

The needs for functional imaging of engineered tissues, *in vitro* and *in vivo*



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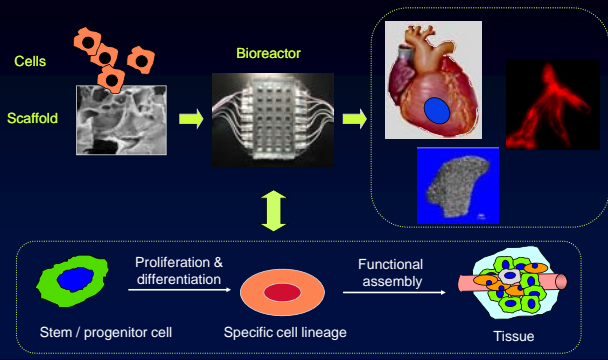
BIROW 5, NIBIB, January 18-19, 2008

Questions to address:

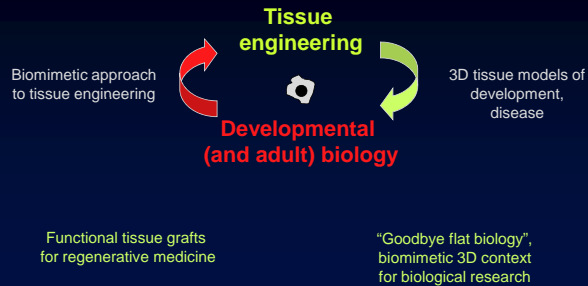
- Which technologies are needed for tissue engineering research?
- What features are most important?

- Key scientific challenges for imaging stem cells and engineered tissues?
- Approaches and technologies enabling rapid progress?
- Can imaging promote interdisciplinary research and translation?

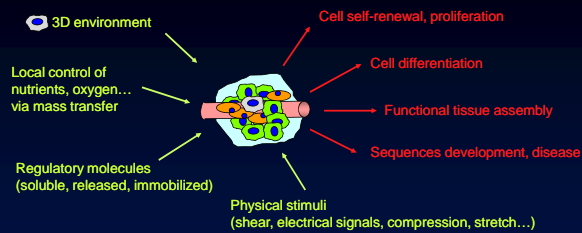
Biological principles, engineering design:



From tissue engineering to biology, and back:



Culture requirements:

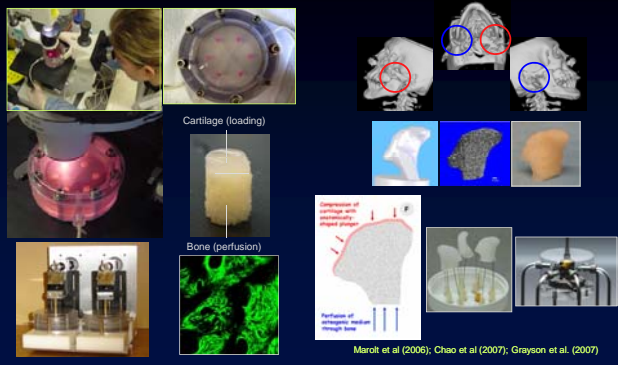


How can we monitor and measure cell/tissue responses?

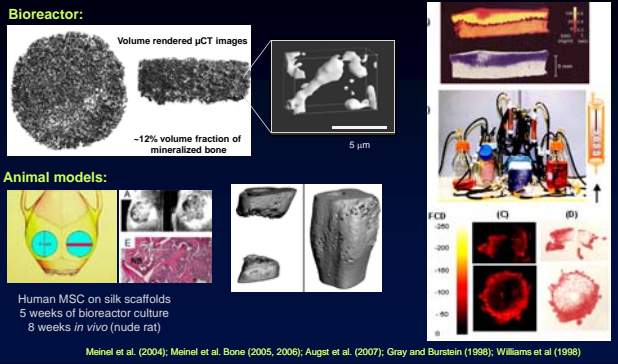
Imaging requirements:

- **Imaging within a 3D context, *in vitro* and *in vivo***
 - High resolution (as in 2D)
 - Cell labeling to track outcomes, multiple markers
 - Live imaging in bioreactors and animal models (interactions of factors)
- **Noninvasive, real time, quantitative, fast**
 - In situ, same specimen/field monitored over long time
 - See and measure cell/tissue responses as they happen
 - Fast imaging for dynamic studies (ion fluxes, signal propagation, gradients)
- **Functional imaging, multiple hierarchical scales**
 - Expression of molecular markers
 - Organization at multiple hierarchical scales
 - Cell/tissue function (coupling, contractility, biomechanics, vascular flow...)

Engineering cartilage/bone grafts

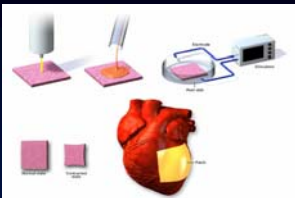


Imaging of engineered human cartilage and bone

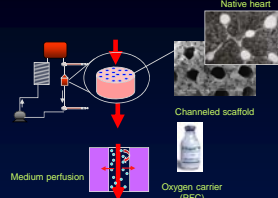


Engineering cardiac grafts:

Electrical stimulation:

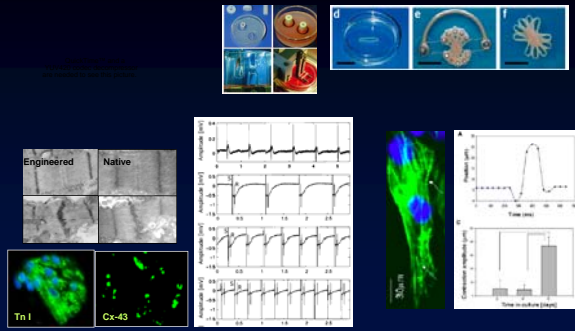


Oxygen supply:



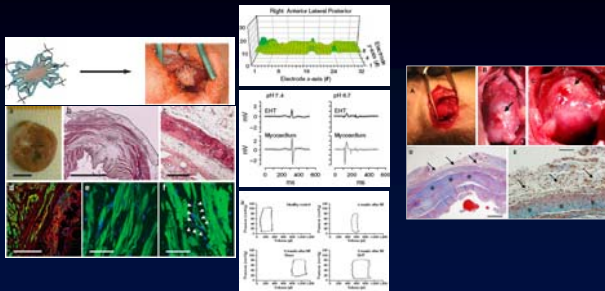
Radacic et al. PNAS (2004); AJP (2005, 2006, 2007)

Cardiac tissue engineering *in vitro*:



Radisic et al. (2004, 2006, 2007); Bursac et al. (1999); Karp et al. (2006); Khademhosseini et al. (2007); Zimmermann et al. (2006)

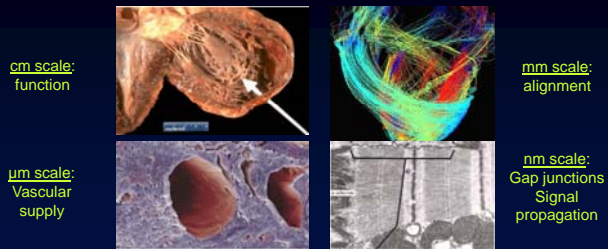
Heart repair in animal models:



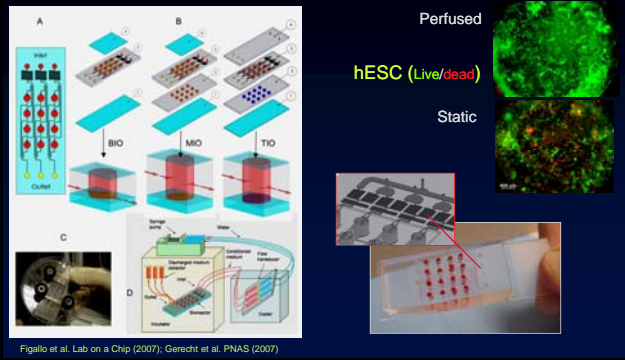
Nude rat model of cardiac ischemia

Eschenhagen and Zimmermann (2005); Zimmermann et al. (2006); Radisic et al. (2007)

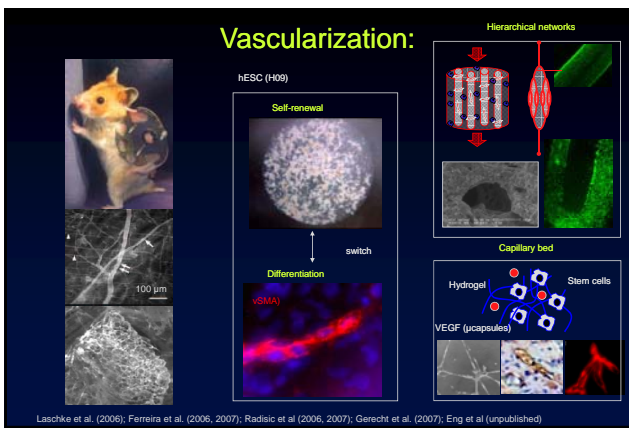
Restore structure and function at all scales:



Microarray bioreactors for stem cell research:



Vascularization:



Summary:

- Which technologies are needed for tissue engineering research?
 - Live, real time imaging *in vitro* (advanced bioreactors) and *in vivo* (animal models)
 - Accurate measurements of molecular and structural properties
 - Functional imaging (cell coupling, contractility, biomechanics, vascular flow)
- What features are most important?
 - High resolution in 3D
 - Multiple markers for cell/tissue responses
 - Real time assessment of biomechanical and conductive properties
 - Tracking the source and differentiation status of cells
 - Fast imaging for dynamic studies (ion fluxes, signal propagation, gradients)
