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Commentary

Measurement of Apoptosis using Dielectric Techniques

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DESCRIPTION

The term "dielectric" was first introduced by William Whewell after a request from Michael Faraday to describe a material through which (Greek —"dia" = through) an electric field passes. Dielectric theory was given an establishment theoretical foundation by Maxwell, and the numerous contributions by Maxwell to the field of dielectrics include the derivate of an analytical result for the conductivity of a dilute suspension of globular particles.

A first major problem one encounters when studying cell death using dielectric ways is that it isn't easily defined what cell death actually is. Numerous forms of cell death have been described — and the precise distinction between the different terms is still a matter of discussion. Some of the difficulties are caused by the fact that dielectric approaches are used for many different cell types, and that the definitions of different terms and methods for ascertaining whether a cell is "alive" or "dead" can be significantly different for different branches of biology. For illustration, the terms "apoptosis" and "necrosis" are generally used to describe programmed cell death and traumatic cell death in animal or plant cell biology, but infrequently in microbiology. Indeed within a subject area, still, there's frequently no clarity, as for illustration the term necrosis has been used for the description of both traumatic cell death, as well as a general term to designate the presence of dead cell or towel. Also in microbiology the distinction between "viable" and "non-viable" cells is disputable. The term "viable" generally refers to the capability of an organism to live, develop, or germinate under favorable conditions, and it's frequently used to describe the capability of microbes to divide and form colonies. This term, still, becomes difficult to use when describing non culturable or dormant micro-organisms which are unable to form colonies but are else intact. Also, the exact moment when a cell can be considered dead is difficult to determine. For illustration, cells have a strong capability of self- repair, and can come back from the brink of death. Therefore, whilst a method may determine that a cell is dead (e.g. because its membranes are broken), because the cell can repair itself the cell is actually not dead, just injured.

Apoptosis, or programmed cell death, occurs after a cell has switched on a self- destruction programme. The process of apoptosis involves a number of ways, including cell shrinkage and rounding as well as condensation of the cytoplasm and nuclear material, followed by the formation of blebs, and eventually complete cell breakdown into vesicles called apoptotic bodies. Considering these large structural changes it's perhaps not surprising that apoptosis is accompanied by large changes in the cells' dielectric properties. Cell rounding is accompanied by the loss of microvilli and smoothing of the membrane. This could explain the decline in the membrane capacitance in HL60 cells and Jurkat cells reported by the numerous experimenters. Label et al. also reported that apoptosis in K562 leukaemic cells gives rise to an initial increase in the cytoplasmic conductivity during cell shrinkage, followed by a decrease as cells start to lyse. For human promyelocytic HL-60 and Jurkat E6-1 cells, still, only a decrease was found.

Unlike apoptosis, in traumatic cell death the cell is the passive victim, and cell death is the direct result of environmental stress, including injury by low and high temperatures, mechanical forces, and chemical or natural challenges.

A survey of the literature on the dielectric dimension of cell death has shown that changes that occur in the dielectric properties of cells when they die depend to a large extent on the system by which cell death is induced, but some general trends can be observed. Cell death is nearly always accompanied by changes in the cell membrane permeability, a fact that's exploited in numerous viability stains. This change in the membrane permeability can be anticipated to be mirrored by the change in the membrane conductance.

An increase in the cell permeability also leads to an increase in the exchange of material between the cytoplasm and the medium, which can cause change (generally a decrease) in the internal conductivity. The decline in the capacitance of cell suspensions that's frequently seen when cell death is convinced is most likely mainly due to this increase in the membrane conductance.

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