AUCKLAND BIOENGINEERING INSTITUTE
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A Multiscale Modelling Approach to Predict Cartilage Growth in Scaffolds: A Computational and Experimental Framework

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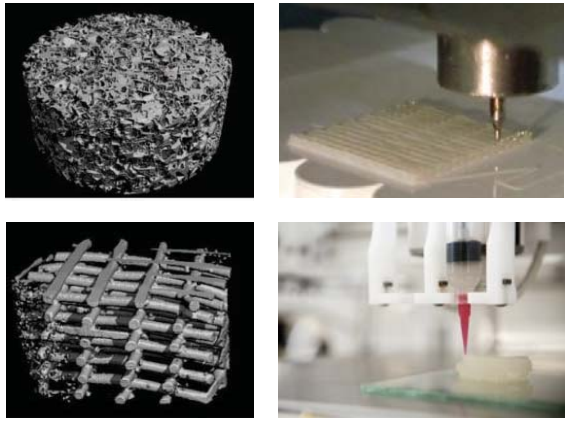
Summary

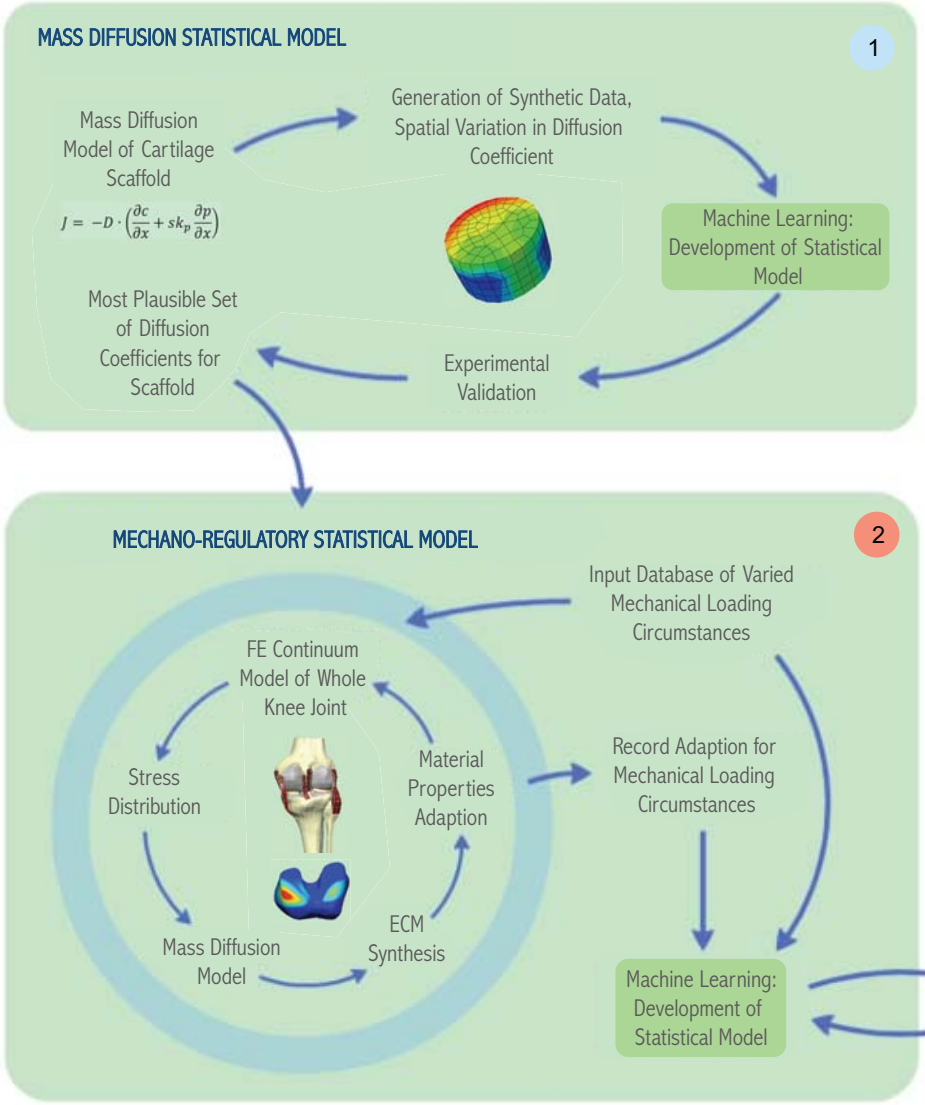
Mechanical stimulation is known to be a determining factor in the maintenance and development of articular cartilage. It has been seen to dictate the level of growth and the organisation of synthesized ECM within cell seeded scaffolds for cartilage tissue engineering. However to date there has been no unique relationship established that describes how the tissues regenerative response is influenced by the mechanical stimulation that is experienced, as has been achieved most notably with bone tissue via Wolffs law.

It is hypothesized that through the development of multi-scaled mechanobiological model, we can investigate how alternate loading circumstances impact the growth and development of tissue engineered cartilage tissue. Furthermore, it is postulated that a scaffold optimization routine can be added to the established model in order to determine the ideal scaffold topology for tissue regeneration, based on its mechanical environment, given that scaffold architecture greatly dictates its spatial mechanical properties.



Example of 3D scaffolds and 3D fabrication technique used for Cartilage Tissue Engineering.

Project Framework



STAGE 1

- Statistical Model to determine spatial variation in diffusion coefficient (D) for a given scaffold.
- Validation with experimental data to back out the most plausible D.

STAGE 2

- Mechanobiological model that iteratively determines the adaption of scaffold-tissue mechanical properties depending on loading circumstances.
- Adaption into statistical model.

STAGE 3

- Incorporation of scaffold optimization.
- Able to idealize scaffold topology to give optimal tissue regeneration based on loading circumstances.

SCAFFOLD TOPLOGICAL OPTIMISATION STRATEGY 3

Maximization of Cell Spatial Distribution through the Minimization of a Cost Function with Terms Relating to Spatial Stiffness and Volume Fraction