

*The Department of
Chemistry & Biochemistry*



Graduate studies



THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

COLLEGE OF SCIENCE AND TECHNOLOGY

Chemistry & Biochemistry



Welcome to the Department of Chemistry and Biochemistry

Dear Student,

Thank you for your interest in our graduate program in chemistry and biochemistry. As you know, scientists in our fields are called upon to solve the complex molecular problems of today through a variety of experimental approaches. Many of the most demanding scientific problems benefit from collaborations of researchers from different disciplines. It is therefore not surprising that our faculty, whose research interests encompass a broad range of areas, collaborate with each other and with colleagues at many institutions in the U.S. and abroad.

If you are looking for a graduate program that provides you with opportunities to distinguish yourself and prepares you for a successful professional career, take a closer look at ours! Our collective research areas are diverse enough to match your interests. Our modern research facilities house the state-of-the-art equipment you need for your research. Our research groups are small enough for you to benefit from intense mentoring but large enough for you to make an impact through cutting-edge research and make your mark in your field. Come join our cohort of graduate students!

Sabine Heinhorst

Professor and Chair.

For more information, visit
www.usm.edu/chem



Chemistry & Biochemistry



Graduate program overview

The Department of Chemistry and Biochemistry offers Ph.D and MS programs within the broad areas of Chemistry and Biochemistry.

The department currently has 27 graduate students and divided among 14 faculty members, providing an excellent student-to-faculty ratio.

The student will benefit from the 'individual attention' from their mentors.



For more information, visit
www.usm.edu/chem



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Graduate program overview

Requirements:

- **Qualifying exam (0-1 yr)** – The incoming student has to pass this exam in within three attempts (for undergraduate students) or two attempts (for students with masters degree) to be enrolled for Ph.D degree.
- **Coursework and credit hours (during graduate work)** – The Department requires that all students pass a minimum of 18 hours of graduate coursework. The student must maintain a cumulative grade point average of 3.0 or higher. This includes three graduate courses (above 600-level).
- **Laboratory rotations (0 – 6 months)** – The students will have to do rotation in minimum of two laboratories.
- **Prospectus defense (1st yr)** – The student proposes their research work to the department.
- **Project updates (each year)** – Oral presentation to the department each academic year.
- **Comprehensives (3rd yr)** – defend questions from the committee or write and defend an original proposal.
- **Dissertation defense** – Submit thesis to the committee and defend before the department.



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The Department of Chemistry & Biochemistry



Infrastructure & Facilities



THE UNIVERSITY OF
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Chemistry & Biochemistry



Graduate program overview

The Department houses several equipments for chemical, biochemical, analytical, and material science research. Some of the major ones are listed below. The complete list can be seen here: <http://www.usm.edu/chemistry-biochemistry/facilities>.

Mass Spectroscopy:

Bruker Microflex MALDI-ToF & Thermo Finnigan LXQ ion trap ESI.

NMR:

Varian 300 MHz,
Bruker 400 MHz NMR
Bruker X-band EPR
Thermo Nicolet FT-IR
Jasco J-815 Spectropolarimeter (CD)
Several UV-Vis spectrophotometer
Hitachi F-2000 fluorometer
Cary Eclipse Fluorometer
Amersham Typhoon 9400 phosphorimager
Zeiss LSM 510 confocal microscope
Several HPLC and FPLC systems
Several Centrifuges
Autoclaves and Freezers (-20 and -80 °C)



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*The Department of
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Our former graduate students....



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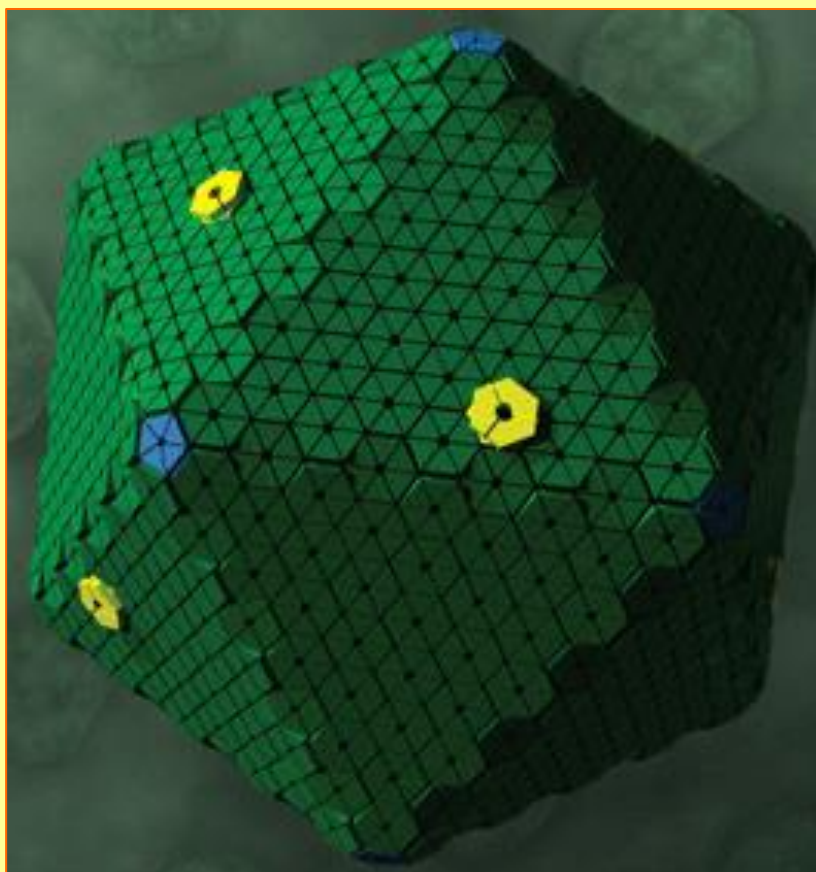
Current positions of some our recent graduate students.

Shijun Wang	Ph.D	UT Austin	(post-doctoral)
Suman Parajuli	Ph.D	U of Nevada-Reno	(Post-doctoral)
Na Li	Ph.D	UT Austin	(Post-doctoral)
Yilin Zhang	Ph.D	University of Chicago School of Medicine	(Post-doctoral)
Praveen Madasu	Ph.D	University of Southern Mississippi	(Post-doctoral)
Souvik Banerjee	Ph.D	University of Memphis	(Post-doctoral)
Amit Kumar	Ph.D	Max Planck Institute, Germany	(Post-doctoral)
Dale Rosado	Ph.D	Mississippi College	(Faculty member)
Balaraj Menon	Ph.D	Harvard University School of Medicine	(Jr faculty)
Nicole Mackey	Ph.D	Carboline Company; Saint Louis, Missouri	(Senior Scientist)
Hanaa Ahmed	Ph.D	Benha University, Egypt	(Lecturer)
David Heaps	Ph.D	GeriCare Pharmaceuticals, Mississippi	(Lab Manager)
Tricia Coleman	Ph.D	Abbott Laboratories	(Senior Scientist)
Guocan Wang	MS	Harvard University School of Medicine	(Ph.D)
Michelle McCluskey	MS	Valspar Corporation	(Chemist)

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*The Department of
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Faculty Research



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Chemistry & Biochemistry



Anthony J. Bell Jr.

Expertise

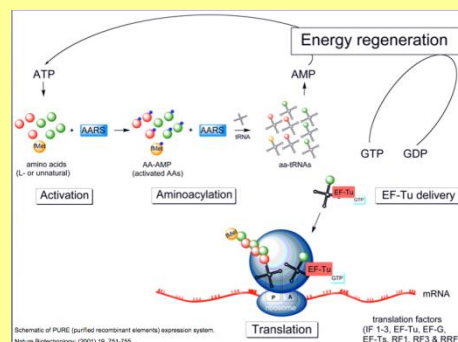
Chemical Biology - Biochemistry

Research Focus

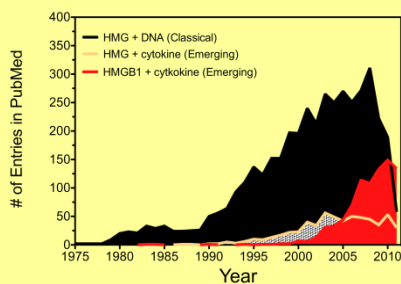
- ✓ Enzymatic synthesis of “unnatural” peptides for novel therapeutic and diagnostic applications.
- ✓ Evaluation of novel biosynthetic methods to attenuate deleterious protein-protein interactions.

Synopsis

The Bell laboratory is currently focused on two research projects. The first one is focused on using a recombinant cell-free system (PURE system) to generate peptides composed of natural and unnatural (non L-) amino acids. The recombinant format of the PURE system offers enhanced user control and compatibility.



As a result, this system is capable of incorporating unnatural residues and coupling with *in vitro* selection technologies. Hence, large peptide libraries composed of L- and unnatural residues can be generated. Our long-term goal is to isolate peptides to treat disorders such as Sickle Cell Disease.



The second research project is focused on designing new strategies to reduce the inflammatory response initiated by the canonical nuclear protein, HMGB1. New studies show direct connections between HMGB1 and a plethora of diseases such as arthritis, sepsis, cancer and lupus. The long-term goal of this project is to design novel biomolecular antagonists to attenuate deleterious HMGB1 binding interactions.

Techniques

Enzyme kinetics, Thin Layer Chromatography Circular Dichroism, UV Spectroscopy and Electrophoretic Mobility Shift Assays

For more information, visit
www.usm.edu/chem



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Douglas S. Masterson

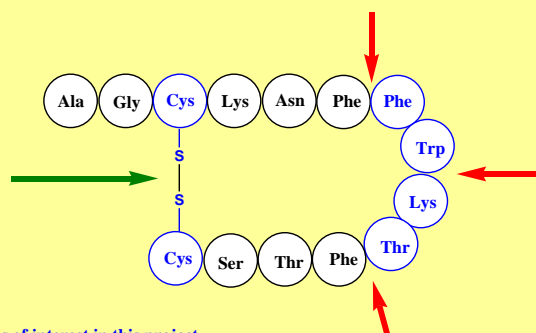
Expertise
Organic and Bioorganic Chemistry

Research Focus

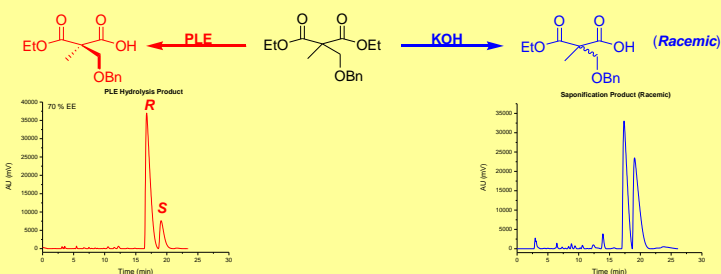
- ✓ Enzymes in Organic Synthesis.
- ✓ Unnatural Amino Acids and Peptides
- ✓ Mass Spectrometry

Synopsis

Our main research interests are in the area of synthetic organic chemistry. We are developing reactions that are capable of producing *homochirally* similar unnatural amino acids from a common intermediate. We have interests in utilizing enzymatic hydrolysis as a key step in the preparation of unnatural amino acids.



We also are interested in the development of mass spectrometry based techniques that can be useful in rapidly assaying the enantioselectivity of enzymatic reactions used in organic synthesis.



Our interests extend into bioorganic chemistry as we are interested in the utilization of unnatural amino acids in peptide synthesis to generate novel Peptide analogues.

Techniques

Mass Spectrometry, NMR, IR, UV-Vis, Microscale and Macroscale Organic Synthesis Techniques, Enzymology

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Karl J. Wallace

Expertise

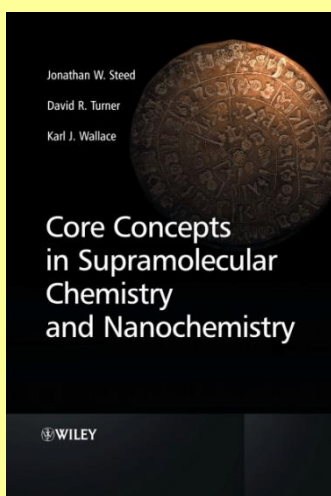
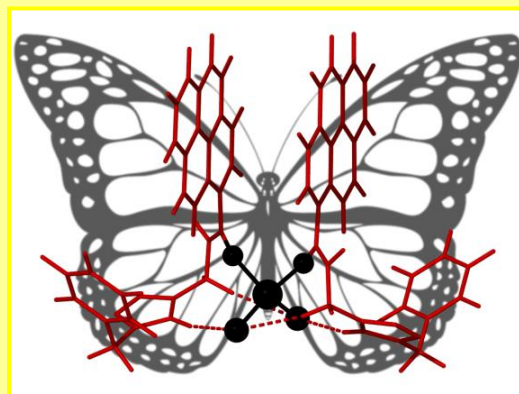
Inorganic & Supramolecular Chemistry

Research Focus

- ✓ Molecular sensors for chemical nerve agent detection & explosives., anions, cations, and legal highs and designer drugs.
- ✓ Nanochemistry; molecular receptors on surfaces.

Synopsis

Supramolecular Chemistry: The study of systems involving aggregates of molecules or ions held together by non-covalent interactions, such as hydrogen bonding, dispersion interactions and solvophobic effects. This area of research is interdisciplinary and many aspects of the supramolecular chemistry world transcend into in many collaborative research projects.



In a broad sense, the Wallace lab is interested in the molecular recognition of environmentally, biological and industrially important species. Specifically, we use various spectroscopic techniques such as colorimetric, fluorometric, electrochemical and QCM technologies to sense target analytes. Our lab designs and synthesizes molecular receptors that can selectively bind target molecules at low concentrations.

Techniques

UV-Vis, Fluorescence,, FTIR, NMR, molecular modeling, X-Ray, surface techniques (AFM and TEM) and TGA.

For more information, visit
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Faqing Huang

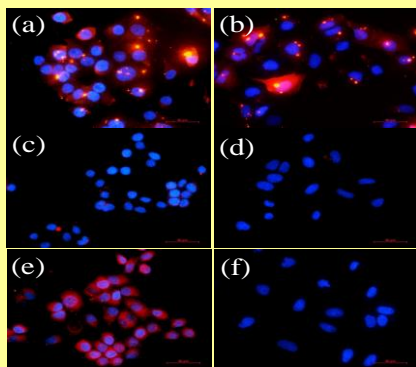
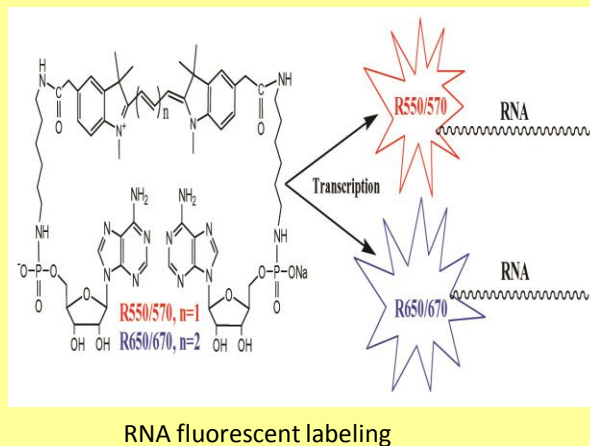
Expertise
RNA Chemistry; Chemical Biology

Research Focus

- ✓ Generation of new catalytic RNA
- ✓ Investigation of the origin and early evolution of life
- ✓ Development of novel RNA-based anti-cancer therapeutics

Synopsis

The Huang lab conducts multidisciplinary research centered on RNA molecules. Our research efforts span from isolation and study of new catalytic RNA molecules that could shed light on the origin and early evolution of life, development of efficient RNA labeling techniques that may be used for RNA analysis and detection, cancer biology, to development of nanoparticle-based novel siRNA delivery systems for anticancer therapeutic applications.



siRNA delivery to cancer cells

Obviously, the outlined broad research projects cannot be effectively achieved by ourselves alone. In addition to fully utilizing our expertise in RNA chemistry and chemical biology, we accomplish our research goals through extensive interdisciplinary collaborations with chemists, cell biologists, and virologists.

Techniques

Chemical and enzymatic synthesis, Chromatography, Spectroscopy (UV-Vis, Fluorescence, NMR, MS), Light Scattering and Microscopy, Cell culture, Animal model.

For more information, visit
www.usm.edu/chem





Julie Pigza

Expertise
Organic Chemistry

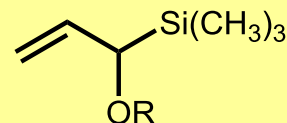
Research Focus

- ✓ Carbon-carbon bond forming strategies
- ✓ Small molecule total synthesis

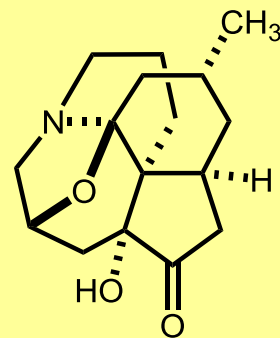
Synopsis

Research in the Pigza group will focus on methodology development and the total synthesis of natural products. The current methodology utilizes oxyallyl silanes. Oxyallyl silanes contain three orthogonal functional groups (vinyl, silyl, and hydroxyl) that can each be converted selectively depending on the reaction conditions. They provide a unique way of installing three carbons and offer an extension to using allyl silane. We would then apply this method to the synthesis of target backbones contained within alkaloid natural products. Alkaloids are structurally complex and often have interesting biological properties.

The Pigza group is also interested in implementing green chemistry techniques into standard organic reactions (see the 12 Principles of Green Chemistry on the ACS website). These include using solvent-free conditions, avoiding protecting groups, and using shorter reaction times via microwave irradiation.



oxyallyl silanes



(+)-huperzine S

Techniques

Organic synthesis and purification techniques
NMR (1D/2D, ^1H and ^{13}C), Infrared, UV/Vis, Mass spec
Air-sensitive handling techniques

For more information, visit
www.usm.edu/chemistry-biochemistry



Chemistry & Biochemistry



Matthew G. Donahue

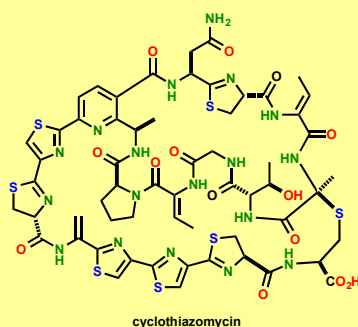
Expertise
Organic Chemistry

Research Focus

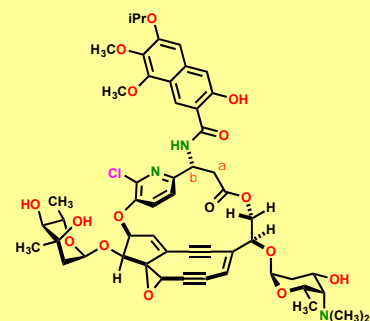
- ✓ Total Synthesis of Natural Products
- ✓ Development of Oxide Promoted Molecular Rearrangements

Synopsis

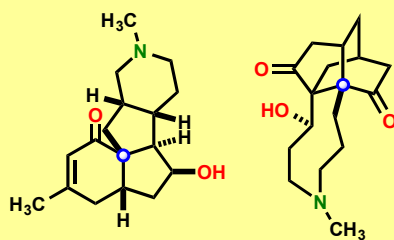
The Donahue Research Group is interested in the development of methods to increase complexity of olefins and aromatic compounds. In particular, we select natural products that contain unique substructures such as vicinal diamines, pyridyl amino acids and spirocyclic quaternary carbons.



cyclothiazomycin



Kedarcidin Chromophore



Magellanine

Palhinine A

○ = spirocyclic
quaternary carbon

The overarching goal of this research is not only the synthesis of complex natural products but the fundamental understanding of how such entities can improve human health. Students participating in this research can expect to develop laboratory and analytical skills necessary to be successful in the medical fields, academic, government, or industrial research laboratories.

Techniques

Wet bench, Inert Atmosphere, Organic Spectroscopy (UV-Vis, FTIR, NMR), Gas and Liquid Chromatography, Mass Spectrometry, Isotopic Labeling.

For more information, visit
www.usm.edu/chemistry-biochemistry





J. Paige Buchanan

Expertise

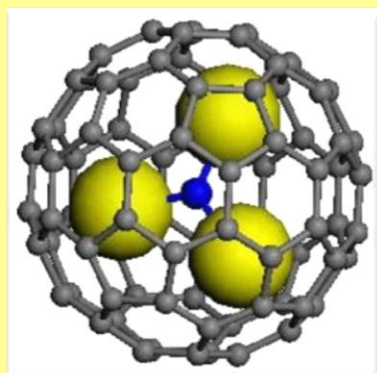
Physical Organic Chemistry/
Materials Science

Research Focus

- ✓ stimuli-responsive polymers and nanocomposites
- ✓ photochemistry and photopolymerization
- ✓ aggregation and precipitation behavior of nanoparticles

Synopsis

Regardless of the discipline, all scientists agree that materials may exhibit very different properties at the nanoscale than those seen in the bulk material. Our group's research efforts traverse the boundaries among nanomaterials, organic chemistry, and polymer science, with the goal of realizing, supporting, and in many cases boosting the unique properties offered by these intriguing materials. This research platform has led to successful projects using nanomaterials as (1) additives in stimuli-responsive, multi-functional adhesives, specifically designed to meet the changing needs of modern wound management applications, (2) nano-dopants for conducting and magnetically responsive polymers, and (3) architectural subunits of biologically inspired materials to address areas of military and civilian concern, e.g. chem-bio defense applications.



Deterring aggregation and subsequent precipitation and the incorporation of these materials into nano-structured polymer composites has been a significant focus of recent work, with an emphasis on developing new methods. Our work is multidisciplinary and highly Collaborative with other academic, industry, and government labs.

Techniques

Modern synthetic and analytical techniques, including TEM, SEM, DLS, surface analysis, and basic materials property characterization.

For more information, visit
www.usm.edu/chemistry-biochemistry



Chemistry & Biochemistry



Philip D. Bates

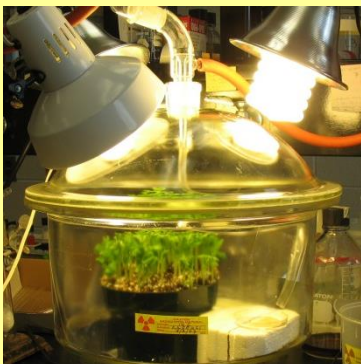
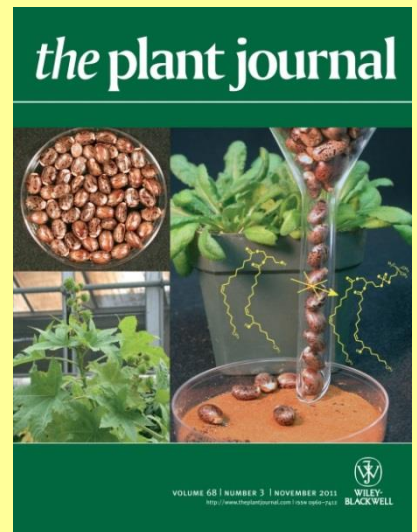
Expertise
Biochemistry of plants

Research Focus

- ✓ Biochemical pathway metabolic flux
- ✓ Biosynthesis of plant oils for food, fuels or chemicals

Synopsis

Oil produced in the seeds of plants is the most energy dense form of carbon storage. Plant oils can be used as food, bio-fuels or chemical feedstocks. However, not all plant oils are alike and the usefulness of different plant oils for various applications depends on the metabolic pathway of how the oil was produced. The goal of the Bates laboratory is to understand the metabolism of plant oil biosynthesis to enhance the bio-engineering of designer plant oils for better nutrition, and to replace petroleum within fuels and industrial chemicals.



The bates laboratory takes an interdisciplinary approach to the analysis of plant metabolism. Utilizing radioactive labeling of plant biochemical pathways, genetic mutants and molecular biology techniques to modify gene expression and metabolic flux.

Techniques

Metabolic labeling, Flux analysis, Genetics, Chromatography, Molecular biology, Enzyme characterization and many more.

For more information, visit
www.usm.edu/chemistry-biochemistry





Sabine Heinhorst

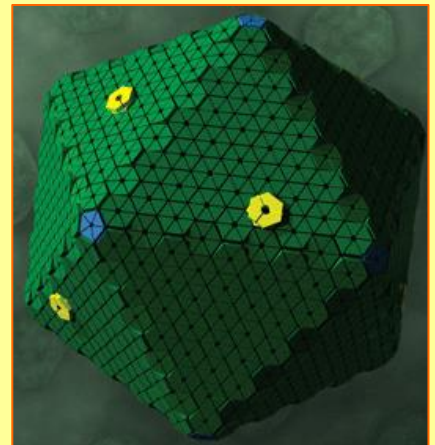
Expertise
Biochemistry/Microbiology

Research Focus

- ✓ Carboxysome structure, function and biotechnological applications
- ✓ Central carbon metabolism of autotrophic bacteria

Synopsis

Research in the Heinhorst lab focuses on carboxysomes, the carbon dioxide fixing organelles of many autotrophic bacteria. Carboxysomes are nano-scale polyhedral protein compartments that are filled with the CO₂ fixing enzyme ribulose-1,5-bisphosphate carboxylase/oxygenase (RubisCO). We seek to determine how the thin carboxysome protein shell enhances the catalytic ability of the rather slow RubisCO enzyme, allowing the bacteria to grow efficiently at low ambient CO₂ concentrations.



Because the carboxysome protein shell has unique permeability properties, we are pursuing possible biotechnological applications of these unique nano-structures. A major effort in the lab is geared towards elucidating the *in vivo* and *in vitro* carboxysome assembly pathway. Of particular interest is the question whether proteins other than RubisCO can be packaged into the carboxysome Interior.

Techniques

Protein and Enzyme Biochemistry, Protein Interaction Studies (Light Scattering, Surface Plasmon Resonance) Structural Characterization (Electron Microscopy), Genetic Manipulations, Microbiology.

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Song Guo

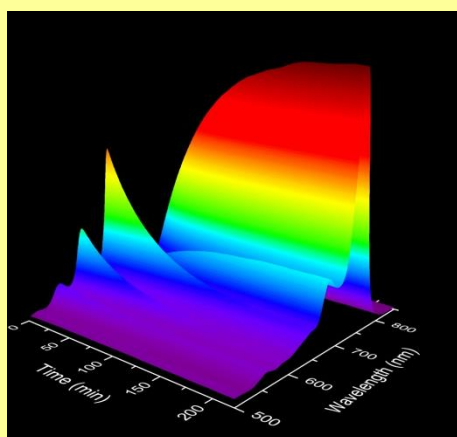
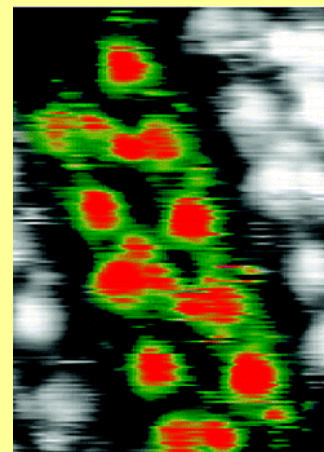
Expertise
Physical Chemistry

Research Focus

- ✓ Organic functional materials and organic solar cells
- ✓ Surface chemistry and reaction kinetics

Synopsis

Dr. Guo's group studies the morphology-structure-property correlations in organic electronic material, in particular, photovoltaic polymer materials, at the molecular level. The performances of organic electronic devices are strongly influenced by the domain morphology, molecular packing within and between domains, and the conformational structures of the polymer molecules.



We are also interested in doping for organic electronic materials. Adding dopants into organic materials, in principle similar to the doping in inorganic semiconductors, increases the density of charge carrier and changes the Fermi levels of the host materials. A more stable and spatially-localized doped devices are expected to have a better performance and longer lifetime.

Techniques

Scanning probe microscopy, single molecule spectroscopy, fluorescence microscopy, and thin film preparations and fabrications.

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Vijay Rangachari

Expertise

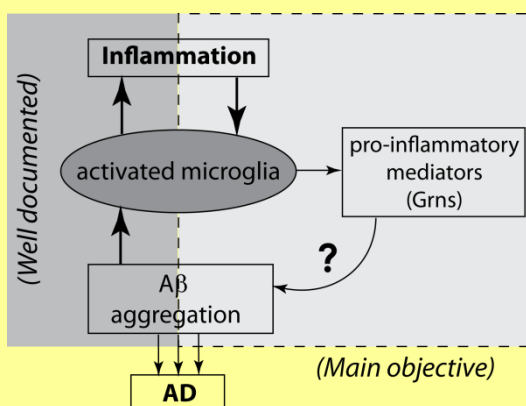
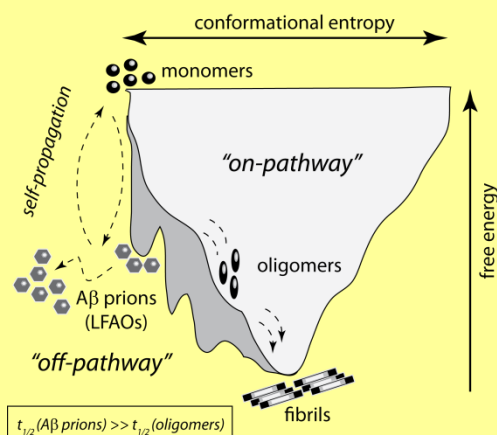
Biophysical Chemistry / Chemical Biology

Research Focus

- ✓ Protein misfolding and amyloid formation in Alzheimer's disease.
- ✓ Rational, structure-based drug design

Synopsis

In a broad sense, Rangachari lab is interested in protein-protein, and protein-ligand interactions as well as molecular recognition. Specifically, the lab is interested in delineating the underlying molecular mechanisms that dictate protein aggregation and amyloid formation. Besides, the group is also involved in developing structure-based design of 'conformation-specific' molecules that are directed towards recognizing pathogenic 'cross- β -sheet' polypeptide structures.



Rangachari lab's quest to unravel the molecular mechanisms involved in amyloid diseases is not confined to their field of expertise; The lab strongly believes that inter-disciplinary research is imperative to translate molecular theories into meaningful therapies. Therefore, the lab is also involved in many collaborative research projects.

Techniques

Protein biochemistry, Biomolecular spectroscopy (UV-Vis, Fluorescence, Circular Dichroism, FTIR and NMR), Light Scattering and Microscopy, Chromatography, Molecular biology.

For more information, visit
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Wujian Miao

Expertise

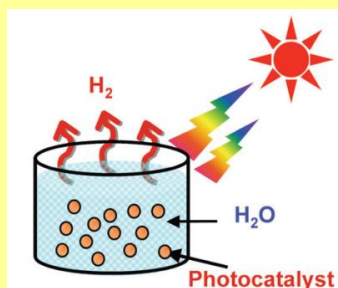
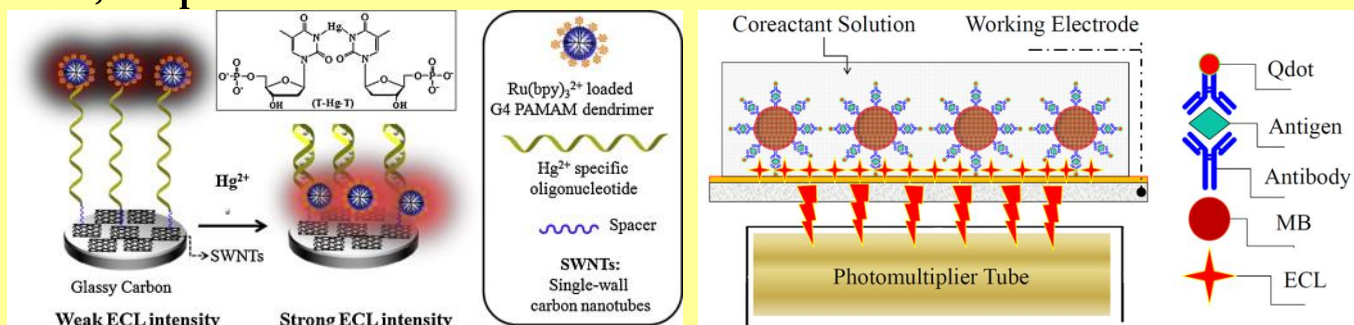
Electrochemistry, Analytical Chemistry

Research Focus

- ✓ Biosensors Based Electrogenerated Chemiluminescence
- ✓ Photocatalytic Water Splitting for Hydrogen Production
- ✓ Polycations as Novel Anticoagulants

Synopsis

Electrogenerated chemiluminescence (ECL) is a process whereby light is generated from electrochemical reactions. Miao lab is interested in the studies of new ECL systems that could be used as biosensors for sensitive, selective, and simultaneous multiplexed detection of a variety of target species including metal ions, explosives, DNA, and proteins.



Renewable energy and environmental issues at a global level are important topics. Miao lab is interested in the synthesis of novel semiconductive nano-materials that are then used as photo-catalysts for water splitting.

Techniques

Electrochemistry, Electrogenerated Chemiluminescence, Scanning Electrochemical Microscopy (SECM), Spectroscopy (UV-Vis, Fluorescence, FTIR and NMR), Scanning and Transmitted Electron Microscopy, Electrochemical Quartz Crystal Microbalance.

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Living in Hattiesburg



THE UNIVERSITY OF
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Hattiesburg, Mississippi

Recreation

Longleaf trace: A 41-mile bikers fantasy!

<http://www.longleaftrace.org/>



Longleaf Trace: Rails-to-Trails
42 paved miles—Hattiesburg to Prentiss

For more information, visit
www.usm.edu/chem



Hattiesburg, Mississippi

Recreation (contd..)



*Camping, hiking, canoeing
and mountain biking*



*Over 50 stores!
Belk, Dillard's and Sears*



18 screen movie theatre



Monthly performances

18 screen movie theatre

For more information, visit
www.usm.edu/chem



Hattiesburg, Mississippi

Recreation

<http://mugshotsgrillandbar.com/>

<http://www.kegandbarrel.com/>



*Keg and Barrel
Local Watering Hole*



Southern Miss Golden Eagles Sports!!!

For more information, visit
www.usm.edu/chem



Hattiesburg, Mississippi

Other amenities..



Close, affordable health care



**Center For
Child Development**

On campus USM daycare



Affordable housing with modern amenities



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