Design and Fabrication of an Artificial Bone Scaffold

► STUDENTS / UNIVERSITIES

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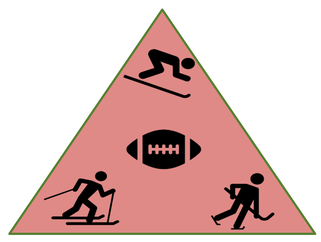
Güllü Kızıltaş Şendur

Introduction

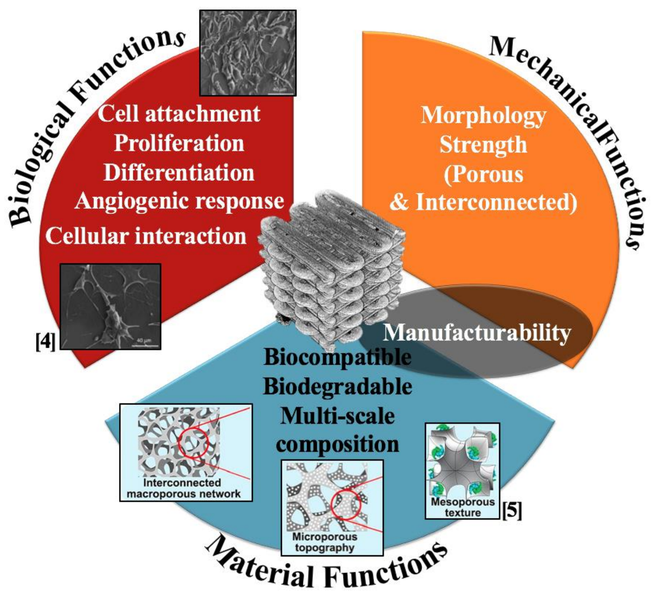
Bone fracture:

- Very common body injury [1]
- Societal productivity loss and individual disability [1]



Bone healing:

- More than billion dollars [1]
- Nonunion and incomplete healing (5-10% of fractures) [2]
- Biological and Mechanical aspect ➡ Mechanobiological modelling



✔ Well-designed scaffold implants which are structures providing support, are good alternatives in bone tissue engineering known to result in effective healing.

Objective

- To understand the bone healing process both biologically and mechanically
- To fabricate the artificial bone scaffold by using more efficient and low-priced methods
- To design and simulate artificial bone scaffold for effective healing.

Design

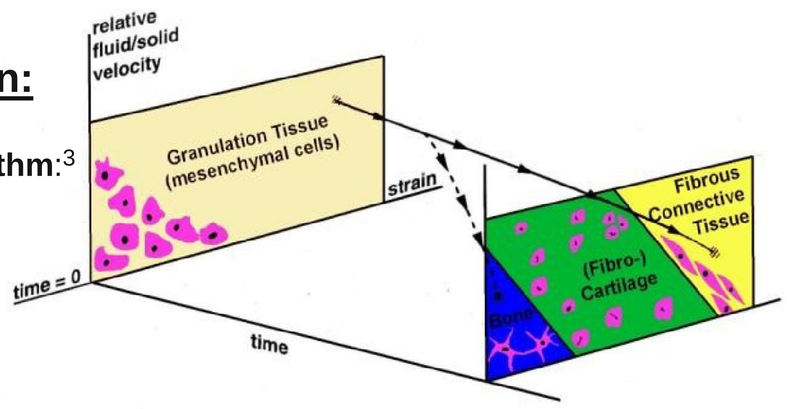
Mechanobiology:

Tissue Differentiation:

Mechanoregulation algorithm:[3]

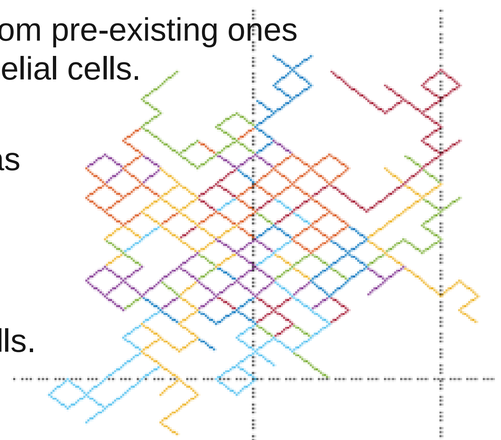
- Shear Strain
- Fluid/Solid Velocity

$$S = \gamma/a + \upsilon/b$$



Angiogenesis:

- The process of forming new blood vessels from pre-existing ones through migration and proliferation of endothelial cells.
- **Aim:** Simulating real environment as much as possible .



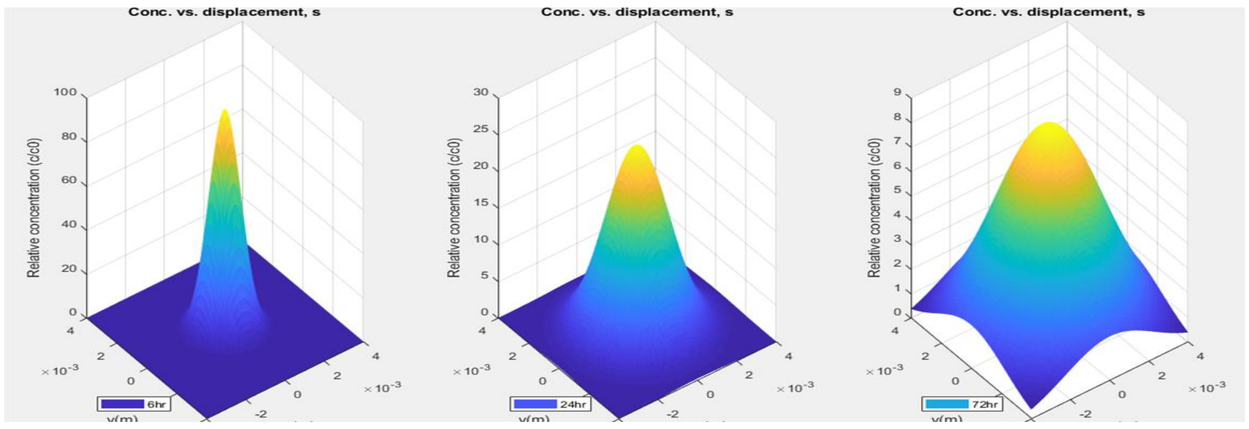
Random Walk: Mathematical modelling of the Movement of animals, micro-organisms and cells.

Growth Factors:

Regulation of cellular processes such as migration, proliferation and differentiation

- Transforming Growth Factor Beta (TGF-β),
- Bone Morphogenetic Proteins (BMPs),
- Platelet-Derived Growth Factor (PDGF),
- Vascular Endothelial Growth Factor (VEGF)

A 2-D Diffusion model is obtained in MATLAB and this can be used for the diffusion of the growth factors.

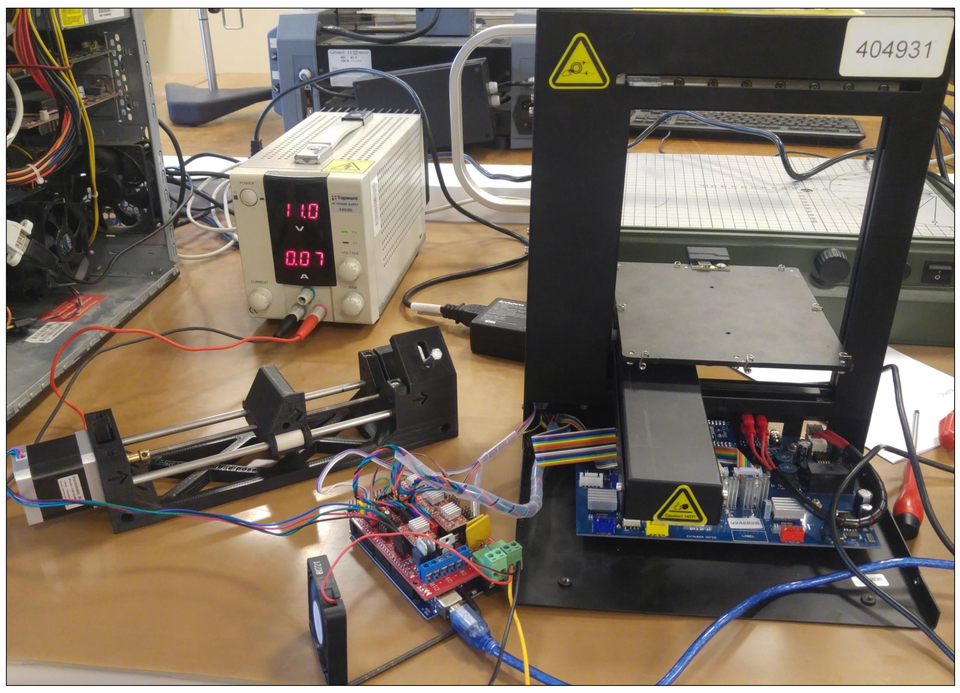


Fabrication

Non-solvent Induced Phase Separation (NIPS) Based 3D Printing:

NIPS based 3D printing method to fabricate composite micro and macro porous PCL-HA scaffold in bone tissue engineering. ➡ NIPS promotes cell attachment & cell proliferation

PCl-HA dissolved in THF ➡ **THF is rapidly removed by extruding in ethanol** ➡ **Rapid volatilizing of solvent creates micro-porosity**



- ➢ Up Plus 2 3D printer ➡ NIPS based Arduino 3D printer
- ➢ DIY mechanically driven syringe pump
- ➢ Open Source firmware (Marlin)
- ➢ Low cost & easily controllable

Conclusion & Improvements

- In the field of computational modeling, coding studies were performed in MATLAB for vascularization and diffusion.
- In order to obtain micro-macro porous scaffold structure, we transformed a commercial 3D printer into an open source NIPS based Arduino 3D printer. By using this 3D printer we can obtain micro-macro porous biocompatible scaffold which is drawn by a CAD program.

References

[1]*Pivonka and Dunstan, 2012; Bonafede et al., 2013*

[2]*Einhorn, 1995; Praemer et al., 1992*

[3]*Finite Element Method (FEM), Mechanobiology and Biomimetic Scaffolds in Bone Tissue Engineering A. Boccaccio, A. Ballini, C. Pappalettere, D. Tullo, S. Cantore, A. Desiate*

[4]*Tansik, G. et al., Biomater. Sci. , 2016, 4, 1328-1339.*

[5]*Tang W, Lin D, Yu Y. (2016). Acta Biomater. 32, pp. 309–323*