Communicating across Disciplines

Working on an Interdisciplinary Team

Prof. Surita Bhatia
Chemical Engineering

Why is communication with non-specialist audiences important?

- Promoting your in non-specialist journals (*Science, Nature*, *PRL*)
- Ensuring that your research results have as broad an impact as possible
- Effectively communicating your ideas in proposals
- “Selling” your ideas to program managers, administration, and management
- Seeking out and building fruitful interdisciplinary collaborations
- Developing innovative approaches that result from diverse viewpoints
- Communicating your results to general public and business sector
- Interacting with K-12 students and teachers to increase excitement for scientific research

Guidelines for Communication

- No jargon!
- Define any acronyms or specialist terms
- In oral presentations and meetings, ask for questions frequently
  - Better to ask specific questions (“Do you know what a micelle is?” rather than general “Does everyone understand?”)
  - Ask collaborators and presenters to define any terms you don’t understand
- Mention potential applications to motivate work
- State the impact of your results
- Use analogies and metaphors to aid in communication
  - Think about your “common currency:” What do you have in common with the audience or other team members? Concepts from basic chemistry, biology, or physics? Sports? Television shows? Cultural phenomena?
  - If you are the “listener,” it is okay to propose an analogy to help you understand a concept
  - If at first you don’t succeed, try, try again!

Best Practices for Writing and Formatting Research Highlights modified from www.nsf.gov, NSF Division of Chemistry

- **Writing Highlights for a Technical Audience**
  - Provide clear and concise text at the level of the *Scientific American* magazine with **no use of disciplinary jargon.**
- **Writing Highlights for a Non-technical Audience**
  - Provide text that is a summary of your research and understandable by the general public.
  - **No use of disciplinary jargon**.
  - Consult with your institution's Public Information Officer (PIO).
- **Writing Highlights in General**
  - Title and lead-in sentence should engage the reader.
  - Describe the problem or issue that motivated the research and how your approach to researching the problem or issue is unique.
  - Describe the result(s) of your research and its impact on current scientific knowledge.
  - Describe why your research result(s) is significant and how it will benefit society.
  - Describe the broader impacts of your research project.
  - Indicate approximately the year in which the results were obtained.

Best Practices for Writing and Formatting Research Highlights modified from www.nsf.gov, NSF Division of Chemistry

- **Formatting Highlights**
  - Highlights should be submitted using two Microsoft PowerPoint slides. One slide should describe the intellectual merit of the research project and one slide should describe the broader impacts of the research project.
  - Provide an interesting title, consistent with the desired audience. (Catchy titles are encouraged for non-technical audiences.)
  - Provide name of Principal Investigator (PI)/research group, name(s) of Co-PIs and collaborators, relevant institution(s)
  - Use compelling image(s) with caption(s) to explain the activity. Images should be large enough to easily see all details. Provide appropriate credits for each image.
  - Include citations resulting from the research.
  - If using abbreviations, first spell out the text and then use the abbreviation. For example, the text “Partial Differential Equations” may be provided first as Partial Differential Equations (PDEs) and thereafter as PDEs.
- **For the main highlight text, use a minimum font size of 12 (18 or higher is better).**
- **For the image and citation text, use a minimum font size of 10 (14 or higher is better).**

Examples of Research Nuggets

from www.nsf.gov

and www.umass.edu/ice

PROTEINS CONTAINING NON-NATURAL AMINO ACIDS AS BUILDING BLOCKS FOR NOVEL MATERIALS

Kristi L. Kiick, University of Delaware, DMR 0239744

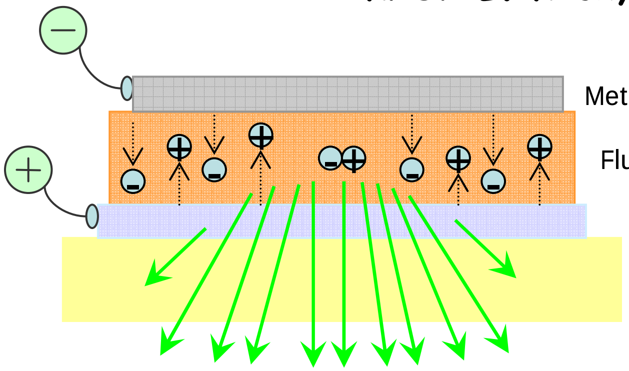


Figure 1. Schematic of polymer light emitting device.

The use of polymer layers in light emitting devices has many applications in flexible devices and electronics, and relies on the ability of these polymers to transport electrons and to emit light upon recombination of electron and hole charge carriers (Figure 1). The efficiency of light emission from the polymer layer is a function of the efficiency of charge carrier transport and the efficiency of luminescence. These two conditions have two different optima: carrier transport is optimized when the chains are closer together, but luminescence efficiency is optimized when the chains are far apart. Peptides and polypeptides offer the potential for controlling the placement of electroactive chain segments and therefore controlling electron transport and the emission of light. The successful integration of the organic and peptide components, however, requires development of chemical methods for the attachment of the electroactive polymer chain segments in controlled fashion.

We have demonstrated several successful outcomes to date:
(1) Chemical protocols can be readily implemented for the modification of peptides with electroactive groups of varying lengths
(2) The electroactive groups can be displayed on the peptides with well-defined placement and orientation (Figure 2), as indicated from spectroscopic measurements of their electronic properties, and
(3) Differences in light emission are possible from chains that differ only in a controlled extent of electronic overlap (Figure 3).

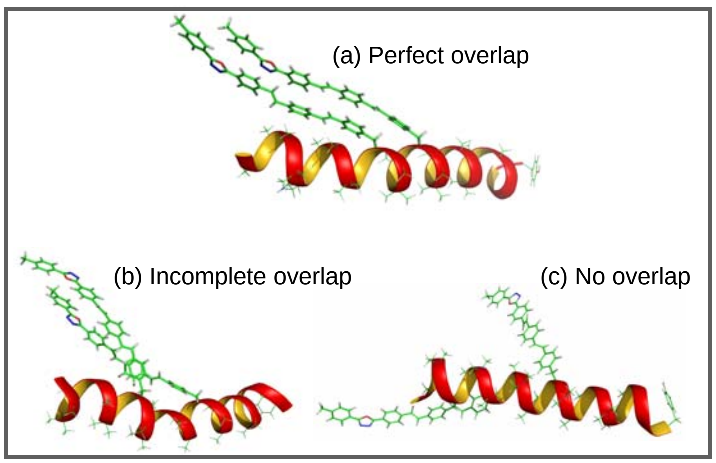


Figure 2. Schematic of chain overlap possible by placement on peptides.

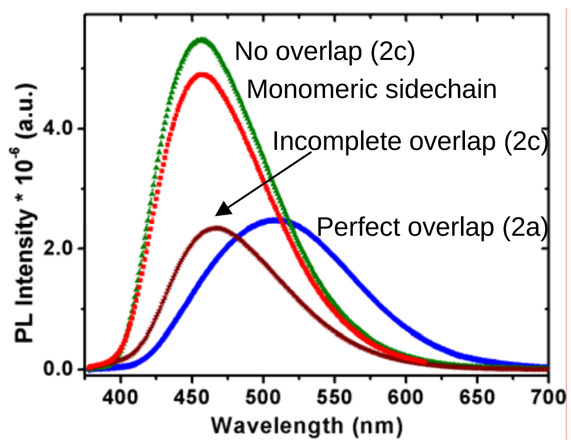


Figure 3. Photoluminescence from molecules 2(a-c).

These results offer intriguing opportunities for the manipulation of light emission from electroactive molecules and for the characterization of electron transport in electroactive molecular aggregates of defined orientations and distances. Opportunities also exist for the use of these molecular systems in studies of photovoltaic materials. Characterization of the photophysical properties of these molecules and their potential integration into devices is underway.

PROTEINS CONTAINING NON-NATURAL AMINO ACIDS AS BUILDING BLOCKS FOR NOVEL MATERIALS

Kristi L. Kiick, University of Delaware,DMR 0239744

In addition to the training and development activities of the PI, this program supports outreach efforts at both the undergraduate and secondary school levels. At the undergraduate level, the PI continues to participate in undergraduate research discussions and poster sessions, and has served as a thesis advisor and reader for several UD undergraduates completing honors theses in the chemical sciences. These students and their work have been included on several published manuscripts and presentations at regional and national meetings, and the students have continued employment in industry as well as in graduate school.

An outreach program, “The Science of Art”, developed by Kiick in collaboration with an art teacher (Karen Kiick) at Haddon Township High School in Westmont, New Jersey, has also been continued over the course of this grant program. The outreach activities have included UD graduate students in Materials Science and Engineering and at least 30-40 students, over 90% of whom are female, in the arts and crafts curriculum at Haddon Township (Figure 1 shows participants in one program). Activities have been focused on the science of materials manipulation and have focused on three main areas to date: ceramic glaze formulation, metal surface modification, and titanium anodization (Figure 2).

Based on the results of this program, students in this curriculum now create their own glazes (Figure 3), and have incorporated a knowledge of metal patinas in their artwork. They have gathered an appreciation for the chemical and materials properties of the materials with which they work, and have hopefully gained increased familiarity and confidence with the manipulation of materials via application of chemical methods. The outreach program is expected to continue and to provide new curriculum materials for the high school in the upcoming years.

Figure 1. Participants in the outreach programs hosted by the University of Delaware

Figure 2. Anodized titanium pieces (left) and metal surfaces (right, Ni shown) prepared for an outreach module. The image on the right is shown as observed under the optical microscope at a magnification=200x.

Figure 3. Examples of the new glaze formulations employed by high school students and teachers at Haddon Township High School in Westmont, New Jersey.

Oxidative Mechanisms of DNA-Protein Cross-Linking

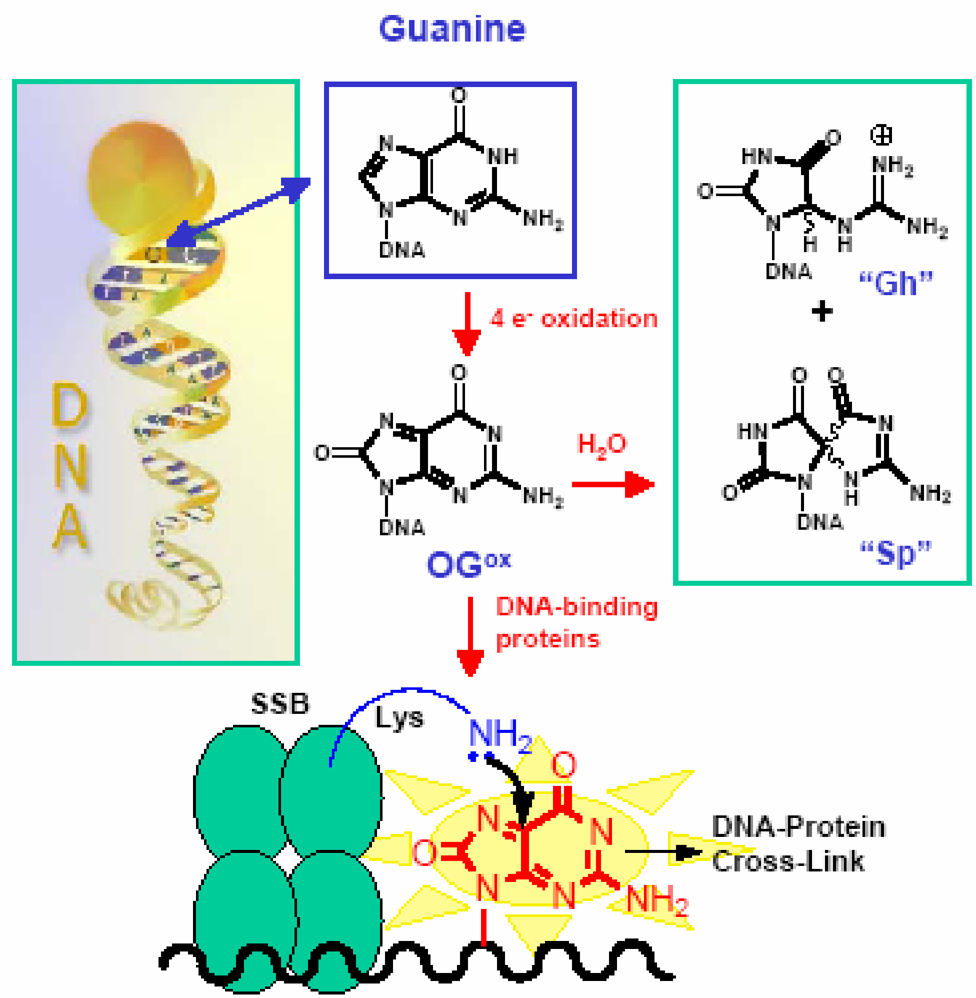
Cynthia J. Burrows, University of Utah

(CHE-0137716)

»Oxidation of DNA by reactive oxygen species (hydroxyl radical, singlet oxygen, superoxide and electron transfer) compromise the genome by introducing base mutations and interrupting enzymatic processing. DNA damage has been linked to cancer, aging and neurological disease.

» The reaction mechanisms underlying DNA oxidation at guanine (G) are the focus of this study including the further oxidation of 8-oxoguanine (OG), a key biomarker of DNA oxidation. The reactive intermediate OG^{ox} is sensitive to nucleophilic attack by solvent water leading to Sp and Gh lesions that are highly mutagenic in cells.

»Under cellular conditions, DNA is surrounded by proteins, and their lysine-rich binding motifs provide amine nucleophiles that can intercept OG^{ox} leading to covalent cross-links. In the present study, cross-linking to single-stranded binding protein (SSB) tetramer was investigated to ascertain the oxidation conditions under which cross-links are formed, the sites of DNA-protein cross-linking, and structures of amino acids adducted to oxidized guanine sites. Understanding the structure and mechanism of DNA-protein cross-link formation builds our foundation for unraveling the molecular basis of mutagenesis.



M. E. Johansen, J. G. Muller, X. Xu, C. J. Burrows *Biochemistry* **2005**, *44*, 5660-5671.

Example of Technical Highlight

Toward Probing Intermediates in Protein Folding: Ultrafast Two-dimensional Infrared Spectroscopy Distinguishes between Different Helical Structures

Nien-Hui Ge, University of California at Irvine

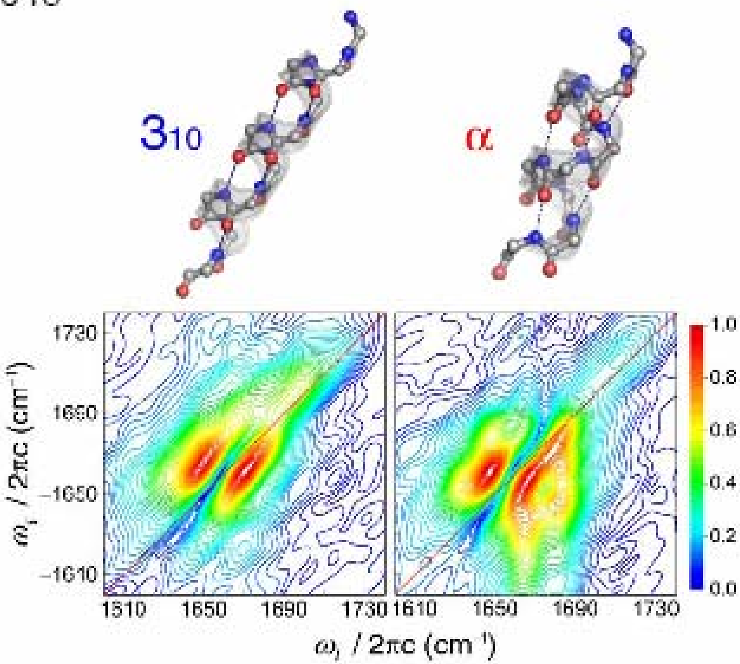
CHE-0450045

Understanding how proteins fold into their unique and highly organized functional three-dimensional structure has significant consequences for basic biology and biomedicine. Although immense progress has been made in this field, the earliest steps of protein folding still are poorly understood.

For example, simulations predict that the 3_{10}-helix secondary protein structure is a transient intermediate in the folding of secondary protein α-helices. However, experimental verification is lacking because conventional spectroscopic techniques do not have sufficient temporal and structural resolution to capture the two helical structures in real time.

Professor Ge has demonstrated experimentally, for the first time, that the relatively new method of ultrafast two-dimensional infrared (2D IR) spectroscopy can distinguish between 3_{10}- and α-helices. The figure shows that the two helices exhibit distinct cross-peak spectral patterns. Connection between the spectra and the structures was made through calculations based on a vibrational exciton model, which treats the system as a network of coupled oscillators.

The result is a key step toward developing experimental approaches that will open avenues for elucidating the role of the 3_{10}-helix in early protein folding events.



Ultrafast 2D IR spectroscopy reveals distinct cross-peak spectral patterns when an octapeptide adopts different secondary structures: a doublet pattern for the 3_{10}-helix and a multiple-peak pattern for the α-helix. Figure provided by Hiroaki Maekawa and Nien-Hui Ge, Department of Chemistry, University of California at Irvine.

Hiroaki Maekawa, Claudio Toniolo, Quirinus Broxterman, and Nien-Hui Ge, "Two-Dimensional Infrared Spectral Signatures of 3_{10}- and α-Helical Peptides," *Journal of Physical Chemistry B*, vol. 111, p. 3222 (2007).
Hiroaki Maekawa, Claudio Toniolo, Alessandro Moretto, Quirinus B. Broxterman, and Nien-Hui Ge, "Different Spectral Signatures of Octapeptide 3_{10}- and alpha-Helices Revealed by Two-Dimensional Infrared Spectroscopy," *Journal of Physical Chemistry B*, vol. 110, p. 5834 (2006).

Example of Non-technical Highlight:

Toward Understanding How Proteins Fold: New Laser Method Distinguishes between Different Protein Structures

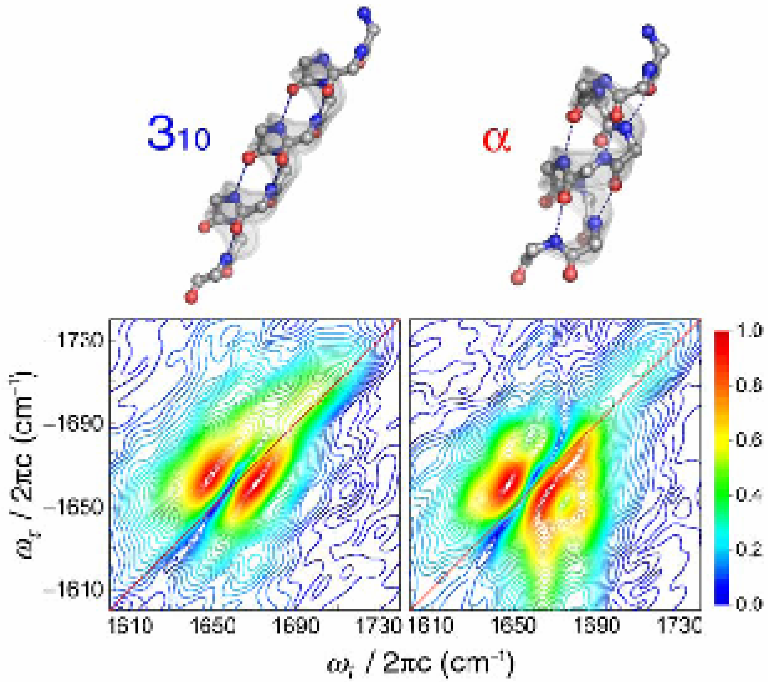
Nien-Hui Ge, University of California at Irvine

CHE-0450045

Since their invention more than 50 years ago, lasers have revolutionized the way chemists understand the molecular world. Through new developments in producing short pulses of laser light, chemists have been able to capture glimpses of very short-lived chemical compounds and structures. The goal is to make "movies" showing how molecules move and react in order to better understand how chemistry and biology work.

Proteins are structures consisting of chains of amino acids. How these structures fold into their characteristic shapes is still not understood, but the shapes are important. For example, misfolding can cause disease.

Development of new ultrafast laser techniques in the Ge laboratory has enabled the researchers to distinguishing a so-called 3_{10}-helix from an alpha (α) helix (see diagram). Using computer simulations, the 3_{10}-helix was predicted to exist as an intermediate on the way to folding an α-helix. No one knows for sure whether this is the case because it exists for only a tiny fraction of a second, and it is difficult to distinguish it from other structures. The colored diagrams resulting from the laser experiments show that the "signature" of each type of helix is distinct. Professor Ge's experiments are exciting for two reasons: they show that the new laser method is highly structure-sensitive and that it can be used as a high-speed molecular camera to take snapshots of protein folding.



New laser method provides signatures that distinguish proteins of subtly different shapes. Figure provided by Hiroaki Maekawa and Nien-Hui Ge, Department of Chemistry, University of California at Irvine.

Hiroaki Maekawa, Claudio Toniolo, Quirinus Broxterman, and Nien-Hui Ge, "Two-Dimensional Infrared Spectral Signatures of 3_{10}- and α-Helical Peptides," *Journal of Physical Chemistry B*, vol. 111, p. 3222 (2007).

Hiroaki Maekawa, Claudio Toniolo, Alessandro Moretto, Quirinus B. Broxterman, and Nien-Hui Ge, "Different Spectral Signatures of Octapeptide 3_{10}- and alpha-Helices Revealed by Two-Dimensional Infrared Spectroscopy," *Journal of Physical Chemistry B*, vol. 110, p. 5834 (2006).

Example of Broader Impact Highlight:

Toward Understanding How Proteins Fold: New Laser Method Distinguishes between Different Protein Structures

Nien-Hui Ge, University of California at Irvine

CHE-0450045

The development of new physical methods for studying biochemical phenomena is key to answering many unsolved problems in biology and medicine. The Ge laboratory is contributing to this pursuit by developing new methods based on ultrafast lasers. The method is a general approach that can be applied not only to the problem of how proteins fold but also to answer many questions in chemistry and biology.

To bring her research to the broader community, Professor Ge contributed lectures and experiments to the California State Summer School for Mathematics and Science at the University of California, Irvine (COSMOS-UCI) program in July 2006 and 2007. These lectures introduced high school students to the interdisciplinary area of the physical chemistry of macromolecules. Impact of her work is further broadened through international collaborations in Italy and the Netherlands.



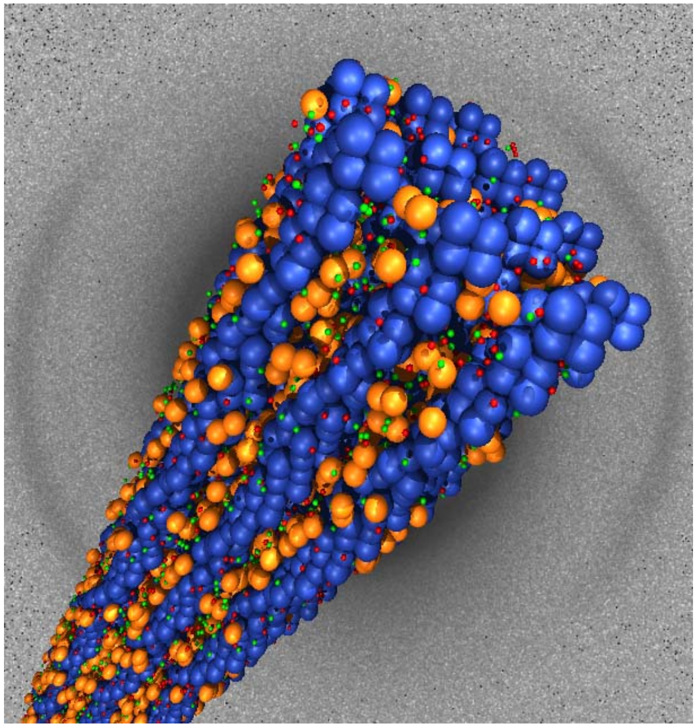

High school students attending lectures, conducting experiments, and working on projects in the California State Summer School for Mathematics and Science at the University of California, Irvine (COSMOS-UCI) program. Photos provided by Nien-Hui Ge, Department of Chemistry, University of California at Irvine. Photos taken by Tescha Thayer, a teacher fellow from COSMOS-UCI, 2006.

Wet electrostatics and biomolecular self-asembly

Gerard C. L. Wong, University of Illinois at Urbana Champaign,

DMR-0409769

Persistent infections are the primary cause of death in Cystic Fibrosis (CF), the most common lethal inherited disease in the U.S. Part of the reason for this is the binding and inactivation of native cationic antimicrobial proteins by anionic polyelectrolytes in the CF airway. By combining high-resolution synchrotron x-ray scattering, genetic engineering, and computer simulations, we dissect the osmotic and electrostatic interactions responsible for the anomalously strong binding between F-actin (a cytoskeletal polyelectrolyte found in the CF airway) and lysozyme (a common antimicrobial protein). By reducing the lysozyme charge from +9 to +5, these interactions can be controlled, and highly active 'non-stick' antimicrobials that remain active in the electrostatic environment of the CF airway can be made (Sanders et al., PNAS 2007)



A bundle of actin filaments (blue) held together electrostatically by lysozyme (orange), as obtained from molecular dynamics calculations in conjunction with synchrotron x-ray diffraction experiments (background). These complexes can contribute to persistent airway infections in cystic fibrosis by sequestering antimicrobials. 'Non-stick' versions of lysozyme can be made: Reduction of lysozyme charge changes its geometric arrangement with actin and destabilize the bundle.

Wet electrostatics and biomolecular self-asembly

Gerard C. L. Wong, University of Illinois at Urbana Champaign,

DMR-0409769

Education:

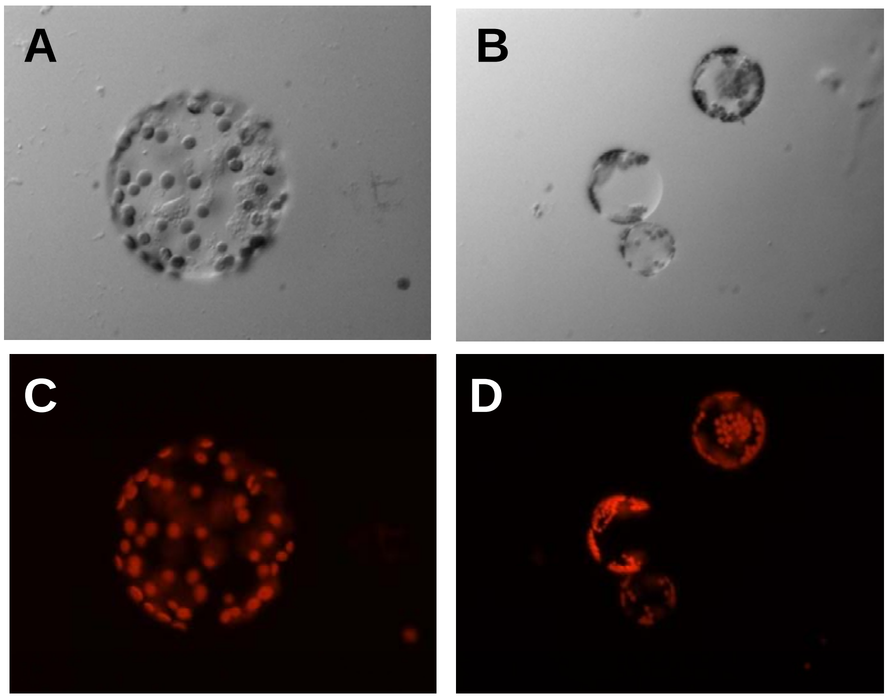
Researchers with a diverse range of backgrounds contributed to this research program. This research includes contributions from 3 undergraduates (Michael Strohman, Chuck Vrasich, and Evelyn Huang), and 1 post-doc (Lori Sanders). Two of the undergraduates above are co-authors on the PNAS paper describing this work. Two of our undergraduates have graduated: Michael has gone on to graduate school at Stanford University, and Chuck has gone on to medical school at Rush Medical School in Chicago.

Societal Impact:

Cystic Fibrosis (CF) is the most common fatal inherited disease in the U.S. The major cause of mortality in CF is persistent bacterial infections in the airways, which are enabled in part by the sequestration of antibacterial proteins by inflammatory polyelectrolytes. This fundamental biophysics research enables the development of 'non-stick' antibiotics that do not bind to airway polyelectrolytes and therefore remain active in the electrostatic environment of the CF airway.

Engineering a Human Protein for Chloroplast Expression

Craig Thomas, ICE REU Program
PI: Prof. Danny Schnell (UMass Biochem. And Molecular Biology)
Collaborator: Antonio Viana (UMass Biochem. And Molecular Biology)



A and B are pictures of plant cells without cell walls under a microscope. C and D show the red fluorescence of the chlorophyll within the chloroplasts

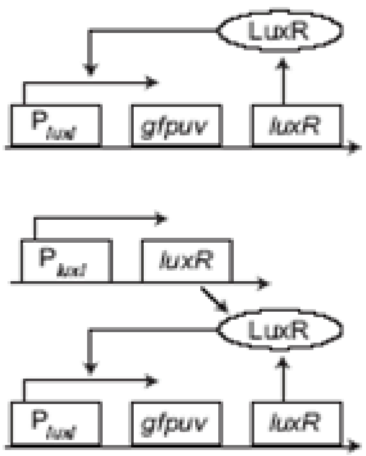
Chloroplasts are the organelles within plant cells where photosynthesis occurs. The chloroplast envelope has two membranes, an inner and an outer, and the goal of our experiments is to better understand how proteins are inserted in the inner membrane. This will be done by engineering a human membrane protein for expression in this membrane. The protein will be manipulated to contain chloroplast targeting and membrane insertion regions that are native to plastid proteins. Previous experiments in our lab have shown that the human protein can be targeted to the chloroplast but not yet inserted in the membrane. Expressing foreign proteins in plants allows for high production and easy isolation for further studies and/or use to produce antibodies or vaccines.

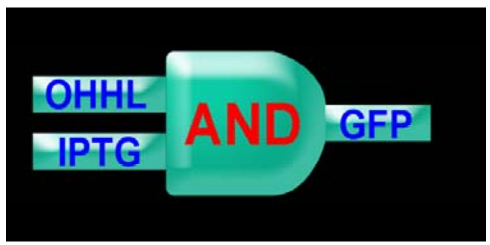
ICE REU Program sponsored by the National Science Foundation EEC-0649041

INSTITUTE FOR CELLULAR ENGINEERING

Bacterial Communication using a Quorum Sensing Network

Hassei Takahashi, ICE REU Program
PI: Lianhong Sun, University of Massachusetts Amherst
Collaborators: Daniel Sayut, Pavan Kambam





Two examples of circuit components constructed by the Sun Research Group: the positive feedback loop (left) uses the LuxR transcription activator to amplify the response of the P_{LuxI} to the signal molecule OHHL, and the AND gate (right) which initiates transcription and expresses GFP only when both signal molecules OHHL and IPTG are present.

A major challenge in applications of natural biological systems lies in the complex interactions of their components, and consequently, difficulty in manipulating these networks to produce a desired output. Synthetic biology is an emerging field which aims to analyze much simpler biological networks to understand their behavior, and use them as tools to engineer complex functional systems whose behavior can be predicted and regulated. Using the LuxI-LuxR quorum sensing network, which allows bacteria to sense population density by local concentration of a signal molecule, simple biological circuit components have been constructed and analyzed. These circuit components can be applied to the engineering of more complex synthetic systems that can be controlled to manufacture desired products.

References:

http://www-unix.oit.umass.edu/~sungroup/research.html
Sayut, D. J., Niu, Y., Sun, L. (2006) Construction and engineering of positive feedback loops, *ACS Chem. Biol.* 1, 692–696

ICE REU Program sponsored by the National Science Foundation EEC-0649041

Exercise:
Draft a “research nugget”

Draft text of nugget on your own
over the next few weeks

Clear content with your advisor by July 20, 2009

Refine, add images, put in template,
and bring on a memory stick on July 20, with an
email copy to Prof. Bhatia (sbhatia@ecs.umass.edu)

Working on Interdisciplinary Teams

- When do you seek out collaborators and new team members?
  - Think about necessary skills needed to complete project or task
  - Be careful to ensure that each team member has a role and brings a unique skill or perspective
- How do you find collaborators?
  - Looking locally vs. non-local
- What makes a good collaborator and team member?
  - Core competence with willingness to be flexible
    - Flexibility in terms of interests
    - Flexibility in terms of work style
  - **Respect for each other’s time and opinions !!!!!**
  - Chemistry with team members
  - Honest communication about team dynamics and project directions
- Time is necessary to find the right collaborators and build collaborative relationships

Managing an Interdisciplinary Team

- During team meetings and conflicts with group members, keep in mind strategies for difficult conversations and negotiations
- Team building does not happen in one or two sessions
- Needs to be more than "a day at the park" or a "fun activity"
- Allow opportunities for team members to learn and explore how others on the team think and work
  - Formal opportunities: long, collaborative-style retreats and meetings to determine project goals, brainstorm new ideas, etc.
  - Informal opportunities: Causal activities to build rapport
  - In either setting, encourage an environment where team members feel comfortable sharing how they think and work

Management Issues that May Arise

- **Conflict due to overlapping roles and expertise**
  - Address explicitly and define roles when new members are added
  - Keep lines of communication open when starting new collaborations
- Team member not meeting technical expectations
- Team member not meeting collaborative expectations
  - Does not integrate well with group
  - Does his or her “own thing” without regard to project goals
- Team member not meeting other expectations
  - Misses meetings and deadlines
  - Does not provide requested data or information for project milestones
  - Not respectful of other team members in meetings and/or communications

Team Building Exercise

- Form groups of ~4, mix of graduate and undergraduate students from different disciplines
- Scenario: You are a group within a large company. Your company has recently acquired IP from a start-up biotech firm on a new material that shows promise as a controlled release agent for an anticancer agent. The "big boss" has charged your team with taking the technology from the research stage to development. The start-up firm has done preliminary animal studies showing biocompatibility and efficacy in treating tumors. Issues related to product scale-up are still unanswered.
- The "big boss" will allow your group to make one new hire to aid in the development process. She would like you to determine the skills that this individual needs to facilitate development. In addition, she may allow an additional hire if a strong case can be made.
- Your task: As a team, determine the type of individual who would be best suited for this position, and make a convincing recommendation to the "big boss."
- Think about: What tasks remain for development of this technology? What skills do your existing team members have? What type of individual(s) will best complete the team?