



Neural regeneration within the central nervous system (CNS) is a critical unmet challenge as CNS disorders continue to be the leading cause of disability nationwide. Engineers can provide a unique perspective in the design and development of materials for human health to help effectively translate them to the clinic. We propose an innovative combination of biomaterial-cell interactions drawing on aspects of engineering, stem cell biology, and neuroscience with a unifying theme of functional neural tissue engineering. Our overarching goal is to develop a new, integrated approach in building material systems that are both cell-instructive and cell-responsive, creating a dynamic feedback loop between a cell and its engineered microenvironment. Promising opportunities for discovery exist at the intersection of biomaterials, stem cells, and reactive oxygen species and we anticipate combining them to cut a unique path as neural engineers.

# Neural Tissue Engineering and Biomaterials Research Group

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“Exploring novel biomaterial, tissue engineering, and drug delivery approaches to address neurodegenerative diseases and injuries to the central nervous system.”

UVA produced video:

<https://www.youtube.com/watch?v=TViUvt0rlg0>



### **New Material Platforms for Neural Tissues that can Direct Neural Tissue Maturation & Function**

We are designing hydrogel materials using both synthetic polymer and recombinant protein strategies to recapitulate the neural stem cell niche and induce dynamic cell-material interactions. The problem of axon regeneration is far from being solved, but axons can extend over long distances in vitro and in vivo by using innovative combinations of tunable materials and physical architecture. While growth is a critical step in neural regeneration, a therapy is only obtained when these axon projections function correctly in signal transmission. We encapsulate both neurons and oligodendrocytes, the cells responsible for myelination of functional axons, and control the growth of each cell type in a tunable 3D environment to begin to recapitulate functional interactions.

### **Localized and Controlled Delivery of Factors Important to Cell Survival & Function**

Delivery of protein therapeutics has been a target for neural regeneration in a host of CNS diseases and injuries including Parkinson's, Alzheimer's, spinal cord injury, and stroke, but their targeted, sustained delivery is a challenge to translational medicine due to fast clearance from the target site of degradation within a couple hours of delivery. We incorporate methods for spatial and temporal control of small molecule and large protein delivery via both passive diffusion and active, cell-controlled mechanisms.

### **Regulating Cellular Reduction/Oxidation to Influence Stem Cell Survival, Self-Renewal, & Differentiation in a Tissue-Like Environment**

We are bringing an engineer's perspective to questions of redox biology. While dysregulation of native reactive oxygen species (ROS)-scavenging enzymes within the cell is linked to a variety of disorders including Parkinson's and Alzheimer's disease, it is increasingly recognized that redox regulation within a cell is a critical signaling mechanism for cellular processes including survival, proliferation, differentiation, and cell motility. In a controlled hydrogel culture system we are harnessing the power of degradable materials to elucidate novel understandings of oxidant and antioxidant effects of biomaterials on cells, to manipulate the redox balance of encapsulated cells, and to positively bias cell fate. We hope that by modulating ROS insults in vivo and providing a permissive environment for transplanted cells by using a ROS-scavenging material, we may decrease secondary injury and greatly improve the efficacy of transplant cell therapy.

### **RECENT RESEARCH DEVELOPMENTS**

- Lab established 2014 producing novel synthetic and engineered-protein hydrogels for stem cell culture and differentiation
- The Lampe Group received a Service Unit grant allocation from the School of Engineering and the Data Science Institute for our collaborative simulation project with Prof. Cam Mura (Chemistry).
- NP Murphy, **KJ Lampe**, "Mimicking biological phenomena in hydrogel-based biomaterials to promote dynamic cellular responses," *Journal of Materials Chemistry B*, 3: 7867-7880 (2015). ([link](#))
- Lampe group undergraduate BME student CJ and grad ChE student Lauren paired up to win a \$5000 Double Hoo Research Grant to support their work on oligodendrocytes in 3D
- Ruth L. Kirschstein NIH NRSA Postdoctoral Fellowship, 2011-2013

#### **SEAS Research Information**

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