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Physics of Life Reviews 10 (2013) 382–383

PHYSICS of LIFE reviews

www.elsevier.com/locate/plrev

Comment

The impact of pulsed electric fields on cells and biomolecules Comment on "Lightning-triggered electroporation and electrofusion as possible contributors to natural horizontal gene transfer" by Tadej Kotnik

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Received 25 July 2013; accepted 26 July 2013

Available online 31 July 2013

Communicated by E. Di Mauro

The discovery of a horizontal gene transfer (HGT) revolutionized the evolutionary biology. Suddenly, a long developed concept of a phylogenetic tree, where all organisms share a common ancestor, could not describe the outcome of gene transfer between perceived unrelated organisms [1]. Consequently, a new concept – net of life – is emerging [1]. In the "net of life", each organisms is a combination of shared ancestry and HGT [2]. T. Kotnik reviews the history of biological classification in the human history and positions the role of HGT in the transformation of "phylogenetic tree" to the "net of life" [3]. Although the most frequent mechanisms for HGT are biological: bacterial conjugation, bacterial competence for DNA uptake and viral transduction, T. Kotnik emphasized in this work the role of a physical phenomena – lightning – as a potential trigger of HGT.

To answer the question, if HGT could happen before biological mechanisms had evolved, T. Kotnik analyzes the potential of lightening induced electroporation on HGT. Electroporation is the increase of biological cell membrane permeabilization by externally applied pulsed electric fields (PEF) [4], probably by the formation of aqueous pores in the cell membrane [5–7]. As described by T. Kotnik, the formation of pores leads to reversible electroporation (REP), electrofusion (EF), and irreversible electroporation (IEP). I would like to point out to two important properties of PEF: 1) heterogeneity of microbial population response to PEF and 2) the effects of PEF on biomolecules.

In the natural marine and fresh water environments, more than two million bacteria species exist [8]. Research on food disinfection by PEF showed the tremendous variation in the different species resistance to PEF. Bacterial properties that affect the electroporation threshold are cell size and shape [9], membrane structure [10], membrane charge [11], cells concentration [12] and growth stage [13]. Given the large number of species of bacteria in marine environment it is likely that IEP, REP and EF happen simultaneously at the same depth. It appears that in nature, the number of species plays a significant role in the PEF induced effects in the population: increasing the number of species increases the probability of each of the IEP, REP and EF events. This is different from classical laboratory electroporation studies where PEF are applied on a single species to induce the desired single effect.

DOI of original article: http://dx.doi.org/10.1016/j.plrev.2013.05.001.

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http://dx.doi.org/10.1016/j.plrev.2013.07.025

In addition, T. Kotnik mentions that certain intensities of electric fields melt DNA molecules. Nevertheless, additional works show that PEF affect biomolecules also by non-thermal mechanisms. For example, research on PEF in the food industry showed that PEF can both decrease and increase enzymatic activities [14]. In addition, pulsed electric fields affect the integrity of DNA molecules [15,16]. We have shown that electroporation type PEF may induce DNA nicking [16], which might lead to the rapid integration into the host genome or create new DNA structures. Therefore, lightning could also have additional to electroporation effects on the formation of new genes by direct effect on the biomolecules.

Though intensively investigated for medical and biotechnology applications, electroporation phenomena in nature have passed under research radar. In this work, T. Kotnik presents an interesting analysis of an impact electroporation triggered by lightning may have in evolution.

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