Bachelor Thesis / Master Thesis

"Investigations of dynamic perfusion of 3D-printed cell-populated scaffolds using software simulations (B.Sc.) and experimental data collection (M.Sc.)"

Supervised by Institutes of Medical Biotechnology (MBT) and Fluid Dynamics (LSTM)

As part of an R&D project (2022-25) with two companies, fundamental aspects of osteogenesis are investigated to yield better artificial bone tissues (tissue engineering). Here, 3D-printed scaffolds (from biomaterials with suitable chemical and physical properties) are seeded with stem cells, cultivated in appropriate culture environments and stimulated biochemically. The scaffold geometry should facilitate the homogeneous flow of culture medium. Homogeneous cell distribution in the scaffold after seeding determines the subsequent tissue structure and functionality (i.e. supply of cells in the scaffold interior). Bone formation is influenced by shear stress and mechanical forces. The maturation of the cell-scaffold construct is monitored using (multiphoton) microscopy as well as ELISA and other biochemical assays. Experiments with a recently developed perfusion system (multi-biochamber connected to high-precision pump) yielded valuable data and perfusion simulations (Ansys Fluent) of flow chamber with/without scaffold (in order to reduce the number of experiments) were successful.

Scope of work:

- Extend simulations to (a) additional scaffold geometries and (b) gradual pore filling with bone cells to study their effects on the whole system
- Optimize parameters with Ansys (medium flow rate, wall shear stress, hydrostatic pressure)
- For Master projects: Implement MEM-based sensors in the perfusion system and perform flow experiments. Sensor data should be fed into simulation modelling and refinement

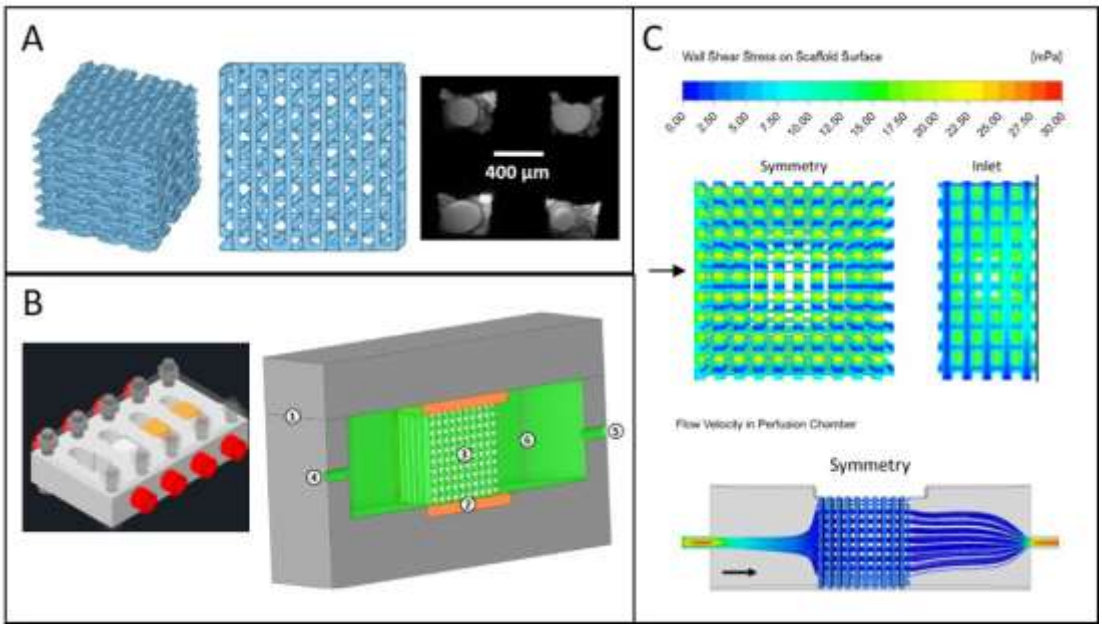

Figure. A: Left: Scaffold with 45 ° layer geometry. Right: Population of scaffold (90° geometry). Pores filled with cells one week after seeding (transmission image). **B:** Left: 3D model of the perfusion multi-biochamber (left). Right: Model of the free fluid space within chamber and scaffold created with Ansys (fluid space divided vertically at symmetry plane). **C:** Top: Wall shear stress at scaffold surface calculated in Ansys (color map). `Symmetry` shows a cross-section in flow direction, `Inlet` the scaffold surface at the inlet side. Bottom: Colored streamlines of flow velocity within the biochamber at the symmetry plane.

Pre-knowledge:	Software Simulations, Concept of Tissue Engineering, Lab experience (MA students)
Methods to learn:	Simulations in Ansys Fluent, Fluid dynamics, Bioreactor technology
Target group:	LSE, CBI, Materials Science, EAM, Medical Engineering, CE, Bioinformatics

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