Applications of Polypyrrole Electrodes and Electrical Stimulation in Optimizing Bone Fusion

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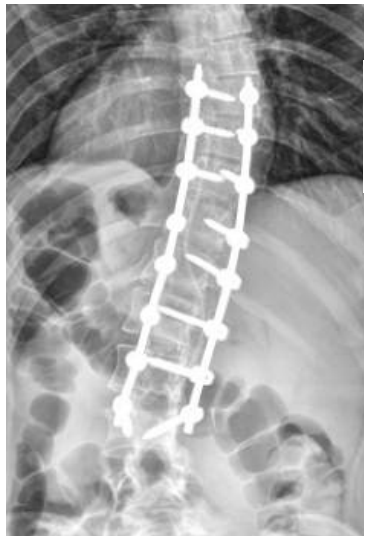

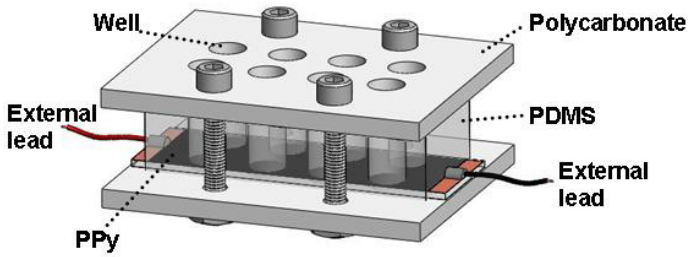

Background: Bone Fusion Research

- Spine fusion is a common neurosurgical procedure, but some patients are at high risk of pseudoarthrosis (non-union)
- Electrical stimulation has been shown to increase osteoblast metabolic activity by 1.8 fold over a period of 7 days (Zhang, Neoh, Hu, Kang, & Wang, 2013).
- Bone morphogenetic protein (BMP) and electrical stimulation together increases metabolic activity by 2.3 fold over a period of 7 days (Zhang et al., 2013).
- The presence of microchannels guides the growth and orientation of human osteoblast cells (Holthaus, Stolle, Treccani, & Rezwan, 2012).

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Project Goals

- Electrical stimulation combined with chemical and mechanical cues
- Determine the parameters that optimize osteoblast growth
  - Electrical stimulation
  - Electrode design
  - Bone morphogenetic protein
  - Micro channels
- Experimental Design

Steps

1. Designing of interdigitated electrodes
2. Electrical stimulation of osteoblasts
3. Synthesis of polypyrrole and drug release

Challenge: Cell Culture Device

- Commercial 8 well chambers led to leaking medium:

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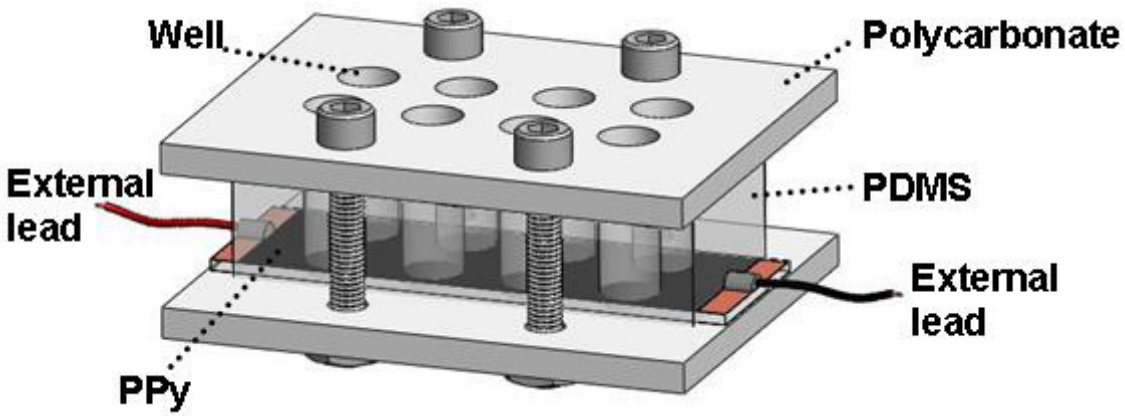
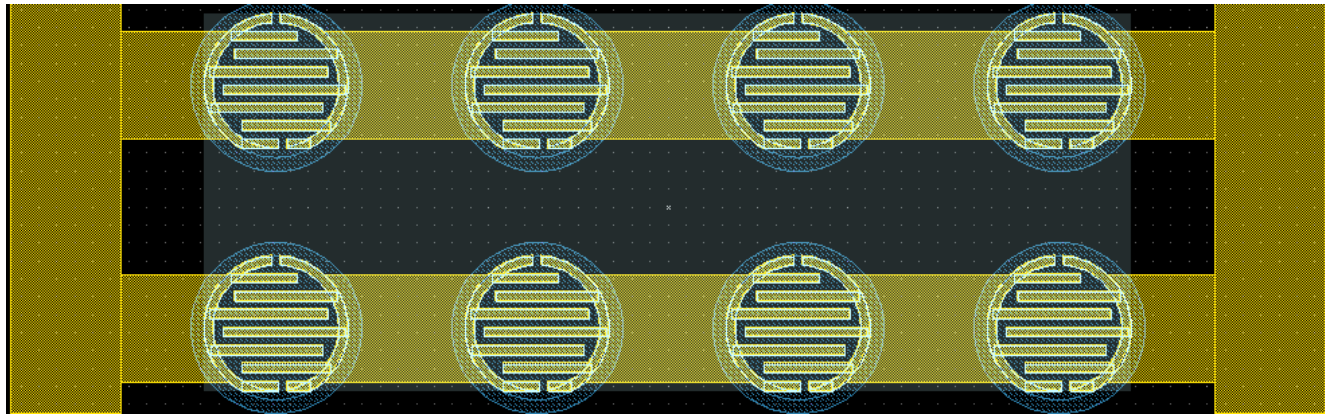
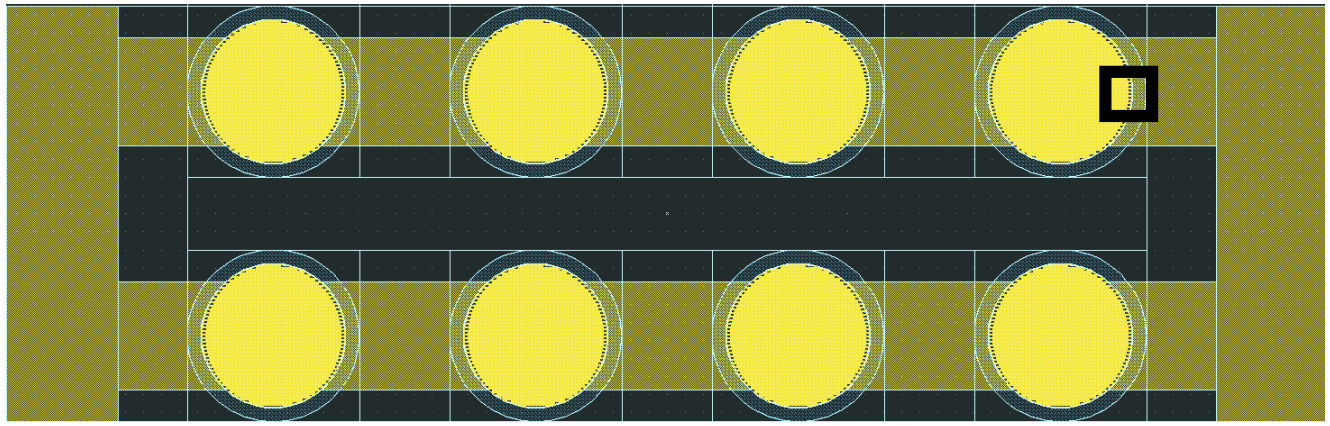
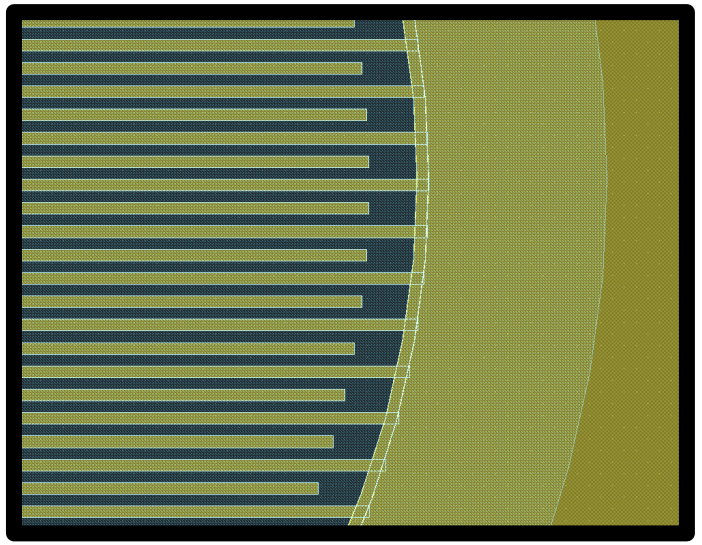
- Custom cell culture device used instead:



Electrode Design







Electrode Design

1. Heidelberg
2. Sputter
3. Acetone

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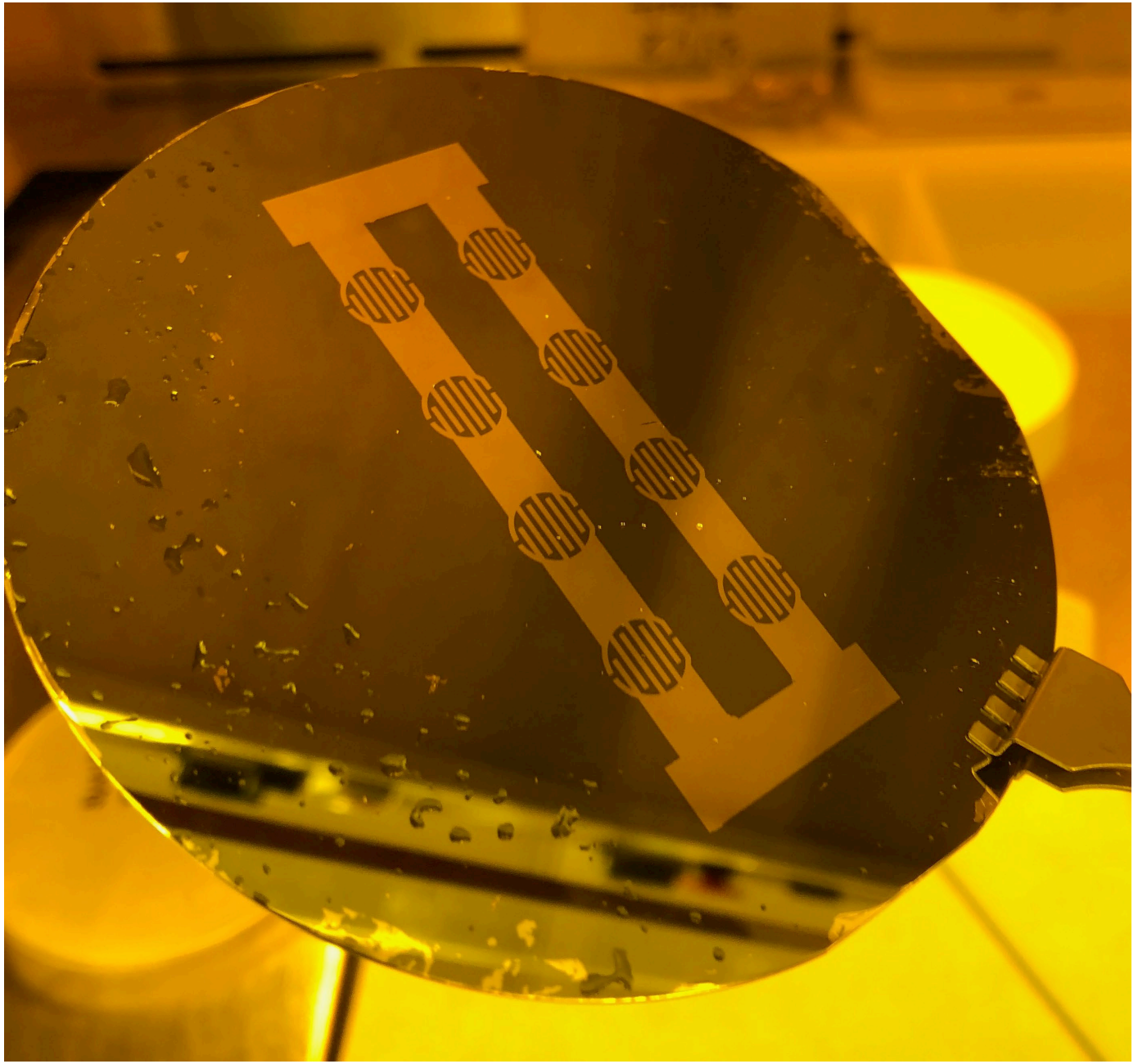
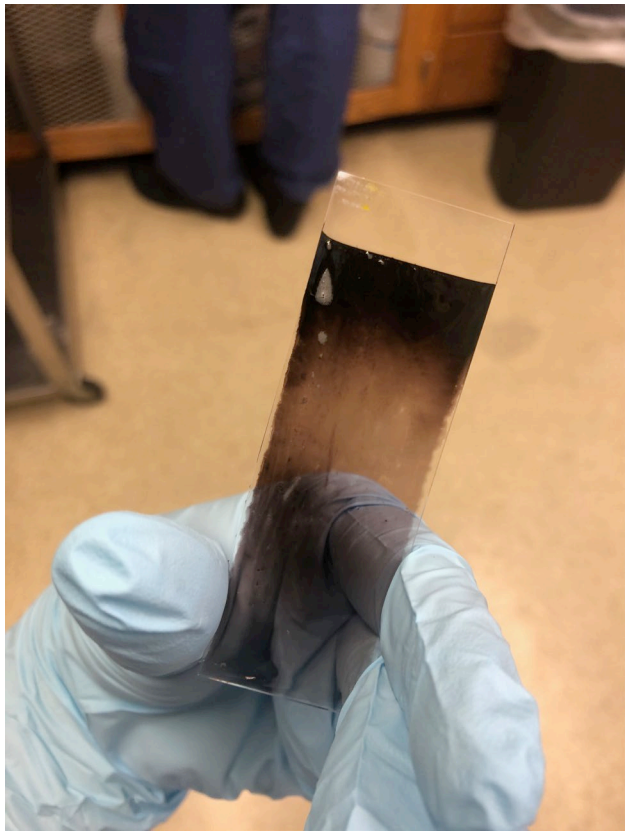
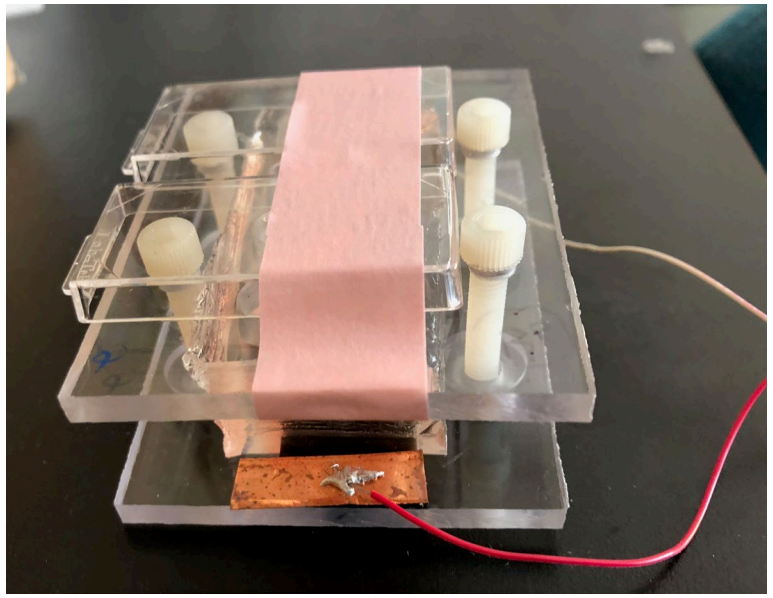
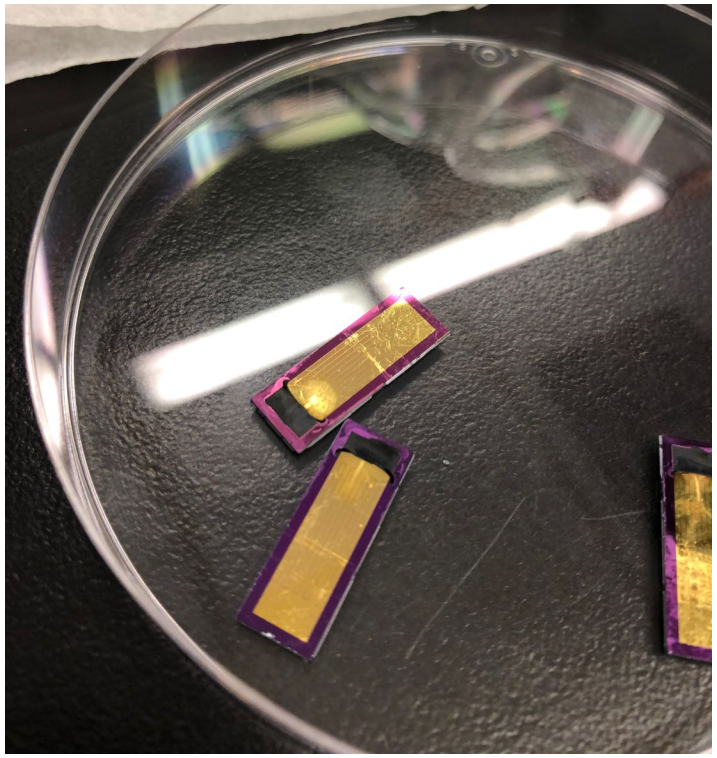


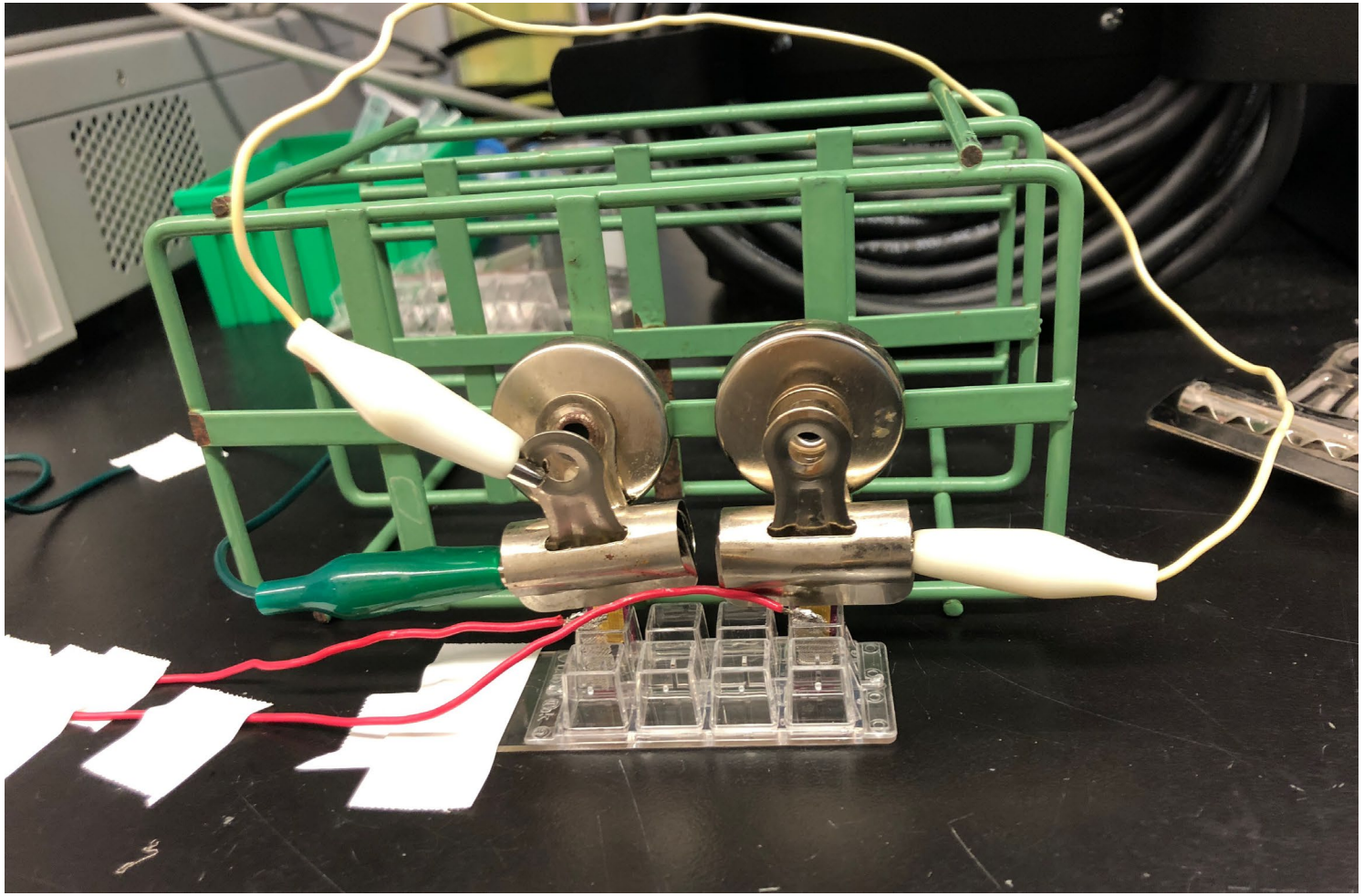
Electrical Stimulation





BMP Electronically Controlled Release





Next Steps

- Alkaline phosphatase activity of the electrically stimulated MC3T3-E1 cells
- Use the ELISA to detect BMP in collected samples
- Implement electrode designs
- Testing micropatterned surfaces

Acknowledgements

Dr. Richard Ellenbogen

Mrs. Sandra Ellenbogen

Jana Pettit

Jim Pridgeon

Dr. Christine Mac Donald

UW Neurological Surgery Donors, Faculty, Staff, and Residents

Saigal Lab

Dr. Rajiv Saigal

Jessica Johnson

Joyce Huang

Max Walter

Alejandro Diaz

Grant: NIH NINDS R25NS095477

Summer Research Experience in Translational Neuroscience and Neurological Surgery

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Zhang, J., Neoh, K. G., Hu, X., Kang, E., & Wang, W. (2013). Combined effects of direct current stimulation and immobilized BMP-2 for enhancement of osteogenesis. *Biotechnology and Bioengineering, 110*(5), 1466-1475. doi: 10.1002/bit.24796