

## STUDENT BIOGRAPHICAL INFORMATION FORM

NAME Rachael Knoblauch DEPT. Chemistry and Biochemistry YEAR OF GRAD STUDY Fifth  
MENTOR(S) Prof. Chris Geddes SOURCE(S) OF SUPPORT NSF Graduate Research Fellowship (September 2018 – current)

### EDUCATION:

INSTITUTION	DEGREE	YEAR	MAJOR
University of Maryland, Baltimore County (UMBC)	B.A.	Aug 2011 - May 2015	Theatre Design and Production Minor: Chemistry
University of Maryland, Baltimore County	Ph.D.	August 2016 – present Expected July 2021	Chemistry

### HONORS:

Awarded National Science Foundation (NSF) Graduate Research Fellowship – 2018  
Graduated summa cum laude from the University of Maryland, Baltimore County (UMBC) - May 2015

### Awards:

Winning Poster in Student E-Poster Competition (physical sciences division) at AAAS Annual Meeting, 2020  
Honorable mention in Student E-Poster Competition (physical sciences division) at AAAS Annual Meeting, 2019  
2<sup>nd</sup> place in poster competition at Bio-X Singapore, 2018  
2<sup>nd</sup> place in poster competition at Bio-X Israel, 2017

### Journal Cover Artwork Accepted:

Journal Cover Artwork by Knoblauch, R. Publication: Knoblauch, R.; Harvey, A.; Ra, E.; Greenberg, K.; Lau, J.; Hawkins, E.; Geddes, C.D. Antimicrobial Carbon Nanodots: Photodynamic Inactivation and Dark Antimicrobial Effects on Bacteria by Brominated Carbon Nanodots. *Nanoscale*. 2021, 13 (1), 85-99.  
Supplementary Journal Cover Artwork by Knoblauch, R. Publication: Knoblauch, R.; Ben Hamo, H.; Marks, R.; Geddes, C.D. Spectral Distortions in Metal-Enhanced Fluorescence: Experimental Evidence for Ultra-Fast and Slow Transitions. *J. Phys. Chem. C*, 2020, 124, 4723–4737.  
Supplementary Journal Cover Artwork by Knoblauch, R. Publication: Moskowicz, J.; Sindi, R.; Geddes, C.D. Plasmonic Electricity II: The Effect of Particle Size, Solvent Permittivity, Applied Voltage, and Temperature on Fluorophore-Induced Plasmonic Current. *J. Phys. Chem. C*, 2020, 124, 10, 5780-5788.  
Supplementary Journal Cover Artwork by Knoblauch, R. Publication: Moskowicz, J. and Geddes, C.D. Plasmonic Electricity: Fluorophore-Induced Plasmonic Current. *J. Phys. Chem. C*, 2019, 123, 45, 27770-27777.

### Positions:

Vice Chair of 2021 “Clusters and Nanostructures” Gordon Research Seminar (since cancelled by GRC)  
President and founder of STEM outreach Graduate Student Organization (May 2017 – August 2019)  
Platform Chair “Micro- and Nanotechnology”: Biophysical Society Annual Meeting (March 2019)

### Professional Memberships:

American Chemical Society (January 2017 – current)  
American Association for the Advancement of Sciences (Nov. 2017 – current)  
Inter-American Photochemical Society (July 2019 – current)  
American Society for Microbiology (January 2020 – current)

### TEACHING EXPERIENCE:

Learning Assistant (Fall 2013) – Organic Chemistry – University of Maryland, Baltimore County  
Tutor (Spring/Fall 2014) – Organic Chemistry – University of Maryland, Baltimore County  
Teaching Assistant (Spring 2015, Spring 2016) – General Chemistry Lab – University of Maryland, Baltimore County  
Tutor (August 2015 – May 2016) – General Chemistry and Organic Chemistry – Varsity Tutors  
Teaching Assistant (Fall 2016, Spring 2017) – Organic Chemistry I Lab – University of Maryland, Baltimore County  
Teaching Assistant (May 2017 – May 2018) – Physical Chemistry I/II Lab – University of Maryland, Baltimore County  
Teaching Assistant (May 2018 – August 2018) – Analytical Chemistry Lab – University of Maryland, Baltimore County

## RESEARCH EXPERIENCE (prior to entering program):

Spring 2016 – Undergraduate Researcher in Dr. Marie-Christine Daniel’s laboratory – University of Maryland, Baltimore County

## CURRENT RESEARCH ACTIVITIES (brief description)

**Dissertation Topic:** Development of silvered, heavy atom carbon nanodots as agents for antibacterial activity via metal-enhanced phosphorescent (MEP) emission and generation of singlet oxygen.

Carbon nanodots have been heavily studied both in the field and by the Institute of Fluorescence (IoF) since their discovery roughly a decade ago. Due to excitation-dependent fluorescence emission, thermal and photostability, nano size, and low cytotoxicity, these carbon nanostructures have seen pervasive application in the biomedical sciences, from use as fluorescent ion probes for *in vitro* applications to use as theranostic agents for drug delivery. Despite these applications, little research has been done to develop these inexpensive nanostructures to combat common bacteria in our everyday environment.

In my research, I will explore different functionalization techniques to add bromine and/or iodine to the carbon nanodot structure. These heavy atoms have been shown to induce spin orbit coupling, allowing for stronger rates of intersystem crossing from singlet to triplet excited states. By adding these atoms to the electronic environment of the carbon nanodots, we have seen that increased triplet yields and therefore phosphorescent signals are produced. Further, we have confirmed the photoactivatable generation of reactive oxygen and nitrogen species from the brominated carbon nanodots and have extended their applications to antimicrobial photodynamic therapies (APDT) against both Gram-positive and -negative bacterial strains, including *Escherichia coli*, *Staphylococcus aureus*, and *Listeria monocytogenes*.

Both phosphorescence, and indeed APDT, can also be amplified in hybrid systems with plasmonic nanoparticles; however, the literature to date for carbon nanodots has largely focused on metal-enhanced fluorescence (MEF) alone. In our work, we have verified the ability of plasmonic silver substrates to produce MEF as well as metal-enhanced phosphorescence (MEP), singlet oxygen generation ( $ME^1O_2$ ), and nitric oxide generation (ME-NO•). Current studies are underway to validate the ability of this same hybrid platform for the amplification of antibacterial activity from the photo-activated carbon nanodot structures as well. Forward-looking investigation also into the development of colloidal silver nanoparticle/brominated carbon nanodot hybrids, as well as into the ability to alter carbon dot photodynamic properties via combustion reagent tuning, are also underway.

## COURSES TAKEN

2021	Issues at the Chemistry/Biology Interface (CBI, Fall; Spring in process)	Pass	2013	Physical Chemistry I	A
2020	Issues at the CBI (Fall and Spring)	Pass	2013	Organic Chemistry Lab I	A
2019	Issues at the CBI (Fall and Spring)	Pass	2013	Organic Chemistry II	A
2018	Issues at the CBI (Fall and Spring)	Pass	2013	Introduction to Chemistry Lab II	A
2017	Literature Assessment	Pass	2012	Organic Chemistry I	A
2017	Mechanisms of Organic Reactions	A	2012	Foundations of Biology: Ecology	A
2017	Development and Cancer	A	2012	Principles of Chemistry II	A
2017	Nanoparticles	A	2011	Principles of Chemistry I	A
2017	Statistical Thermodynamics	A			
2017	Issues at the CBI (Fall and Spring)	Pass	2017	Ethics in Research	Pass
2016	Bioinorganic Chemistry	A	2016	Ethics in Research	Pass
2016	Inorganic Chemistry	A	2011	Calculus and Analytical Geometry II	A
2016	Issues at the CBI	Pass	2011	Calculus and Analytical Geometry I	T
2016	Introduction to Biomedical Chemistry	A	2011	Introductory Physics I and II	T/T
2016	Analytical Chemistry	B			
2014	Organic Chemistry Lab II	A			
2013	Organic Chemistry Lab I	A			

#### APPLICATION(S) FOR PRE-DOCTORAL FUNDING:

2018 National Science Foundation (NSF) Graduate Research Fellowship Program (GRFP) – *Funded*  
August 2017 National Institutes of Health (NIH) F31 – *Not funded*  
Spring 2019 UMBC Graduate Student Association (GSA) Research Grant – *Funded*  
Fall 2019 UMBC Graduate Student Association (GSA) Research Grant – *Funded*

#### APPLICATION(S) FOR POST-DOCTORAL FUNDING: N/A

#### APPLICATION(S) FOR POST-DOCTORAL EMPLOYMENT:

Northrop Grumman Future Technical Leaders Program – Applied September 2020 – *Hired*

#### CROSS DISCIPLINARY TRAINING COMPONENT:

While the focus of our research is aimed at combating bacteria, photodynamic therapies are also under intense investigation in the literature for applications in anticancer approaches. In another vein, the application of our carbon nanodot structures as a light-activated sterilization agent brings into question possible cytotoxicity experienced by any handlers of the agent downstream. In light of both of these factors, the cross training project currently underway with the laboratory of Dr. Charles Bieberich at the University of Maryland Baltimore County aims to assess the toxicity, both in general and with photo-activation, of the brominated carbon nanodots against cancerous cell lines including HeLa and A375 cells. Preliminary results have demonstrated some measure of toxicity of the dots against HeLa cells when incubated for long periods (greater than 1 hour), although minimal toxicity effects are observed via the MTT assay for shorter periods (20 minutes). With photoactivation, similar results are seen, although a significant reduction in cell viability is observed for both cell lines. This implies that while the user health risk for sterilization applications may be minor, there is also the potential to further tune the structure of the carbon dots for applications as anticancer PDT agents as well.

#### PUBLICATIONS (this graduate program)

- Knoblauch, R.** and Geddes, C.D. Plasmonic Enhancement of Nitric Oxide Generation. *Nanoscale*. **In revision May 2021.**
- Knoblauch, R.;** Harvey, A.; Geddes, C.D. Metal-Enhanced Photosensitization of Singlet Oxygen ( $ME^1O_2$ ) from Brominated Carbon Nanodots on Silver Nanoparticle Substrates. *Plasmonics*. **2021**. <https://doi.org/10.1007/s11468-021-01438-1>.
- Nichols, Z.E.; Saha, L.; **Knoblauch, R.;** Santaus, T.M.; Geddes, C.D. Development of a Microplate Platform for High-Throughput Sample Preparation Based on Microwave Metasurfaces. *IEEE Access*. **2021**, 9, 37823-37833.
- Knoblauch, R.;** Geddes, C.D. (2020). Carbon Nanodots: Antimicrobial Photosensitizers. In *Encyclopedia*. Retrieved from: <https://encyclopedia.pub/2856>.
- Featured on Front Cover:* **Knoblauch, R.;** Harvey, A.; Ra, E.; Greenberg, K.; Lau, J.; Hawkins, E.; Geddes, C.D. Antimicrobial Carbon Nanodots: Photodynamic Inactivation and Dark Antimicrobial Effects on Bacteria by Brominated Carbon Nanodots. *Nanoscale*. **2021**, 13 (1), 85-99.
- Invited Feature Review:* **Knoblauch, R.;** Geddes, C.D. Carbon Nanodots in Photodynamic Antimicrobial Therapy: A Review. *Materials*. **2020**, 13, 4004 (35p).
- Knoblauch, R.;** Moskowitz, J.; Hawkins, E.; Geddes, C.D. Fluorophore-Induced Plasmonic Current: Generation-Based Detection of Singlet Oxygen. *ACS Sensors*, **2020**, 5, 1223-1229.
- Knoblauch, R.;** Ben Hamo, H.; Marks, R.; Geddes, C.D. Spectral distortions in zinc-based metal-enhanced fluorescence underpinned by fast and slow electronic transitions. *Chemical Physics Letters*, **2020**, 744, 137212.
- Knoblauch, R.;** Ben Hamo, H.; Marks, R.; Geddes, C.D. Spectral Distortions in Metal-Enhanced Fluorescence: Experimental Evidence for Ultra-Fast and Slow Transitions. *J. Phys. Chem. C*, **2020**, 124, 4723-4737.
- Lucas, E.; **Knoblauch, R.;** Combs-Bosse, M.; Broedel Jr., S.E.; Geddes, C.D. Low-concentration trypsin detection from a Metal-Enhanced Fluorescence (MEF) platform: Towards the development of ultra-sensitive and rapid detection of proteolytic enzymes. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, **2020**, 228, 117739.
- Schmitz, R.; **Knoblauch, R.;** Ra, E.; Geddes, C.D. Alpha-Fluorescence ( $\alpha S1$ ) from Thermally Stable Carbon Nanodots. *Chemical Physics Letters*, **2019**, 721, 123-128.
- Knoblauch, R.** and Geddes, C.D. Silvered Conical-Bottom 96-well Plates: Enhanced low volume detection and the MEF Volume/Ratio effect. *Nanoscale*, **2019**, 11 (10), 4337 – 4344.
- Knoblauch, R.;** Ra, E.; Geddes, C.D. Heavy Carbon Nanodots 2: Plasmon Amplification in Quanta Plate™ Wells and the Correlation with the Synchronous Scattering Spectrum. *Physical Chemistry Chemical Physics*, **2019**, 21 (3), 1254-1259.
- Knoblauch, R.;** Bui, B.; Raza, A.; Geddes, C. D., Heavy carbon nanodots: a new phosphorescent carbon nanostructure. *Physical Chemistry Chemical Physics*, **2018**, 20 (22), 15518-15527. DOI: 10.1039/C8CP02675K.

**Knoblauch, R.**, Geddes, C.D. Reviews and Advances in Metal-Enhanced Fluorescence. In *Reviews in Plasmonics 2017*; Geddes, C.D., Ed.; Springer: New York; London. 2019; pp 253-283.

PRESENTATIONS: (this graduate program)

*First Author Presentations:*

- Knoblauch, R.**; Ra, E.; Harvey, A.; Greenberg, K.; Geddes, C.D. *Tuning Light-Activated Antimicrobial Character from a Carbon Nanodot Architecture*. Virtual Chemistry Biology Interface Symposium. May 2020. (talk)
- Knoblauch, R.**; Geddes, C.D. *Photodynamic Enhancement of Antimicrobial Properties from Brominated Carbon Nanodots*. AAAS Annual Meeting. February 2020. (poster/microtalk)
- Knoblauch, R.**; Geddes, C.D. *Development of Nano-Systems for the Metal-Enhanced Generation of Singlet Oxygen ( $ME^1O_2$ ) from Carbon Nanodot Structures*. Gordon Research Conference and Seminar: "Clusters and Nanostructures." June 2019. (talk, poster)
- Knoblauch, R.**; Geddes, C.D. *Metal-enhanced phosphorescence and singlet oxygen generation from brominated carbon nanodots*. Biophysical Society Annual Meeting. March 2019. (talk)
- Knoblauch, R.**; Geddes, C.D. *Heavy Carbon Nanodots: A Potential Light-Activated Antimicrobial*. AAAS Annual Meeting. February 2019. (poster/microtalk)
- Knoblauch, R.**; Geddes, C.D. *A novel carbon nanodot architecture: Heavy Carbon Nanodots as New Photosensitizer for Antimicrobial Inactivation*. 11th Frontiers in Chemistry & Biology Interface Symposium. May 2018. (poster)
- Knoblauch, R.**; Geddes, C.D. *Enhancing Decay Pathways of Luminescent Carbon Nanodots by Proximity to Metal Nanostructures*. 2018 UMBC Graduate Research Conference. Baltimore County, Maryland. March 2018. (Poster)
- Knoblauch R.**; Geddes CD. *A novel carbon nanodot architecture: luminescent probe for potential immunodiagnostics*. Bio-X. Singapore. February 2018. (Poster, Flash talk)
- Knoblauch R.**; Geddes CD. *Enhanced luminescence from silvered carbon nanodots: potential applications as an ultra-bright luminescent label*. Bio-X. Singapore. February 2018. (Poster)
- Knoblauch R.**; Geddes CD. *Brominated and iodinated <10 nm carbon nanodots*. Fall 2017 ACS National Meeting. Washington, D.C. August 2017. (Poster)
- Knoblauch R.**; Geddes CD. *Brominated and iodinated <10 nm carbon nanodots: "Heavy Carbon"*. Bio-X. Israel. June 2017. (Talk)
- Knoblauch R.**; Geddes CD. *Plasmon enhanced emission of carbon nanodots*. Bio-X. Israel. June 2017. (Poster)
- Knoblauch R.**; Geddes CD. *Functionalizing Carbon Nanodots: and exploration of halogenation and silver metal deposition for photoluminescence tuning*. 2017 UMBC Graduate Research Conference. Baltimore County, Maryland. March 2017. (Poster and microtalk)

*Mentored Presentations:*

- Greenberg, K.; Lau, J.; **Knoblauch, R.**; Geddes, C.D. *Determining the viability of brominated carbon nanodots as bacterial inactivators*. UMBC Summer Undergraduate Research Festival. August 2019. (poster)
- Ra, E.; **Knoblauch, R.**; Geddes, C.D. *Detection of delayed fluorescence emission ( $\alpha S_1$ ) from aggregated forms of carbon nanodots*. American Chemical Society 47th Middle Atlantic Regional Meeting. June 2019. (poster)
- Ra, E; **Knoblauch, R.**; Geddes, C.D. *Metal-enhanced fluorescence and phosphorescence from brominated carbon nanodots on silver 96-well plates*. UMBC Summer Undergraduate Research Fest. August 2018. (poster)
- Raza, A; Gwanvoma, H.B; **Knoblauch, R.**; Geddes, C.D. *Optimizing the synthesis of heavy atom carbon nanodots for phosphorescence character*. UMBC Summer Undergraduate Research Fest. August 2017. (poster)
- Bui, B; **Knoblauch, R.**; Geddes, C.D. *Novel Strategies for intrinsic metal-enhanced fluorescence from carbon nanodots*. UMBC Summer Undergraduate Research Fest. August 2017. (poster)