**SUMMARY**

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| I am a strong interdisciplinary researcher with experience in a diverse range of fields. I have a foundational degree in biochemistry and advanced degrees in environmental engineering. I am experienced in microbiology, molecular biology, bioinformatics, and nanoscience as well as analytical chemistry, environmental engineering, water and wastewater treatment, international development work, statistical modeling, and hydrology. I developed these skills while working on a range of projects during my academic career. My primary experience is in environmental evolution of antibiotic resistance examined through bioinformatics and molecular biology; in this effort, I have drafted two models of indirect evolution of antibiotic resistance predicting its evolution in engineered systems. I also excel in nano and surface chemistry; I have built a descriptive model of nano-bacteria interaction that predicts the toxicity of metal core nanoparticles, and I am thoroughly knowledgeable in surface characterization. Beyond core this core experience, I have worked on smart concrete technologies, rainwater harvesting, international aid and development programs, and contaminant transport modeling. I have also led a metagenomics consulting group, analyzing the function of biologically active water filters. Further, I have written three interdisciplinary courses in full and have taught over 100 hours of course-work at an R1 institution. In total, I am an independent researcher who excels at applied molecular microbiology, is capable of developing novel research ideas, and has proven experience communicating in industry-relevant formats.  A note on my American Ph.D.  The nature of an American university Ph.D. requires students to work on many projects over many years. These programs are often undefined, most of the time not connected to a PI’s existing line of inquiry, and students have to function as their own investigator orchestrating project design, goals, reporting, and funding. While this approach now often requires 7 years of study, the result is a fully capable independent researcher ready for industry or academia. |

**MAJOR PROJECT HISTORY**

The following is a detailed account of projects that I have worked on in a lead or supporting role. Again, the nature of an American degree is such that I have specialized in many fields. History is listed by descending amount of contribution.

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| **Bacterial antibiotic resistance derived from silver nanoparticles exposure (2014-18)**  Antibiotic resistance is a growing problem responsible for immeasurable deaths and economic loss. I identified a new route of antibiotic resistance derived from bacterial exposure metal core nanoparticles that has broad implications in material-bacterial interactions. I used a range of microbiological, molecular, and bioinformatic techniques to characterize how metal stress evolutionarily selects for antibiotic resistance. Furthermore, I found that a nano form of the metal was capable of inducing a significantly greater degree of antibiotic resistance. I coupled these molecular and bioinformatic approaches with adaptive resistance growth assays I developed to unequivocally show that my molecular data predicted a biological shift towards an antibiotic-resistant organism. This work has applications in environmental remediation of metals in landfills, water treatment, regulation of nanomaterials, as well as hospital antibiotic stewardship programming.  *Role: This project was developed and conducted completely independently. I am responsible for all work, and intellectual design, data analysis, and publications.* |
| **Molecular model of silver nanoparticle cytotoxicity (2015-2018)**  The mechanism of action of silver nanoparticles has been hotly debated over the last 10 years. In this project, I built a molecular biological model of a bacterial cellular response to silver nanoparticles using transcriptomic, proteomic, and physical-chemical data. My model uses expression data from cellular stress response systems challenged over a range of water chemistries characteristic of key differences in silver nanoparticle stability. The result is a model capable of explaining most observed differences in toxicological results in the current literature. This project identifies key mechanisms in the mechanism of silver nanoparticle toxicity and has applications in regulation, nanoparticle design with industry and medical uses. Furthermore, this project is the first of its kind to use a full biological genetic profile to explain nanoparticle toxicity.  *Role: This project was developed and conducted completely independently. I am responsible for all work, and intellectual design, data analysis, and publications*. |
| **Physical aqueous parameters controlling silver nanoparticle toxicity (2011-2013)**  Silver nanoparticles have found inclusion in a range of applications including textiles, medical devices, and engineered systems. Understanding how solution chemistry controls physical and toxicological behavior of silver nanoparticles is important for designing silver nanoparticles with enhanced characteristics. In this project, I used many novel physical characterization techniques to build a multiparametric descriptive model of silver nanoparticle toxicity. The core of this project linked observed differences in nanoparticle stability described by techniques included static light scattering, dynamic light scattering, ICP-OES dissolution, and surface plasmon resonance with toxicological data over a range of water solution chemistries. The result was descriptive model linking degree of fractal dimension of nanoparticle aggregate to cellular surface binding potential. These results have applications in nanoparticle design theory.  *Role: This project was developed and conducted completely independently. I am responsible for all work, and intellectual design, data analysis, and publication, except the completion of in lab dynamic light scattering experimentation.* |
| **Generalized evolution of antibiotic resistance in the environment (2018-present)**  Understanding the core mechanisms of antibiotic resistance evolution in the environment has eluded researchers. Many theories have explained direct mechanisms by which resistance forms from exposure to antibiotics found in animal husbandry applications; however, these fail to explain the persistence of antibiotic resistance outside of these engineered systems. In this project, I have begun to identify an evolutionary pattern by which large changes in antibiotic resistance occur and are selected for by environmental stressors. Initial transcriptomic data indicate a similar pattern of gene changes to that found in hospitals suggesting a generalized route. Ongoing mesocosm and forced evolution experiments will attempt to confirm this pressure in genome-scale analyses by tracking single nucleotide polymorphisms. The goal of this project is a generalized model of antibiotic resistance evolution that is applicable in hospitals and in the environment. This project has applications in healthcare and environmental regulation as well as identifying drug targets.  *Role: This project was developed and conducted completely independently. I am responsible for all intellectual design, the majority of data analysis and publications. I oversee two graduate students and two undergraduates who are working to complete the experiments.* |
| **Predicting contaminant and sewage influx into an urban river system (2018-present)**  Texas has some of the most polluted river systems in the United States. Recent increases in urban development have led to an increased strain on urban temporal river systems. To better understand when and where contamination enters these small stream systems, I am working on a random forest model to predict contaminant influx sites and events. This model pulls from more than 20 parameters including microbial source data, metagenomics, water quality, and human-linked contaminants of interest to find where potential sewage point sources lie. I developed microbial source tracking assays and the initial construction of a statistical model. I also co-led a yearlong field sampling campaign along the river designing remote samplers. This project combines my molecular skill set with my bioinformatics foundation to help remediate urban ecosystems.  *Role: I assisted in the intellectual design of this project identifying the approach for integrating data. I am responsible for the design of the statistical model, and molecular source tracking assays. I am assisting in writing the publications for this project.* |
| **Metagenomic and EPS analysis of denitrifying water filters (2014-2019)**  Water treatment plants are often subject to a sudden shift in source water qualities. Understanding the broader impacts of these changes on biologically active filters is important for ensuring water treatment plant success. I co-led a metagenomic analysis consulting group characterizing microbial ecology of more than 12 water treatment plants microbial diversity. I conducted hierarchical modeling and clustal analysis of metagenomic data, ran complete metagenomic analyses, and chemically characterized microbial exopolymeric substances. These efforts tracked the successful operational parameters for biologically active water filters to ensure good water quality for consumers.  *Role: I developed 4 metagenomic analysis pipelines, statistical clustering analysis pipelines to evaluate sample similarity and correlation to process function.* |
| **Design of novel drug formulations for birth control and pain relief (2007-2009)**  In this series of projects, I worked with a pharmaceutical company to design two birth controls and a pain relief drug. Over this time, I help to design 5 working formulations, created an organic chemistry model to predict the degradation of drug products during compounding and storage. I also worked as a member of a team to design a new release technology for more stable delivery of morphine to intensive care patients. I utilized analytical chemistry instrumentation to characterize release profiles, drug stability, and identify uncharacterized degradants. I integrated these data to build theoretical degradation routes and also built thermodynamic model of degradation processes. I authored 3 USP testing protocols.  *Role: I am responsible for the design of all thermodynamic degradation model, all USP stability testing protocols, and participated in a team to design three drug formulations.* |
| **Nanoparticle interactions with biofilms and microwaves (2016-2019)**  Nanoparticles have found use in controlling biofouling in engineered systems. When applying such a treatment, an in-depth understanding of interactions with biofilms is necessary to predict efficacy and activity. In this project, I grew bacterial biofilms on polycarbonate coupons and in microfluidic devices to understand the uptake and inclusion of nanomaterials into biofouling. I used Ramman microscopy to image silver nanoparticles buried in my film and develop a model for EPS-silver nanoparticle inclusion. This project identified a cost-benefit growth region wherein enough nutrients could support an adapting biofilm under toxic loading of silver nanoparticles. Further, indium tin oxide nanoparticles were found to interact with microwaves, possibly through a heating mechanism, can cause the biofilm to degrade. Characterization of these interactions is ongoing. The results indicate limited success in the management of biofouling with naked nanoparticle inclusion. Incorporation of a cellular binding-capping agent would likely improve toxicity, but additional management measures are necessary for efficient reduction of biofouling.  *Role: I am responsible for the intellectual design of the silver nanoparticle biofilm inclusions experiments and acted in a support role for all other experiments and investigations.* |
| **Economical water filter design in for native groups in the Panamanian jungle (2012-2015)**  Native residents of the northern rainforests of Panama often have trouble with water access in a primarily tribally governed community. While water is abundant, recent increases in agriculture output have led to bacterial and cyst contamination of water sources. With very limited infrastructure in the region, development of water treatment systems is slow. In this project I designed a slow sand filtration unit that can be built for $50 USD using in region components only. Because of the structure of the community, filters are utilized at the family level. Life span of the filters was predicted at 10 years. I traveled to Panama leading a team of 8 undergraduates to implement these filters, teach courses on germ theory, and general health. This project resulted in the reduction of water borne illness in the community and its applicable to other communities with similar water access issues.  *Role: I assisted a team of over 20 people in the overall design and implementation. I led the travel group and coordinated all on-the-ground efforts. I was responsible for the final design and all in community microbial testing.* |
| **Rainwater harvesting is impacted by roofing materials (2010-2011)**  Water access infrastructure in developing regions can be costly and inefficient. People in developing regions have turned to rainwater harvesting. Collected water quality can vary greatly by region and collection and storage systems. In this project, I characterized water collected from different roofing materials based on its disinfection by-product potential and its probability of impacting water quality. This research found that metal roofs had the highest disinfection potential while green roofs could form disinfection by-products if bleach treatment was used and could serve as a breeding ground for bacteria. The research has implication in regulatory efforts and international aid efforts.  *Role: I served in a supporting role in this investigation. I designed several testing methods, a collection system, and participated in defining the project scope* |
| **Smart, self-repairing, concrete for increased structure longevity (2010-2014)**  Concrete structures have been found last less than predicted life span costing taxpayers and construction firms more. This reduced lifespan has implications in CO2 production as well. Concrete’s reduced life span is attributed to micro-fractures, small breaks in the structure that eventually lead to large cracks. I help to find methods to culture sporulating bacteria that would survive in this concrete, upon exposure the environment, sporulated bacteria, carrying a modified genome, could produce lime and seal microfractures before concrete was at risk of forming real cracks. Interestingly, the research also found a mechanism for reducing the amount of fly ash, a CO2 intensive producing component of concrete necessary to formulate a strong material. This research has implications in construction and building life span.  *Role: I served in a supporting role in this investigation. I developed methods for counting bacterial retention through the incubation and concrete setting process.* |
| **Isolation of a novel antibiotic, kijanimicin (2005-2006)**  Through overuse, the total number of effective antibiotics is falling leaving fewer options to treat infections. Combinatorial approaches office a new mechanism to create novel antibiotics from existing structures. Aminoglycoside antibiotics offer a unique route to develop new treatment alternatives. By varying the arrangement of sugars on the aglycone ring structure novel antibiotics may be generated. I participated in this project by helping to isolate synthetic proteins to manufacture alternate forms of the antibiotic, kijianimicin. Efforts in this project will produce next-generation drugs for treating infections.  *Role: I served in a supporting role in this investigation. I developed protein isolation protocols and began characterization of sugar attachment to main ring structures.* |