Electroporation of cells and tissues - interactive e-learning E1

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Duration of the experiment: app. 90 min
Max. number of participants: 4
Location: Computer room (CIT)
Level: Basic

PREREQUISITES

No specific knowledge is required for this laboratory practice.

THEORETICAL BACKGROUND

Electroporation is an effective method for introduction of either small molecules (i.e. therapeutic agents such as chemotherapeutic drugs), of macromolecules (such as DNA) or other molecules which in normal conditions do not cross cell membrane. The method is used in different electroporation based therapis such as: clinical electrochemotherapy of cutaneous and subcutaneous tumors, in non-viral gene electrotransfer, irreversible tissue ablation and transdermal gene and drug delivery. The effectiveness of cell and tissue electroporation depends on one hand on the parameters of the applied pulses such as amplitude, duration, number and repetition frequency and type of electrodes used and on the other hand on the characteristics of the cell and tissues to be electroporated. Depending on the electric pulse parameters used the electroporation can be reversible or irreversible. The key role in electroporation effectiveness plays the local electric field distribution, which can be directly modified by electric pulses and electrodes. For controlled use of the method in each particular electroporation based therapy the pulse parameters and electrodes have to be specifically optimized.

In electroporation based therapies development a multidisciplinary expertise is required. The collaboration and knowledge and experience exchange among the experts in the fields of medicine, biology and engineering is needed. To collect, organize and transfer the acquired knowledge web-based technologies are being an indispensable tool in modern teaching.

In this exercise we present a web-based e-learning application we developed in order to provide the knowledge and experience about cell and tissue electroporation. We used computer graphics such as model-based visualization and simple 2D and 3D computer animations and graphical illustrations to facilitate the representation of complex biological and electrical mechanisms involved in electrochemotherapy. The educational content is based on previously published results from molecular dynamics, lipid bilayers, single cell level and simplified tissue models to complex biological tissues.

For the development of the e-learning application we used 3D StudioMax, PhotoShop, CorelDraw, Macromedia Flash, Comsol Multyphisics and Matlab. The educational content (textual and graphical information) is published using Hypertext Markup Language (HTML). The designed e-learning application is integrated into E-CHO e-learning system developed at the Faculty of electrical engineering (University of Ljubljana) by the Laboratory of telecommunications [www.ltfe.org]. The E-CHO e-learning system is an interactive e-learning environment enabling use of various types of communications among users, such as forums, e-mail correspondence, videoconferencing, as well as the authentication of users, statistical analysis, support for video streaming, network traffic measurement, etc.

The aim of this exercise is to provide the participants with basic knowledge on visualization and modeling of local electric field distribution in cells and tissues exposed to high voltage electric pulses (i.e. electroporation pulses) by means of an interactive e-learning application.

PROTOCOL OF THE E-LEARNING SESSION

The participants will be gathered in a computer-based classroom providing each participant with a computer. Before the start of the e-learning session a Power Point presentation will be presented by the instructor giving instructions on how to study the educational content. The participants will be encouraged to collaborate while studying the educational content in order to create a collaborative e-learning environment. The purpose of the collaborative e-learning environment will be to encourage experience and knowledge exchange among experts coming from different scientific fields.

The e-learning content will present three different levels of knowledge on cell and tissue electroporation. The first part will bring together the educational material on basic mechanisms underlying electroporation process on the levels of cell membrane, cell and tissues as a composite of cells (Figure 1).

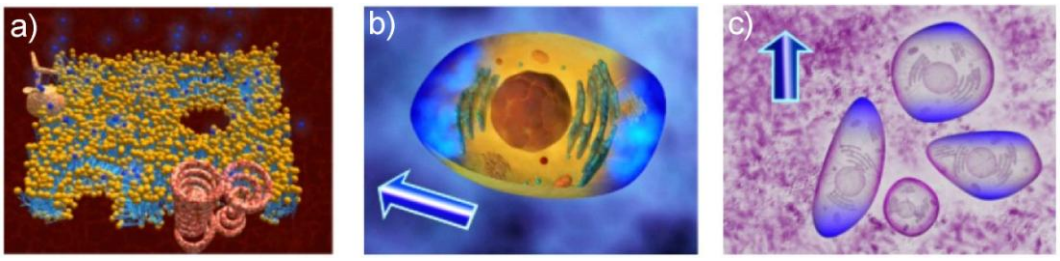

Figure 1: Introduction of small molecules (blue molecules) through a cell membrane (a) into an electroporated cell (b) and into the successfully electroporated cells within an exposed tissue (c)

The second part will provide basic knowledge on important parameters of local electric field needed for efficient cells and tissue electroporation, such as: electrode geometry (needle or plate electrodes), dimension of the particular electrode (width, length, diameter), distance between electrodes, electrode position with respect to the target tissue, electrode orientation with respect to the target tissue, geometry of the target tissue, geometry of the tissue surrounding the target tissue, the contact surface between the electrode and the tissue, electric properties of the target tissue i.e. tissue conductivity, electric properties of the surrounding tissue, the voltage applied to the electrodes and electroporation threshold values.

In the third part we will present an interactive module enabling visualization of local electric field distribution in three dimensional tissue models. The module allows for local electric field visualization in cutaneous (protruding tumors) and subcutaneous tumors (tumors more deeply seeded in the tissue). The module will provide a guideline on how to overcome a highly resistive skin tissue in order to permeabilize more conductive underlying tissues. Participants will be also acquainted with the distribution of local electric field in tissue when electroporated directly or through the skin by using plate or needle electrodes.

After the learning session the pedagogical efficiency of presented educational content and the e-learning application usability will be evaluated. The participants will be asked to provide their agreement on the use of the evaluation results for research purposes.

FURTHER READING:

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NOTES & RESULTS