

Johns Hopkins Engineering

Immunoengineering

Immunoengineering: Tissue Engineering

The Role of the Immune System in Tissue Regeneration

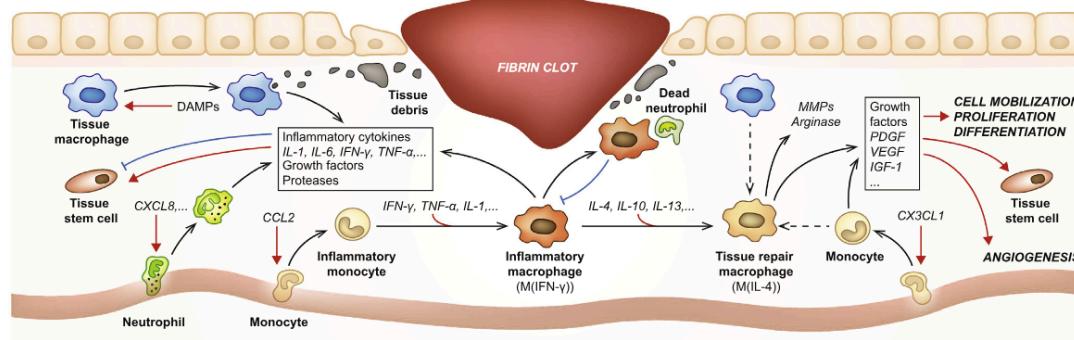


JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Immune Response Following Tissue Injury

B

Initial immune response

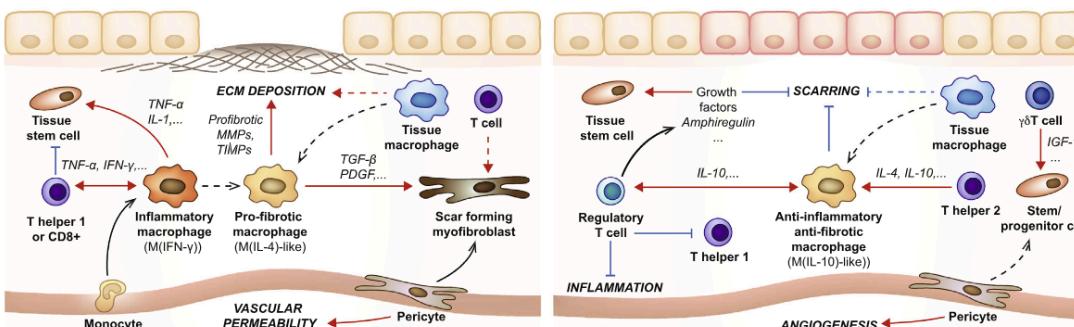


C

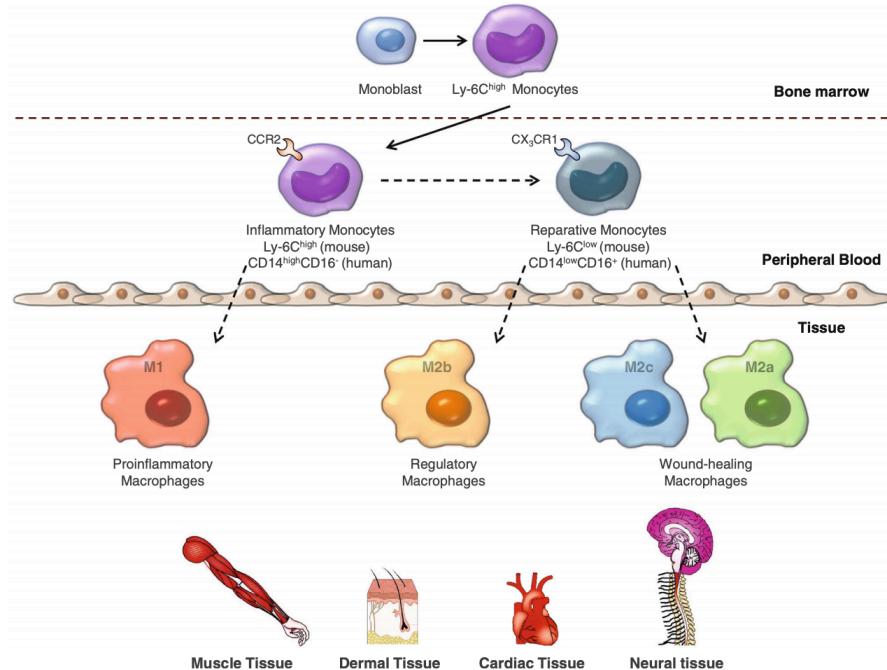
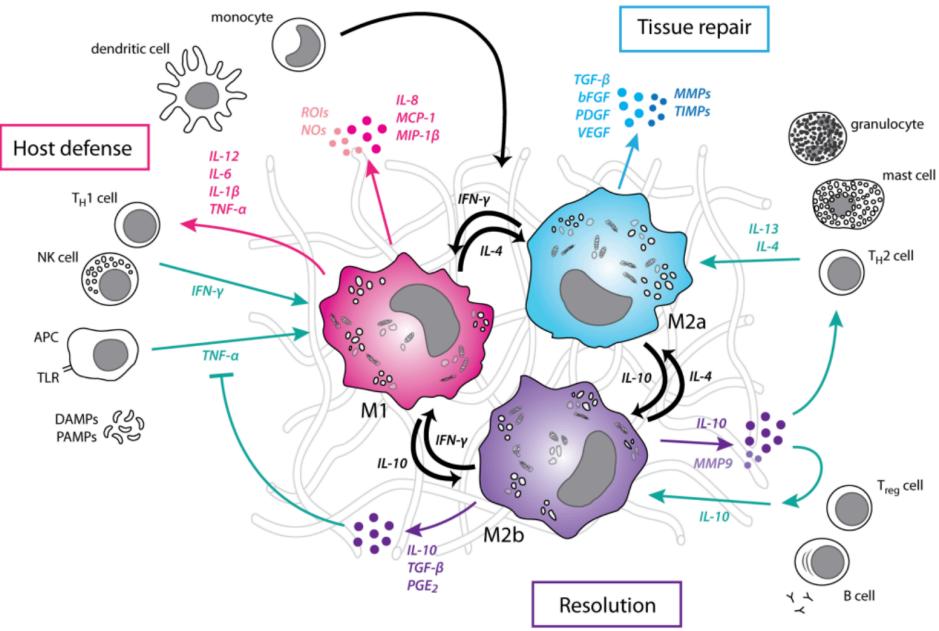
Impaired healing, scarring or fibrosis

D

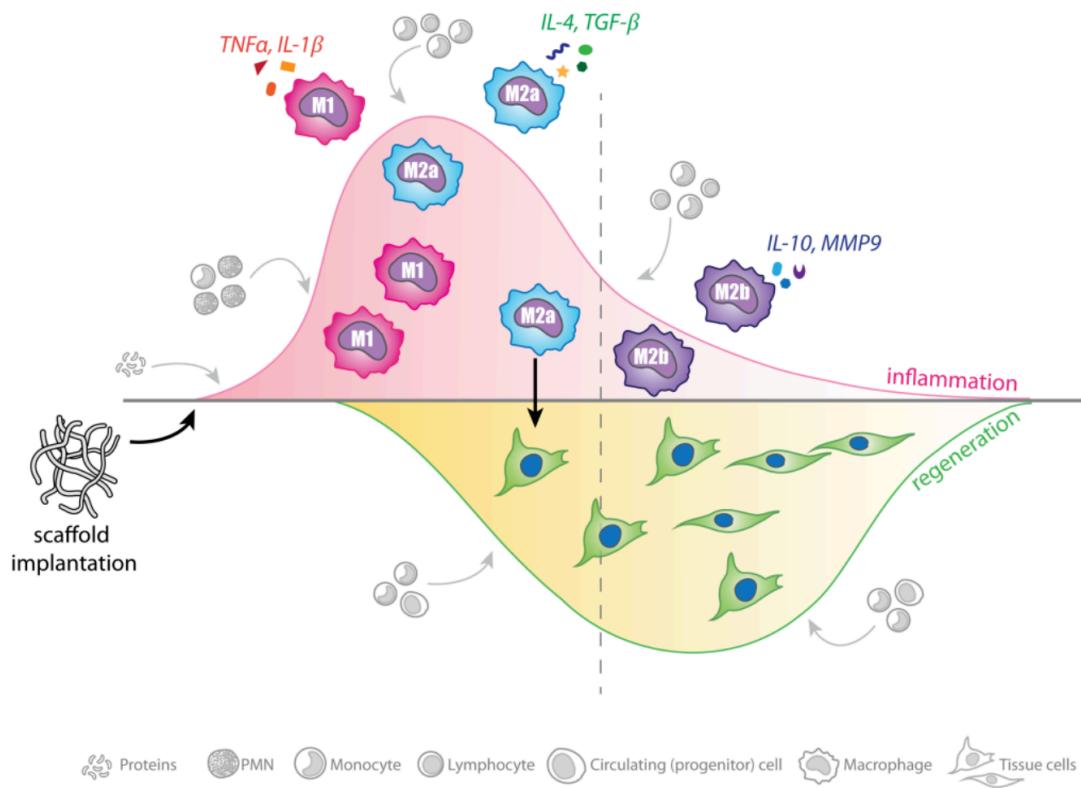
Regeneration



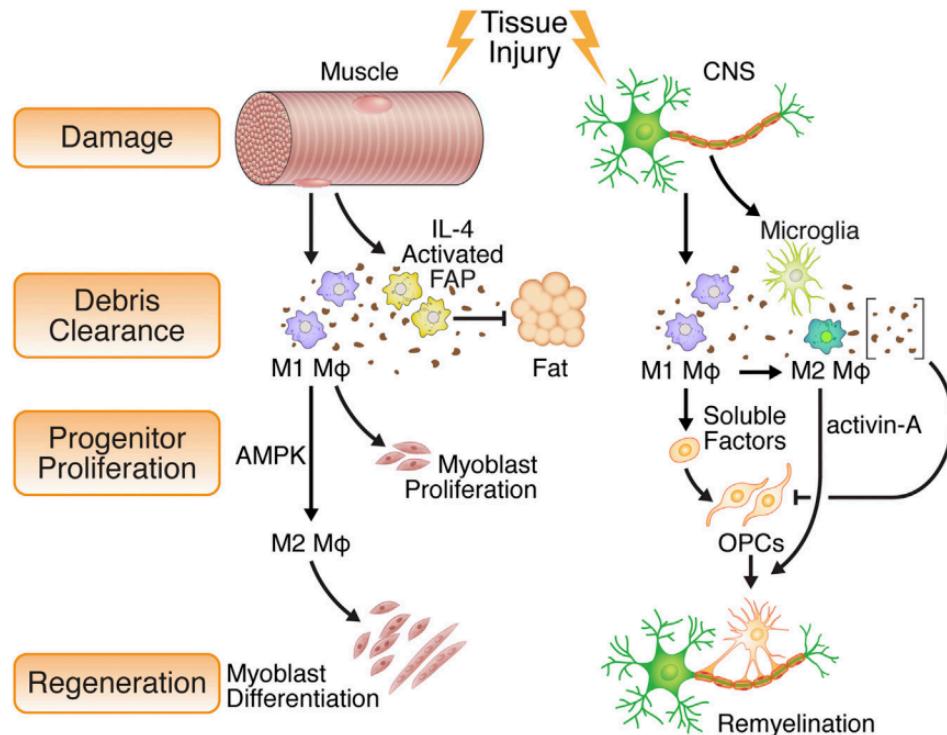
Macrophage Phenotypes



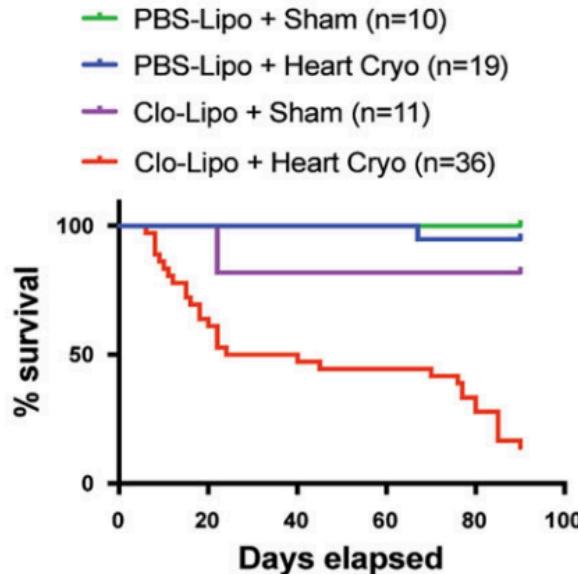
Role of Macrophages in Tissue Regeneration



Macrophages play an important role in tissue regeneration



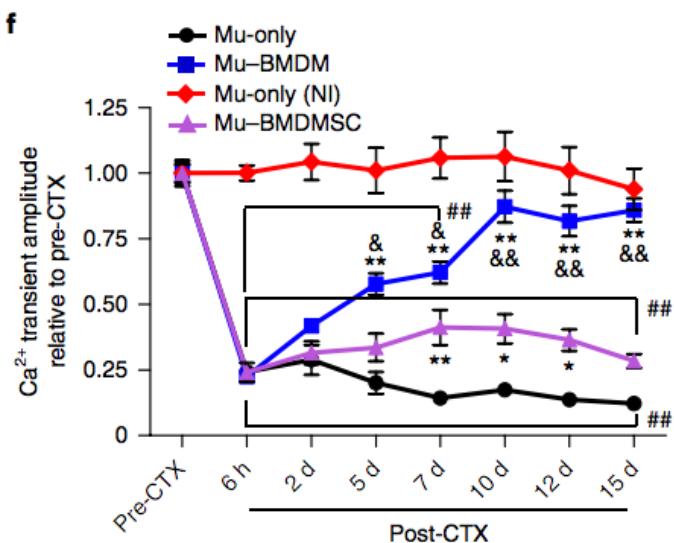
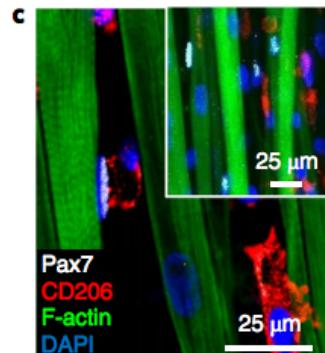
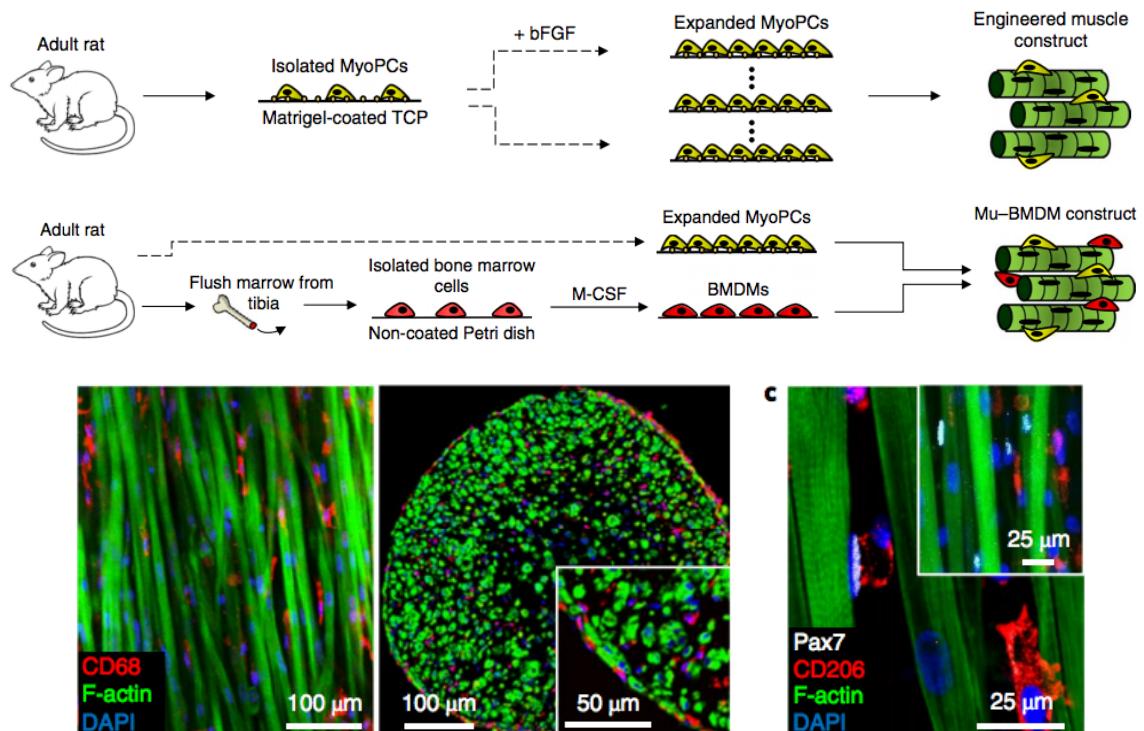
D. Macrophage depletion increased mortality from cardiac cryo injury



Aurora et al. "Immune Modulation of Stem Cells and Regeneration" *Cell Stem Cell* 15, (2014): 14-25.

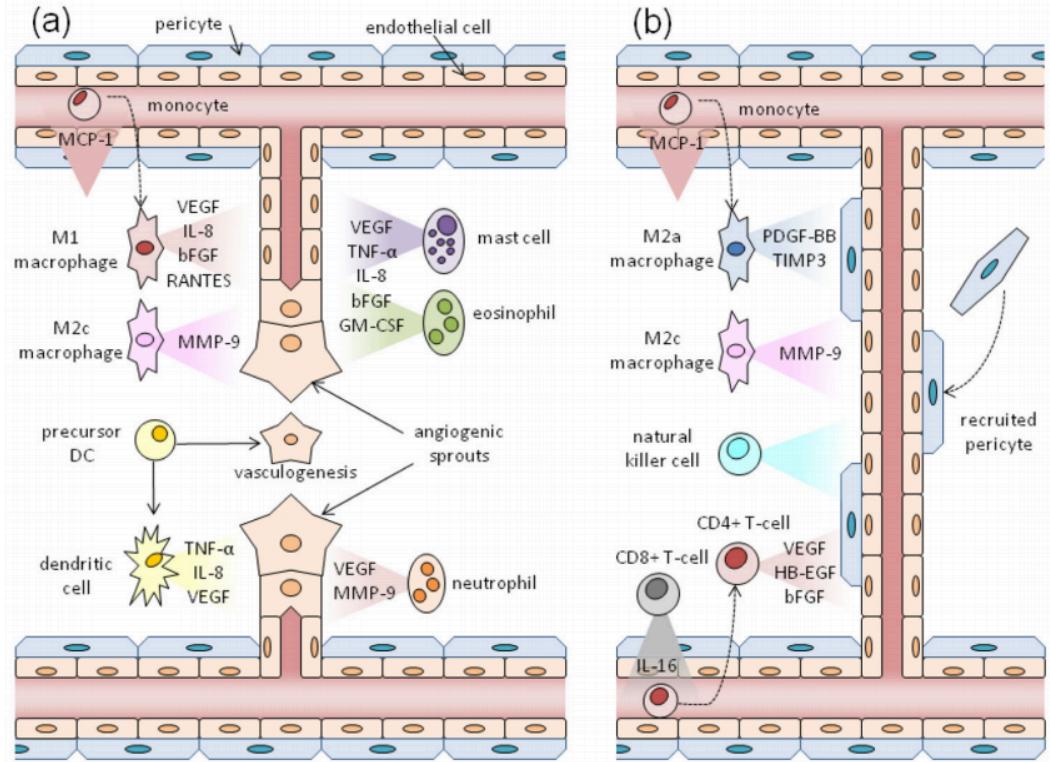
Godwin et al. "Heart regeneration in the salamander relies on macrophagemediated control of fibroblast activation and the extracellular landscape" *Nature Regenerative Medicine* 22, (2017): 1-11.

Incorporation of macrophages into engineered skeletal muscle enables enhanced regeneration

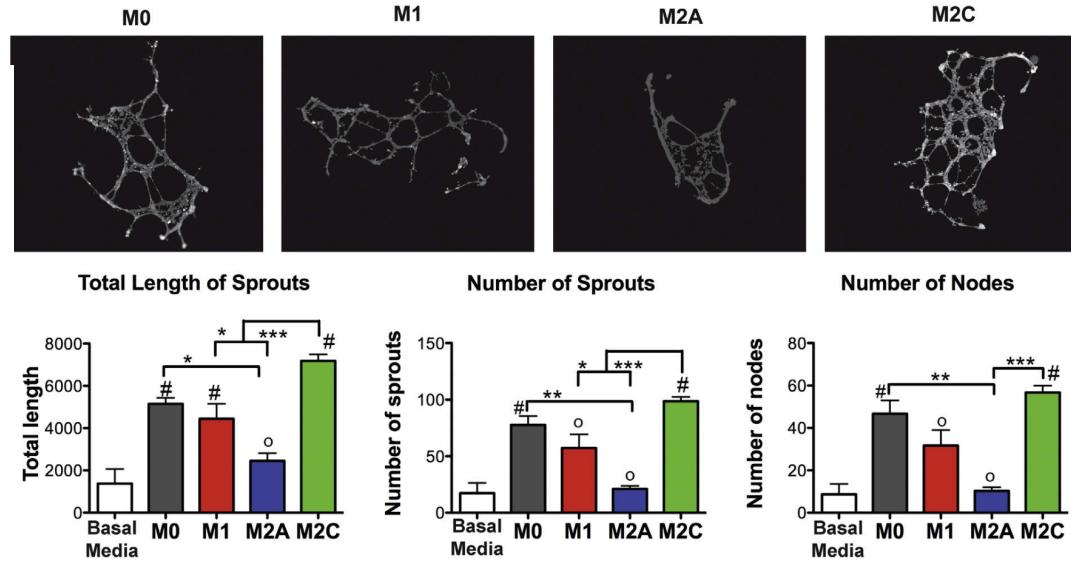
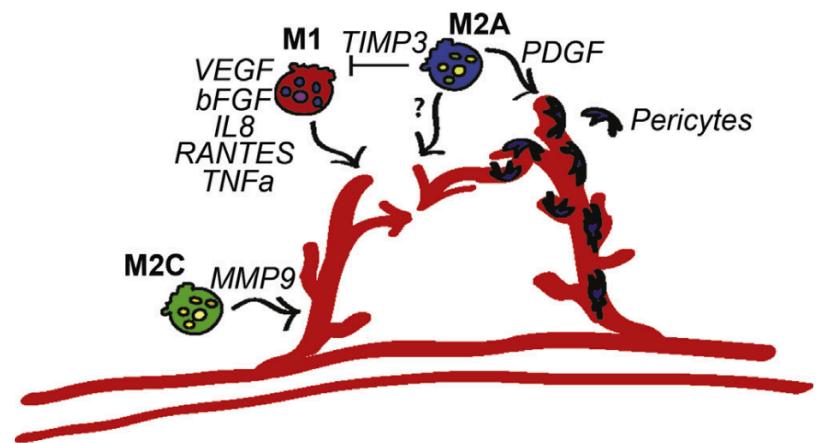


Immune system and vascularization

- Immune cells play a role in promoting angiogenesis and vascular remodeling



Role of Macrophage Phenotype in Scaffold Vascularization



Role of Macrophage Phenotype in Scaffold Vascularization

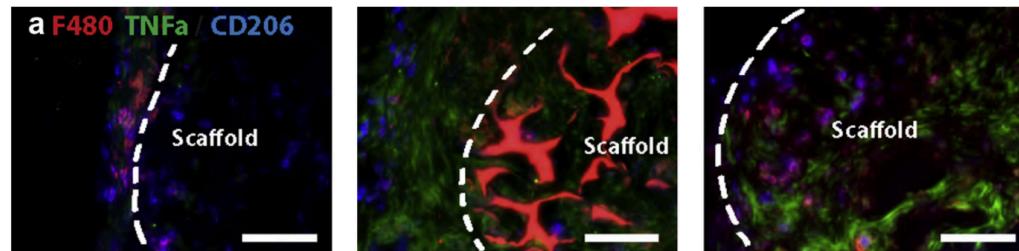
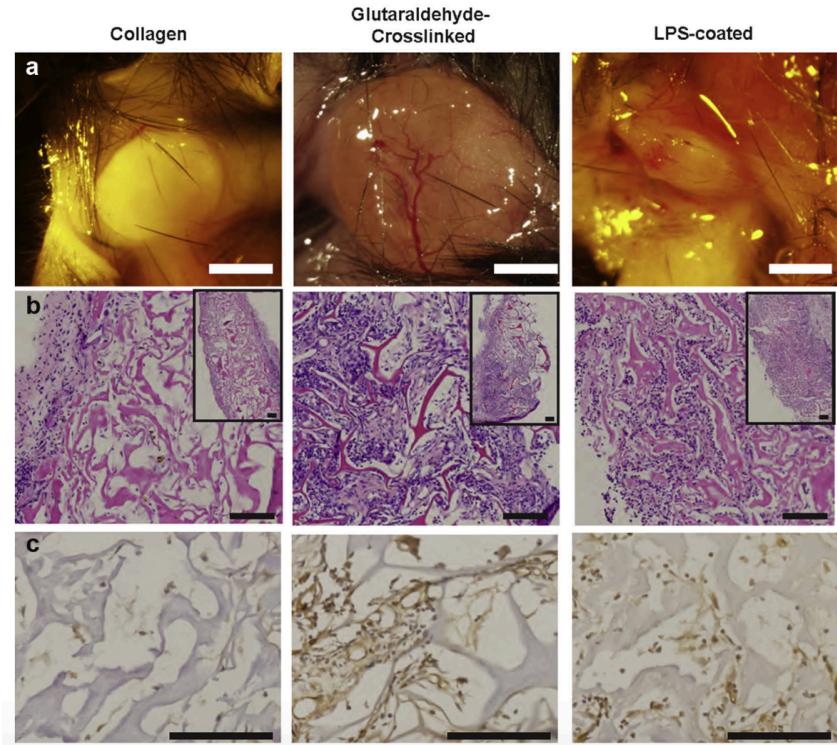
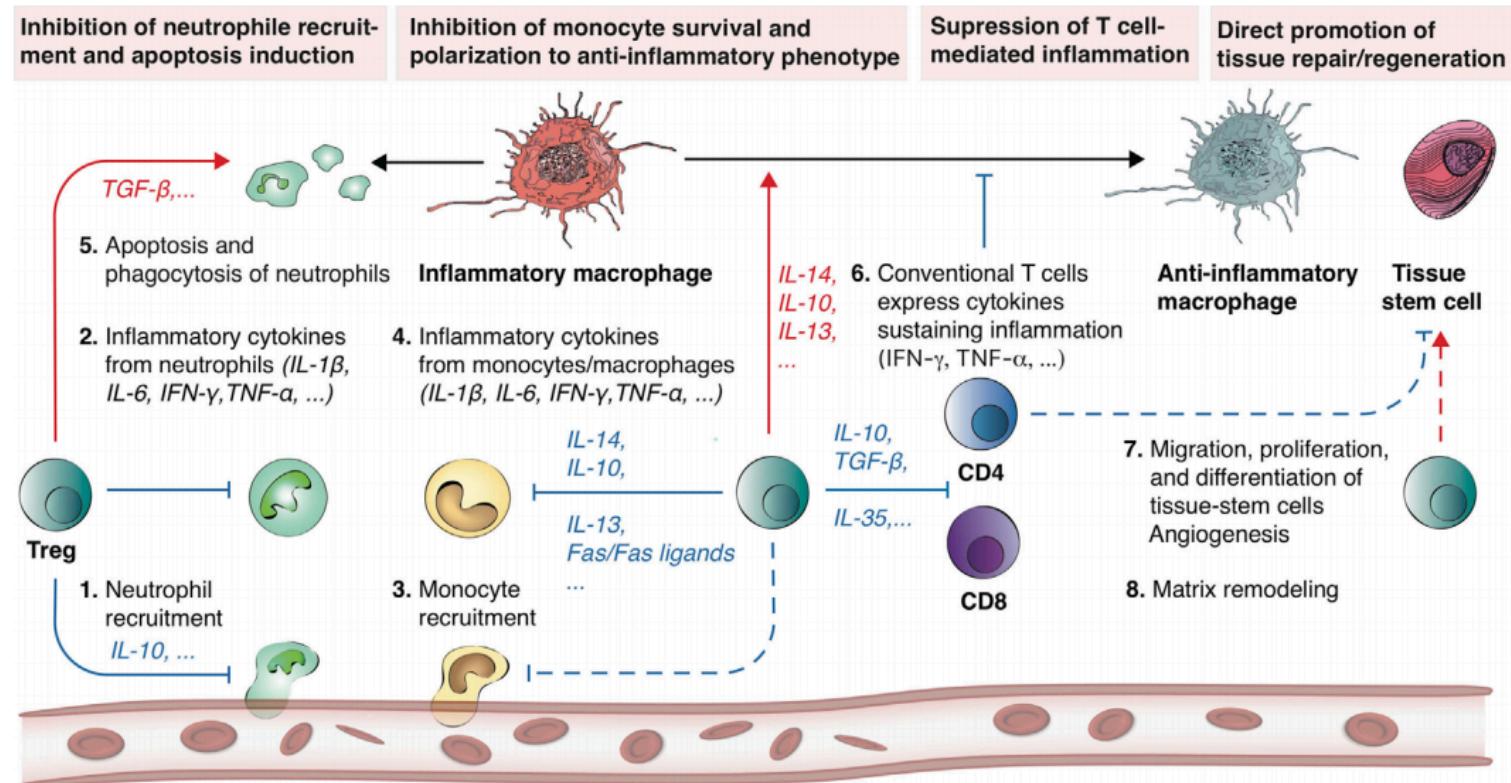


Table 1

Qualitative observations for immunofluorescent staining of macrophage phenotype in explanted scaffolds and surrounding tissue from *in vivo* study (Fig. 7a–d).

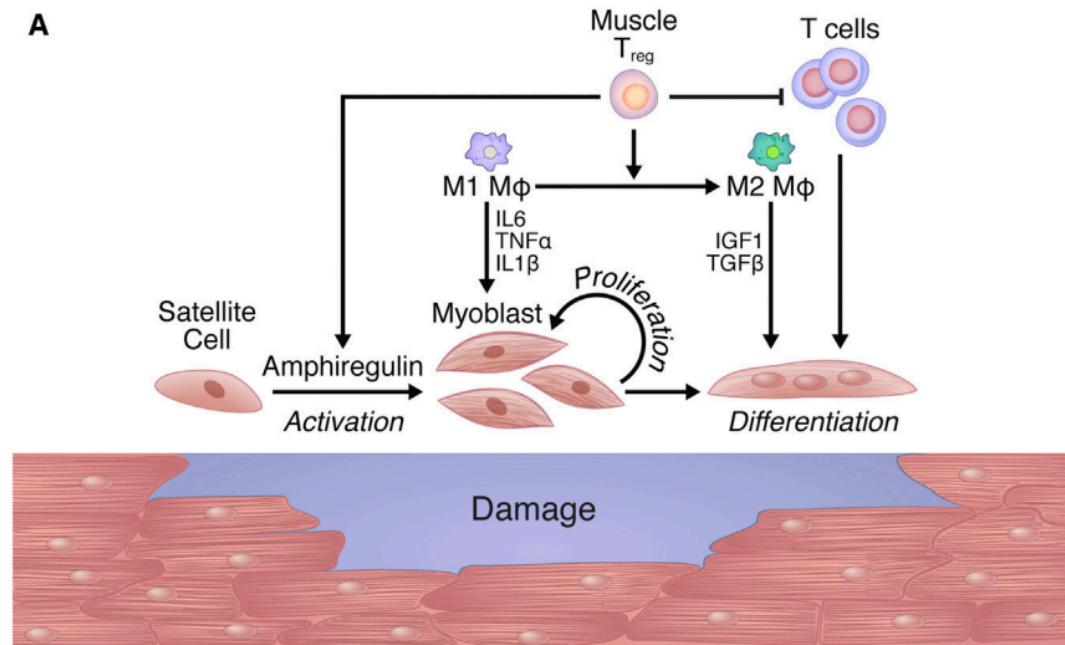
Marker	Collagen	Glutaraldehyde-crosslinked	LPS-coated
TNF α (M1)	+	+++	+++
iNOS (M1)	+	+++	++
CCR7 (M1)	++	++	++
CD206 (M2)	++	++	++
Arg1 (M2)	+++	-	+
CD163 (M2)	++	+++	+

Role of Tregs Cells in Tissue Regeneration



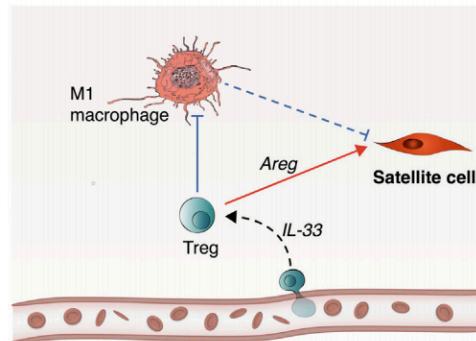
Tregs in skeletal muscle regeneration

- Treg functions:
 - Activate myoblast proliferation
 - Necessary for myotube regeneration
 - Cause M1 to M2 polarization
 - Inhibit effector T cell responses

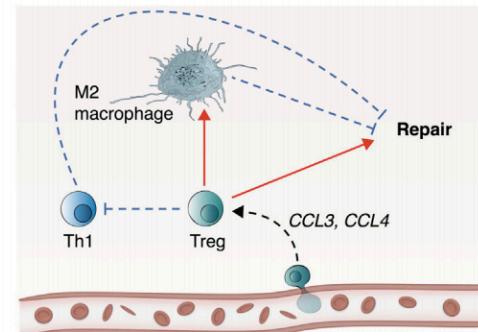


Role of Tregs in regeneration of other tissues

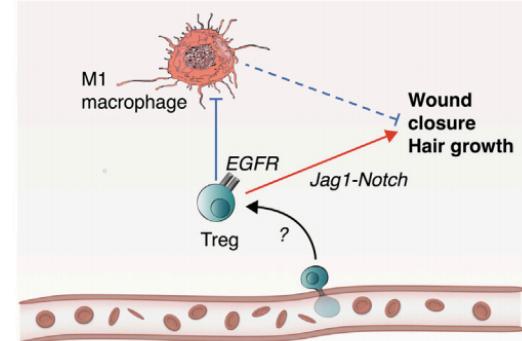
A Skeletal muscle



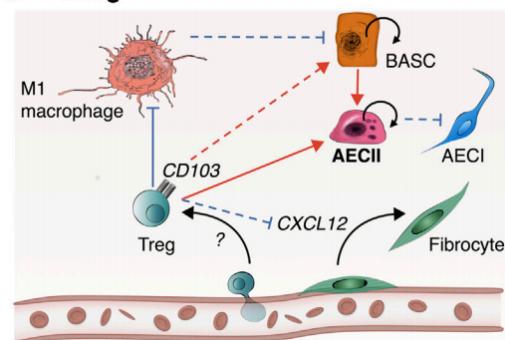
B Heart muscle



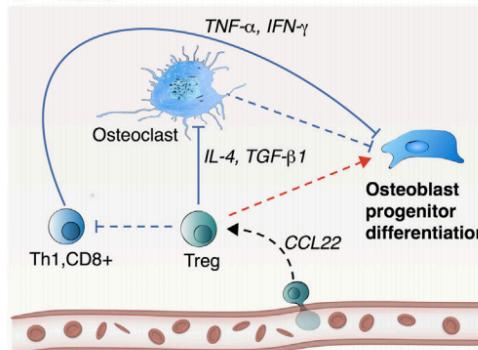
C Skin and Hair



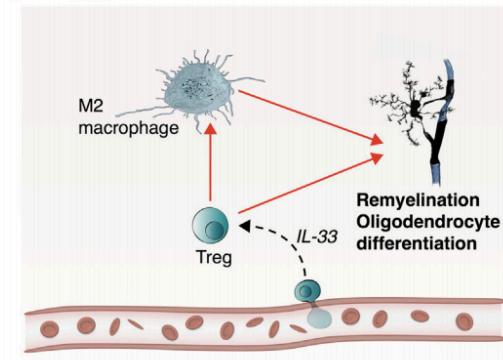
D Lung



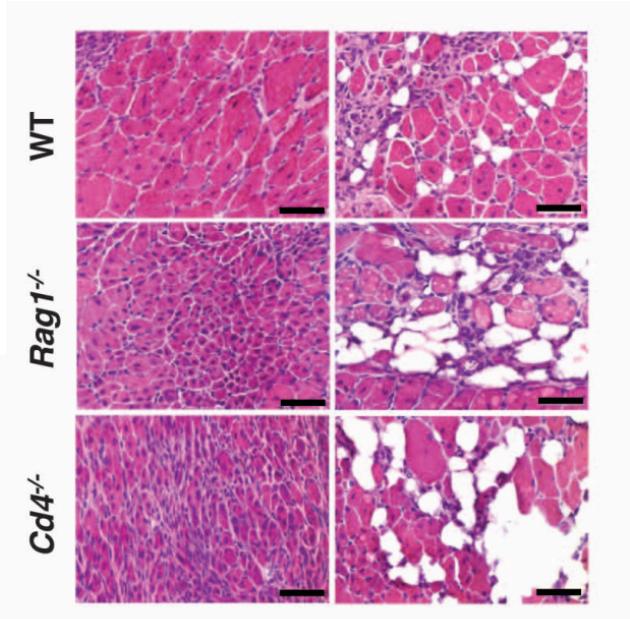
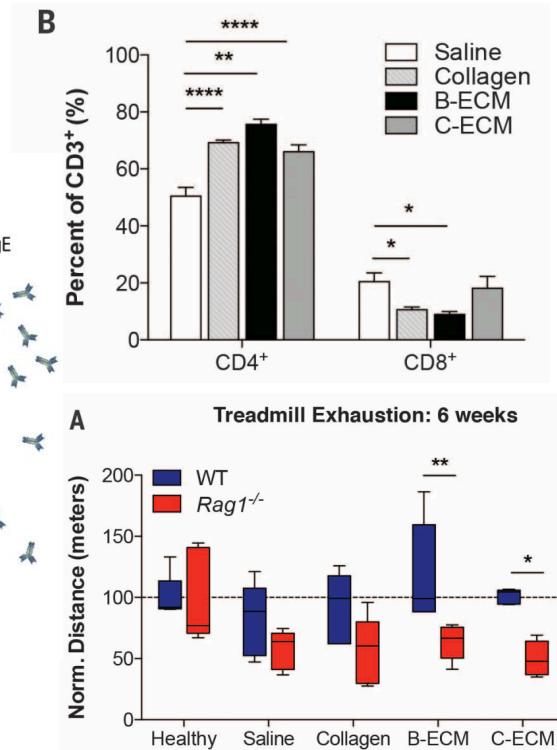
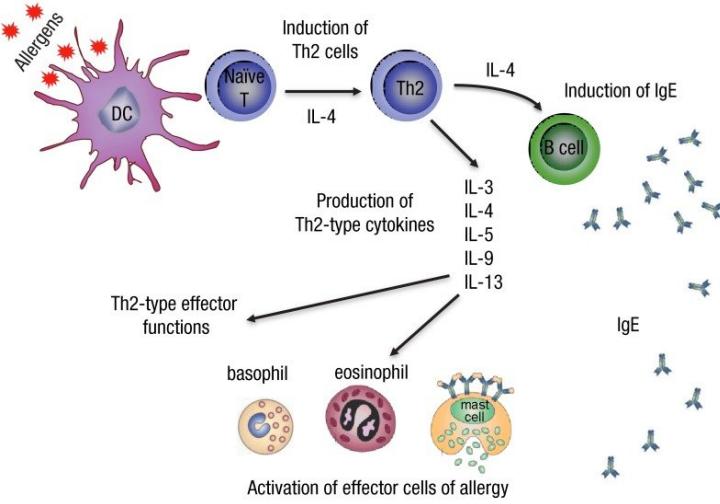
E Bone



F CNS



Developing a pro-regenerative biomaterial scaffold microenvironment requires T helper 2 cells





JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING