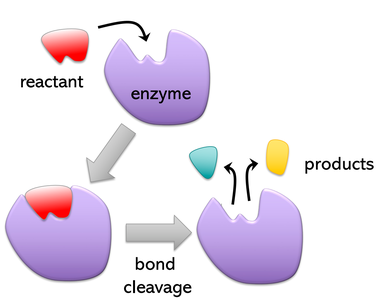
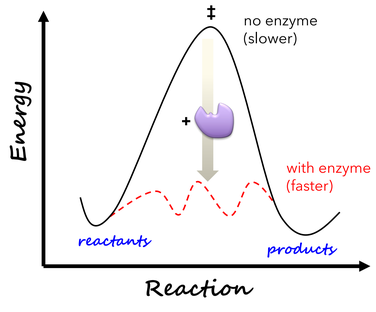
To Tunneling and Beyond! Engaging Students in (Bio)Quantum Science

Adam R. Offenbacher, Assistant Professor, Department of Chemistry, East Carolina University

Research Interests in the Offenbacher Lab

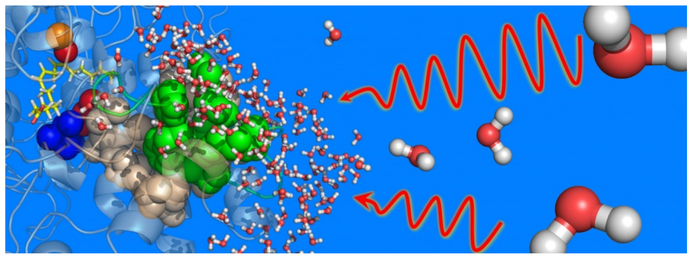
Research in the Offenbacher lab is at the interface of Chemistry, Biology, and Physics. The lab focuses on elucidating the mechanisms for how enzymes (Nature's catalysts) work. Information gained from these studies will inform protein design efforts for green chemistry as well as development of next generation anti-inflammatories to combat chronic inflammatory diseases.





How Do Enzymes Work? And What is Tunneling?

- Enzymes catalyze the cleavage of C-H bonds by a non-classical, quantum tunneling process, in which the hydrogen atom is 'wave-like'. In other words, the hydrogen *tunnels through the barrier.*
- In these reactions, the energy barrier arises from the reorganization of the protein complex that is governed by long-range solvent interactions at the protein surface. The goal of this research is to understand how thermal energy or heat is transmitted from solvent to the enzyme active site. In doing so, this research will answer the question into how the classical properties of proteins (i.e., conformations) interplay with quantum phenomena (i.e., tunneling).



Student Achievements in the Offenbacher Lab

- Since 2017, the Offenbacher lab has published 22 peer-reviewed journal articles in various journals with 13 ECU undergraduate students as first- or co-authors.
- Students have been awarded a George T. Barthalmus UG research award and several URCAs.
- Students have presented at regional and national conferences

Development of a Cross-Disciplinary CURE lab

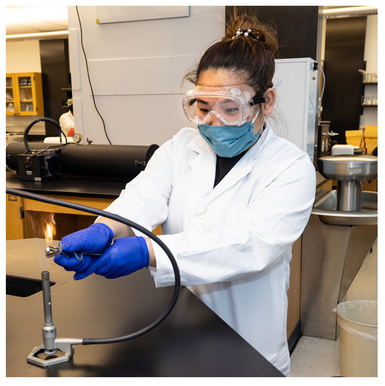
BIOL 3110
LOX gene cloning
(Dr. Eric Anderson)

CHEM 3771
LOX kinetics
(Dr. Offenbacher)

UC Merced
Protein structures
(Dr. Mike Thompson)

Goal: *This CURE aims to test this question by building a library of recombinant plant LOX clones and characterizing the reaction kinetics and examining the structural conservation of the 'thermal loop'.*

Science in Action!!!

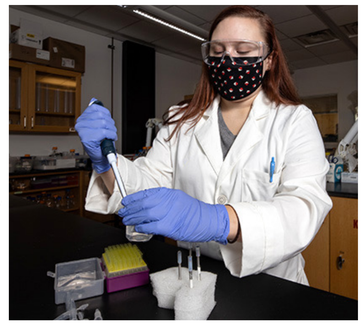


Student Success in CUREs

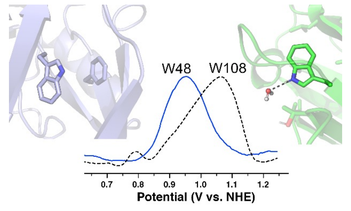
- From the three semesters of CUREs in CHEM 3771, over 25 students have participated. Three former students are pursuing M.S. degrees in the department of Chemistry at ECU, one student is in a research program in Virginia and others are pursuing other professional degrees.
- Student feedback: "*I feel like the strength of this course is that it feels like a real research lab. That makes it fun and more engaging for the students.*" and "*Student research is an invaluable opportunity. It is a great way to learn what it will be like to do research in your major.*"

The Road to Discovery: From 'Accident' to Publication, NSF Grant

Former UG student, Kristin Tyson (right), led a team with two other female students who tested their own designed electrochemical experiment with a protein, azurin, in a CURE lab. **It failed**, but they fortuitously discovered a more interesting result that later led to a publication in *The Journal of Physical Chemistry Letters!*
Kristin was featured in the 2020 Winter THCAS Dean's Cornerstone pub.



Left: Electrochemical device. *Right:* Results that show a difference in the reactivity (potential) of an amino acid, tryptophan (W), in mediating electron transfer for bioenergetic processes



CUREs Inspiring CUREs: Biochemistry to Instrumental

- In Fall 2020, we implemented a CURE in Biochemistry lab (CHEM 2771) for the first time. Students designed and prepared mutants to study a putative protein-protein interaction implicated in ferroptosis, a non-apoptotic form of cell death.
- Chemistry major, Rachel Signorelli from fall '20 CHEM 2771, participated in an Instrumental CURE lab in the Spring 2021 semester. She proposed to use instrumentation available in the spring CURE lab to test the samples she made in the Biochemistry CURE lab.
- While no publication stemmed from this work, it demonstrates the inspiration that CUREs can provide students by integrating relevant research into the UG curriculum.

Community Outreach: Science Demos "Thermal Energy Transfer"

- I perform hands-on science demos at local schools and youth organizations to engage and expose our youth in the community to science.
- Concepts include matter and 'thermal energy' or heat. One example to demo thermal energy is the use of liquid nitrogen to 'freeze' air-filled balloons.