A statistical model to predict diffusion patterns in bone scaffolds and learn latent behaviours

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Background

Bone, an integral part to the musculoskeletal system of the human body. It provides not only the protective casing for vital organs such as lungs, heart, nerves, but also acts as a mineral reservoir for calcium and phosphorus ions, supports movement and makes blood. Although bone is capable of self-healing, there are cases where damage is beyond self-repair such as non-union fracture. Intervention may be needed.

Scaffolds help bone repair. However, the mechanism is yet to be fully determined. Factors such as architecture, pore sizes, density, interconnectivity, manufacturing process, and biomaterial constituents play a role in determining the effectiveness of the scaffolds. We research how cell growth, proliferation, migration and adhesion relates to scaffold properties.

Aims

We aim to:

1. Integrate live/ dead straining assays with a mechanical and statistical computation model
2. Investigate scaffold architecture and the resultant cell viability

Methods

1. Process images: Dr Sandy Lin provides live/ dead staining images as well as structural images of her PLLA and PETG scaffolds from scanning electron microscope [1]. Live cell concentration, C= $\{c^1_{t1}, c^2_{t1}, c^3_{t1}, \ldots, c^n_{tm}\}$ is estimated from these images.
2. Train a support vector regression model: many synthetic scaffolds are made with different diffusivity values, D = $\{d_1, d_{2,\ldots,} d_n\}$, and their resultant cell concentration patterns, C, are solved by finite element method in Abaqus. The model learns to estimate the D from C.
3. Estimate D: support vector regression models estimate the optimal D_1, D_2 for PLLA and PETG respectively.
4. Identify latent behaviours: using singular value decomposition, we may associate the characteristics of PLLA and PETG with their respective cell growth pattern.

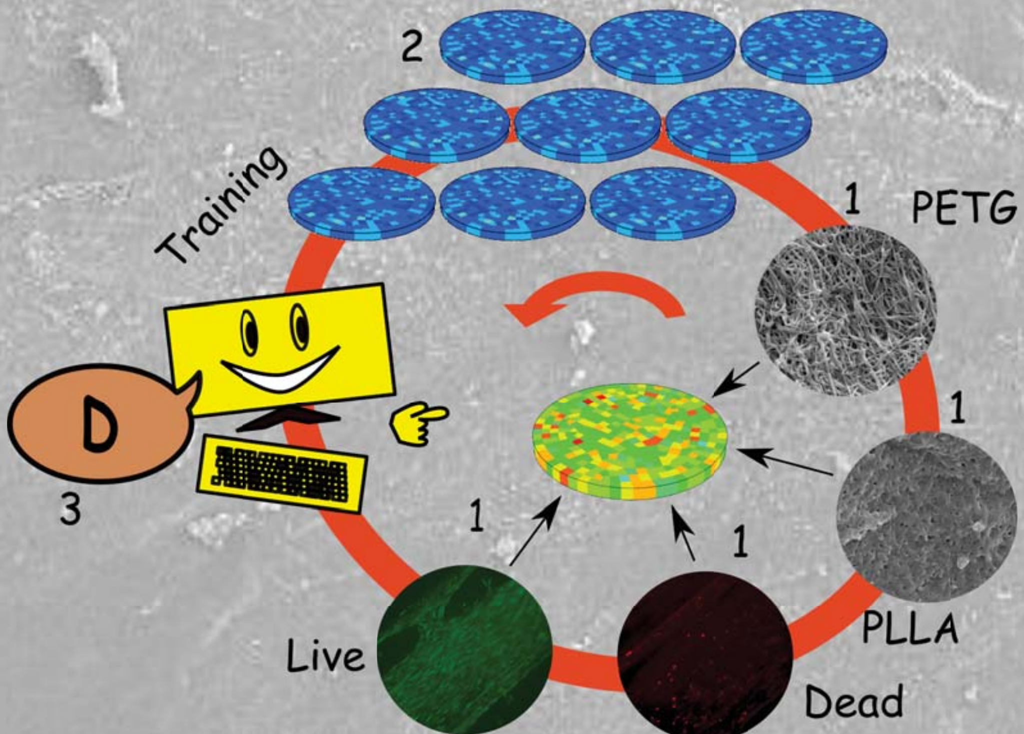
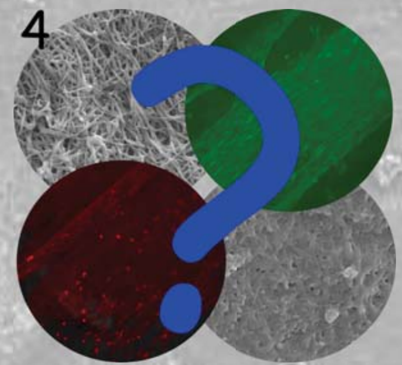


Image courtesy of Dr Sandy Lin [1]

Summary

This is our first attempt to combine commonly collected experimental data with mathematical equations in hope of providing a new perspective on how osteoblasts grow on scaffolds.



References

[1] Lin, S., Bhattacharyya, D., Fakirov, S. and Cornish, J. 2014. Novel Organic Solvent Free Micro-/Nano-fibrillar, Nanoporous Scaffolds for Tissue Engineering. *International Journal of Polymeric Materials and Polymeric Biomaterials*. 63, 8 (2014), 416–423

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