**Title**: Physics-informed neural network model for cell viability and oxygen consumption of pancreatic islets

**Authors**: Mojtaba Barzegari, Liesbet Geris

**Affiliations**: Biomechanics Section, Department of Mechanical Engineering, KU Leuven, Leuven, Belgium; Biomechanics Research Unit, GIGA in Silico Medicine, University of Liège, Liège, Belgium

**Abstract**: Pancreatic islets (islets of Langerhans) transplantation is one of the best treatment approaches for the most severe forms of type 1 diabetes, but this needs a proper preparation of the islets in a culturing process. The cultured and encapsulated islets are highly sensitive to hypoxia, a situation in which they lose their vasculature due to the lack of supplied oxygen and cannot survive. For the islets, the oxygen is provided through a gradient-driven passive diffusion, a process that can be well described by mathematical models. In fact, a mechanistic mathematical model of cell viability and oxygen transport can help to improve the design of culture devices.

The mathematical model of oxygen consumption of pancreatic cells can be constructed based on time-dependent reaction-diffusion partial differential equations (PDE) by incorporating realistic assumptions from the biological point of view. Due to the nature of the underlying phenomena, the derived equations are usually non-linear, requiring specific considerations to be solved by conventional numerical techniques such as finite element (FE) method.

Machine learning (ML) and deep learning (DL) have already been extensively used in a wide range of engineering disciplines to seek unknown patterns behind a high volume of data. A recently introduced class of DL models, known as physics-informed neural network (PINN), has proved to be suitable for finding the solution of the governing non-linear PDEs of various physical systems. These models are gaining attention as they can benefit from rapidly-growing developments in DL technologies.

In this study, a PINN model of the oxygen consumption of pancreatic islets was developed to solve the non-linear PDE of transient oxygen transport to predict the viability of cultured cells. In order to reproduce the physiological conditions, the domain of interest was divided into two materials, cells and the culture environment, each of which with different diffusion coefficients and initial conditions. This tricky assumption was properly implemented by defining appropriate Heaviside functions. The boundary conditions were applied in accordance with commonly used experimental setups for islets encapsulation. A time-dependent FE model was also implemented using the same conditions, in which the Picard method was used to linearize the cell viability equation. The PINN model was trained using NVIDIA SimNet and TensorFlow libraries, and its predictions were compared with the FE model implemented in FreeFEM solver, showing a good agreement between the results, demonstrating the model's equivalence to the traditional numerical schemes in this case.

**Keywords**: Physics-informed neural netwroks, Finite element modeling, Partial differential equations