1153rd General Monthly Meeting

Joint Meeting with the Australian Institute of Physics (NSW Branch), Royal Society of NSW & The University of Sydney

Electro-Mechanics of Living Cells and Cell Membranes in Intense Electric Fields

Professor Hans Coster, School of Chemical & Biomolecular Engineering, University of Sydney

Date: Tuesday, 26th June, 2007 at 6.00 pm.
Venue: Slade Lecture Theatre, School of Physics, University of Sydney
Dinner with the Speaker at 8.00 pm, Buon Gusto (Italian), Abercrombie Street, Chippendale.

ABSTRACT

The electric field in the membrane surrounding living cells is very intense; in the range 10^7-10^8 V/m. This field arises from the potential difference of around 80 mV normally present across the membrane which is typically 3 nm in thickness. The membrane, which has a fluid structure, is very stable despite this very intense electric field. However, electrical breakdown of the membrane can be induced by increasing the field strength approximately 5 fold. The electrical breakdown process is very rapid once a critical membrane potential is reached. Application of short, intense electrical pulses, then leads to the formation of transient, highly conducting, pores in the cell membrane, a process first described by the speaker. Cells can be repeatedly subjected to this process that is now known as electroporation and is widely used in genetic engineering to insert DNA into cells.

The application of external AC electric fields to living cells suspended in a medium causes the cells to deform, spin as well as translate (in non-uniform electric fields). These electro-mechanical effects can be used to manipulation cells under the microscope and the fields applied for this purpose are typically in order of several hundred kV/m. The electro-mechanical responses depend in a complicated way on the frequency of the applied field, the dielectric structure of the cells as well as the conductance and dielectric constant of the medium in which they are suspended. Cells do not appear to suffer any deleterious effects when manipulated in this manner. Using the electromechanical responses it is possible to assemble an individual pair of different cells and then to use electroporation to cause the two juxtaposed cells to fuse to form a hybrid cell. This process is also used in the cloning of animals. Apparatus for electroporation for genetic engineering and cloning is now available from many manufacturers and the routine use of this technology is now common place although the practitioners generally do not have any knowledge of the physics behind the process. An illustrated overview of the electromechanics of cells as well as the physics behind these processes will be presented.

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BIOGRAPHICAL NOTES

Appointed to the University of Sydney in 2004 to lead a new initiative in Biophysics and Bioengineering at the University of Sydney. Founded the Australian Society for Biophysics. This has become the major biophysics focus group in Australia with an Australia wide membership. Past President, Australian Institute for Nuclear Science and Engineering (2002-2004). Founded the Department of Biophysics at the University of New South Wales and became its first Head of Department. Founded the Centre for Membrane Science and Technology which was designated as a Commonwealth Special Research Centre, (was establish as one of 6 Special Research Centres in the first round in 1988). Was instrumental in this Centre being designated as a UNESCO Centre in 1992 and was the Director (Biophysics) of the Centre until 2005. Discovered, whilst engaged in PhD research at the University of Sydney, the phenomenon of reversible electrical breakdown in cell membranes; a process now known as "electroporation" and now widely used in genetic engineering (DNA transfection) and cell fusion (including animal cloning). Founded FuCell Pty Ltd, a "spin-off" company of the University of New South Wales. Editorial Board Member of International Scientific journals. Visiting Professor Appointments at several Institutes abroad. More than 150 scientific publications in addition to conference papers and 6 patents in the area of biotechnology, membrane technology and bionanotechnology.