COMPUTATIONAL MODELING OF WOUND CLOSURE

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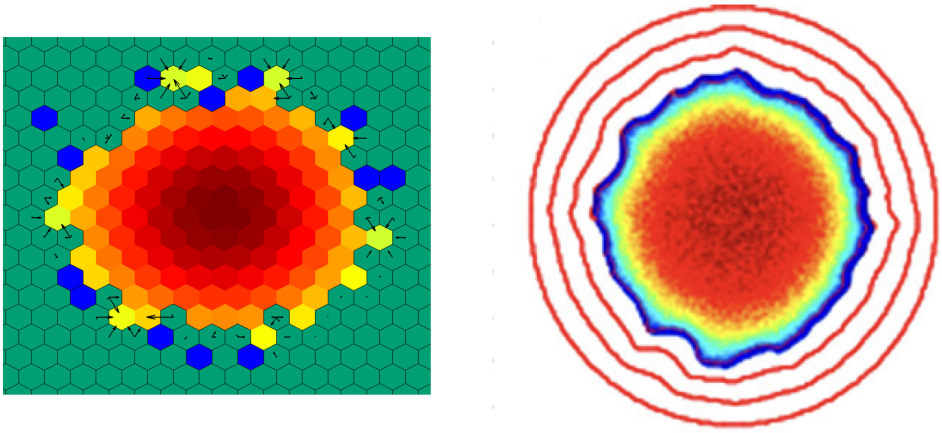

Effective summary

Wound healing is a complex process [3] in which the skin heals itself after injury, and many of the underlying mechanisms are still poorly understood. One of the important processes is wound closure (or so-called re-epithelialization). Without an appropriate wound closure, patients will develop a chronic wound and even a skin cancer in long term [3].

It has been observed that the same (optical) diagnosis of the wound sometimes results in a completely different healing process, which indicates that wound healing is patient-oriented (e.g. age and stiffness of the skin). With mathematical model, one can convert these patient characteristics to input parameters and predict the specific healing process from the model.

In this project we wish to set the foundations for a model of wound closure in an existing agent-based framework [2], i.e. cellular automata model, where the cells are represented as discrete agents migrating and proliferating by local rules. We seek to interpret a previous Partial Differential Equation (PDE) model of wound healing [1] in a continuous setting into the discrete, stochastic framework. The model includes proliferation, migration due to overcrowding and upward a chemical gradient. Such model facilitates investigation into wound healing morphology, the speed of wound closure due to the balance between proliferation and migration, as well as the impact of stochasticity and comparisons with the qualitative behaviour of the macro-scale PDE model.

Background

In this project, we consider the top-view of the wound, and modelling the subsequent wound closure process by an agent-based model in two spatial dimensions. One of the *aims* of this project is to investigate the "mathematical-computational bridge" between agent-based (micro-scale) and continuum-based (macro-scale) models on wound closure (specifically, the model in [1]). For instance, relating the parameter values between two scales, analysing whether extra conditions are needed for obtaining similar (key) results and quantifying the differences between two models that describe the same biological phenomena. If time permits, it is possible to explore further research questions, e.g., the impact of the wound geometry on healing process (in general, circular wounds heal worse than rectangular ones). In the long run, we expect to develop a patient-oriented model including the patients' characteristics, facilitating prediction of the healing process and its interference.

There are several foreseen challenges in the project. First, the student is expected to establish the model consisting of various mechanics, of which some require constructing and analysing PDEs. Moreover, as we reduce the model in [1] to the micro-scale, the challenge lies in how to properly interpret and connect models at different scales that describe the same biological phenomena. In addition, student is expected to qualitatively or even quantitatively validate the agent-based model.

References

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[3] A. Jakovija and T. Chtanova. "Skin immunity in wound healing and cancer". In: *Frontiers in Immunology* 14 (June 2023). ISSN: 1664-3224. DOI: 10.3389/fimmu.2023.1060258. URL: http://dx.doi.org/10.3389/fimmu.2023.1060258.

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