Understanding Nanoparticle Biodistribution via Optical Imaging

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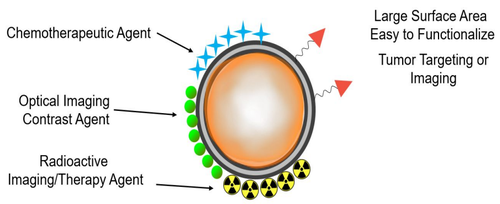
USC Viterbi School of Engineering

SHINE Summer High School Intensive in Next-Generation Engineering

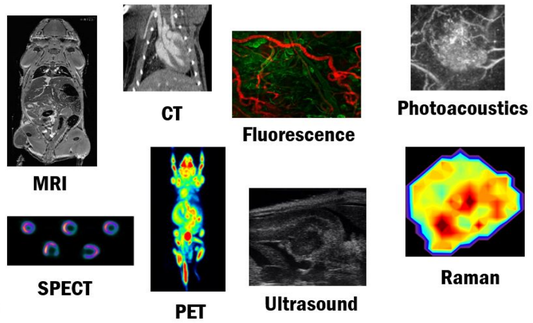
Introduction

Dr. Cristina Zavaleta's lab combines biology, engineering, and chemistry to aid in the detection of cancer and solve practical problems in the imaging space. The focal point of their research project is developing nanoparticle based contrast agents that will aid in the identification process of cancer treatment. Dr. Zavaleta's team is guided by fundamental questions pertaining to why, how, and where nanoparticles interact in our bodies. These questions have led to the work being done today given that previous known methods have failed to provide answers. (Figure 1)



Skills Learned

Skills learned within this project center around the introduction of nanoparticles and the different ways medical professionals can obtain images of the body. In addition, I have learned to differentiate various optical imaging devices such as PET, Fluorescence, & Multi-Photon Microscopy. Although, MRI scans and ultrasounds are the most common there are other ways to look inside the anatomy. Prior to this research project, these skills were foreign so it felt refreshing to learn something completely new and out of my comfort zone.(Figure 2)



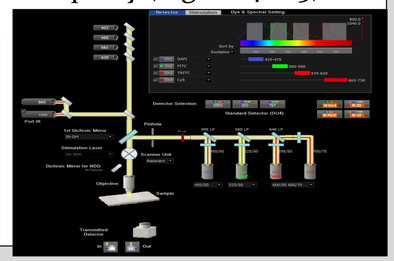
Objective & Impact of Professor's Research

The objective of my Professor's research is to provide new optical imaging techniques that promise long-term and effective detection for patients with abnormal reproduction. At the same time, the goal is to bring awareness to tools such as multi-photon microscopy which has the ability to assist in analyzing nanoparticle exposure. This includes the advancement of personalized medicine, label free benefits, and a higher rate of successful surgeries. In sum, this will impact doctors who will be able to possess a variety of devices in order to assist them for combating cancer. (Figure 3)

Criteria:	MPVIM	Blood Draw	Flourescent Microscopy	TEM
Rapid Prep Time	✓	✗	✗	✗
Rapid Analysis Time	✓	✗	✗	✗
High Temporal Resolution	✓	NA	✓	✗
Label-Free	✓	✗	✗	✓
Unique Spectral Identifier	✓	✓	✓	✗
Large Field of View	✓	NA	✓	✗
Spatial Information	✓	NA	✓	✓
Non-Destructive	✓	✗	✓	✗

How This Relates to My STEM Coursework

My SHINE participation has provided me with hands on and first time experience within the STEM field. As a first generation and latinx women, the impact of my involvement in SHINE has led me to better understand STEM coursework by providing me with the necessary equipment needed to succeed. At the same time, I have been surrounded by inspirational individuals that have given me the clarity I yearned for revolving my interests going into my senior year of high school. In all, everything I have learned throughout this program has challenged me to accept failure, growth, and confidence equally.(Figure 4 & 5)



Experimental Design & Results

One of the fundamental problems in the nanoparticle field is that you have to label nanoparticles in order to visualize them. These labels, typical fluorophores, are imperfect and lack the ability to provide information for longer experiments because they can be degraded. Using a multiphoton imaging technique to image gold nanoparticles developed by the lab, we sought analyze the changes in fluorescence from labeled gold nanoparticles in the liver and compare it to signals generated using our technique.

Hypothesis:

- Overtime the amount of fluorophore will diminish as the gold nanoparticles stay equivalent to its initial quantity during injection.

Experimental Design:

- 2 Mice were injected with equal volumes of Dylight 650 labeled 50 nm gold NPs
- Mice Livers were harvested at 24 hrs and one week after injection
- Biodistribution and fluorescence was analyzed via 2P and 1P imaging.(Figure 6)

Results:

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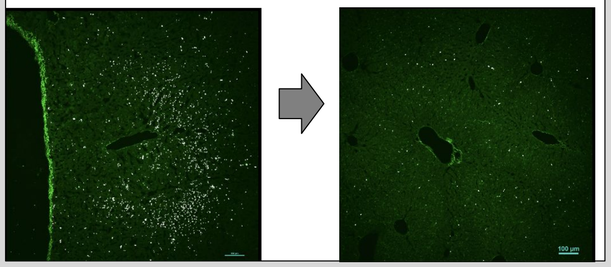
Timepoint	Total Cluster Area	Nanoparticle Clusters
24 Hours	25.6%	42.2%
1 Week	12.2%	32.9%
Percent Difference	**13.4%**	**9.3%**

Significant decrease in both number of clusters and the total area of the clusters. Photos below show the amount of gold associated with the fluorophore. (Figure 7)

24 Hours **1 Week**



Advice for SHINE Students

My advice to future SHINE students is to not be afraid to ask questions because even the simplest of questions matter. Not only will it make things a lot easier but it will also give you clarity on how to better approach the program in terms of what is expected of you. Keep in mind you are not required to know everything right off the bat and it will be normal to feel overwhelmed at first, however, do not let that discourage you from your desire to learn. Lastly, remember that there is a reason you were accepted into SHINE therefore take it all in, enjoy and have fun! Take this from someone who doubted herself at the beginning but in the end learned not to.

Contact Information

zavaleta-lab: Home

Images courtesy of Sean Burkitt M.S., PhD Student Zavaleta Lab

Acknowledgements

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