

# Electroporation of cells and tissues - interactive e-learning course

E1

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Duration of the experiments: 90 min

Max. number of participants: 18

Location: Computer room (CIT)

Level: Basic

## PREREQUISITES

No specific knowledge is required for this laboratory practice.

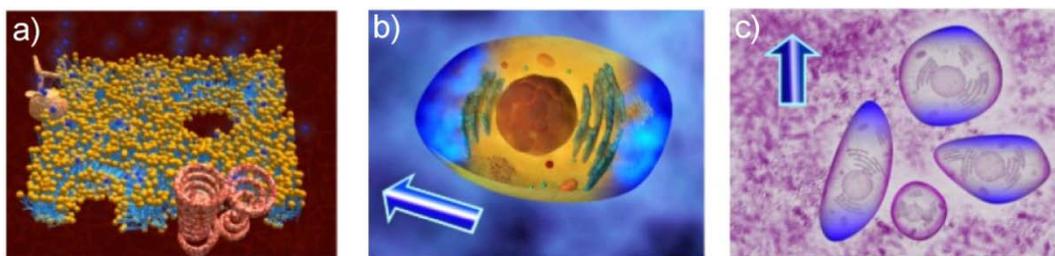
## THEORETICAL BACKGROUND

**The aim** of this exercise is to provide the participants with basic knowledge on local electric field distribution in cells and tissues exposed to high voltage electric pulses (i.e. electroporation pulses) by means of interactive e-learning course content. The e-learning content is based on the available knowledge from the scientific literature.

## PROTOCOL OF THE E-LEARNING COURSE

The participants will be gathered in a computer-computer classroom providing each participant with a computer. A short test will be given to establish the baseline knowledge before the e-learning course.

Within the first part of the e-learning course we 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).

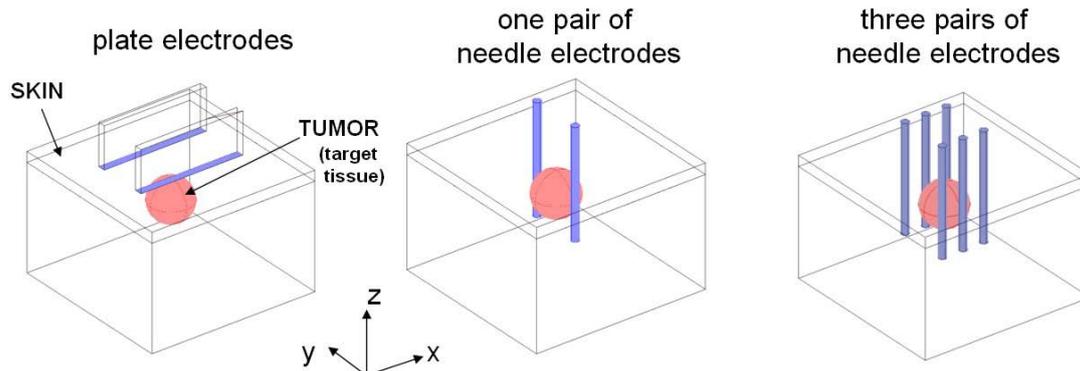


**Figure 1:** Introduction of small molecules (blue molecules) through a cell membrane (a) into an electroporated cell (b) and into the successfully electroporated cells within an exposed tissue (c) (Čorović et al., 2009)

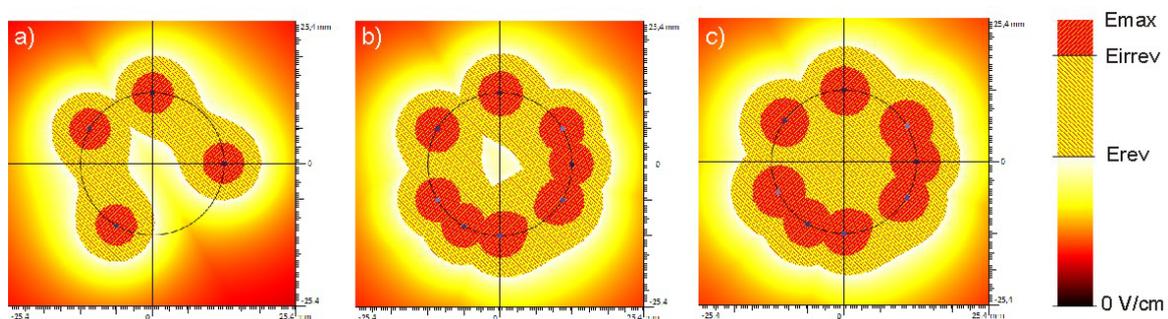
Within the second part of the course we will provide basic knowledge on important parameters of local electric field needed for efficient cells and tissue electroporation, such as: electrode geometry (needle or plate electrodes as illustrated in Figure 2, electrode position with respect to the target tissue and its surrounding the tissues (Figure 3), the contact surface between the electrode and the tissue, the voltage applied to the electrodes and electroporation threshold values. This part of the e-learning course content will be provided by an interactive module we developed in order to visualize the local electric field distribution in 2D and 3D dimensional tissue models.

The objective of this module is to provide:

- local electric field visualization in cutaneous (protruding tumors) and subcutaneous tumors (tumors more deeply seeded in the tissue);
- guideline on how to overcome a highly resistive skin tissue in order to permeabilize more conductive underlying tissues and
- visualization and calculation of successfully electroporated volume of the target tissue and its surrounding tissue (i.e. the treated tissue volume exposed to the electric field between reversible and irreversible electroporation threshold value  $E_{rev} < E < E_{irrev}$ ) with respect to the selected parameters such as: number and position of electrodes, applied voltage on the electrodes.



**Figure 2:** Plate electrodes vs. needle electrodes with respect to the target tissue (e.g. tumor tissue)



**Figure 3:** Electric field distribution within the tumor (inside the circle) and within its surrounding tissue (outside the circle) obtained with three different selection of parameters (number and position of electrodes and voltage applied): (a) 4 electrodes, (b) 8 electrodes and (c) 8 electrodes with increased voltage on electrodes so that the entire volume of tumor is exposed to the  $E_{rev} < E < E_{irrev}$ .

After the e-learning course the pedagogical efficiency of presented educational content and the e-learning application usability will be evaluated.

### FURTHER READING:

- Miklavčič D., Snoj M., Županič A., Kos B., Čemažar M., Kropivnik M., Bračko M., Pečnik T., Gadžijev E., Serša G., Towards treatment planning and treatment of deep-seated solid tumors by electrochemotherapy, *Biomed. Eng. Online* 9: 10, 2010.
- Serša G., Miklavcic D., Electrochemotherapy of tumours (Video Article), *J. Visual Exp.* 22: 1038, 2008.
- Čorović S., Županič A., Kranjc S., Al Sakere B., Leroy-Willig A., Mir L.M., Miklavčič D., The influence of skeletal muscle anisotropy on electroporation: in vivo study and numerical modeling, *Med. Biol. Eng. Comput.* 48: 637-648, 2010.
- Čorović S., Pavlin M., Miklavčič D., Analytical and numerical quantification and comparison of the local electric field in the tissue for different electrode configurations, *Biomed. Eng. Online* 6: 37, 2007.
- Corovic S., Al Sakere B., Haddad V., Miklavcic D., Mir LM, Importance of contact surface between electrodes and treated tissue in electrochemotherapy, *Technol. Cancer Res. Treat.* 7: 393-399, 2008.
- Čorović S., Županič A., Miklavčič D., Numerical modeling and optimization of electric field distribution in subcutaneous

tumor treated with electrochemotherapy using needle electrodes, *IEEE T. Plasma Sci.* 36: 1665-1672, 2008.

Čorović S., Bešter J., Miklavčič D., An e-learning application on electrochemotherapy, *Biomed. Eng. Online* 8: 26, 2009.

Garcia P.A., Rossmeisl J.H. Jr, Neal R.E. 2nd, Ellis T.L., Olson J.D., Hena-Guerrero N., Robertson J., Davalos R.V., Intracranial nonthermal irreversible electroporation: in vivo analysis, *J Membr Biol.* 236(1):127-36, 2010.

Garcia P.A., Rossmeisl J.H. Jr, Neal R.E., Ellis T.L., Davalos R.V., A Parametric Study Delineating Irreversible Electroporation from Thermal Damage Based on a Minimally Invasive Intracranial Procedure, *Biomed. Eng. Online* 10: 34, 2011.

Bergues Pupo A.E., Reyes J.B., Bergues Cabrales L.E., Bergues Cabrales J.M., Analytical and numerical quantification of the potential and electric field in the tumor tissue for different conic sections, *Biomed. Eng. Online*, 2011

## **NOTES & RESULTS**

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