Australian Academy of Science

# East Asia and Pacific Summer Institutes Program (EAPSI)

## 2012

# Participant Research Reports

Australian Government
Department of Industry
Innovation, Science, Research
and Tertiary Education

NSF

## Contents

## Introduction

The Australian Academy of Science was delighted to welcome the ninth group of twenty outstanding graduate students from the United States of America to Australia to participate in the East Asia and Pacific Summer Institutes (EAPSI) program for 2012.

The program was developed in collaboration with the US National Science Foundation and aims to introduce the students to Australian science and engineering in the context of a research laboratory and to initiate personal relationships that will better enable them to collaborate with their Australian counterparts in the future. The program began on 13 June 2012 and lasted for eight weeks.

The Academy acknowledges the importance of research collaboration that goes beyond national borders and academic disciplines, and places great importance in strengthening exchanges that are both competitive and cooperative among talented young researchers.

It was with great pleasure that I read the participants' reports to learn that so many achieved, if not exceeded their immediate research goals, and initiated strong collaborative links that will provide the foundation for lifetime cooperative research. I was also pleased to learn that several students have expressed interest in returning to Australia to further their research. These graduate students and the Australians with whom they shared their research will play an important role in advancing cooperative research between Australia and the United States in future years.

I would like to extend my gratitude to the Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education for their continued support in funding this program, and of course to our colleagues at the National Science Foundation. Without their kind assistance and cooperation, this important activity could not be sustained.

The Academy looks forward to continuing this program in 2013 and beyond.

Professor Suzanne Cory AC FAA FRS

President
Australian Academy of Science

## Orientation program

*Wednesday 13 June*

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|---|---|
| Afternoon | Arrival at Canberra airport<br>Administrative details at Ian Potter House |
| Evening | Welcome reception at the Academy's Shine Dome |

*Thursday 14 June*

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|---|---|
| Morning | Tidbinbilla Nature Reserve: including ranger guided tour and self-paced walk through the wildlife sanctuary |
| Afternoon | Guided tour of New Parliament House<br>Guided tour of the National Gallery of Australia's Aboriginal and Torres Strait Island art exhibitions |
| Evening | Dinner at Shogun Japanese Restaurant |

*Friday 15 June*

| | |
|---|---|
| Morning | Official opening of the EAPSI program for 2012, Ian Potter House |
| | Welcome address:<br>Dr Sue Meek, Chief Executive, Australian Academy of Science |
| | Lecture on the Atlas of Living Australia:<br>Dr John LaSalle, Director of the Atlas of Living Australia, CSIRO |
| | Frank Stillwell Antarctic Diaries<br>Dr Bernadette Hince, Publications Manager, Australian Academy of Science |
| | Communicating your science<br>Dr Fiona Leves, Science Policy Research Project Officer, Australian Academy of Science |
| Afternoon | Depart Canberra for host cities |

**Participant:** Mallory Barkdull, Stanford University

**Australian research advisor:** Professor Ryan Lowe

**Australian host organisation:** University of Western Australia

**Title of research proposal:** *The effect of buoyancy driven flow on a wave dominated coral reef system: Kaneohe Bay, Oahu, Hawaii*

**Research description:**
After reviewing the data, it was decided that we would look at the effect of buoyancy within the reef and lagoon instead of the effect of the longshore current.

Previous studies of Kaneohe Bay have focused on wave driven forcing in Kaneohe Bay, Oahu, Hawaii. These studies used numerical models that show the hydrodynamics in the Bay cannot be fully explained by wave action. The purpose of this research was to determine the effects of other forcing mechanisms, specifically horizontal buoyancy gradients, in the bay. During the time period of the collected data, January - March 2006, there was an increased amount of rainfall and surface runoff. This created a strong buoyancy gradient that resulted in baroclinic, or depth varying, flows.

At the locations on the fore-reef and in the channels, the flow was baroclinic and was characterized by a logarithmic layer profile. At the locations in the lagoon, where there is less wave action and the velocities are smaller, the velocity profile had a baroclinic profile. The baroclinic profile is characterized by buoyant, fresh water moving one direction on the surface and dense, salty water moving in the opposite direction on the bottom. This buoyancy driven flow will have an effect on the overall circulation in the lagoon, and could drastically change the residence time in the lagoon. Our initial results suggest that increased freshwater input results in a shorter residence time.

These results could have a variety of applications. For example, increased rainfall often results in sewage overflow into the Bay. This increased freshwater input would work to dilute the sewage input and mix the water throughout the Bay. Thus, the sewage would be carried out of the Bay faster and shorter beach closures would be necessary. To understand the effects of this buoyancy driven flow on the biogeochemical reactions throughout the Bay, further analysis is required.

**Research activities:**
First I tried to determine what factors were forcing flow in the lagoon by analyzing the collected data from 2006. To determine if baroclinic forcing was important in Kaneohe Bay, I used Empirical Orthogonal Functions (EOFs) and a 1-D model.

The EOFs show characteristic spatial patterns called modes. The first mode at locations in the lagoon had a baroclinic, or depth varying, profile. The flow in the rest of the bay has a logarithmic, barotropic profile. This suggests that flow in the lagoon is driven by the horizontal buoyancy gradient in the lagoon. This buoyancy gradient is created by freshwater input into the system.

After determining that the flow in the lagoon is driven by the horizontal buoyancy gradient, I tried to see if the flow could be modeled using a simple 1-D model. The model uses the buoyancy gradient to determine the velocity profile and transport. The baroclinic transport calculated using the model was consistent with the transport observed in the lagoon in 2006. This could be used to predict circulation in the Bay based on freshwater input.

**Perspective of research after this program:**
I think this summer project was a great start to my Ph.D. research, and while we answered a lot of our initial questions through this research, we also created new, more complex questions about the hydrodynamics of Kaneohe Bay.

The next step of the research is to employ a more complex model of the flow in Kaneohe Bay. The model from Lowe et al will be altered to include an initial horizontal buoyancy gradient. Fresh water inflows and an offshore longshore current will also be added to the updated model. Also, field work will need to be done to study the effect of the horizontal density gradient in more detail.

**Participant:** Anna Herring, Oregon State University

**Australian research advisor:** Dr Adrian Sheppard

**Australian host organisation:** Australian National University

**Title of research proposal:** *How the chemistry of rock surfaces affects trapping of carbon dioxide*

**Research description:**
Investigate low velocity flows of air and water in Bentheimer sandstone cores which have been chemically treated to exhibit different surface chemistry properties, in order to better understand the fate and transport of geologically sequestered CO2.

**Research activities:**
Treat Bentheimer sandstone cores via vapor- and liquid-phase deposition of various silane compounds. Conduct water-air drainage-imbibition experiments on treated cores to investigate changes in fluid flow as a function of wettability (surface chemistry). Image and quantify distribution and amount of fluid phases via x-ray microtomography.

**Perspective of research after this program:**
I think my perspective of the research process has been greatly enhanced through this program. This is the first experience I have had working directly with the international scientific community, and the helpfulness and spirit of collaboration has been fantastic.

**Australian advisor's remarks:**
From my perspective, this was an extremely fruitful visit. Anna is a very bright and motivated student and she was able to carry out the bulk of an ambitious experimental program at our imaging facility. She brought experimental skills - and a comprehensive set of equipment - that significantly assisted our own research. The first imaging experiments of Anna's project generated a better set of 3D tomographic images of water imbibition than we'd acquired previously. This improved data allowed other researchers in the ANU group to validate dynamic tomography algorithms, work which has just been presented at the August 2012 SPIE conference in San Diego, and which will appear in the conference proceedings as a full paper.

The remainder of the project was a complex program that required changing the wettability of rock cores before conducting imaging sequences of drainage and imbibition within them. While Anna has carried out this program, the results are not yet known since the data analysis has yet to be performed. I expect that these results will be publishable in high-impact international journals. Even if this data doesn't lead directly to publications, I still consider the project to be highly successful on account of the information exchange and the dynamic tomography results.

**Participant:** David Hondula, The University of Virginia

**Australian research advisor:** A/Professor Adrian Barnett

**Australian host organisation:** Queensland University of Technology

**Title of research proposal:** *Spatial dimensions of heat- and cold-related hospital admissions in Brisbane, Australia*

**Research description:**
Extreme heat and cold are responsible for a significant health burden in many middle-latitude climates. Extreme heat events are known to be a leading weather-related cause of death, and growing literature indicates that extreme cold events also lead to elevated risk of mortality. Less research has been conducted examining the impacts of extreme heat and cold on human morbidity. Furthermore, the majority of previous studies examining the relationship between temperature and health have focused on the aggregate response of the population of large metropolitan areas. There are a number of reasons to expect that the health risks are spatially variable within these areas as there are community-level differences in population demographics and environmental exposure. We sought to examine vulnerability to heat and cold amongst residents of greater Brisbane using a six-year time series of hospital admission data. Examining spatial variability in heat- and cold-related morbidity offers a new framework to identify opportunities for reducing the public health burden associated with extreme weather.

**Research activities:**
The majority of our summer collaboration in Brisbane was focused on acquisition and processing of data from primary sources and construction of statistical models. We used a combination of generalized and Bayesian hierarchical models to (1) understand the impact of heat and cold on hospital admissions in Brisbane, (2) identify zones (Statistical Local Areas, SLAs) where the risk is higher, and (3) determine the demographic and environmental characteristics associated with high-risk zones. A challenge we faced early in the modelling phase was determining the role that non-weather-related seasonality in hospital admissions plays in modifying the daily counts, as properly accounting for this confounding factor is critical when testing for the effects of temperature. We found that hospital admissions in Brisbane are especially sensitive to human behaviour, with significant variability linked to holiday periods and different days of the week.

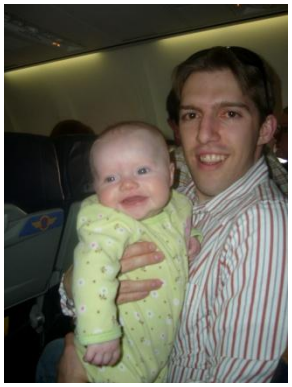
Our results indicate that there is a significant effect of both extreme high and low temperatures on the health of Brisbane residents. Furthermore there is a number of SLAs where the risk is especially high. Preliminary evidence shows that these zones are associated with higher population densities and lower socio-economic status. Communicating these results to local emergency management personnel, city planners, and public health officials could lay the groundwork for more targeted short- and long-term response measures aimed at reducing the health burden associated with extreme heat and cold

**Perspective of research after the program:**
Working on this research project with Dr Barnett taught me a number of practical skills and methods that will strengthen my future work, including Bayesian hierarchical modelling and parallel computing. More importantly, however, our time together will shape my future approach to research problems in a number of different ways. First, the project highlighted how every study and data set is different and the importance of rigorous exploratory data analysis, as we discovered some unusual patterns that differed from our original expectations. I also gained awareness of the

dynamic nature of statistical methods, as Dr Barnett and I had a number of ongoing conversations about evolving techniques and previous standards that are falling out of favour. Outside of our specific project, I developed an affinity for the friendly, engaging work environment at my host institution that has been built through a number of different team-building activities that I could envision implementing in my own department in the future.

It was a tremendous privilege and pleasure to work with Dr Barnett for two months and I am optimistic that we will find new and interesting research problems to again collaborate on in the future.

**Australian advisor's remarks:**
David was an ambassador for the EAPSI program and his country. His enthusiasm was infectious, and he crammed in an amazing amount of work and pleasure during his ten week visit. On the work front, David's persistence paid off with some fascinating results concerning what areas in Brisbane suffer more when the weather heats up. These results will be invaluable for city policy makers in their efforts to curb the effects of Brisbane's sweltering summers. We are currently working together to create a paper based on these results, and future collaboration is very likely, especially as David is never short of interesting ideas.



**Participant:** Garrett Hughes, University of Arizona

**Australian research advisor:** Dr Mark Harvey

**Australian host organisation:** Western Australian Museum

**Title of research proposal:** *Morphological character matrix for phylogenetic analysis of Microcreagrinae (Pseudoscorpiones: Neobisiidae)*

**Research description:**
Investigate morphological characters (attributes) that are useful for identifying genera and species of the pseudoscorpion subfamily Microcreagrinae. This subfamily is found throughout the northern hemisphere. It has nearly two dozen described genera in it, but many of these genera are poorly diagnosed and may not be monophyletic. Indeed, there is a possibility that the subfamily itself is not monophyletic. I will use the morphological characters I discover to revise the classification for this group once I have completed phylogenetic analyses using DNA back in the U.S.

**Research activities:**
Mostly examining slide-mounted specimens under a compound microscope and recording observations of the hundreds of individuals examined. While my objective was to design a morphological matrix, I felt that the actual recording of characters for hundreds of specimens is something I could do on my own if the specimens were shipped to me, so I instead focused on exploring as many characters as I could in order that I could receive guidance and input from my host researcher about his experience with those traits, whether he had used them before and how useful they were.

**Perspective of research after this program:**
I see an even greater need for revisionary work in this subfamily than I did before I arrived because the type specimen for this subfamily was found (it had been lost for about a century) and all the work done in this group in the past 30 years needs to be verified by comparing it with this type. There appear to be plenty of morphological characters that can be used to identify genera, but molecular data (DNA) will be necessary to resolve the relationships between these species and discover whether a new classification is needed, which it most likely will. The morphology can then be used to build the new classification based on the relationships outlined by the molecular phylogeny.

**Australian advisor's remarks:**
Garrett's visit to our laboratory was a wonderful experience for me. His interactions with me and other lab group members were exemplary as he was always willing to throw up new ideas for discussion. His willingness to soak up newly acquired information was outstanding, and his work ethic could not be faulted. It was a pleasure to host him in our institution, and I wish him the very best for the successful completion of his dissertation. I'm always available by email, and he knows that I will try to answer his questions as quickly as possible.

**Participant:** Emanuel Indrei, University of Texas at Austin

**Australian research advisor:** Professor Neil Trudinger FAA

**Australian host organisation:** Australian National University

**Title of research proposal:** *Investigating strategies that optimise the partial allocation of resources*

**Research description:**
The research investigates free boundary regularity for the partial optimal transport problem. This problem is a generalisation of the classical Monge-Kantorovich problem in which one tries to find a strategy of allocating a given number of resources as cheaply as possible. The research seeks an understanding of the regularity of this optimal strategy. The natural setting for this work is the field of partial differential equations and convex geometry, more specifically, the study of a double obstacle problem for the Monge-Ampère equation.

**Research activities:**
I mostly worked in my office at ANU. My host, Professor Neil Trudinger, invited me to attend a two-week winter school at the University of Queensland; hence, some of the research I worked on was conducted during this event. Subsequently, he invited me to present my research at a follow-up workshop at ANU entitled: Transport, flows and applications.

**Perspective of research after the program:**
I have learned a lot of new mathematical tools which I hope to apply to new problems when I get back to my home institution.

**Australian advisor's remarks:**
Emanuel's reseach flourished during his time in Australia. As well as completing his original project he embarked on a new project concerning extensions to general costs in optimal transportation and loss of energy in geometric optics.

**Participant:** Amy Jordan, University of Washington

**Australian research advisor:** Dr Judith Field

**Australian host organisation:** University of New South Wales

**Title of research proposal:** *Identifying starch residues on pots from early Colonial plantation sites in the Banda Islands, Maluku Province, Indonesia*

**Research description:**
A starch grain analysis of food residue on ceramic sherds from colonial plantations in the Banda Islands, Indonesia, will give direct evidence of dietary choices in this time period. Starch grain analysis is a novel approach to investigating colonial era archaeological remains and will build on the growing body of Neolithic and pre-colonial archaeological studies that have previously been conducted in the Banda Islands, Indonesia (e.g., Lape 2000). The Banda Islands were the location of early experiments in colonialism by European powers; research into various aspects of European occupation can provide information for cross cultural studies of the different responses to colonialism, as suggested by Deetz (1991). The microfossil evidence will be used in conjunction with historical records to determine if ethnic background may have influenced food choice during the colonial period.

**Research activities:**
I learned the basic methodology for starch grain identification including separation from surrounding matrix, mounting on slide, and identification via microscopy. I was able to create a starch reference collection based on foods expected from historical records, mounted over 120 samples of starch and began identification of starches based on reference collections.

**Perspective of research after the program:**
While I am not yet finished identifying all the starches retrieved from the pottery sherds, a few tentative claims can be made. Rice grains were identified on two porcelain sherds but not the lower status earthenware sherds, supporting the hypothesis that elites restricted access to the higher status food source. While the reference collection was based on historically described starches, many starch grains on the archaeological samples did not match reference samples. It is likely, then, that the inhabitants of the plantations were supplementing their food sources with local foods unknown to the record-keeping elites. Prior to my departure from Australia, I also received pottery samples from the colonial governor's mansion which I was unable to process due to time restraints. However, the addition of these samples to use in comparison with the plantation samples will give a much broader view of the colonial diet of both plantation workers and the elites. This information will be used in conjunction with the archaeological data to provide a more holistic picture of how people adapted to their new colonial situation in 17th-19th Century Spice Islands.

**Participant:** Jessica (Franne) Kamhi, Boston University

**Australian research advisor:** Dr Simon Robson

**Australian host organisation:** James Cook University

**Title of research proposal:** *Neurobiology of individual and collective behaviour in a superorganism, the weaver ant*

**Research description:**
The Australian weaver ant, Oecophylla smaragdina, is often considered one of the most socially complex ant species due to its elaborate leaf nest construction and highly territorial behaviour. Generally, worker ants perform cooperative tasks in part through specialising in particular behaviours; however, it is unknown to what extent weaver ants specialise in tasks or maintain behavioural flexibility. Additionally, it is unknown what role the neural substrate plays in task performance. By studying the behaviours of workers in the two morphologically distinct subcastes at known ages, we can identify the extent of task specialisation, which can vary with subcaste and age, in this species. Quantifying microglomeruli, or synaptic connections in the mushroom bodies, a region of sensory integration, within these individuals can identify potential differences in synaptic connectivity, a correlate of cognitive processing ability. Further, controlling for sensory experience will suggest the degree to which these workers are behaviourally plastic via the level of synaptic plasticity measured.

**Research activities:**
During my stay at James Cook University during the EAPSI program, I raised ants of both subcastes of known age in controlled colony fragments. Proficiency in taking care of immatures and movement in the absence of stimuli were measured at days 1, 10, 20, and 30. Brains of individuals were removed and stained via immunohistochemistry for microglomeruli and imaged via confocal microscopy.

Another set of colony fragments with ants of known age were raised with no contact to immatures. At 30 days, these ants were provided with one of 4 behavioural treatments: no experience, experience with immatures, experience with territorial exploration, or encounters with non-nestmates. At least 12 hours after behavioural treatment, brains were removed and processed identically to the above individuals.

**Perspective of research after the program:**
The data I gathered during this program will now be analysed to determine whether there are differences in microglomerular characteristics that are related to age, subcaste, and experience. I will also be studying neurochemical differences in age and subcaste and how neurochemicals may be causally related to task performance, specifically territorial aggression.

**Australian advisor's remarks:**
Jessica was a great member and contributor to the social insect research group. Her own research advanced considerably and she returns to the U.S. with skills and materials that could not have been obtained elsewhere. Jessica's contributions also extended to an excellent presentation to the Evolutionary Biology Discussion group here in the School of Marine and Tropical Biology, at which she presented the results of her PhD work and studies in Australia to date. Jessica's research bridges an important gap between behaviour, evolution and neurobiology and I look forward to future visits and involvement in her academic career.

**Participant:** Morgan Levy, University of California, Berkeley

**Australian research advisor:** Dr Karen Hussey

**Australian host organisation:** Australian National University

**Title of research proposal:** *Reconstructing historical agricultural water use from crop records to observe changes in agricultural water use efficiency and productivity*

**Research description:**
This research responds to well-documented gaps in knowledge about historical trends in agricultural water use efficiency and productivity in water-limited regions. The research aims to provide important, missing historical water use information based on a comparative, empirical analysis, rather than upon generalised models. The aim of this research is to better inform sustainability-focused policy and management efforts promoting agricultural water use efficiency and productivity improvements.

This proposal is an extension of prior MS/PhD research. At the end of the 2011-2012 academic year, for a case study of an irrigation district in California, I completed the following project: 1) reconstructed long-term historical agricultural water use (irrigation consumption) from agricultural production records using a hydrological model, 2) collected total water supply (irrigation application) from district hydrological records, and 3) assessed long-term water use efficiency and productivity trends. I used established quantitative analysis methods from the environmental sciences and hydrology, and econometrics and statistics.

I proposed to run a parallel exercise in Australia. I proposed to collect and process historical water and agricultural data in a SE Australian irrigation district or similar agricultural region, and analyse the water-efficiency and productivity changes over a similar period of time (1970-present). Due to Australia's water management reforms over the past two decades, I anticipated revealing significant differences in efficiency and productivity trends between California and SE Australia case studies, and intended to analyse those differences.

**Research activities:**
Week 1-2: Hold first-round consultation with ANU hosts, CSIRO and Cooperative Research Centre (CRC) researchers to establish and refine my research question, locate appropriate sources for data, and adapt my planned analysis to the Australian context.

Week 3-4: Collect and process data on crop yield (by crop type), harvested acreage, water deliveries/supplies (by water supply district), crop price and revenue data, hydrological information, and irrigation method (flood, sprinkler, drip) where available. This will come from digital and non-digital records from Australian government agencies, ANU, and Australian libraries and historical archives (when digital records are not available). My host institution is in a location amenable to travel to all sites where this information would be available.

Week 5-6: Process/input data to harmonised digital form, and locate an Australian water use estimation model (or method of calculation) similar to the California model and method in order to generate water use estimates (by crop or crop type, for a given area); verify water use estimates with available 'real' data; run preliminary investigative analyses; refine calculations and model.

Week 7-8: Based on second-round input from host researchers, CSIRO and CRC personnel and farm organisations, I will refine data and calculations further; generate a second round of estimates, and verify those estimates. From these findings, generate a summary report of findings to circulate to host researchers and others consulted on the project.

Post-Fellowship (End of Summer – Fall, 2012): Refine analysis remotely in collaboration with host contacts via email and phone communications, prepare paper for journal submission, and submit to a peer-reviewed journal for publication. Make all data available and accessible to fellow researchers and the general public.

**Perspective of research after the program:**
Through meetings with ANU faculty and CSIRO staff, Fenner School students, and through related literature, I found that my proposed comparative study was well-founded, and of interest to Australian researchers. However, my proposed project was more data-constrained than I anticipated. As stated in part A above, greater-than-expected challenges in the data collection phase resulted in a longer data-finding process, and a modification of my proposed analysis in terms of spatial and temporal scales for comparison. Thus, at the completion of the fellowship period, I am still completing the Week 3-4 items listed above. The remainder of the study will therefore need to be completed upon return to the US, and with feedback via email or phone with ANU hosts and contacts made during the EAPSI fellowship.

Thus, the more immediate benefit of this program in terms of my current research has been in 1) understanding Australian data collections relevant to my current (and future) research, and the constraints therein, 2) gaining necessary historical and methodological context for my analysis and eventual findings through a targeted literature review and meetings with Australian experts, and 3) valuable contacts made with researchers in academia (ANU faculty and students alike), government research groups (CSIRO, CRCs), and private sector water management persons (irrigation district/company staff).

Although it is not ideal that I could not complete my proposed project during the fellowship period, the process of understanding why and how I needed to modify my project was informative, and will improve my ability to conduct difficult comparative analyses elsewhere. Furthermore, I did ultimately encounter excellent data for related studies of water efficiency and productivity, and was provided guidance by my US advisor and ANU host about new directions I might take my comparative study that respond directly to important US/Australian differences in agricultural water management research. I am excited to continue to work in collaboration with the contacts I've made at ANU (and elsewhere) in order to complete, present, and publish a modification of the proposed study, and also investigate additional interesting research questions generated by my time in Australia.

**Australian advisor's remarks:**
Morgan's proposed research topic was (and continues to be) of direct interest to me and other scholars in the agricultural water use field. Her project proposes to overlay data on historical trends of agricultural water use with major policy interventions in water management, which in turn sheds light on the impact and efficacy of those policy interventions. However, the opportunity to compare data sources from the US and Australia provides particularly useful insights owing to the very different policy approaches used in water resources management in the two domains. International comparative analysis such as this is only possible when one or other of the researchers is able to spend time with the other team - the NSF scholarship facilitated that collaboration.

Not surprisingly, Morgan encountered problems with the accessibility and comparability of data sources in Australia, so she had to spend more time than anticipated to locate her data. Nevertheless, I think Morgan's time in Australia was enormously valuable for both Morgan and us. Morgan was 'forced' to spend a considerable amount of time meeting a wide range of scholars and industry folk whom she might never had met if the data had been readily available! These contacts will no doubt prove useful for future work. Moreover, I think Morgan benefited from many conversations with colleagues in ANU, CSIRO and elsewhere which really contributed to her understanding of the evolution of Australia's water policy and alternative ways to craft a research project - again, a very useful outcome for her.

For our part, we look forward to continuing our collaboration with Morgan as the data analysis gets under way (in the US) and we would very happily support any future application from Morgan to spend time with us. Aside from being terrifically clever, she was a delight to have around which is a critical but often overlooked factor in international collaborative research!!!

**Participant:** Shay Mailloux, Clarkson University

**Australian research advisor:** Professor Justin Gooding

**Australian host organisation:** University of New South Wales

**Title of research proposal:** *Self-assembled nanowire arrays for electrocatalytic and biocatalytic applications*

**Research description:**
The project focused on the modification of electrodes for biocatalytic and bioelectrocatalytic systems for biomedical and environmental applications. The performance of catalytic and electrocatalytic surfaces requires large active areas and efficient electron transfer. Recent advances in nanostructured materials allows for the formation of nano-architectured surfaces composed of nanowires, nanorods, metallic nanoparticles, etc, and have been used as supporting structures for catalytic, electrocatalytic, photoelectrocatalytic, and, particularly, biocatalytic systems.

**Research activities:**
The main focus of my work at UNSW was building an electrode surface with an immobilised redox active protein or active centre. My initial proposal was adapted to better fit what the current interests and activities of the host lab were once I got there. Assembling the surface was intricate and not met without problems. I began with the method developed by Professor Gooding's lab using gold nanoparticles to 'switch on' or 'switch off' the electrode surface in the presence of an isolating immobilised molecule. Once I could successfully build the surface, I began trying to immobilise a protein. This proved difficult because of its asymmetric active centre. Time was short, so I quickly switched to a simpler system, using just the redox cofactor of a popular group of enzymes. The work during my stay got the project off the ground and going, allowing for continued collaboration between my host laboratory and my group at home.

**Perspective of research after the program:**
The time I spent in Australia was short, but irreplaceable. My host was wonderful and all the members of the group helpful and friendly, making for a very enjoyable experience. The EAPSI program has provided me with a very special chapter in my graduate study, allowing for the potential of international friendships and collaborations that would not have come about otherwise. I have taken away a better understanding of science and the way it connects people throughout the world.

**Australian advisor's remarks:**
Shay was a fantastic member of the team for the short while she was with us and we only wish she could have stayed longer. She fitted in seamlessly with the group and was well liked immediately. Shay was new to electrochemistry when she arrived, but she worked so effectively with my team that it was hard to identify that she was working in a new field. What her visit has done is provide a more formal link between our group at UNSW in Sydney and her research group led by Professor Katz in Clarkson University in Postdam, New York. We have previously discussed science extensively but now we have an avenue by which collaboration will continue. The Australian Academy of Science and the National Science Foundation of the United States should be commended for this program which made Shay's visit possible to Australia and which has launched, hopefully, a long standing collaboration.

**Participant:** Allison McInnes, Texas A&M University

**Australian research advisor:** A/Professor Anya Waite

**Australian host organisation:** University of Western Australia

**Title of research proposal:** *Using new techniques to understand the carbon cycle of the Eastern Indian Ocean*

**Research description:**
The Indian Ocean is among the least studied portions of the global ocean. What we know of this system is that it is unique, being confined primarily to the southern hemisphere with a large landmass occupying the entire northern hemisphere. This geography has interesting consequences to the oceanography of the system including seasonal changes in dominant current regimes {Tomczak et al., 2001}. In keeping with the dynamic nature of this ocean the Leeuwin Current (LC) is a globally unique eastern boundary current. Unlike most eastern boundary currents the LC is a warmer, less saline, poleward flowing current; yielding a downwelling dominated coast {Pearce , 1991}. This current—and consequently the phytoplankton community structure—are influenced by seasonal changes as well as El Niño/La Niña cycles {Feng et al., 2003 & Koslow et al., 2008}. During the summer the LC is weaker and is shifted offshore by the Capes Current which travels northward between the LC and the Australian continent {Pearce and Pattiaratchi, 1999}. This current system is responsible for episodic upwelling events causing increases in phytoplankton biomass {Hanson et al., 2005}. In the winter the LC increases in strength and moves closer to the continent flooding the shelf with low nutrient (oligotrophic) waters.

Despite the downwelling nature and oligotrophic conditions, for part of the year a phytoplankton bloom covering more than 700 km of the Western Australian shelf coincides with the strengthening of the LC during the Austral winter {Koslow et al., 2008}. The source of nutrients fuelling this midwinter peak in phytoplankton biomass is still undetermined. Several hypotheses have been set forth including: eddy motion against the continental slope and shelf directly upwelling nutrients {Koslow et al., 2008}, cross-shelf currents advecting coastal waters onto the shelf {Hanson et al., 2005}, or delivery of nitrate from a low oxygen high nitrate thin layer directly under the LC core transported from northwest Australia {Thompson et al., 2011}.

The source of the nutrients supporting the base of the food web in this region is of special importance as Western Australian waters support 35 commercial fisheries which can yield over AUD$400 million annually. Among these is the West Coast rock lobster fishery, Australia's most valuable single species wild capture fishery. The west coast is also the most heavily used for recreational fishing of pelagic game fish {Department of fisheries '10-'11}. What would traditionally be considered an oceanic desert is clearly more productive than our current knowledge base allows us to hypothesize.

There is extensive research focus on the global-ocean's role in the carbon cycle, particularly the drivers and fate of phytoplankton biomass. Photosynthesis preformed by phytoplankton in surface waters is the source of food for the oceanic food web; some is not consumed in the surface waters and is exported. This export has been the primary focus of oceanographers as understanding the ocean's role in CO2 sequestration is vital for global climate models. In the effort to quantify the amount of fixed carbon available for export, Eppley and Peterson {1979} defined production based on the form of nitrogen that supported it. New production is that which is supported by nitrogen

from upwelled nitrate from the deep, or nitrogen fixed by organisms in the surface waters—this production is then quantified as the amount available for export as it is not required to keep the system running. Regenerated production is that which is fuelled by microbially recycled nitrogen and supports the surface ecosystem. This distinction between new and regenerated production has been used to estimate export to understand the ocean's role in the global carbon cycle (quantification of new production, f-ratio). However, this distinction has also provided a way to determine the amount of production available to the oceanic community—regenerated production.

Part of my dissertation research has been to develop a method to simultaneously quantify C and N fixation in the same sample (typically done on separate samples using different instruments, times, and tracers) without incubation (as incubation can lead to modification of the community and likely their activity as well). The effort to develop a new method has been made because N-fixation is traditionally thought to only support a negligible portion of new production. Recently this has been called into question particularly in oligotrophic regions {Zher et al., 2001}. By simultaneously quantifying C and N fixation we not only quantify the amount of production available for export but the amount of production to keep the system running, this latter portion is especially important for fisheries.

The primary objective of my study this summer was to compare my new molecular method for quantification of C and N fixation in the same sample without incubation and traditional methods, and increasing the applicability of this new method in environmental studies.

**Research activities:**
In order to address our primary objective of method comparison, five coastal stations were visited along the coast of Western Australia in addition to 32 stations offshore in the Eastern Indian Ocean. Samples were collected for C and N fixation using traditional techniques, molecular method for C and N fixation measurements, pigment, nutrient, particulate C and N concentrations.

**Perspective of research after this program:**
This program has been an incredible experience. While this summer has been challenging, I have emerged a better scientist with better developed ideas and hypotheses, more skills and incredible contacts. Exchanging ideas with researchers on the forefront of oceanography has enlivened my curiosity about the world's oceans. Further, my new knowledge of the workings of the Australian scientific community has equipped me better to explore future collaborations and research interests in the region.

**Australian advisor's remarks:**
This fellowship has offered my research group the extremely valuable experience of working closely with Ms McInnes, whom we have found to be hardworking, enthusiastic and insightful. We look forward to developing long-term collaboration with both her and her supervisor. I am very hopeful of considering Ms McInnes for a post-doctoral fellowship here in Australia should this opportunity arise. We have enjoyed learning more about the cutting-edge research being developed at Texas A&M, and still more, the opportunity of applying these insights to our own very under-studied Indian Ocean. The insights and opportunities created by this fellowship have been considerable.

**Participant:** Kevin Miller, University of Florida

**Australian research advisor:** Professor Roger Lewis

**Australian host organisation:** University of Wollongong

**Title of research proposal:** *Terahertz transmission study of magnetic and electric excitations in novel single crystals*

**Research description:**
In 2006, the discovery of a hybrid magneto-electric excitation, termed electromagnon, was put forth by researchers in Germany. The new excitation was determined to be a direct manifestation of magneto-electric coupling in a homogeneous material and thus possessed enormous technological implications. Briefly, the performance of modern-day technological devices rely separately on the electron's charge (electronics) and its spin. Magnetoelectric coupling provides an opportunity to harness both the electron's charge and its spin within a single material (spintronics) which would open the door toward faster and more efficient devices. One can envision both the hard drive and other internal electronics present in modern-day computers being replaced someday by a single component that performs both tasks in unison.

The aforementioned electromagnon excitations are only able to be studied using light in the terahertz region, which is notoriously known as the blind spot in our spectrum of light owing to the dearth of sources and detectors available in that region. However, experts in the field of terahertz, such as Professor Roger A. Lewis, are able to probe materials in this region using precision and complementary experimental techniques. The proposed research therefore involved the study of materials for potential spintronic devices using terahertz light. Two of the most promising compounds studied were Cu3Bi(SeO3)2O2Cl and CuSe2O5.

**Research activities:**
Single crystals of different complex oxides grown in Switzerland and thoroughly characterised in the infrared at the University of Florida were subsequently studied in the terahertz region during the summer program in Australia. The measurements involved cooling the crystals down to temperatures near that of liquid Helium (4 K) to supress thermal noise and allow the internal interactions of the electrons to manifest themselves. Additional information was gleaned by applying external magnetic fields up to 6 T. The magnetic fields can help to distinguish electromagnon excitations as well as catalyse new electromagnon excitations. Despite the difficult nature of the experiment (low temperature, high field), the collaborative effort was a success. Excitations were identified and a manuscript from the team is currently under review at a high impact journal.

**Perspective of research after the program:**
Having completed this program, I have acquired a greater appreciation of the commonalities and differences in two distinguished research labs a half a world apart. Wollongong both corroborated and extended my Gainesville FL research experience. Wollongong enabled analysis I could not achieve in Gainesville. That analysis also verified suspicions I had about the behaviour of novel materials that I brought with me. Not surprisingly, therefore, I foresee future collaborations between the two labs as well as collaborations I would maintain after I move on from Gainesville in my research career. To conclude on a personal note, Wollongong reinforced in me the need for patience in experimental physics wherein unexpected setbacks are to be expected within an overall successful strategy.

**Australian advisor's remarks:**
It was a pleasure to host Kevin Miller at the University of Wollongong (UOW) during June, July, and August of 2012.

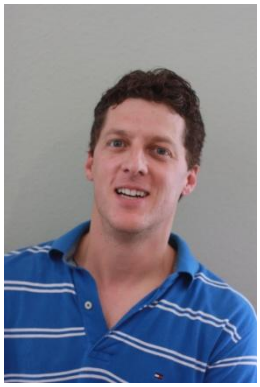
The work Kevin proposed and carried out was technically challenging, involving simultaneously low temperatures and high magnetic fields. Using equipment at UOW and not available to Kevin elsewhere, experimental data were obtained to lower photon energies than previously. From direct experience, I personally have great admiration for Kevin's experimental skills and consider the interchange of experimental techniques between him and my students was of great benefit to both.

Kevin fitted very well into the research environment at UOW. He worked easily and well with the other students. He fully took part in group meetings and other generic laboratory activities. He has high standards in all he does and performs well both individually and in a team setting.

Kevin had the opportunity to contribute to more than simply his laboratory work. He gave an excellent and well-attended symposium at the Innovation Campus of UOW. Likewise, he spoke at the University of Sydney. He had the opportunity to tour the Australian Synchrotron, comparing the facilities with those at Brookhaven, and exploring possibilities for future experiments there.

Kevin's new results obtained at UOW are already being incorporated in a journal manuscript and also form the bases of two conference presentations in preparation. It is expected further joint publications will flow on from the visit.

This was my first experience of the EAPSI program and I have nothing but praise for it. Based on the excellent interaction we had during Kevin's visit, we would be very happy to host another such high-calibre student in the future. Of course, we would also gladly welcome Kevin back to UOW any time he has the opportunity to visit us again.



**Participant:** Craig Milroy, University of Texas, Austin

**Australian research advisor:** Professor Gordon Wallace FAA

**Australian host organisation:** University of Wollongong

**Title of research proposal:** *Improving the mechanical and electrical properties of conducting polymers for biomaterials, renewable energy, and water purification membranes*

**Research description:**
Conducting polymers (CPs) are organic compounds that exhibit electrical conductivity and offer the traditional advantages of polymeric materials: they are light, easy and inexpensive to synthesise, amenable to blending and copolymerisation with other polymeric materials, and may be doped with a variety of compounds that can be adsorbed and released under desired conditions. As a result, CPs have been investigated for use in fuel cells, batteries, photovoltaics, water purification membranes, clinical devices for delivering biologically active compounds, and tissue engineering scaffolds. However, CPs have significant limitations related to their difficult processability, brittleness, and poor long-term stability; these factors have greatly delayed the widespread utilisation of CPs.

To overcome these limitations, I have synthesised blends of polypyrrole with polyurethane using emulsion polymerisation. The resulting improvements in processability allow this material to be cast, sprayed, and electrospun into electrically conductive nanoscale fibers that can withstand significant mechanical strain. However, there is significant batch-to-batch variation in the conductivity and elasticity of the blended material. Chemical analyses and electron microscope images suggested this phenomenon was attributable to the highly variable size and inconsistent orientation of the conductive domains within the bulk material. This important limitation must be addressed to prepare the material for industrial and clinical use.

**Research activities:**
I learned how to use Kelvin force probe microscopy (KFPM) and scanning electrochemical microscope (SECM) to more thoroughly characterise the distribution and alignment of conductive domains within the polyurethane matrix. I also learned to quantify the size of growing conductive polymer particles during synthesis as a function of polymerisation time using dynamic light scattering. The spatially-resolved conductivity measurements and particle size analyses have provided a quantitative tool for visualising the root cause of the observed heterogeneity in conductivity, and have helped generate strategies for improving subsequent synthesis and processing iterations.

I also used the host institution's advanced electrospinning apparatus to improve the homogeneity and orientation of my nanofibres, achieve large-scale fibre production, and evaluate advanced electrospinning configurations that were not available to me at my home institution (including ultra-high fields, improved spinneretes, aligned spinning and multicomponent electrospinning). To expand the processibility of my raw material, I also learned techniques for wetspinning and wetprinting, which have allowed me to start a completely separate project for fabricating elastic electrical circuits made entirely of organic materials.

**Perspective of research after the program:**
My host is recognised internationally as a leader in conducting polymer research, so it was a great honour to spend time at the Intelligent Polymer Research Institute. My general knowledge of conducting polymer materials has been greatly enhanced through interactions with other graduate

students whose research involves aspects of conducting polymers that I had not been exposed to previously, and this experience has vastly expanded the realm of opportunity for my future research initiatives. I now have a network of Australian collaborators, and IPRI's highly international focus has also allowed me to forge friendships and professional relationships with students and professors from Germany, India, Iran, Ireland, China, Korea, Thailand, Russia, and Netherlands. These interactions have allowed me to fully understand that multi-centre cooperation is essential for achieving advanced research and development objectives. We are presently discussing ways to expand our original collaboration, and I anticipate spending more time at the host institution in the near future.

**Australian advisor's remarks:**
The research undertaken by Craig has made a considerable contribution to our ARC Centre's research into conducting polymer composites. Craig has worked tirelessly to achieve significant results to date. Since arriving Craig has been an asset to the group and has been very proactive in developing new skills and passing on his knowledge to staff and students.

**Participant:** Nikole Nielsen, New Mexico State University

**Australian research advisor:** A/Professor Michael Murphy

**Australian host organisation:** Swinburne University of Technology

**Title of research proposal:** Gas properties in interacting galaxies using fingerprints in background quasar light

**Research description:**
Understanding the evolution of galaxies is one of the foremost goals of astronomy. In the modern 'bottom-up' paradigm of galaxy formation, all galaxies have violent histories. These histories comprise a series of merging events, in which two or more galaxies generally rip, shred, eat, and destroy each other, yet emerge as a single, larger system. These chaotic processes, which occur countless times in a given galaxy's lifetime, are dominant mechanisms by which galaxies are constructed and evolve. The Milky Way, for example, is scarred by multiple cannibalistic events in which smaller galaxies have been consumed. The end results of galaxies which have consumed all of their neighbours and have finally relaxed, exhibit clear traces of their past violence in the form of hugely extended, dynamically complex gaseous halos. Over the last three decades, studies employing the sensitive technique of 'quasar absorption lines' have revolutionised our understanding of how gaseous halos are linked to galaxy evolution. However, to date none of these studies have systematically explored galaxies caught in the act of merging.

The goal of this project is to compare the halo gas kinematics of a large sample of 'isolated' and 'group' galaxies using high resolution quasar spectra. I built a catalogue of 205 galaxies from literature known to have extended halo gas as measured by absorption in quasar spectra. Of the 205 galaxies, 36 are groups - defined as having a nearest neighbour within 100 kpc (projected on the sky) and having a velocity separation <500 km/s. All other galaxies are considered isolated. I hypothesise that the kinematics of halo gas in group galaxies will be broader and more complex than those in isolated galaxies. Kinematic studies of this kind have never been conducted for group galaxies.

**Research activities:**
I obtained the gas kinematics for a subset of the galaxy sample described above with high resolution spectra. Using 43 isolated galaxies, I was able to characterise their gas kinematics in order to do a future comparison with group galaxies. I looked at how the kinematic properties (widths and shapes of the absorption line systems in background quasar spectra, radial velocities of each cloud in the absorption systems, and how much gas was being probed) changed with different galaxy properties such as colour, luminosity, and redshift. I found that red, lower luminosity, and lower redshift galaxies are more likely to have gas clouds with small velocities. On the other hand, blue, higher luminosity, and higher redshift galaxies are more likely to have large velocities. This may confirm the theory that brighter blue galaxies (in particular, those with large amounts of star formation) at higher redshifts expel much of their gas via outflowing winds more commonly than less bright, red galaxies at lower redshifts.

I have made significant progress at characterising the gas kinematics in isolated galaxies more fully. This will likely result in a paper written with Dr Glenn Kacprzak, Professor Michael Murphy and my home advisor Dr Chris Churchill. Also, Dr Kacprzak, Professor Murphy, Dr Churchill, and I now plan to propose for time on the Keck Telescopes to obtain high resolution quasar spectra for 6 more galaxy

groups, consisting of 14 more galaxies. This will improve my statistics when comparing group galaxies to isolated galaxies.

**Perspective of research after the program:**
The opportunity to conduct research in Australia was an excellent experience. I had a productive two months due to the work environment at Swinburne's Centre for Astrophysics and Supercomputing and I hope to continue that level of productivity at my home institution. While at Swinburne, I was invited to attend Professor Murphy's quasar group meetings. These meetings were helpful in that I was able to more fully develop my skills at describing my research to others who do not know the details of my project, but are familiar with some of its aspects. In those meetings, I also learned more about other interesting uses of quasar absorption lines besides my own, such as studying the evolution of the fine structure constant. My experience with EAPSI was invaluable given that astronomy is a highly international field.

**Australian advisor's remarks:**
Remarks from Dr Glenn Kacprzak:
It was a pleasure to host Nikki, she made the absolute most of her opportunities while at the Centre for Astrophysics and Supercomputing (CAS) at Swinburne University of Technology. Nikki worked incredibly independently and the amount of research accomplished during her visit will likely result in two publications in a top international journal and represents an important fraction of her PhD thesis.

Remarks from Professor Michael Murphy:
Nikki uncovered some truly intriguing results during her work at the Centre for Astrophysics and Supercomputing (CAS) at Swinburne University of Technology. A simple interpretation of those results runs counter to some of the evidence already in the scientific literature on the topic, so it will be interesting to explore these results further and to test different interpretations and hypotheses using them. On behalf of Swinburne and CAS, I'd like to thank the EAPSI program for providing this opportunity.

**Participant:** Gordon Ober, University of Rhode Island

**Australian research advisor:** Dr Guillermo Diaz-Pulido

**Australian host organisation:** Griffith University

**Title of research proposal:** *Impacts of ocean acidification on tropical marine algae*

**Research description:**
Ocean acidification has quickly become a hot topic in climate change research. As atmospheric CO2 levels rise the pH of ocean waters drop. Most of the existing research on ocean acidification targets calcifying species and how their health and productivity changes. However, all species as well as communities are likely to be impacted by acidification. The goal of my EAPSI project was to investigate how increasing levels of CO2 impact turf algal communities in the Great Barrier Reef.

Turf algae are an often-neglected group of primary producers; but they play an important role in their ecosystem and are often composed of taxonomically diverse species. In coral reef ecosystems, turf algae are an important source of food for grazers and are also key in nutrient cycling due to a rapid turnover in generations. For this project I was interested in determining how growth rates and species composition of turf communities were affected by increased amounts of CO2. As non-calcifiers, algae are likely to outcompete corals for space and nutrients when under stress from CO2. Understanding how corals, as well as algae, are affected by climatic stress will provide insight into how ecosystems will change in the future. Because of their role, changes in turf algal communities could have profound effects on an entire ecosystem.

**Research activities:**
This research project was completed under Dr Guillermo Diaz-Pulido at Griffith University (Australian Rivers Institute). I analysed preserved turf algal communities growing on pieces of coral rubble under control, medium, and high CO2 treatments. My analysis was done post-treatment and was divided into two phases. In the first phase I took dimensional measurements of the coral rubble and removed (by scraping) half of the turf algal community. Wet mass of the turf was recorded and the sample was placed in a drying oven. Dry mass was recorded after 24 hours in the oven and the sample was then placed into a muffle furnace to burn off carbon-based tissue. This allowed me to determine the organic content of the turf community. This process was done for 31 total samples. Mass measurements were standardised to a mg/cm2 unit and results were compared by treatment.

In the second phase, I removed a small section of turf algae from each sample and mounted it onto a microscope slide. Using a compound microscope, the slides were analysed for genera present. Once the present genera had been identified, 5 randomly chosen fields of view were selected and the relative abundance of each genus was determined. This process was completed for all 31 samples. Results were combined and compared by treatment.

**Perspective of research after the program:**
Coral reef ecosystems are some of the most diverse on earth. It is nearly impossible to place a value on them, so protecting them is of the utmost importance. The EAPSI program allowed me to work and interact with some of the top researchers in this field and be at the heart of ocean acidification research. My work in Australia has also provided me with a global view on how climate change impacts ecosystems. I am now able to make comparisons between diverse ecosystems. I can apply

the trends I saw in Australia, as well as the techniques, to my research in the temperate ecosystems of the Atlantic. Global change really is global; international collaborations and partnerships are needed in order to fully understand and quell its impacts.

**Participant:** Karan Odom, University of Maryland, Baltimore County

**Australian research advisor:** Dr Naomi Langmore

**Australian host organisation:** Australian National University

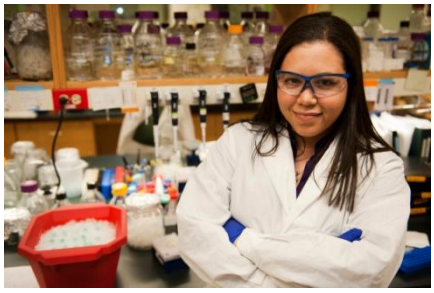
**Title of research proposal:** *Reconstructing the evolutionary history of female song in birds: did the ancestral female songbird sing?*

**Research description:**
To determine the evolutionary history of female song in songbirds. Songbirds are heavily studied for their complex, learned songs; however, the majority of research focuses mostly on males from temperate regions. Yet, in the tropics and Southern Hemisphere, where the majority of bird species are found, females of many species sing. Furthermore, the songbirds (oscine passerines) evolved out of Australasia, making the likelihood that song evolved in females alongside male song particularly high.

**Research activities:**
We gathered information from species accounts and references on the presence and absence of female song in 1141 species of songbirds. I then conducted ancestral state reconstruction to determine the ancestral state of female song in songbirds to assess whether female song existed in the ancestral songbird.

**Perspective of research after the program:**
We found female song to be ancestral in songbirds and are currently preparing this result for publication in Science.

**Australian advisor's remarks:**
I couldn't have been more delighted with Karan's visit. She is an outstanding student and showed great initiative in analysing a difficult dataset. I greatly enjoyed our interactions over this project. I and my colleagues, Drs Hall and Riebel, are also immensely excited about the outcomes of this research.



**Participant:** Jaylene Ollivierre, Northeastern University

**Australian research advisor:** Professor Nick Dixon

**Australian host organisation:** University of Wollongong

**Title of research proposal:** *Interaction between Pol III and the umuD gene products in coordinating the SOS damage response*

**Research description:**
The SOS induced umuD gene products are involved in an intricate network of interactions with components of the replicative DNA polymerase, Pol III. It is likely that the switch from error-free replication to the damage tolerance mode is facilitated in part by interaction between the UmuD proteins and the α, ε, θ, and β subunits of Pol III.

**Research activities:**
Native Nano-ESI-MS on complexes involved in DNA replication and DNA damage tolerance.

**Perspective of research after the program:**
I will highly recommend the EAPSI program to all of my colleagues. The research and life experiences gained from this program will have a positive impact on my career and has strengthened my commitment to science.

**Australian advisor's remarks:**
It was a pleasure to host Jaylene Olivierre during the EAPSI program. She worked hard, interacted very positively with my research group (12 people), and generated a large body of data that will take some time to analyse completely. Once that analysis is done, we will be in a good position to plan an ongoing collaborative project that should yield publishable insights into the interplay between proteins involved in DNA replication and the DNA damage response.

**Participant:** Christopher Rokicki, University of Florida

**Australian research advisor:** Ms Mary Drikas

**Australian host organisation:** Australian Water Quality Centre

**Title of research proposal:** *Bicarbonate-form anion exchange: Regeneration efficacy of resins from full-scale treatment systems*

**Research description:**
Growing water demands and decreasing availability of high quality water supplies has led to an increased interest in using alternative water treatment techniques to meet demands. Ion exchange is a water treatment technology that allows for the targeting of specific ions for removal from water to improve the finished water quality. Magnetic Ion Exchange (MIEX) resin is one such resin used for the removal of natural organic matter (NOM), which is a disinfection by-product precursor. A major benefit to the use of ion exchange and MIEX is that these resins are able to be regenerated and reused.

The focus of my research is on how the mobile ion that the resin is regenerated with impacts the performance of the resin; and how this impacts the permanent fouling of these resins. The primary goal of this project was to investigate how different regenerant solutions impacted the performance of resins taken from actual water treatment plants in order to evaluate how the differently regenerated resins impacted the performance of the resin in its source water. After treatment with the resin, the water was analysed to determine NOM removal and then further analysed to investigate size fractionation of NOM. Determination of size fractionation will provide insight into mobility of NOM in the pores of the resin and how the regenerant impacts this.

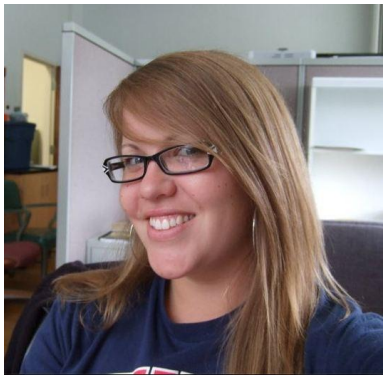
**Research activities:**
My main goal while doing research in Australia was to work with water treatment plants that were utilising full scale MIEX treatment processes. My research involved site visits to collect samples of spent resin as well as raw water. Spent resin from each site was regenerated using either a bicarbonate or chloride based regenerant at two different strengths. The regenerated resin was then used to treat the raw water to compare the performance of the different regeneration processes. Samples were analysed using high performance size exclusion chromatography to determine which size fractions of organic matter were being removed and which size portions were likely to foul resins depending on regeneration method.

**Perspective of research after the program:**
Working at the Australian Water Quality Centre was a unique learning experience for me. As a graduate student working at a large research based university, I'm used to a certain lab experience. Going to Australia and working in a government laboratory was an eye opener and allowed me to experience things from a different perspective. I learned how different stakeholders and requirements impact a lot of the decisions and operations within the laboratory, and that often times this can impact current work objectives.

Additionally, I was able to interact with a wide array of water treatment professionals. This allowed me to hear from those working in the treatment plants as well as those working in the laboratories. These interactions are invaluable for me going forward professionally as it allowed me to see how

water issues differed between the U.S. and Australia, as well as allowed me to determine potential topics to focus on going forward professionally to maximise my potential impact.

**Australian advisor's remarks:**
Chris joined our team for a two month period and was able to undertake an intensive range of laboratory experiments which will provide an insight into the impact of different regeneration mechanisms on the effectiveness of ion exchange in water treatment and will lead to a collaborative publication. We were keen to have Chris work on this project as in recent years we have not been able to undertake further research into improvements since developing and implementing this process in water treatment. Chris' enthusiasm and motivation was matched with his cheerful personality and he blended in well with the team. As a utility based research institution there are some obvious differences to a university environment and Chris found some of these beneficial and some less so, but no doubt this has broadened his perspective on research in the water industry. The EAPSI program was an excellent opportunity for us to extend our links with the U.S. and is certainly a worthwhile opportunity for young researchers.



**Participant:** Maija Sipola, University of Iowa

**Australian research advisor:** Dr Kira Westaway

**Australian host organisation:** Macquarie University

**Title of research proposal:** *Red Thermoluminescence dating of Homo erectus-bearing sediments from Java, Indonesia*

**Research description:**
The purpose of my research was to determine the fluvial dynamics of site formation and depositional age of the Ngandong Homo erectus site in Central Java, Indonesia. Homo erectus crania and tibiae were discovered at Ngandong by Dutch Geological Survey researchers in the 1930s and the site has been high-profile since that time due to the seemingly young (recent) morphology of the Homo erectus crania found there. The bones are fossilised, rendering radiocarbon dating of bone material useless, (and the age of the fossils might be outside the radiocarbon dating time frame (up to the last 40,000 years)). Uranium-Thorium dating of the fossils has proven difficult due to immeasurable diagenetic uranium leaching or uptake through groundwater interactions. The bone and sediments were likely mixed with older sediments prior to fluvial deposition, preventing the valid use of precise tephrostratigraphic age dating. In light of these obstacles to age dating of the fossils and associated sediments, our team decided to pursue luminescence dating techniques to determine the burial age of the Ngandong sediments, which would provide a meaningful formation age for the site as well as a minimum age for the Ngandong Homo erectus fossils.

**Research activities:**
As part of an international excavation team comprised of American and Indonesian geologists and paleontologists, I collected light-tight sediment samples from the Ngandong site in July of 2010. I brought these samples to the Environmental Science Luminescence (OSL/TL) Laboratory at Macquarie University and prepared them for luminescence dating as part of my EAPSI research fellowship. Sample preparation all took place under subdued red light conditions so as not to compromise the natural luminescence signal in the sediments. I first wet sieved my samples to isolate the 90-212 um sand fraction and then treated them with diluted HCl, H2O2 and HF acid washes to remove carbonates, organic materials and feldspar inclusions, respectively. I used heavy liquid (sodium polytungstate) to separate sand grains by density into heavy mineral, feldpar and quartz fractions. I conducted magnetic separations on the quartz fraction to remove magnetic materials that dilute luminescence signal, and dry sieved the 90-212 um quartz fraction to isolate the 90-125 um fraction that is preferred for red thermoluminescence dating. At this stage, Dr Westaway and I conducted glow curve and dose recovery tests on the grains in the Riso luminescence dating machine to discern the natural luminescence signal and grain responses to laboratory radiation doses. This information was necessary to determine the laboratory dose levels in the Dual Aliquot Procedure (DAP) we would implement for the actual dating of the grains (see Westaway and Roberts, 2006). We completed aliquot A and aliquot B analyses but encountered an obstacle in the amount of intra-sample variability between aliquots. The next step in our continuing collaboration will be to date multiple aliquots of each sample and calculate average equivalent doses for the samples as part of the DAP protocol.

**Perspective of research after the program:**
My whole EAPSI adventure in Australia was a wonderful experience and working with Dr Kira Westaway at Macquarie University was an especially incredible opportunity. Besides making progress with my dissertation research, I gained important insight into the day-to-day trials and

tribulations of laboratory management and both the challenges and rewards in the academic faculty position to which I aspire. My progress in the program repeatedly highlighted to me benefits of international collaboration, and especially the importance of in-person collaborative activities that cannot be easily replicated by email, telephone, or even video chat communications. I look forward to continuing work with Dr Westaway on our current project and additional projects on Southeast Asian paleoanthropological sites in the future.

**Australian advisor's remarks:**
It was a please to have Maija working in our laboratory - she was very keen, enthusiastic and worked hard to achieve her goals. Unfortunately her samples proved to be more difficult than anticipated, but this in itself was a valuable lesson in the difficulties posed by cutting-edge research. At the very least, she has been fully trained in the techniques of luminescence dating and has acquired some valuable laboratory skills and research experience that will prove useful if she decides to continue on an academic career path. In addition, this opportunity has provided a platform for future research collaborations both with Maija and her PhD supervisor Dr Art Bettis. I think this scheme provides a wonderful opportunity for students to broaden their horizons both personally and academically and I would be happy to host another student if the opportunity arises in the future.

**Participant:** Jonathan Warnock, Northern Illinois University

**Australian research advisor:** Dr Leanne Armand

**Australian host organisation:** Macquarie University

**Title of research proposal:** *A comparative study of diatoms in Southern Ocean surface sediment across 30 years: Phytoplankton response to climate change*

**Research description:**
In 1979, a set of surface sediment samples was collected from the Mertz Glacier Polynya, off the coast of Antarctica. A polynya is an area in the ocean where both sea ice and nutrient rich deep water are formed. The MGP is especially significant in that it creates very large amounts of deep water, which feeds the ocean's most productive upwelling zones. In 2009, this area was resampled. My research compared the diatom assemblage in these two sets of sediment samples. Diatoms are an algae that form a very significant portion of the base of the marine food web. As the oceans continue to warm and acidify, changes to the diatom flora will be significant to marine biology and global climate. This research compares changes in the diatom flora of a significant marine ecosystem to changes in ocean conditions available from the satellite record.

**Research activities:**
I prepared sediment for permanent mounting to microscope slides by chemically removing organic carbon and calcite. The remaining siliceous diatom cell walls were mounted to microscope slides. In each sample, the diatoms were identified to the species level and counted to quantify diatom community composition.

**Perspective of research after the program:**
I believe that the EAPSI program was a valuable research experience. Our results should be easy to write up and publish.  Future collaborations will be both fruitful and enjoyable.

**Participant:** Anatoly Zlotnik, Washington University in St Louis

**Australian research advisor:** Professor Matthew James

**Australian host organisation:** Australian National University

**Title of research proposal:** *Control of large-scale or uncertain dynamical systems*

**Research description:**
The project involves a fundamental investigation of mathematical models for the control of large-scale complex systems, with particular focus on applications in the area of quantum information and quantum control. Many challenging applications in these emerging areas require the control of complex systems consisting of large collections of structurally similar sub-systems, often with parameter uncertainty, in which state feedback may be either difficult or impossible to obtain, or the types of feedback laws that can be used may be restricted due to system complexity. In such cases, developing open-loop control laws that are robust to every subsystem of a large-scale complex system is of fundamental and practical importance. The research priorities of physicists working on manipulating matter at the smallest level motivate new methods for control design and synthesis that will enable the realisation of emerging quantum technologies. A goal of this collaborative project is to identify challenging large-scale optimal control problems of importance to researchers in the quantum domain that can be solved by leveraging promising recent advances in computational methods for optimal control of ensemble systems.

In addition, recent leaps in quantum technology have enabled the state of individual quantum systems, such as atoms trapped in harmonic potentials, to be measured and manipulated by quantum controllers through the formalisms of quantum measurement feedback and coherent feedback control. Such quantum feedback control systems are fundamentally different from classical systems, because the quantum measurement process results in direct couplings to the system that affect the state in an uncertain way, as well as due to the noncommutativity of quantum observables. This motivates a rich variety of theoretical and computational work on the design and control of quantum systems using measurement and coherent feedback.

**Research activities:**
Initial research activities involved review of foundational and recent literature on quantum control, including on the notions of quantum measurement, quantum information, and quantum feedback. To fix the notion of quantum measurement and filtering, we focused on modelling of quantum systems probed by an electromagnetic input field, where the state of the system conditioned on photon detections undergoes stochastic quantum jumps. We developed simulations of the resulting quantum jump process, as measured by a homodyne detector, in the case of a single-photon two-level system. Furthermore, we studied the simulation of filtering processes for continuously-measured systems consisting of superpositions of single photon and vacuum states, as well as coherent states. The procedure involves the derivation of stochastic master equations and the reformulation, or unravelling, of these equations into a computationally amenable wave function representation. The resulting model for the measurement process is a large system of coupled nonlinear stochastic differential equations driven by a Poisson jump process, in which the state variables represent the conditional probabilities of the quantum system being in the associated Fock basis states. The numerical stability of this simulation method has been established, and Monte Carlo sample runs can be collected to estimate the solution of the Fokker-Planck equation for the

process. Subsequent work involves developing feedback control and open-loop input strategies to steer and stabilise the wave functions to desired states, in order to establish and maintain coherence.

Additional modelling work has been conducted to formulate another class of quantum dynamical problems as bilinear ensemble control systems. Many experiments in quantum manipulation require the minimum energy or time-optimal control of bilinear systems with multiple control inputs that take the form of electromagnetic fields applied in three dimensions and with spatially dependent gradients. Such ensembles must be steered between distributions that depend on system parameters or spatial coordinates without feedback information, which presents a class of challenging ensemble control problems whose solution is of interest to theorists and experimentalists in quantum physics. We have posed these problems in the Bolza formalism of optimal control.

**Perspective of research after the program:**
The immediate outcome of my research during the EAPSI program is a collaborative interdisciplinary project involving the control of an ensemble of bilinear quantum systems. I will extend a computational pseudospectral optimal control method recently developed at my home institution to a class of complex open-loop ensemble control problems of interest to researchers in quantum control at ANU. Prospective long-term projects include feedback control for systems involving noncommutative quantum measurement operations, practical pulse design for experiments, as well as control design for theoretical ensemble control problems for which quantum physical models are rapidly evolving. Participation in the EAPSI program in Australia has broadened my understanding of the exciting area of quantum control, and my interactions with visitors to ANU from around the world were extraordinarily informative. I am very grateful to the Australian Academy of Science, the National Science Foundation, and to my host, Professor Matthew James, for this experience.

**Australian advisor's remarks:**
Anatoly spent six weeks visiting my research group which focuses on quantum control theory. The work we do is somewhat different to what Anatoly had been doing at his home institution. This meant that he spent a good deal of time gaining some knowledge of background material. Anatoly was able to successfully complete some simulations, demonstrating success in mastering some new ideas and methods, which will be of great benefit in his future research. Indeed, Anatoly developed a number of contacts not only within my group, but also with others in the physics department. I fully expect to see some high quality joint work in the coming years. Overall, it was a pleasure having Anatoly with us.