

SRI International – REU Students, Summer of 2015

Student Research Projects and Accomplishments:

Below is a summary of each student's project at SRI International during the summer of 2015 in their own words with some editing of the text as appropriate.



Student: Shu Rong Huang, San Francisco State University

Mentors: Drs. Hua Lin and Thomas Shaler

Project Title: Proteomic Analysis of Exosomes from Breast Cancer Cells by Liquid Chromatography/Tandem Mass Spectrometry

Exosomes are nano-sized vesicles, typically 30 nm to 100 nm, that are shed from the intracellular to the extracellular environment.¹ Exosomes contain protein and RNAs and are often used as a method of intercellular communication.¹ In tumor cells, exosomes are used for growth, the promotion of angiogenesis, and metastases.¹

A liquid chromatography/tandem mass spectrometry (LC/MS/MS) instrument was used to determine protein content and abundance in isolated exosomes as a function of tumor progression or morphology. Two groups of Michigan Cancer Foundation-7

(MCF-7) early stage breast cancer cell lines were obtained with only one group treated with Transforming Growth Factor-beta 1 (TGF- β 1), a protein associated with cell-proliferation, differentiation, and, ultimately, making the cells in the treated-group much more aggressive. Exosomes in the growth medium from the treated group and the control group were extracted using a commercial exosome isolation kit (Life Technologies) and lysed. Proteins from these tumor-cell-derived exosomes were subjected to tryptic digestion, where proteins were cleaved specifically at arginine and lysine residues after reduction and alkylation of cysteine residues. Reversed-phase liquid chromatography was used to separate peptide sequences based on polarity for cleaner mass spectra and desalination of peptide samples; tandem mass spectrometry for peptide sequencing and protein identification. Figure 1 is a schematic of this bottom-up proteomic approach, commonly used in the field of proteomics.

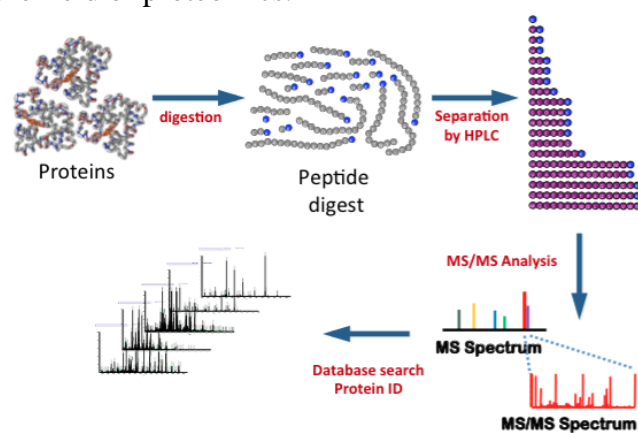


Figure 1. General schematic of bottom-up proteomics.

Based on library searches and match, a total 254 proteins were identified: 111 of these proteins were exclusively in the treated sample, 68 were in the control sample, and 75 proteins were identified in both. However, validation of these search results is still a work-in-progress for these results are extremely preliminary. After validation, some of these proteins might be potential biomarkers for cancer diagnosis or progression.

My research experience here has been phenomenal. Although I had prior mass spectrometry research experience from my university, I obtained some biological mass spectrometry experience in this REU program that I would never have the opportunity to in my undergraduate institution.

Reference

1. Raposo, G.; Stoorvogel, W.: Extracellular Vesicles: Exosomes, Microvesicles, and Friends; *J. Cell Biol.*, **2013**, 200, 373-383; DOI: 10.1083/jcb.201211138.

Student: Brendan Marsh, University of Missouri-Columbia

Mentors: Dr. Gregory Faris

Project Title: Hyperspectral Imaging

During my summer at SRI International, I was lucky enough to help develop a high-speed imaging system. This type of system is important to manage large data throughput required for biomedical imaging. Once complete, this device will combat the complexity and variability inherent in biological samples by capturing, and analyzing large amounts of high-throughput data from the sample all in real-time. The Phantom high-speed camera captures around two billion pixels per second.

Normal computers couldn't handle this amount of data in their wildest of dreams; to process this data and reduce the data bandwidth to the computer, specialized hardware is needed. Enter the Field Programmable Gate Array (FPGA) and the guts of my project this summer. FPGAs are configurable hardware elements that consist of many thousands of programmable logic gates and interconnects, allowing for highly-parallelized, high-frequency digital signal processing. Using Very High Speed Integrated Circuit Hardware Description Language (or just VHDL), it was my goal to design an FPGA architecture to handle the incredible amount of data from the sample being output, and implement algorithms to analyze the data in real time.

Undoubtedly, the biggest challenge this summer was deciphering and processing the high-speed camera data in the FPGA. Vision Research, who supplied the high-speed camera, did not provide documentation describing the formatting of the real-time camera output. While we did have documentation made by one of their clients, it was very inaccurate. In order to decipher the digital signals from the camera, I first designed an FPGA architecture to generate images according to the incorrect documentation. Then I analyzed the distorted images in Igor Pro and reverse engineered them until the correct image was reproduced. Once that was figured out it was a simple matter of working the appropriate transformation back into the FPGA architecture.

Another significant challenge was performing the data analysis procedure in the FPGA quickly and efficiently enough to support high-speed data acquisition at the 106.25 MHz clock rate. The analysis procedure mainly consists of a single matrix multiplication. This sounds easy on paper, but performing a large number of arithmetic operations on very short time scales, managing quickly accessible memory spaces for matrix coefficients and fit coefficients, and making the procedure variable enough to support different camera resolutions proved to be challenging when the system must run so efficiently that it can handle pixels coming in 100 million times per second. The solution I designed takes full advantage of the FPGA's highly parallelized design; a number of identical Multiply-Accumulate elements work simultaneously in different parts of the FPGA performing pipelined matrix multiplication operations. This solution affords real-time processing at the expense of a small lag between input images and output coefficients.

Currently, the completed FPGA architecture is undergoing its final simulations and tests before testing the whole imaging device on some simple test samples. Unfortunately, my time in Menlo Park is up, but I will continue to remotely work on the project while in school. Some things that still need to be done include the development of a LabVIEW interface to control the FPGA, camera, and experimental operations along with fine-tuning of the FPGA architecture. I look forward to supporting this project further and someday seeing the device function in all of its glory!

Truly I had a great time this summer at SRI International. I'm inexplicably grateful for the help and guidance of my mentors and all of the biosciences staff for this

opportunity from which I learned so much, and I will surely miss them and all of my fellow interns as well.

Student: Asais Uzcategui, Florida International University, Miami, Florida

Mentors: Drs. Gregory Faris, Chia Pin-Pan, Sanhita Dixit

Project Title: Fast PCR Platforms

My goal this summer was to help in the fabrication and testing of a device that would enable us to perform polymerase chain reaction (PCR) in a high-throughput and fast mode. PCR is widely used in biological assays to quantify and amplify short segments of target DNA. PCR is a cyclical process, where each cycle requires a temperature of 95°C for DNA denaturation and ~60°C for primer annealing and complimentary DNA extension. The thermodynamics of PCR and the parameters under which the reaction runs successfully were crucial aspects of device development. Currently, PCR requires an average of 40 cycles and popular bench-top devices complete these in an hour. The timing of completion is highly dependent on reaction-chamber heating rate and cooling rate. Therefore, I was faced with the analysis of polymerase chain reaction (PCR) as it relates to thermal processes.

My aim was to perform measurements on an in-house fabricated miniaturized high-throughput platform through the use of a novel heating mechanism for thermal cycling, and nanoliter droplets as reaction chambers. With my mentors, Dr. Gregory Faris and Sanhita Dixit, I worked to develop a platform with uninterrupted sample heating by placing samples on an Indium tin oxide (ITO) surface, hoping this would mitigate some of the inefficiencies of current PCR devices and run 40 cycles in less than 10 minutes. ITO is an optically clear conductive material, which allowed for fast heating, and for detection of quantification through fluorescence microscopy. We incorporated voltage based heating into an in-house written LabView program. I worked to improve the methods for placing the samples on the surface.

Subsequently, I went on to build the PCR platform. Although there was a platform prototype when I got there, preliminary tests proved that we had to improve our setup. I worked on methods for surface treatment to improve the PCR performance and on methods for containing the samples. Working with Dr. Chai-Pin Pan, I developed methods to improve attachment of electrodes to the ITO. Working with Dr. Faris, I developed several iterations of methods for temperature measurement and control.

During the last days of my internship, my mentors and I worked to run PCR on the platform. I was able to run a few successful PCR experiments in 9 minutes and 33 seconds, but it lacked reproducibility according to subsequent tests. Dr. Dixit and Dr. Faris will continue work to optimize the thermal parameters for the platform to ensure reproducibility. I plan to carry on by ensuring my remote availability as the optimization continues.

My experience at SRI was more than I could've ever hoped for. This work exposed to aspects of biology, chemistry, physics, circuits, and engineering that I had only heard about in an academic setting. Having the ability to apply scientific theories to real-world problems, and being able to navigate several labs and disciplines to accomplish this goal has been my first truly interdisciplinary research experience. I also

appreciated visiting neighboring companies, as it introduced me to diverse research initiatives, environments and capabilities. My time at SRI further inspired me to work in this interdisciplinary field, and I am forever grateful for the opportunity to learn from great scientific research and distinctively skilled researchers.

Student: Sara Callahan, Harold Washington College

Mentors: Drs. Gregory Smith and Yingdi Liu

Project Title: Measurement of H + O₃ kinetic Rate Constant with LP-LIF

This summer I have worked in the lab of Dr. Gregory Smith alongside Dr. Yingdi Liu; together our team has attempted to obtain a rate constant for the H + O₃ → O₂ + OH (v=5 to 9) reaction. The H + O₃ reaction is important in the mesosphere, mesopause, and lower thermosphere regions of the atmosphere because it is highly exothermic and functions as an important source of warming in those regions. Our goal has been to obtain empirical data to determine rate constants at a variety of temperatures, but with an emphasis on collecting rate data at low mesospheric temperatures (approximately 140 K). To date, the uncertainty associated with H+O₃ rate constant at 140 K is very high — approximately 20%. Our group has worked with the goal of reducing low temperature uncertainty to 10%. Our motivation to perform these measurements has been threefold: first, we hope that our low temperature measurements could inform the NASA's JPL recommended rate constant handbook for atmospheric scientists; second, we hoped that our measurement could serve to improve modeling of the upper atmosphere; and lastly, we hoped our measurements might help scientists understand anthropogenic changes to the energy balance of the mesosphere. Although the chemistry of the reaction we measured was complex, the setup of our instrumentation is simple. High purity argon (Ar) at 180 Torr acts as an inert carrier gas pushing ozone (O₃) from a cooled silicone gel trap into an absorbance cell. Inside that absorbance cell a mercury lamp emits light at 253 nm so that the concentration of O₃ can be measured using Beer's law. From the absorbance cell the O₃ and Ar gas mixture were then combined with 10 Torr of diatomic hydrogen (H₂), and all three gasses flowed into the reaction chamber. Inside the reaction chamber the H + O₃ reaction is induced with a two laser system known as Laser Photolysis- Laser Induced Fluorescence (LP-LIF).

Our LP portion of the LP-LIF system utilizes a Neodymium Yttrium Aluminum Garnet (Nd:YAG) laser that emitted ultraviolet light at 266 nm wavelength. This light photolyzes O₃, and the resulting excited atomic oxygen (O*) can go on to react with H₂ and Ar to produce atomic hydrogen and hydroxy radicals (OH). The production of O*, H, and OH are all fast preliminary reactions, which set the stage so the H+O₃ reaction of interest can occur. The other laser, the LIF laser, is more complex. The LIF system utilizes a second Nd:YAG laser, a dye laser to amplify the beam, and two crystals to double beam and finally emit light at 205 nm. The 205 nm light is absorbed by H atoms, which become excited to the n=3 energy state. These excited H atoms reradiate their excess energy, at 100 nm and 626 nm wavelengths. We detect this 626 nm fluorescence of the H atoms using a photomultiplier tube. The strength of the signal allows us to determine the H atom concentration at various time delays throughout the reaction; therefore a rate constant can be calculated. This is a novel way of measuring this particular reaction. It is worth noting that OH also participates in slower secondary

chemistry which occurs after the $\text{H} + \text{O}_3$ reaction. OH can combine with atomic oxygen to regenerate H atoms, and thereby convoluting the H atom signal at times beyond the initial 80 microsecond reaction. Fortunately, rate constants are most often influenced by the initial rate of reaction so the effects of this interfering secondary chemistry can be avoided, and corrected for using kinetic models.

My work this summer was initially focused on running the $\text{H} + \text{O}_3$ experiments. In the beginning of the summer I would vary reactant concentrations and perform rate constant studies at a variety of low temperatures. After data had been collected I would then perform a preliminary analysis on a data set by fitting curves and using kinetic models to verify and understand our results. Despite our labors, as the summer progressed, our group had yet to obtain a result consistent with what the models and previous groups' measurements predicted. We were attempting to measure the $\text{H} + \text{O}_3$ reaction at cold temperatures; however, our group was only able to generate a single feasible result at room temperature and none at cold temperatures. This room temperature result gave us a rate constant equal to 2.6×10^{-11} molecules $(\text{cc} \cdot \text{sec})^{-1}$ with approximately 30% associated uncertainty. The published rate constant at room temperature is 2.9×10^{-11} molecules $(\text{cc} \cdot \text{sec})^{-1}$, and this made us confident that it is possible to obtain the desired results from our instrumentation. But, try as our group might, our group struggled with understanding why our results were consistently slow with a large non-zero intercept.

I've learned a lot about instrumentation and modeling this summer, and I feel that the best lessons I received had to do with creative problem solving and critical thinking. I enjoyed working in the lab, and this REU gave me a better idea of what graduate school lab work could be like.

Laser Photolysis- Laser Induced Fluorescence

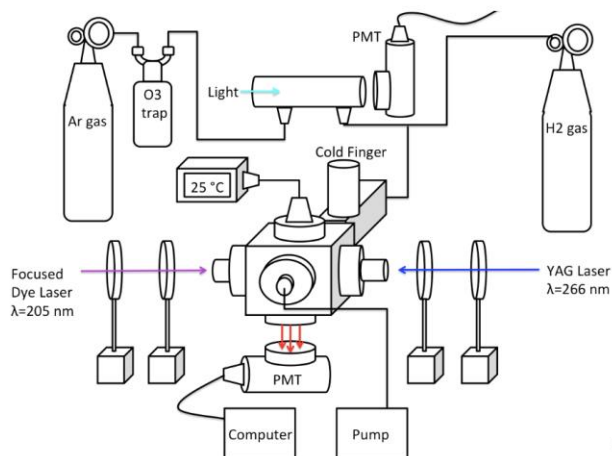


Figure 1. LP-LIF diagram: shows gas flow paths and laser paths to the reaction cell

Student: Kevin Chaves, Stanford University

Mentors: Drs. Daniel Matsiev, Tom Slanger, Gregory Faris.

Project Title: CESAR

Over the course of the REU program, I was tasked with the goal to automate the data analysis process with regards to Echellogram CESAR Data. Over the course of the

first few weeks I had to familiarize myself with the data's structure and the software tools the CESAR group was used to working with. Through that learning process I learned how to use iSpyder interface with write python codes, how to use QtiPlot to set up graphs and figures to display relevant data, and how to use ImageJ's image analysis software and Macro script system to complete image analysis on the .FITS files that stored the CESAR echellogram data. In using these tools for the first few weeks, I was looking at the infrequent aurora activity that occurred on the date of March 25th 2014. On this day, a Coronal Mass Ejection (CME) was emitted by our sun and this indirectly caused high aurora activity in the lower latitudinal areas of our planet. A phenomena that resulted in this high aurora activity was the presence of strong Nitrogen Red spectral lines in the echellogram data. With the high resolution of the CESAR Spectrogram, these nitrogen lines were recorded with high accuracy. Through this subproject I wrote a few scripts that quickened the data analyses and graphing processes in order to adequately observe the spectra data off of the echellograms. After spending the time to observe and measure this phenomena, I went on to try and automate the data analysis of the CESAR echellogram data. Upon my arrival to the REU program, all of the data analysis of the echellogram data was mainly manual due to the awkward formatting of the data. My first effort was trying to write a script that detected the presence of the beginning of the spectra data lines down one of the sides of the echellogram image. While I was working on this, Greg Faris took interest in the project and with his level of knowledge with image processing through the ImageJ software, he wrote up a preliminary code that would find the spectra data in an image of the echellogram data and analyze it. This program worked with considerable accuracy with echellogram data that had moderate background noise. However, the program did falter with images of different rotations, because the instrument's echellograms were sometimes rotated in different positions to find an optimal detection angle, and with high background noise caused by unpredictable bouncing of light in the CESAR instrument. I tried to modify Greg's script in order to make it functional at even the highest background noise occurrences in the echellogram data. I started off with trying to adjust the noise tolerance options on the macro functions that were used in his code. However, I could not find a sweet spot where the script would ignore the background noise and still detect all spectra lines on the echellogram data. Next I tried to add macros of my own to try and compensate for the noise tolerance in the data analysis process. These macros used different mathematical techniques to eliminate noise from the echellogram image but still not enough to ensure complete detection of all the spectra data on the echellogram. Greg suggested to forget about trying to add onto his code and suggested to see if there were any macro devices that other individuals had created to detect the spectra data on the echellogram image. Through trial and error, I found 2 macros that successfully identified all the spectra data on the echellogram and analyzed it in all the test cases of echellogram images. I wrote up a script to automate this process and successfully analyze the CESAR echellogram data.

Student: Elissa Picozzi, Whitman College, Walla Walla, WA

Mentors: Drs. Gregory Faris and Yingdi Liu

Project Title: New Nonlinear Optics Methods for Stimulate Rayleigh-Brillouin Scattering

This project focused on the use of novel optical techniques using stimulated Rayleigh and Brillouin scattering, or thermal and acoustic scattering, to create a microscopy system for biological applications. The system consisted of pump and probe beams crossed at their foci, producing a grating. This grating is stationary for Rayleigh scattering and moving for Brillouin scattering. The probe beam is scattered off the grating and the heterodyne between probe and the pump becomes our signal.

When I began the experiment, it was already setup in a co-propagating geometry, which is when both the probe and the pump are propagating in the same direction. Additionally, the system already produced a signal for liquids such as hexane, isopropanol, methanol, and water. This signal is characterized by a large center peak (Rayleigh peak) with transient effects enclosed by two smaller peaks (Brillouin peaks). My first action was to modify the set-up of the AOM on the pump beam. Originally, the AOM was set to 0 and -1 for the diffracted beams. I changed this set-up to +1 and 0 and consequently realigned the system. The new system was found to also produce a signal for the same liquids under the conditions of a small steady cell and low power to lessen scatter from diffusion. I then tested for variance in the Rayleigh and Brillouin peaks between different liquids. I determined that there were differences in height and width for the Rayleigh peak. Furthermore, there were differences in height, width, and phase shift for the Brillouin peaks. This finding was consistent with the substances having different physical properties.

Once I determined that I could distinguish between different liquid samples using the set-up, I began testing different gels. I focused on gels in particular because a cell behaves like a gel. The network of biopolymers – which include proteins, nucleic acids, and sugars – interact with a water solvent to create a gel-like consistency. The first gel I tested was an agarose gel. I tested 5%, 3%, 2%, and 1% agarose gels. Each agarose gel produced only scattering and no signal. I, then, switched to a lifetime measurement to determine if I could obtain a better signal. In the process, the beams went out of alignment and took three weeks to realign. Once the signal was regained, I switched to polyacrylamide gel. Polyacrylamide gel produced a signal. I, then, tested polyacrylamide 7.5%, 9%, 10.5%, 12%, and 13.5%. These different gels were found to produce dissimilar Rayleigh and Brillouin peaks. This finding was consistent with the different physical properties of gels at different percentage. Additionally, I discovered that I could obtain a much stronger signal with the polyacrylamide gel than I could with the previously tested liquid. This occurred because light doesn't diffuse as much in gel due to its structure. I could increase the power, and therefore increase the signal which achieved a better signal to noise ratio. However, I could still see the transient effects in the signal. These transient effects were found to be caused by the pulse width being too short and cutting of some of the signal. There were a couple options for solving this problem. My first choice was to switch to a counter-propagating geometry. In this setup, the probe and pump beams would be propagating in opposite directions. This set-up was considered to be beneficial because the lifetime of the signal was theoretically supposed to be inversely related to the angle between the probe and the pump beams when they intersect. For this new setup, I included two lenses of foci length 1 m to increase the foci width and help with alignment. The change in setup took two weeks after which I found a signal that was a factor of ten smaller than the signal from the co-propagating setup. I, then, switched back to a co-propagating set-up and optimized the transient effects, while

considering the signal to noise ratio, by increasing the pulse width and consequently decreasing the pulse strength.

I then began focusing on creating a gel sample that would be suitable for imaging but also interesting. For this sample, I wanted to place a liquid inside of a polyacrylamide gel. By using two different types of soft matter, I hoped to maximize the contrast between the physical properties of the two materials. This would lead to a greater distinction between the two signals. However, in order to use this sample, I needed to find a liquid that would not react with polyacrylamide gel, produce a signal, and be able to match the refractive index of the polyacrylamide gel. For this liquid, I settled on a solution of isopropanol and water. Both isopropanol and water do not react with polyacrylamide gel. Additionally, both isopropanol and water were found to produce a signal at the beginning of the summer. Furthermore, I could index match the isopropanol-water solution to the polyacrylamide gel since the polyacrylamide gel was determined to have an index of refraction of 1.3670 while water and Isopropanol have indices of refraction of 1.340 and 1.3775 respectively. After index matching the solution, I measured the absorbance to be 0.008 which indicates a good index match. I then tested the sample using the experiment and discovered that the signal behaved differently than expected. I hoped to see a large signal for the poly acrylamide and a smaller signal for the liquid with some scattering at the boundaries. However, I noticed scattering inside the sample not at the boundaries. One problem that has been isolated is that the LabView program that runs the probe lasers is programmed incorrectly. The last part of my research experience will be devoted to fixing the LabView program and retesting the sample.

SRI REU Program Activities:

Regular meetings with the REU students were scheduled to gauge student progress and address any concerns. In addition, several activities were included in the 12-week program to provide a well-rounded REU experience.

1. Seminars:

Several opportunities exist for the REU students to attend seminars on the SRI campus. Staff members from across the campus routinely give seminars. In addition, there are invited speakers visiting the campus as well. For example, SRI is the venue for seminars hosted under the Café Scientifique Silicon Valley initiative (<http://www.cafescipa.org>).

A list of seminars attended by the REU students during the summer of 2015 is included below.

06-01-2015	Multiplex Lateral Flow Diagnostic Assays	Dr. Robert Haushalter, Parallel Synthesis Technologies, Santa Clara, CA
06-02-2015	Pressure Swing Membrane Absorption Process for Separation of Simulated Low Temperature Post-Shift Reactor Syngas	Dr. John Chau New Jersey Institute of Technology
06-03-2015	Medical Technology Lunch Series at SRI International	Dr. Peter Madrid and Dr. David Huber, SRI International
06-09-2015	A Cubic Mile of Oil	Dr. Ripudaman Malhotra, SRI International
06-29-2015	The Night Without Stars	Drs. Tom Slanger and Daniel Matsiev
07-13-2015	Perfect Reflection of Light, Heat, and Sound	Dr. Brian Slovick, SRI International
07-14-2015	Got Planets? We See Them and We Can 'Make' Them, Cafe Scientifique Silicon Valley @ SRI	Dr. Olenka Hubickyj, San Jose State University, Director of Systems Teaching Institute at NASA Ames' University Affiliated Research Center
07-16-2015	'Tuolumne To All of You'; Short film about the history as well as current and future issues of the Tuolumne River and its watershed that supply the Bay Area with Sierran water from Yosemite National Park	Dr. Leah Rogers (Director)
07-24-2015	Better Living through Biosensors	Prof. Kevin Plaxco, UCSB

07-27-2015	Chasing Algae Derived Bio-Fuels	Dr. Jordi Perez, SRI International
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2. Field Trips:

- 07-14-2015: The REU students accompanied by the program directors Drs. Faris and Dixit visited the start-up facilities of a local Silicon Valley company, zNano (<http://www.znano.biz/>). In an interactive session, scientists from the company gave an overview of zNano's efforts in building filtration systems to recover greywater.
- 07-15-2015: The REU students accompanied by the program directors Drs. Faris and Dixit visited IBM Research Center (<http://www.research.ibm.com/labs/almaden/>) in San Jose. The students were hosted by Dr. Kumar Virwani who is a research scientist working in nanometer scale measurements, characterization and fabrication of electronic devices. The group spent half a day at IBM Almaden, interacting with scientists and engineers who graciously volunteered their time to show the REU students cutting edge research being performed at IBM Almaden. Talks and presentations were given Dr. Phil Rice, Dr. Charles Rettner, Dr. Geoffrey Burr, Dr. Jane Frommer, and Dr. Kumar Virwani.

3. REU Student Presentation:

Around the 11th week of the program, each REU student is required to give a presentation outlining the research they conducted over the summer. Staff members and the CEO attend these seminars schedules permitting. Presentations last approximately 20 minutes with an additional 10 minutes reserved for questions and discussion. Prior to these presentations, each student hosts the remaining group for a tour of their lab and experimental set up. The 2015 REU students gave the following presentations:

August 4, 2015

Sara Callahan: *"Rate Wrangler: On the Trail of H+O₃ Mesospheric Kinetics"*

Elissa Picozzi: *"Rayleigh and Brillouin Scattering from Soft Materials"*

Shu Huang: *"Imaging of Drugs & Drug Metabolites in Tissue by Mass Spectrometry"*

August 5, 2015

Brendan Marsh: *"High-Speed Hyperspectral Imaging: Hardware Design and Implementation"*

Asais Azcategui: *"High Throughput Platform for Multiplexed PCR in Fast Mode"*

Kevin Chaves: *"A River of Red in the Night Sky"*

4. Graduate School Application information:

A one hour group discussion was organized by Drs. Faris and Dixit to help answer questions from the REU students regarding graduate school applications, graduate school study abroad options and helping students understand that a variety of career options are available in the STEM disciplines.

The program coordinators also encouraged our REU students to attend webinars on the website hosted by the Institute of Broadening Participation. These included:

- **Funding your Graduate Education**

Information for students on different funding options for graduate school including fixed and portable funding sources, tips and strategies for applying to funding opportunities, and an overview of the basic differences between the undergraduate and graduate experience.

June 17th 3pm Eastern

Click here to register:

<http://www.pathwaystoscience.org/webinarregistration.aspx?eventID=EVE-20150617-01>

- **How to Succeed in your Graduate Program**

Information for students on making the most of your graduate program including key strategies for academic success, developing a support system, mentoring and professional development resources and preparing for a postdoctoral position.

July 15th 3pm Eastern

Click here to register:

<http://www.pathwaystoscience.org/webinarregistration.aspx?eventID=EVE-20150715-01>

- **Fellowship applications and personal statements**

Tips on completing successful applications including personal statements and research statements, with examples of strong and weak statements, and advice from guest speakers.

August 5th 3pm Eastern

Click here to register:

<http://www.pathwaystoscience.org/webinarregistration.aspx?eventID=EVE-20150805-01>

5. Ethics Training

A formal mechanism to train the students in the ethics of scientific research was put in place in the summer of 2010. As part of this training, the students were required to take an online course to educate themselves about ethics in a research environment. The online course is available freely at:

http://ori.dhhs.gov/education/products/montana_round1/issues.html#intro. The study of the following three sections was mandatory; Section One: Ethical issues in Research, Section Two: Interpersonal Responsibility, and Section Four: Professional Responsibility. At the end of their study of each section, this website provided a test. The students were asked to take the test and furnish copies of their scores to Dr. Sanhita Dixit or Jacqueline Kritzer in the MRL.

6. Social Events

Students were invited to attend SRI events during the course of the REU program. The campus summer BBQ was a special event. Before the REU students left SRI, a farewell celebration was given in their honor.

7. James R. Peterson Award for Excellence in Undergraduate Research

During its 50th anniversary reunion in 2006, the Molecular Physics Program announced the creation of the James R. Peterson Award for Excellence in Undergraduate Research. This award is given to the summer undergraduate student participating in SRI's NSF-supported Research Experiences for Undergraduates (REU) program that best combines Jim Peterson's technical excellence and spirit of friendliness and cooperation.

REU student nominations determine the winner of the Peterson Award. The 2015 winner was Brendan Marsh of University of Missouri, Columbia. Previous winners include Anand Oza, Princeton University (2006), Zachary Geballe, University of Michigan (2007), Brad Hartl, University of Wisconsin, LaCrosse, (2008), Aya Eid, Illinois Institute of Technology (2009), Alejandro Ceballos, Northern Arizona University (2010), Michael Rodriguez, California Lutheran University (2011), Stefan Mellem, St. Olaf College (2012), Timothy Weber, Columbia University (2013), and Collen Werkheiser, Reed College (2014).