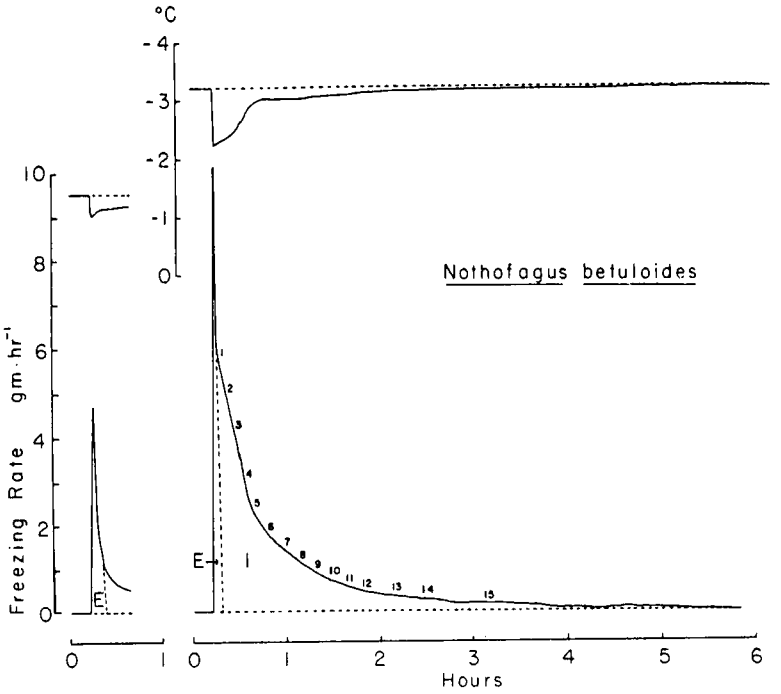

Figure 1. Freezing calorigrams and thermograms of a 50 g twig of Southern Beech, Nothofagus betuloides.

First the twig was undercooled to −1.5C when freezing was initiated. Only extracellular water (E) froze. Next the twig was rewarmed and then undercooled to −3.2C when freezing was initiated. The extracellular water (E) froze immediately, followed by slow freezing of water from the intracellular solution.

animal membranes[2]. In the plant the membrane is constrained by a cellulose-lignin matrix, whereas the animal membrane can be taken as free. We plan subsequently to repeat the experiment described below on the animal cell to assess the effect of the matrix constraint on the reported behaviour to follow. First we note that the experiment rests on the fact that, on cooling, freezing begins in the extracellular fluid, when seeded by ice after small supercooling, and water is removed from the intracellular solution to freeze outside the cell. This is vital in plants, since freezing of the intracellular solution results in the death of the cell, whereas many winter-hardened plant cells survive freezing of the extracellular fluid as well as water from the intercellular solution.

What was, essentially, observed in the above experiment (Figure 1) was a mass of water transported through the semipermeable cell membrane as a function of time. After some initial structure, a long-time tail was observed on a scale of minutes to hours, which has a non-exponential dependence on time t of inverse power form t^{-n} where we might have anticipated that in a diffusion-controlled process n would be 3/2. The experiment has been analyzed to yield an approximate exponent $n = 1.2$ and independent evidence is available from further experimental studies of H.T.H. that the above process is, in fact, diffusion controlled.

This long-time behaviour is what we propose as a useful characterization of the intracellular aqueous solution. We plan to perform experiments on the analogue of cancerous cells in plants (e.g. witches broom) as well as on both normal and cancerous forms of animal cells[2].

Acknowledgments

Two of us (H.T.H. and N.H.M.) collaborated during a period spent at the Scripps Institution of Oceanography during the Winter of 1989. These visits were made possible through the hospitality of Dr A. A. Yayanos to whom our grateful thanks are expressed. N.H.M. also wishes to acknowledge valuable discussions with Dr J. Huke, and to thank the International Cancer Foundation, and in particular Dr C. Thomson, for financial support and for much encouragement of our work in this general area.

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