Using Simulations to Evaluate the Proper Conditions of the *in Vitro* Culture of Bone Tissue

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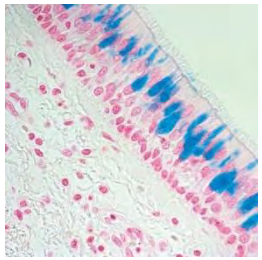
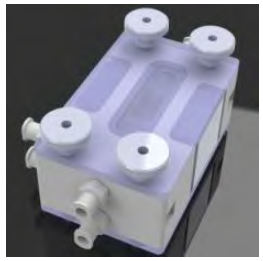
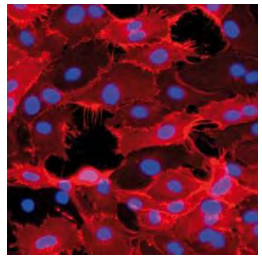


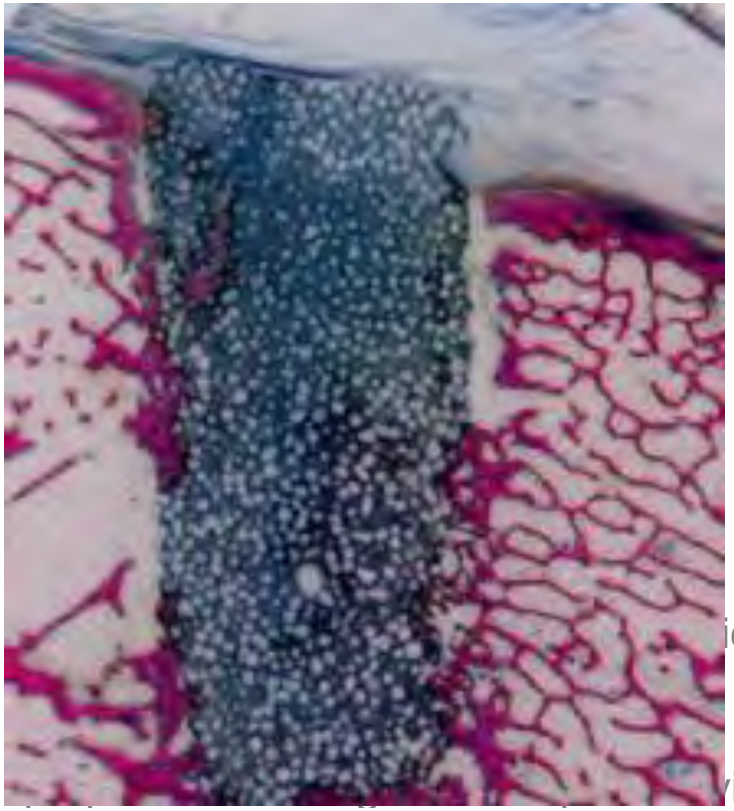




Motivation

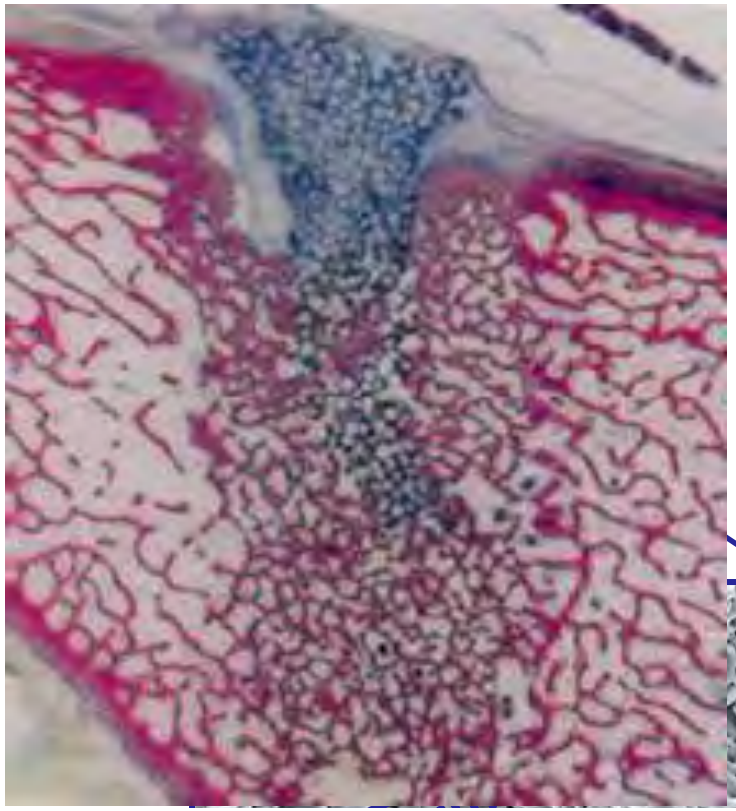
Source: Butzbacher Zeitung from 29.10.2010

http://www.kinderchirurgie-augsburg.de/images/fraktur.jpg

State of the Art in Bonesubstitues



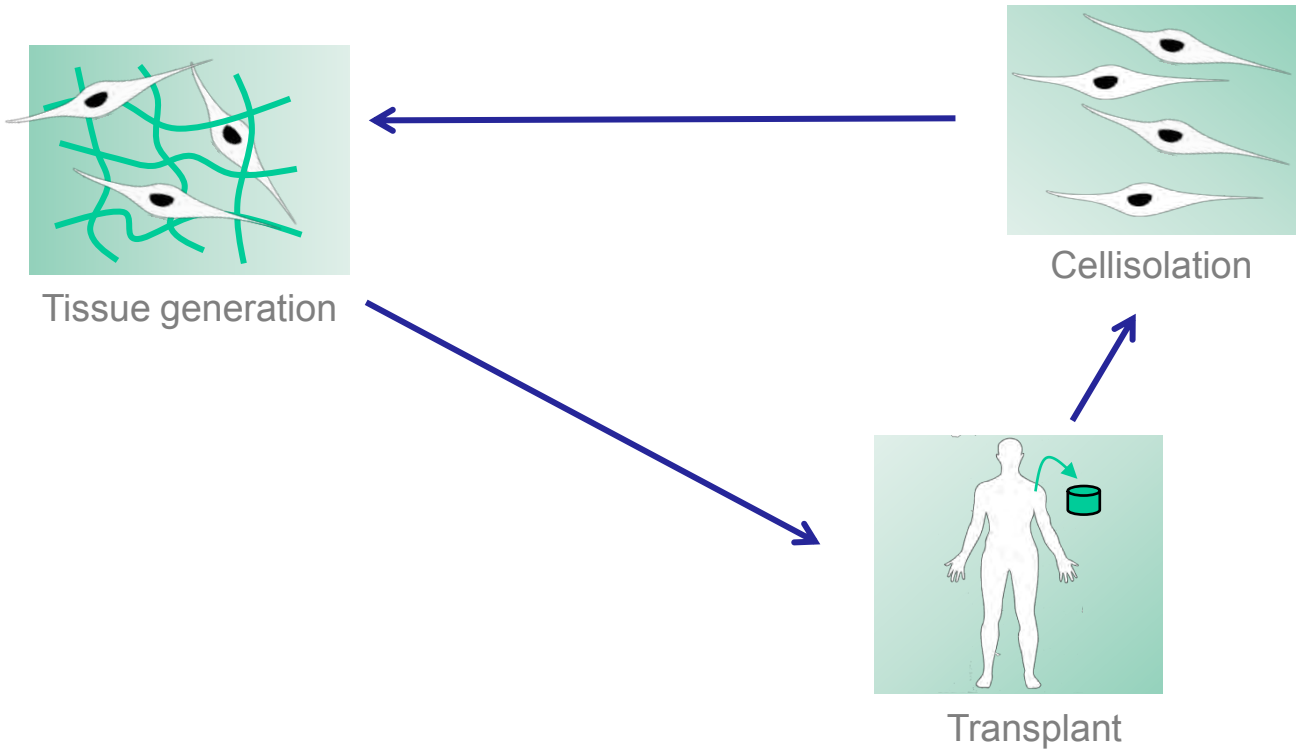
Unseeded scaffold after 12 weeks of implatation



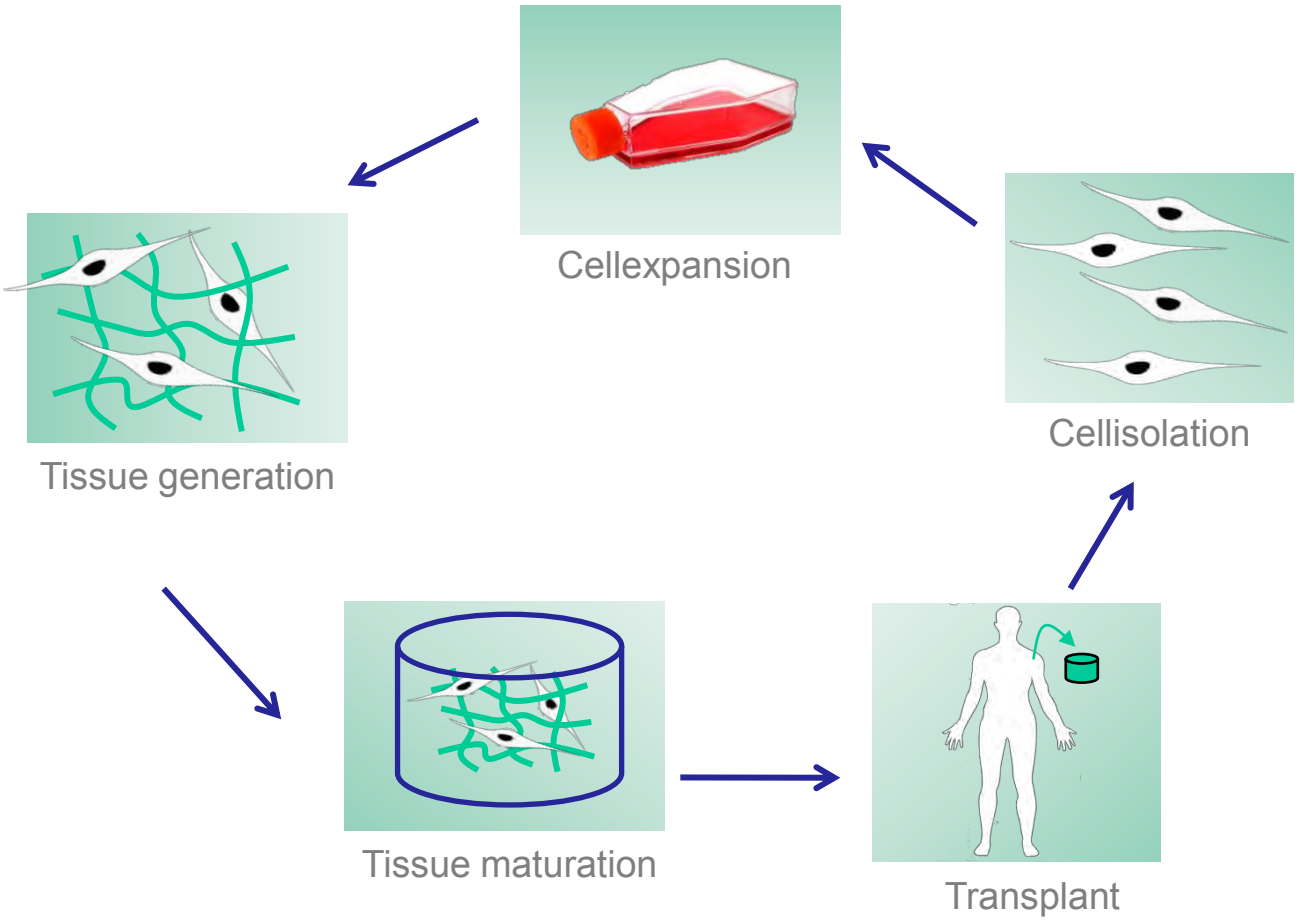
Preseeded scaffold with mesenchymal stem cells, 12 weeks of implatation

Pictures from Synthes ® Product Sheet „chronOS. Bone Graft Substitute.“ 2011

Tissue Engineering: an Overview



Tissue Engineering: an Overview



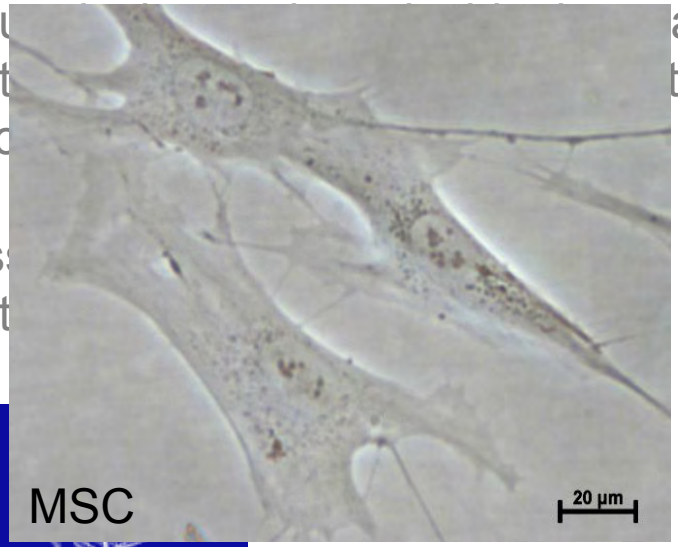
Our Aim

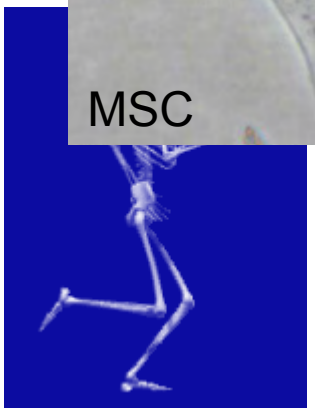
Flow:

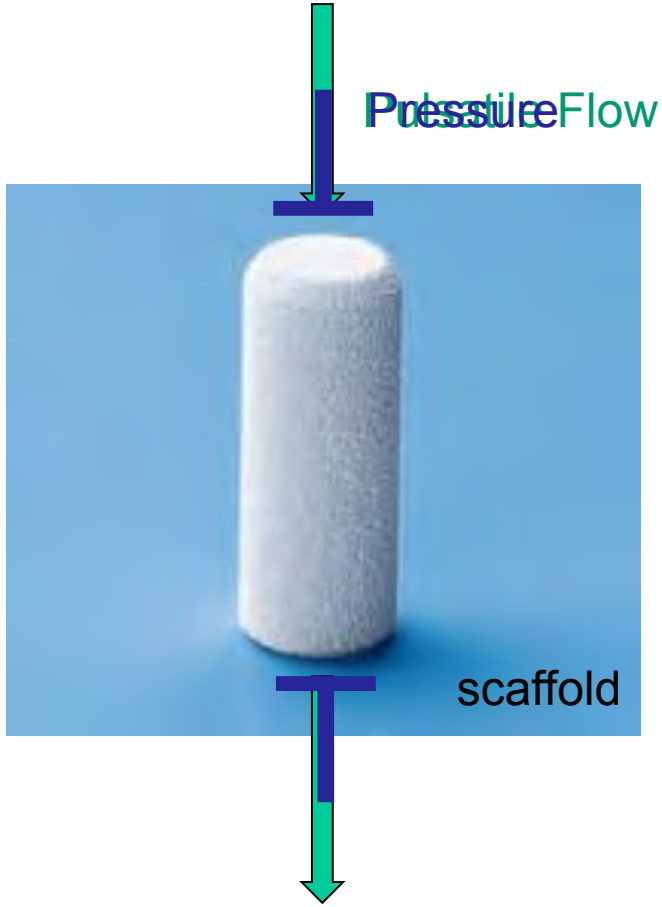
- Su affold
- St te into bo

Press

- St

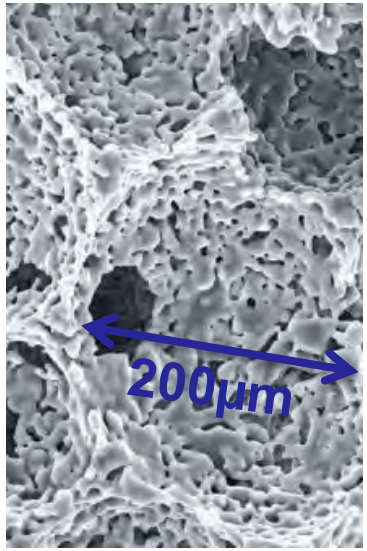






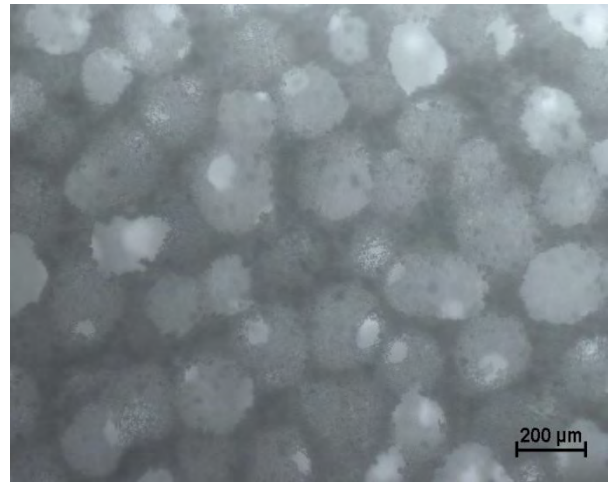
Geometric Reproduction of the Scaffold

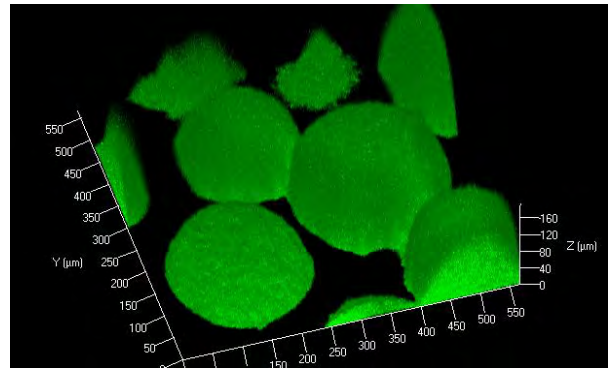
On macroscopic and microscopic scale



SEM

Light microscopy

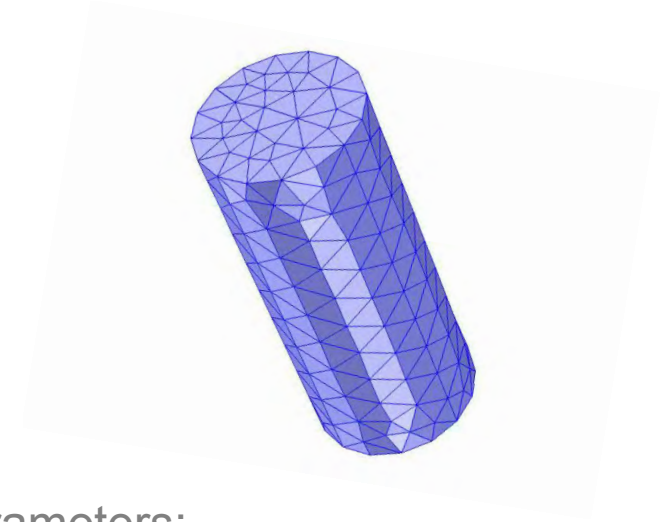




CLSM

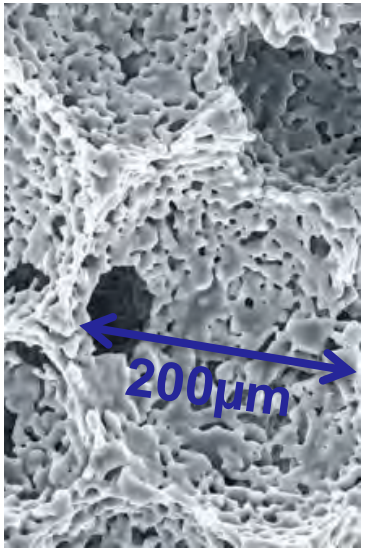
Geometric Reproduction of the Scaffold

On macroscopic and microscopic scale



Parameters:

- Porosity of the scaffold



SEM

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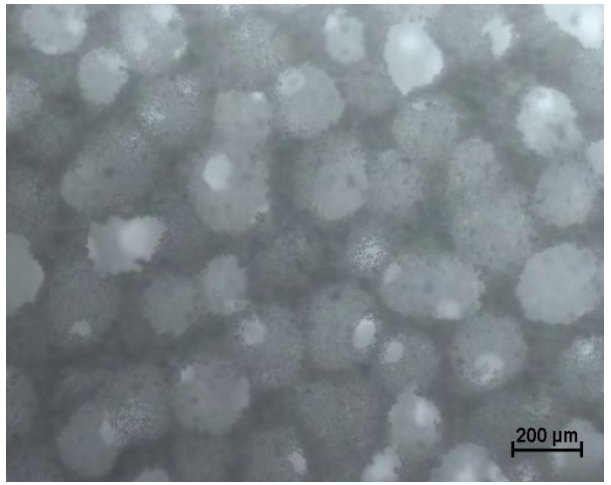
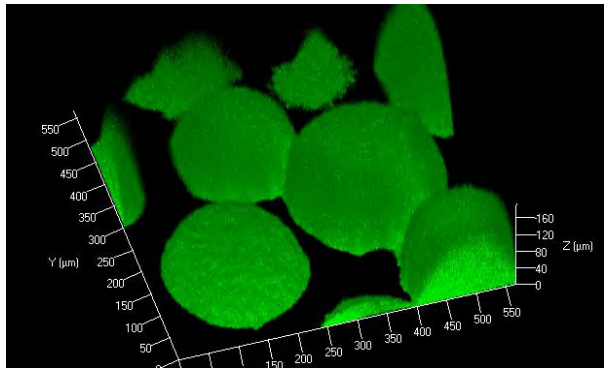


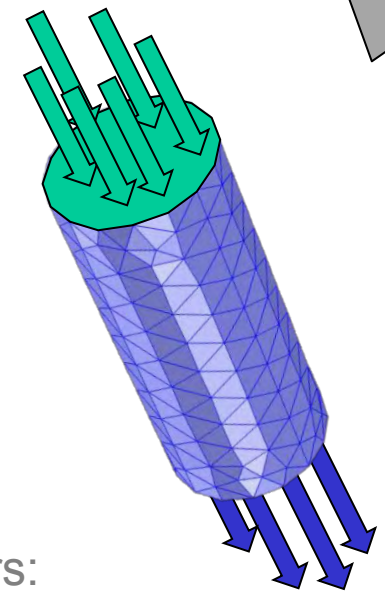


CLSM

Geometric Reproduction of the Scaffold

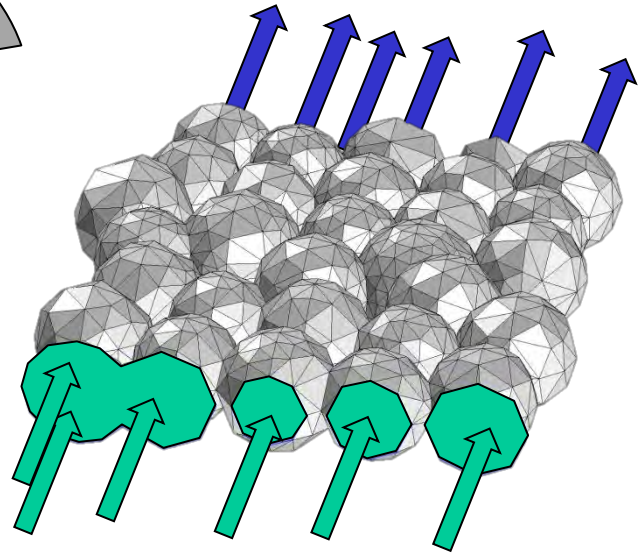
On macroscopic and microscopic scale

Iterative adjustments



Inlet

Outlet



Parameters:

- Porosity of the scaffold
- Pore diameter
- Pore interconnectivity

Surface: confluent monolayer of cells

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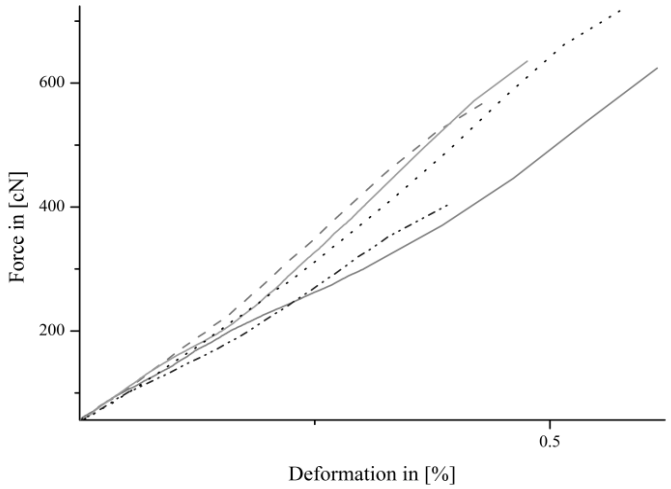
University of Stuttgart
Institute for Interfacial Engineering

Measurements of the relevant bio-physical parameters



-> Young`s Modulus

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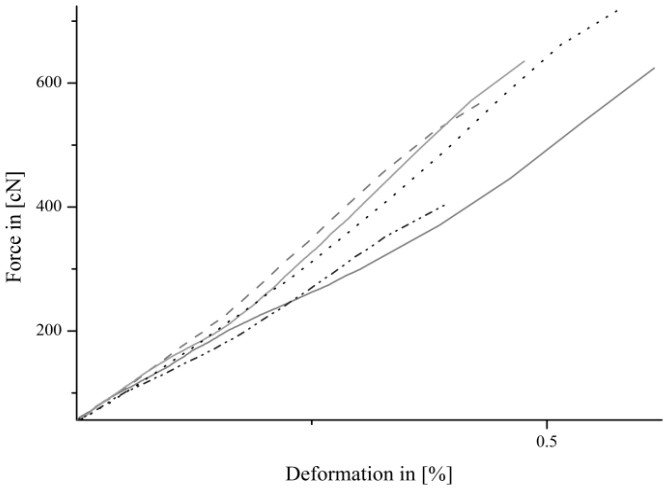
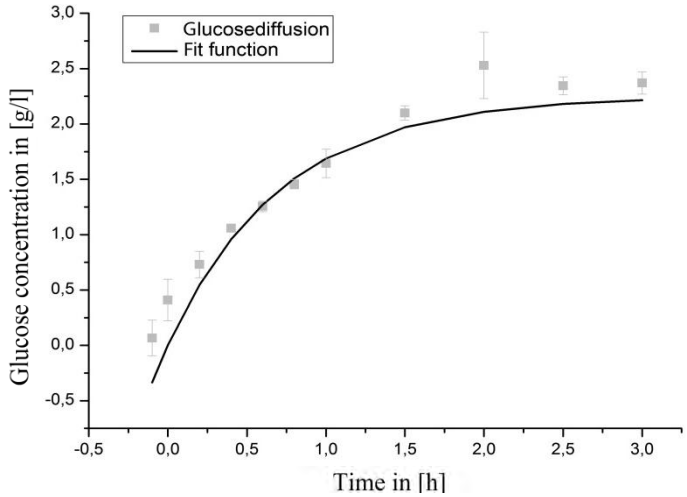
Measurements of the relevant bio-physical parameters





-> Young`s Modulus
-> Diffusioncoefficient of glucose

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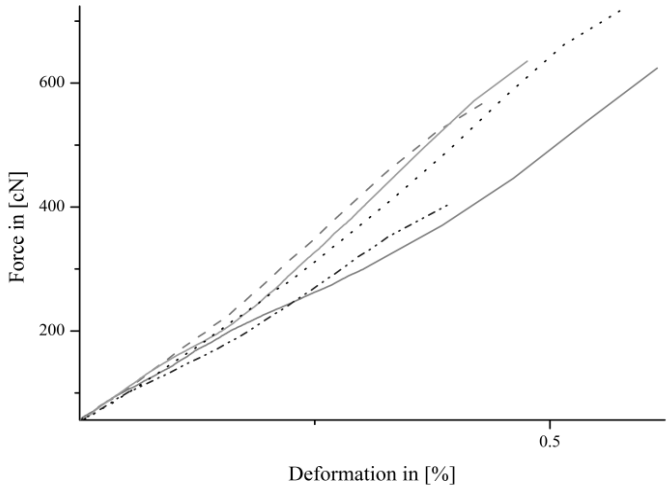
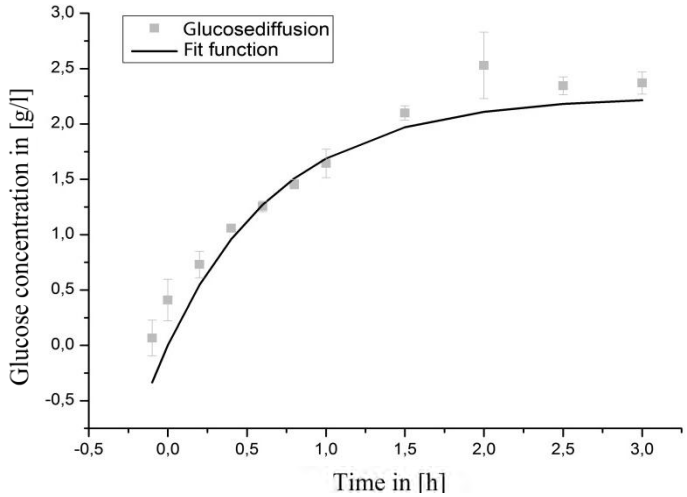
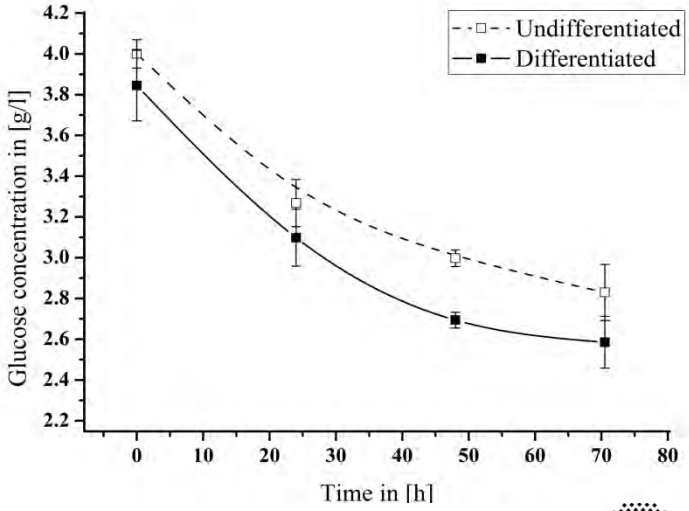
Measurements of the relevant bio-physical parameters







-> Young`s Modulus
-> Diffusioncoefficient of glucose
-> Glucose consumption rate

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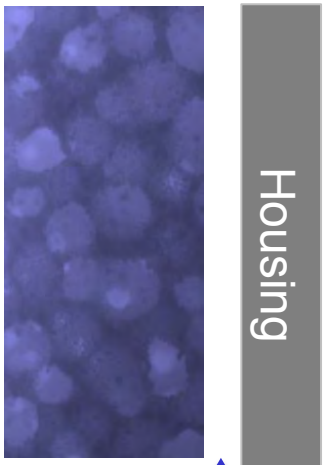
Simulations

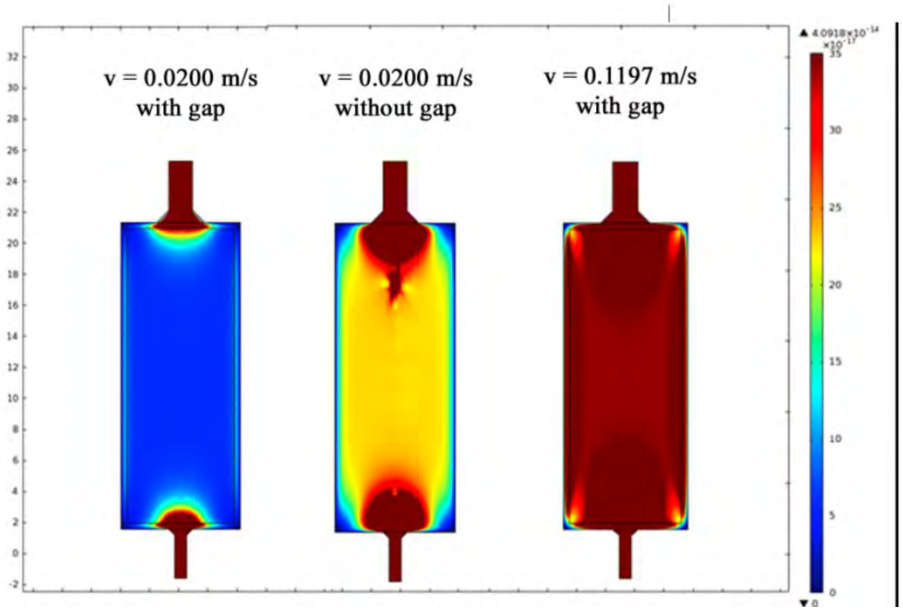
Macroscopic Model

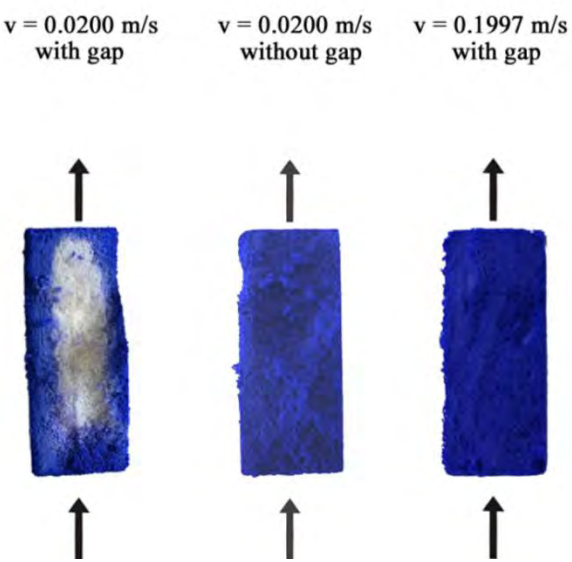
Scaffold



Housing

Gap





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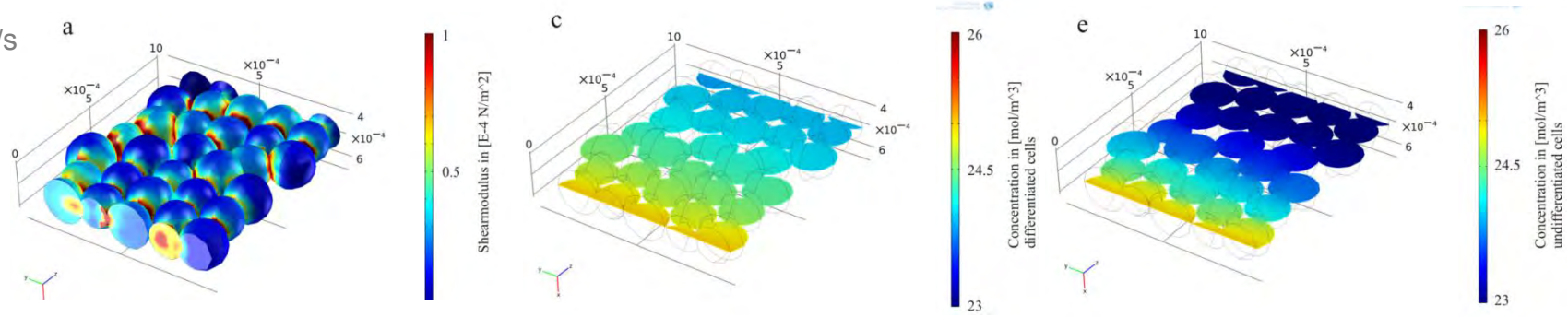
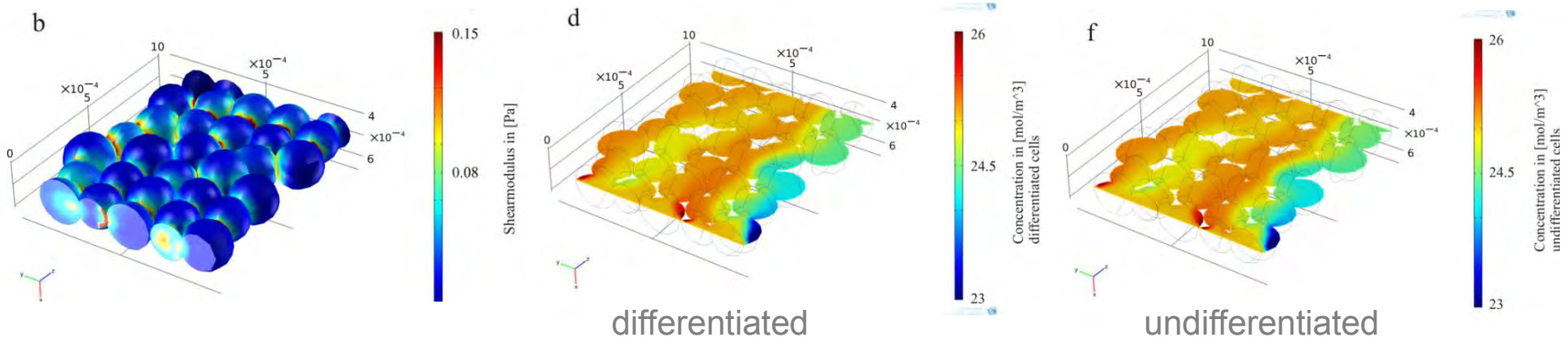
Simulations

Microscopic Model

V=1e-6 m/s



V=1e-3 m/s



differentiated undifferentiated

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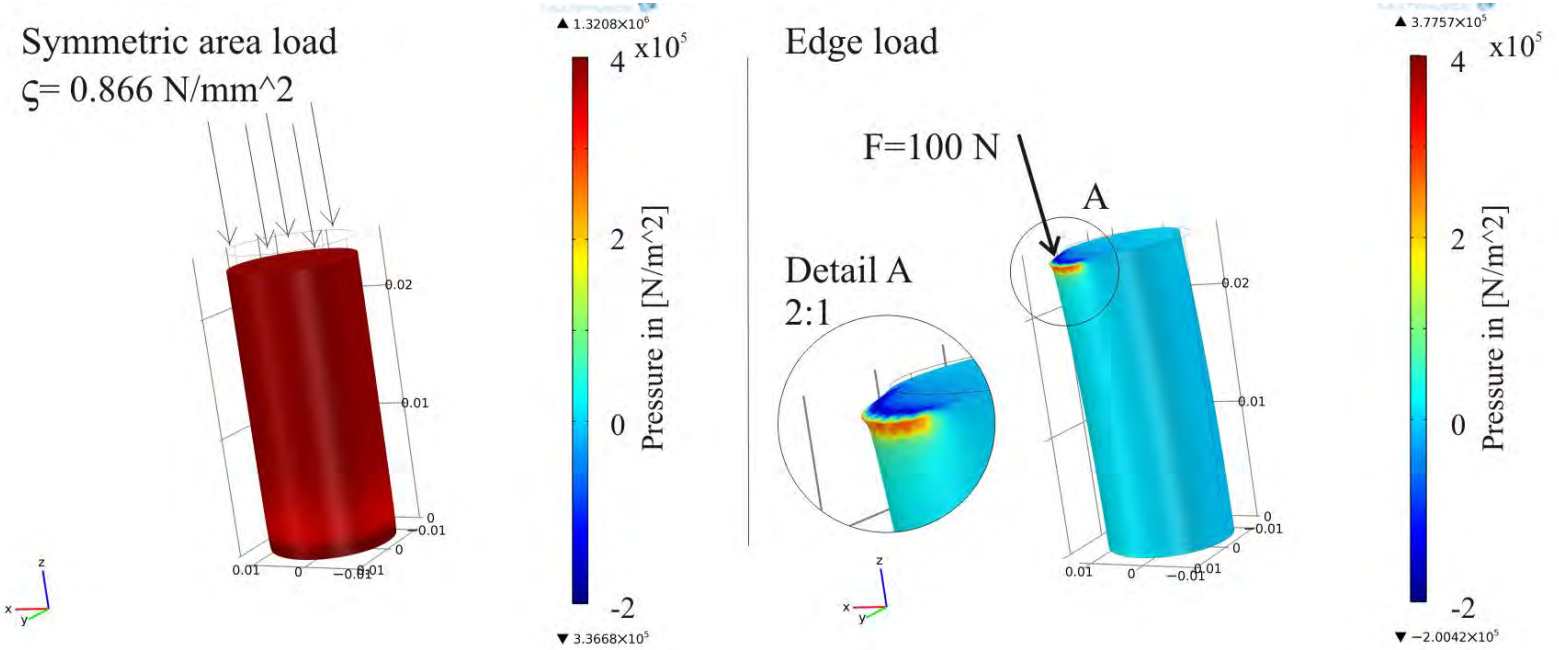
Simulations

Deformation of 1 % for MSC differentiation



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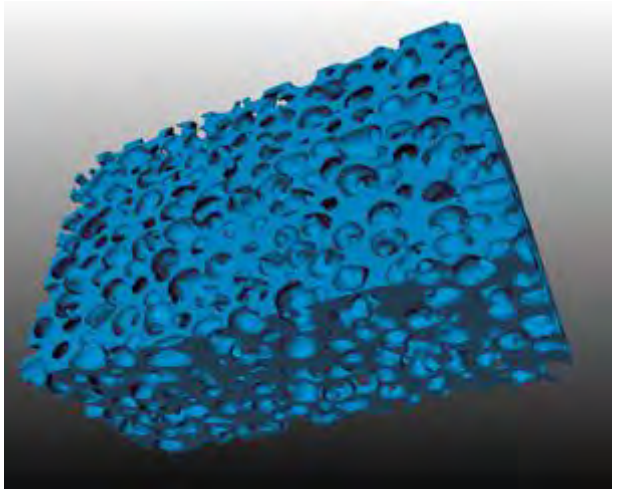
Conclusions

- The required perfusion speed for a *in vivo* like situation could be found by *in silico* analysis
- A parameterized mechanical model could be developed
- The derived culture parameters can be used to develop a bioreactor system

Outlook

- Integration of other metabolics into the simulation
- Also use reaction-kinetics to simulate the full cell metabolism
- Simulations with MRI derived 3D Models instead of the sphere model



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Dr.-Ing. J. Hansmann
Dipl.-Biol. F. Groeber

Department of Cell and Tissue Engineering

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