NDnano Summer Undergraduate Research
2016 Project Summary

1. Student name:

James Tedesco

2. Faculty mentor name:

Prof. Ryan Roeder

3. Project title:

Non-invasive quantification of biomaterial degradation using nanoparticle imaging probes

4. Briefly describe any new skills you acquired during your summer research:

Gold nanoparticle synthesis and functionalization with additional molecules. Tissue engineering collagen scaffolds with defined morphology. Conjugating nanoparticles with scaffolds for improved imaging. Imaging with spectral computed tomography.

5. Briefly share a practical application/end use of your research:

The degradation behavior of implanted biomaterials is not well understood *in vivo*, limited by the lack of an effective method to monitor the biomaterial while in the *in vivo* environment. Successful establishment of non-invasive and reliable imaging modality will significantly improve the future design and application of tissue engineering biomaterials.

Begin two-paragraph project summary here (~ one type-written page) to describe problem and project goal and your activities / results:

Understanding the degradation behaviour of biomaterials *in vivo* is important for the successful design and application of tissue engineering scaffolds. Past approaches to gain such an understanding have involved histological studies where animal sacrifice at numerous time points is required. Current non-invasive approaches are limited to subcutaneous implants, two-dimensional images, and by endogenous tissue autofluorescence. The goal of this project is to establish a non-invasive, three-dimensional method to image and quantify scaffold degradation *in vivo* using contrast-enhanced computed tomography (CT) to detect nanoparticle imaging probes conjugated to the scaffold matrix.

Nanoparticles acting as imaging probes were synthesized and conjugated within collagen scaffolds. Gold nanoparticles were successfully synthesized with a 10-20 nm diameter using the Turkevich method and functionalized with mercaptosuccinic acid (MSA). MSA functionalized gold nanoparticles are capable of forming multiple crosslinks with the collagen. Type 1 collagen

scaffolds were fabricated with 85% porosity and 300-425 micron pore size, and successfully conjugated with the functionalized gold nanoparticles. Collagen scaffolds with as little as 10mM of gold nanoparticles are detectable and quantifiable with spectral CT. *In vivo* scaffold degradation was simulated in vitro using a collagenase digestion. Over the course of the degradation, the scaffolds were imaged using spectral computed tomography and the intensity of signal related to the extent of degradation. The concentration of gold eluted in the media was also determined using inductively coupled plasma optical emission spectroscopy (ICP-OES) to confirm CT measurements. Finally to ensure the observed gold signal accurately describes scaffold degradation, a hydroxyproline assay was used to measure the actual collagen content in the media.

Publications (papers/posters/presentations):

J. Tedesco, T Curtis and R. Roeder., "Non-Invasive Quantification of Biomaterial Degradation Using Nanoparticle Imaging Probes", *NDnano Undergraduate Research Fellowship Poster Session.,* University of Notre Dame, Notre Dame, IN, 46556.