Australian Academy of Science

East Asia and Pacific Summer Institutes Program (EAPSI)

2013

Australian Government
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Introduction

The Australian Academy of Science was delighted to welcome the tenth 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 2013.

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 eight week program began on 12 June 2013.

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 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 2014 and beyond.

Professor Suzanne Cory AC FAA FRS

President
Australian Academy of Science

Orientation program

Wednesday 12 June

Morning	Arrival at Canberra airport
Afternoon	Lunch Administrative details at Ian Potter House
Evening	Official opening of EAPSI 2013, Shine Dome Welcome address: Dr Sue Meek, Chief Executive, Australian Academy of Science Lecture: Welcome to Australia Professor Bill Gammage Adjunct Professor, Australian National University Lecture: My short journey through the Universe Professor Brian Schmidt AC FAA Nobel Laureate ARC Laureate Professor and ANU Distinguished Fellow, Australian National University Dinner at the Shine Dome

Thursday 13 June

Morning	Tidbinbilla Nature Reserve: including ranger guided tour, self-paced walk through the wildlife sanctuary and Australian morning tea (complete with vegemite sandwiches, tim tams and lamingtons)
Afternoon	Lunch at Tidbinbilla Nature Reserve Guided tour of New Parliament House
Evening	Depart Canberra for host cities

Participant: Ariel Atkinson, University of North Carolina Chapel Hill

Australian research advisor: Dr Maria José Farré

Australian host organisation: The University of Queensland

Title of research proposal: *The effect of organic matter on the fate of disinfection by-products during the production of high quality recycled water*

Research description:
Water scarcity and compromised source water quality is a major issue facing many areas of the US and around the world, including Australia; the need for alternative water sources continues to grow. Membranes can be used to address this problem. Specifically reverse-osmosis membranes are used in Australia to treat wastewater in conjunction with other treatment processes to produce high quality recycled water. Disinfection by-products (DBPs) are potentially harmful to humans and so the fate of these compounds and whether they end up in finished water during high quality recycled water production is important for the protection of public health in the context of both indirect and direct potable reuse. The goal of this research project was to evaluate how organic matter in the water, which causes fouling on the membrane, affects the passage of DBPs through the membrane into the final waters.

Research activities:
The first research activity was a visit to the local advanced water treatment plant, Bundamba Advanced Water Treatment Plant, for a tour and discussion with the operations manager. There we discussed technologies and techniques used to make the high quality recycled water and also the public's attitude toward drinking water, water conservation, and recycled water. Wastewater (secondary effluent) was also collected for laboratory experiments.

Four sets of bench scale laboratory experiments were performed for the remainder of the program timeline. In each experiment the wastewater was filtered and then treated in a way to alter the organic matter (no modification, dilution, use of anion exchange resins, and ozonation). The altered water was then characterised using various techniques (fluorescence spectroscopy, size exclusion chromatography, UV absorption, total organic carbon, total nitrogen). The altered water was then disinfected for 24 hours. The water was spiked with DBPs and then recirculated in a bench scale membrane system for seven days. The DBPs were monitored in the feed and permeate ("clean") water each day (using a liquid-liquid extraction technique and gas chromatography-electron capture detector analysis). Throughout the seven days the membrane was increasingly fouled with the organic matter from the water. After seven days the membrane was taken out of the system and was analysed (using scanning electron microscopy, contact angle, and DBP sorption).

Other research activities included weekly DBP meetings, weekly seminars given by students in the centre, biweekly water recycling meetings, scheduled gatherings that allowed for networking with other students and faculty, and informal research discussions with various centre members.

Perspective of research after this program:
The program allowed me insight into how important and valuable international collaborations are. The experience has greatly benefitted my research progress as well as my professional development.

I was allowed insight into how other institutions are structured, how they approach research, and how they manage interactions both in and outside of the university. This gives me an advantage in how I can approach the continuing collaboration with the Australian researchers and also in forming new collaborations in the future.

I was also able to learn new analytical techniques and skills that I will be able to use in my future research. The research experience was fruitful and will add to my thesis work. It is also expected to result in a publication and/or conference presentation.

Australian advisor's remarks:
I was already collaborating with Ms Ariel Atkinson and her supervisor Associate Professor Howard Weinberg before Ariel came to visit us within a project funded by the WateReuse Research Foundation. However, this experience allowed me to better get to know Ariel, to discuss her ideas, and to enforce our relationship which will be beneficial for this and future collaborations. I truly appreciate the experience and would welcome her and/or others students from Associate Professor Weinberg at any time.

I did find, however, that although she managed very well to achieve all her expectations, the program was very short for executing an experimental plan. She worked hard and planned very well her experiments but she was also lucky that everything ran quite smoothly and no repetitions were required. Unfortunately, this is not the usual case in experimental science.

Participant: Howard Chiou, Emory University

Australian research advisor: Professor Lenore Manderson

Australian host organisation: Monash University

Title of research proposal: *Comparative ethnography of the globalisation and localisation of biomedicine in Australia*

Research description:
Medicine is rapidly changing; shifting from older models that emphasise the autonomy of individual caregivers towards interdisciplinary teams. What effects does this new emphasis have on local hierarchies, nurse-physician relationships, and medical authority? How does this affect our understandings of medicine as a complex human institution, even as it becomes increasingly globalised?

These questions can begin to be answered by seizing on an opportunity to conduct comparative ethnography of physicians and nurses working in a hospital care model exported to Australia from the United States, extending my dissertation research to the Australian context. By applying traditional anthropological methods (ethnographic participant observation, semi-structured interviews, and focus groups) towards studying this particular hospital care model in Australia, we can compare its differences in a nation with similar biomedical technology, but with a nationalised healthcare system and a distinct cultural context.

This comparison will further anthropological understandings of how biomedical interventions are localised into local contexts, even as it is simultaneously exported and globalised. The Australian data will also allow for the connection of small group dynamics on a hospital unit with the greater institutions of the hospital and biomedicine, furthering our knowledge of biomedicine as both bureaucracy and institution. This knowledge will help expand theory on the sociological structure of biomedicine, and ultimately inform the anthropology of biomedicine as a complex and international human phenomenon.

Research activities:
The research project generates a thick ethnographic description triangulated from unstructured negotiated interactive observations, and semi-structured interviews. Due to excellent support, I was able to successfully capture nearly twice the amount of data as originally proposed.

During the study period, I completed over 110 hours of negotiated interactive observations, which generated more than 45 701 words of ethnographic field notes. I also conducted a total of 44 semi-structured interviews with nurses, doctors, administrators around both cultural change on the unit and the nature of work in general. These interviews were transcribed into more than 214 000 words. I also conducted two focus group sessions to share data with my participants, both to engage the participants and provide a check for validity.

Data coding and analysis remains ongoing, especially as I continue to collect the comparative ethnographic data at the United States sites. Preliminary analyses have been based on a combination of grounded theory and constant comparative methodologies. These methods are well established in anthropology and appropriate for capturing emergent themes from both the observations and identified by the participants.

Perspective of research after this program:
The primary outcome of this project is the generation of a thick description of a hospital unit undergoing a highly complex and cultural change. At the Australian field site, teamwork has now become a critical component of core biomedical practice, and evident in both inter- and intra-professional interactions. Traditional hospital hierarchies, however, remain prevalent despite intervention success, and only partial flattening of hierarchies was possible despite an explicitly designed intervention. Participants reported that informal interactions were highly significant for navigating these hierarchies.

This project extends anthropological theory of hospitals as bureaucracies and institutions within medicine. The unit provided an opportunity to examine power networks around the hospital unit, detailing both local negotiations and politics of change as the unit continued to adapt to the new intervention. When compared against data from the United States, connections can be made between cultures on the hospital unit to the institution and to medicine globally.

Study of this field site contribute towards an anthropology of medicine through documentation of local Australian cultural values of doctors and nurses, as well as attitudes towards work, other employees, and patients. I also unexpectedly collected a small series of local medical slang, which was surprisingly different from what we use in the United States.

Overall, I'm incredibly thankful to have had the opportunity to conduct this comparative ethnography of medicine! I'm returning to my field sites in the United States inspired and invigorated from the fieldwork in Australia.

Participant: Joanna Corby, University of Virginia

Australian research advisor: Dr Maria Cunningham

Australian host organisation: University of New South Wales

Title of research proposal: *Mapping molecules in the centre of the Milky Way*

Research description:
Stars form in massive clouds of turbulent, molecule-rich gas and dust that can be studied using molecular emission lines. Near the centre of the Milky Way galaxy sits the most extreme star forming cloud known in our galaxy or any nearby galaxies, Sagittarius B2 (Sgr B2). It is more than a million times the mass of the sun, 15-light-years in diameter, and host to the most complex organic chemistry observed outside of the solar system. My EAPSI supported research uses newly available radio telescope instrumentation to study the physical structure and organic chemistry in a star-forming core of Sgr B2.

The research consisted of an analysis of a 30 to 50 GHz spectral line survey of Sgr B2 conducted with the Australia Telescope Compact Array (ATCA). The ATCA has recently undergone significant upgrades that enable detailed studies that were previously impossible. The data reveal the chemistry and kinematic structure of gas in (1) warm (~300K) dense gas immediately surrounding one or more protostar(s), (2) in the vicinity of near-ultraviolet radiation, and (3) in an envelope of molecular material in which the core is embedded.

Research activities:
The data set is a 3D data cube (two spatial dimensions and one spectral dimension) containing more than 1000 spectral lines. In order to process the wealth of information contained, I wrote python scripts to automate most steps of the analysis. The code detects spectral lines, finds best-fit Gaussian profiles including multiple-Gaussian fits for blended spectral lines, and identifies the molecule and transition by comparing against a spectral line database. My work included developing the scripts, iterating on new methods, and discussing hurdles and interesting science results with my mentors.

Perspective of research after the program:
While I am still iterating to improve the analysis, the project has produced significant science results deserving of one or more papers. A first survey paper is in draft form. Furthermore, I presented results from this work at, and submitted conference proceedings for, the International Astronomical Union's 303rd symposium entitled *The galactic centre: Feeding and feedback in a normal galactic nucleus*.

In addition, the program fostered a valuable collaboration that will prove fruitful in my thesis work and hopefully further down the line. It has additionally helped strengthen collaborations between my mentors and my PhD advisor. On the personal side, the program enabled me to develop a working understanding of the astronomical community in Australia, as well as a deep appreciation of people, sights, and sounds in Sydney.

Australian advisor's remarks:
Joanna has done an amazing job on the project, and she is currently preparing a paper on the research done using ATCA observations of complex molecules in the rich molecular source Sgr B2. Joanna integrated extremely well into the department, and really made the most of the opportunity. The work she completed, particularly the automated molecular line fitting, puts her in the top 1% of PhD students that I have been involved in supervising, of which there are seven. We are really hoping to entice her back to Australia for a post-doctoral fellowship.

Participant: Dana Dolan, George Mason University

Australian research advisor: Professor Stephen Dovers

Australian host organisation: Australian National University

Title of research proposal: *Governance for climate change adaptation in complex, cross boundary, social-ecological systems*

Research description:
The goal of this study was to understand the evolution of institutional arrangements for long-term governance, in theory and in practice. Climate change is a scientifically and socially complex challenge marked by irreducible uncertainty, very long feedback cycles and significant variations at the local scale. Adaptation will require coordination and collaboration across multiple institutional boundaries and across multiple sectors. These requirements present novel challenges to traditional, hierarchical approaches to governing as well as to decentralised market approaches; networked governance theories may help explain emerging decision-making structures. This study responds to calls from the climate change research community for empirical research that analyses place-based adaptation and that extends existing work in the natural sciences to incorporate social sciences through a qualitative case study of the governance networks in the Murray-Darling Basin region in south-east Australia, an ecologically rich, politically fragmented, and institutionally diverse social-ecological system. This study may also provide insights for the literature on institutional change, broadly defined. Traditional theories such as punctuated equilibrium have provided a wealth of insight into how institutional change occurs, or is resisted, in complex public policy areas: governance through reaction to crises. However, the long-term crisis of climate change threatens to produce events ("punctuations") with unacceptable consequences in terms of human suffering. Developing alternative models of institutional change that support proactive approaches to long-term governance issues may help reduce these negative consequences.

Research activities:
I realised almost immediately that the governance networks I aimed to study were more complex and far noisier than I had anticipated. Proceeding along the research path I proposed would leave me far from the goal of "saturation", the generally accepted rubric for qualitative study. There were too many perspectives to consider, too much geography to cover, and too little time to triangulate interview data with documentary evidence and participant observations as well. To make best use of my time in Australia I prioritised face-to-face interviews, while collecting documents and references to study after my return to the US. I was able to complete nearly fifty interviews during my stay and build an extensive contact list for future visits. Interviewees were generous with their time and their personal insights on the regions' efforts to reform institutional arrangements in preparation for a more uncertain future. This highly successful data collection effort would not have been possible without the generous suggestions and introductions of my host scholars, for which I am deeply grateful.

Three relevant presentations have been completed to date. My first presentation was at the 2013 National Climate Change Adaptation Research Facility conference in Sydney which offered an early opportunity to introduce my research to other scholars presenting in a parallel session on *The role of tools and knowledge in adaptation*, as well as the large audience in attendance. The second presentation was at a seminar at the Fenner School which directly addressed my research as an EAPSI Australia fellow, laying out the case for comparing climate change adaptation governance in the Murray-Darling Basin and Chesapeake Bay regions, providing a preliminary view of the different discourses I observed during my field work, and setting the stage for discussion and future collaboration. Finally, upon return to the US I presented a poster at the American Political Science Association annual conference. The goal of this presentation was to clarify how various frameworks for analysing linked social-ecological systems were interrelated, in part as a means for me to gain a deeper understanding of analysis options for my research. Insights from field work in the Murray-Darling Basin were instrumental for understanding and communicating strengths and trade-offs among the various frameworks.

Research on this effort continues toward a working paper based on the preliminary findings outlined during my Fenner Seminar. This may result in a paper suitable for peer-reviewed publication, or alternatively a proposal for funding to pursue collaborative research. I look forward to feedback and follow-on discussions with my host scholars.

Perspective of research after this program:
Preliminary insights from my research confirm the value in comparing governance networks across the two regions. From the perspective of US public policy, the social, economic, and political commonalities between our two regions, layered upon Australia’s more variable and fragile environment, provides an excellent opportunity for policy learning for climate change adaptation governance. Australia's adoption of the adaptive management principle of “learning by doing” may be usefully expanded to enable learning by observing others. Case comparisons between the Murray-Darling Basin and the Chesapeake Bay based on governance similarities, rather than climate similarities, suggest an untapped opportunity to gain new perspectives and insights.

Perhaps the most important perspective I gained was a deepened understanding of interdisciplinary scholarship. I learned much through observations and discussion with Professor Stephen Dovers, the director of a highly successful interdisciplinary program. His leadership and orchestration skills are remarkable and widely respected. Dr Karen Hussey's success in collaborative scholarship is easily “googled”, but a first-hand perspective is best for appreciating her strengths in strategic partnership and networking. I am grateful to have the opportunity to work with them both and the world-class scholars and students at the Australian National University and beyond, and deeply appreciative of the warm welcome I received during my stay. I look forward to returning, and staying in touch in the meantime.

Australian advisor’s remarks:
Dana's research visit to the Australian National University, in my judgement, was highly successful, both for her and also for researchers and policy makers here in Australia. Through Dr Hussey’s and my own contacts, and colleagues here including former public officials now in academia, she was able to access materials and interviews with a wide range of people and agencies, and it is clear that her research was enriched for the purposes of her dissertation and for later possibilities. The complexity of the Murray-Darling Basin situation was a challenge, however the merit in comparison

with the Chesapeake Bay as a case-to-case analysis generated significant insights. The feedback from those researchers and public officials I have spoken to indicates strong interest in Dana's research and indeed benefits for them in terms of exploring issues and possibilities that they had not focused on previously. The seminar Dana gave at the end of her visit was well attended by researchers and agency staff and generated considerable interest.

Participant: Lindsey Dougherty, University of California Berkeley

Australian research advisor: Professor Justin Marshall

Australian host organisation: Queensland Brain Institute

Title of research proposal: *Mechanisms, ultrastructure and behavioural function of flashing in Ctenoides ales: "Disco clams"*

Research description:
The ocean's euphotic zone is an environment in which light is extremely variable, yet a wide array of organisms use visual displays that require ambient light for reflection. The bivalve mollusc Ctenoides ales (C. ales) lives at depths up to 20 m, and often inside crevices where ambient light is dim and wavelength-restricted. Despite its light-limited habitat, this species evolved a reflective mantle edge that emits vivid light, leading to its common name, "disco clam". C. ales is the only known bivalve with a behaviourally controlled photic display, yet virtually nothing is known about its mechanism, function or life history. Preliminary research in transmission electron microscopy, high speed video, spectrometry, hyper-spectral imaging and particle modelling have advanced intracellular and mechanistic understanding of how the photic display is produced, but its behavioural purpose remains unknown. During this field season, hypotheses about the function of the flashing were tested, including that it acts to attract phototaxic prey, larval juveniles for settlement, or is an aposematic warning toward predators. The study of photic displays by organisms advances knowledge about visual systems, communication, physical optics, photonics, structural composition and biomimetic technology.

Research activities:
My research activities included: field work at Lizard Island and at the Great Barrier Reef (species collection, in situ film, spectrometry, habitat spectrometry, video analysis, time-lapse photography, plankton analysis and water samples); meetings and research at The University of Queensland Brain Institute; extensive work within the Centre for Microscopy and Microanalysis at The University of Queensland (elemental analysis and transmission electron microscopy).

Perspective of research after the program:
This program expanded my views for what is possible with my current research track, including future and extended field opportunities and advanced techincal applications. My host researcher is a leader in the field and I will undoubtedly utilise our collaborative efforts in the future.

Australian advisor's remarks:
Lindsey worked very hard in my laboratory and has progressed this project to the point of publication in (we hope) a very high-impact journal. She is to be commended on her excellent work-ethic and commitment to getting the job done. Further to this, she is clearly a highly motivated and interested young marine scientist and such beasts are increasingly rare. I would not hesitate to have her back in the lab and look forward to seeing her career progress.

Participant: Mohammad Fanaei, West Virginia University

Australian research advisor: Professor Abbas Jamalipour

Australian host organisation: The University of Sydney

Title of research proposal: *Increasing energy efficiency in distributed sensing using limited-feedback and collaborative strategies*

Research description:
In this project, the problem of distributed estimation in wireless sensor networks (WSNs) was investigated in two important aspects, namely limited-feedback strategies and spatial collaboration for the optimal power allocation.

One of the goals of this project that we defined in the midst of our studies was to propose an optimal power-allocation scheme that allocates a limited total transmission power to local sensors in such a way that the average lifetime of the network is increased by assigning transmission powers to spatially distributed sensors in a more fair and uniform manner.

Another goal of this project was to apply limited-feedback strategies in the domain of distributed estimation in WSNs. Most studies in the literature assume that spatially distributed local sensors in a WSN have access to the instantaneous channel state information between themselves and a central entity in the network, called the fusion centre (FC), through a reliable feedback mechanism between them. This assumption is not generally feasible in most applications, especially in large-scale WSNs, due to its high bandwidth requirements. The notion of limited feedback is proposed to reduce the amount of required information needed to be fed back from the FC to local sensors in order to reduce the aforementioned bandwidth requirements.

During our investigations, we decided to also study the effects of spatial collaboration among local sensors in a WSN performing distributed estimation of a vector of unknown parameters. In almost all previous studies in the literature except a recent work, it had been assumed that there is no inter-sensor collaboration and/or communication among spatially distributed sensors, and that each sensor only has access to, and will separately process, its own local noisy observations. The idea of spatial collaboration among sensors extends this framework to the case in which local sensors could collaborate with each other by sharing their local observations through error-free, low cost links.

Research activities:
Suppose that a set of spatially distributed sensors make local noisy observations correlated with a parameter of interest. The parameter of interest could, for example, be the location of an object or the strength of the signal that a transmitter is broadcasting. Each sensor processes its noisy observations locally and sends the processed data to a central entity in the network, called the fusion center (FC), for further processing. The FC will then combine all of the received locally processed, noisy observations to reliably estimate the parameter of interest.

One of the simplest and most feasible local-processing schemes is the amplify-and-forward mechanism, in which each sensor amplifies its local observations by multiplying them with a specific amplification gain. It can be seen that the local amplification gain determines the transmission power of the sensor.

If there was no constraint on the transmission power, each sensor would send its local observations with the highest possible transmission power, and the estimation error at the FC would be at its minimum. In practice, however, the transmission power of each sensor, as well as the total transmission power in the entire network, is limited in order to increase the lifetime of local sensors and restrict the interference that their transmissions create in the network. Note that the local sensors are almost always battery-powered, and in most applications replacing their batteries is not feasible. Therefore, there is a problem in determining how to allocate the limited transmission-power budget to sensors in an optimal manner. Intuitively, any optimal power-allocation scheme should assign higher amplification gains to the sensors that have higher quality observations and/or better communication channels between themselves and the FC. Nevertheless, assigning very high transmission powers to a subset of sensors and silencing the rest of them due to having lower quality observations and/or communication channels could result in a situation where some sensors transmit with high transmission powers all the time and deplete their batteries, while others are silent and never use their batteries. This unfair scheme of power allocation could in turn result in network partitioning.

In the first phase of this project, we proposed an optimal power-allocation scheme that indirectly considers the problem of fairness in determining the optimal local amplification gains with the goal to increase the lifetime of the network by reducing the transmission powers assigned to the set of best sensors (in terms of the observation quality and/or communication-channel quality). In our proposed scheme, the difference between the maximum and minimum transmission powers assigned to the local sensors is decreased, and the percentage of the total number of sensors that are silenced is reduced drastically. Therefore, our proposed approach distributes the total transmission power among the sensors more fairly and reduces the chances of network partitioning and sensors dying due to constantly transmitting at their maximum transmission power.

Most optimal power-allocation schemes proposed in the literature require the FC to estimate the quality of the communication channel between each sensor and itself. The FC will then feed the exact instantaneous channel state information (CSI) back to local sensors. Each sensor will use this information to find its optimal local amplification gain. The requirement of feeding back the instantaneous CSI from the FC to the local sensors is not generally feasible in most applications, especially in large-scale WSNs, due to its high bandwidth requirements.

In the second phase of this project, a limited-feedback strategy was proposed to eliminate the above-mentioned requirement of feeding back the exact instantaneous CSI from the FC to local sensors. In the proposed approach, an optimal codebook is designed in an iterative, off-line process, containing a set of vectors of optimal local amplification gains. The codebook-design process is based on the generalised Lloyd algorithm with modified distortion functions. Upon observing a realisation of the communication channels between local sensors and itself, the FC finds the corresponding optimal vector of amplification gains. It then finds the closest code word in the codebook to the optimal vector of amplification gains and broadcasts the index of that code word. Since each sensor has access to the optimal codebook, it can refer to the code word whose index has been broadcasted by the FC and pick up the amplification gain that it has to use in its future local processing. Note that by using this approach, the FC will only need a few bits for the feedback of the instantaneous CSI to local sensors, resulting in a drastic saving in the bandwidth requirement of the feedback process in the network. To the best of our knowledge, this is the first work that has applied the notion of limited feedback, which is very popular in the domain of wireless relay networks, to the field of distributed estimation in WSNs.

In the third phase of this project, the idea of spatial collaboration among sensors in a WSN performing distributed estimation was investigated. This idea has recently been studied for the first time in a special case of scalar-parameter estimation. In our work, we have further extended this concept to the case of vector estimation. In almost all previous studies in the literature, it had been assumed that there is no inter-sensor collaboration and/or communication among spatially distributed sensors, and that each sensor only has access to, and will separately process, its own local noisy observations. The idea of spatial collaboration among sensors extends this framework to the case in which local sensors could collaborate with each other by sharing their local observations through error-free, low cost links. In the case of linear spatial collaboration, each sensor will form a linear combination of its own local observation as well as the observations of other sensors that it has access to. The question that arises in such a scenario is to find the optimal coefficients in each linear combination that local sensors form. We have proposed an approach to optimally find the set of coefficients used to form linear combinations at different sensors. As our numerical results have shown, even a moderate spatial collaboration among local sensors improves the quality of estimation at the FC.

Perspective of research after the program:
The wonderful time that I spent in Australia during my EAPSI Fellowship was short, but an incredible, irreplaceable, and productive experience. For two months, I was tremendously privileged and honoured to work with an extraordinary researcher and internationally recognised leader in the field of wireless communication networks, Professor Abbas Jamalipour, at The University of Sydney. Working in a new environment and collaborating with a bright research group with a different style and focus helped me make tremendous progress with my dissertation research, develop new ideas and hypotheses, and look at my research from another perspective. There were many Invaluable experiences, such as exchanging ideas and analysing alternative solutions with my host and other members of the Wireless Networking Group (WiNG) during my presentations as the guest speaker in their group meetings (as well as our late-afternoon informal coffee talks and interactions). These interactions repeatedly reinforced my belief that international collaborations, especially in-person interactions and cooperative research activities, in scientific communities are an essence of the future and could benefit the society and research community in ways that cannot be easily replicated by email, telephone, or even video-chat communications. I believe that our fruitful experiences during this short visit have paved the way for the expansion of our collaborations in the future on solving new, challenging and interesting problems of practical significance, and I am impatiently looking forward to such opportunities. In a nutshell, the EAPSI fellowship provided me with a great opportunity to expand my professional network of collaborators beyond the borders of

the United States and to forge special and long-lasting international friendships, potential partnerships, and scientific cooperation that would not have been possible otherwise.

Last but not the least, I would like to express my sincere gratitude and appreciation to my host, Professor Abbas Jamalipour, all members of the WiNG, the Australian Academy of Science and its staff, especially Ms Shannon Owen, and the National Science Foundation and its staff, especially Ms Elena Hillenburg, with whom I have been in close contact during this incredible journey.

Australian advisor’s remarks:
Mohammad was an ambassador for the EAPSI program and his university. I could not have been more delighted with his extremely fruitful visit. He is an outstanding, motivated student and showed great initiative in analysing a difficult problem during his stay at our university. His enthusiasm was infectious, and he crammed in an amazing amount of work and pleasure during his nine-week long visit. Mohammad's interactions with me and other lab members were exemplary as he was always willing to contribute new ideas for discussion. His enthusiasm and motivation was matched with his cheerful personality. He seamlessly blended in well with the group and was well-liked immediately. He worked easily and well with other students and fully took part in group meetings and other laboratory activities. He has high standards in all he does and performs well both individually and in a team setting. Mohammad’s willingness to soak up newly acquired information was outstanding, and his work ethic could not be faulted. We have found him to be hardworking, enthusiastic and insightful. Aside from being terrifically clever, he was a delight to have around, which is a critical but often overlooked factor in international collaborative research.

On the work front, Mohammad's persistence paid off with some fascinating results concerning collaborative amplify-and-forward local processing for distributed estimation in wireless sensor networks. We have already submitted two papers and are currently working together to create a new paper based on these results, and future long-standing collaborations are very likely, especially as Mohammad is never short of interesting ideas. Mohammad gave two excellent and well-attended seminars in the Wireless Networking Group at The University of Sydney. During these presentations, he proved to be a great public speaker that has a gift for being a successful teacher.

What Mohammad's visit has achieved is to provide a more formal link between our research group at The University of Sydney and his team led by Professor Valenti at West Virginia University. It was a pleasure to host Mohammad in our institution, and I wish him the very best for the successful completion of his dissertation. I look forward to future visits and involvement in his academic career. Of course, we would also gladly welcome Mohammad back to The University of Sydney any time he has the opportunity to visit us again. I am very hopeful of considering him for a post-doctoral fellowship here in Australia should this opportunity arise.

This was my first experience of the EAPSI program and I have nothing but praise for it. The Australian Academy of Science and the National Science Foundation should be commended for this program. I think this scheme provides a wonderful opportunity for students to broaden their horizons both personally and academically. Based on the excellent interactions we had during Mohammad's visit, we would be very happy to host another such high-calibre student in the future.

Participant: Benjamin Fine, Texas A&M University

Australian research advisor: Professor Salah Sukkarieh

Australian host organisation: The University of Sydney

Title of research proposal: *Manipulating migratory bands of locust: A computational exploration*

No report was provided by this student.

Participant: Christina Forbes, University of Delaware

Australian research advisor: Professor David Craik FAA

Australian host organisation: The University of Queensland

Title of research proposal: *Synthetic modifications to the cyclic protein kalata B1*

Research description:
Cyclic peptides are remarkably stable structures with natural insecticidal, antimicrobial, and hemolytic activity. Recently, grafting of peptide epitopes within the flexible regions of the cyclic motifs have allowed for modifying natural activity of cyclotides. However, grafting methods impart size limitations, can affect global fold and stability of the cyclotide, and do not generally allow for modification with fluorophores, antibodies, or small molecule prodrugs. Employing non-natural amino acids equipped with bioorthogonal chemical "handles", we aim to synthesise a general scaffold based on Kalata B1 which can be used for general, modular scaffolding. These chemical "handles" were selected to be compatible with proteins and small molecules, with mild conditions for conjugation. We will synthesise the modified scaffold, and characterise the structure in order to establish that the fold and stability of the native cyclic peptide has been maintained. We will then demonstrate utility of the scaffold by conjugating peptides and small molecules to each of the modified sites.

Research activities:
We explored several routes to synthesise a modified variant of cyclic protein, Kalata B1, in order to functionalise it as a template for modular scaffolding. The design of the scaffold would allow for conjugation of peptides, small molecules and proteins at three different sites on the derivatised scaffold. Synthetic methods included non-natural amino acid incorporation via solid phase peptide synthesis, and solid phase synthetic modification using the "proline editing" technique. We achieved successful synthesis of the modified scaffold containing one modification site using incorporation of the synthesised amino acid. We were able to acquire some structural data on this modified scaffold and established that it is structurally consistent with the native Kalata B1. We also established the viability of the "proline editing" technique as an alternate, more practical strategy to synthesise the scaffold, although this method will require some optimisation. In addition to synthesis of the core scaffold, short recognition sequences were synthesised for attachment to the scaffold, which would be further studied for anti-angiogenesis activity.

Perspective of research after the program:
After acquiring some preliminary reaction results, I am confident that we can synthesise the modified Kalata B1 scaffold containing three conjugation sites after some optimisation. We plan on continuing this work which will result in a publication in early 2014. We have also discussed possibilities for further applications of these synthetic techniques that we tested during the program, and hope to have additional publications in broader-reaching projects. Through this program, we have established an international collaborative effort that will extend beyond this initial work.

Not only was this experience in Australia valuable for scientific and collaborative reasons, but it was also enlightening to experience how a larger lab is managed successfully. I certainly learned a lot about logistical requirements in lab management, both in funding and resource allocation, which will serve as valuable experience when I need to manage my own lab.

Australian advisor's remarks:
It was a great pleasure to host Christina Forbes in our lab during her visit. She was an extremely well organised researcher and had done substantial preparation before arriving for the visit. Christina fitted in extremely well to the lab and had very clear aims and an outstanding work ethic. She worked exceptionally hard during her time here and made very pleasing progress. She opened the door to new aspects of cyclotide chemistry that we are very excited about continuing in collaboration with her.

Important things to come out of the visit from my perspective were:

- Progression of some very interesting chemistry on cyclotides that is complementary to existing studies in our lab, but quite different from what we might otherwise have done
- An opportunity for my PhD students to see a high achieving, mature and intellectually gifted, US-based graduate student perform in the lab and seminars. Christina provided an excellent role model so that early stage PhD students could see the level of maturity and scientific sophistication that is possible for a high achieving student nearing the end of their PhD degree
- The creation of new linkage with her home lab in the US
- The expectation that two scientific manuscripts will derive from this work over the next six months.

Finally, I congratulate the Australian Academy of Science and the National Science Foundation on the EAPSI program. It has proven extremely valuable for my lab. I wish Christina every success in her ongoing studies. She is an outstanding researcher who has a bright future in front of her.

Participant: Thomas Heider, University of Connecticut

Australian research advisor: Professor Marilyn Renfree FAA

Australian host organisation: The University of Melbourne

Title of research proposal: *WallaBase: Jump starting the Tammar Wallaby genome database*

Research description:
The tammar wallaby's popularity as a model marsupial is growing; it has found a role in several fields including immunology, early embryo development and comparative genomics. However, unlike many other model organisms, it lacks a genome database that serves as a central hub for the organisation of much of the information generated during the course of research. My research this summer was to create *WallaBase*, a genome database that will reduce the costs and time associated with research for any researchers using the tammar wallaby as it will reduce the amount of duplicated effort and include custom designed bioinformatics pipelines to help researchers.

Research activities:
During my time working with Professor Marilyn Renfree at The University of Melbourne, I worked on implementing key tools that will make up *WallaBase*. That included developing custom bioinformatics pipelines for the scientists across Australia that I was meeting with. There is also a component to the database that is designed to explain the importance of studying marsupials (in particular the tammar wallaby) to the general public that I focused on developing. During my time in Australia, collaborators in Japan generated an improved genome assembly for the wallaby that I included in *WallaBase*. I have continued to work on *WallaBase* after returning to the University of Connecticut and expect to finish *WallaBase* soon.

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 am equipped with a better understanding of science and the way it connects people throughout the world.

Australian advisor's remarks:
We were delighted to have Tom visit our laboratory. His project was to take advantage of the extensive new sequencing of the tammar wallaby now available to collate and organise all tammar wallaby genomic and transcriptomic data, as well as to include biological information, publications, etc, to create a new, publically available *Wallabase* genome browser. This database will provide unique access for all marsupial biologists in the world, as well as for the broader scientific

community who are constantly approaching us for tissues and information, which is a time consuming task.

The simple graphical interface that Tom is developing will be of great benefit. The database construction is almost complete and there will be ongoing interactions with him and new collaborative projects developing in the future as a result of his visit.

Tom was an enthusiastic participant in all things to do with the tammar wallaby, learning how we catch and handle the animals as well as enjoying the camaraderie of the “Walgroup”. He is a great ambassador for the EAPSI program, and all members of my group benefitted from their interactions with him. The results of his visit will have lasting benefits on both our laboratory and his home laboratory.

Participant: Nicholas Johnson, University of Minnesota

Australian research advisor: Professor Bob Williamson FAA

Australian host organisation: National ICT Australia (NICTA)

Title of research proposal: *Real-time learning in multi-agent systems for ad hoc robot teams*

Research description:
The goal of this project was to gain an understanding of how we can make performance guarantees for a coalition of robots in complex environments.

Research activities:
The activities associated with this research project included a literature review, problem identification, solution discussions, and solution development.

Perspective of research after this program:
This program allowed me to identify a concrete problem and potential solutions which Professor Bob Williamson and I plan to solve together as we collaborate in the future. The goal is to publish a paper on our findings which this program allowed us to start.

Participant: Kathleen Lask, University of California Berkeley

Australian research advisor: Dr Paul Medwell

Australian host organisation: The University of Adelaide

Title of research proposal: *In-situ measurements of pollutant production in the Berkeley-Darfur stove using laser extinction*

Research description:
Worldwide, approximately three-billion people cook their food using biomass fuels such as wood and charcoal. The smoke produced by these fires leads to four-million premature deaths annually as well as large environmental consequences. Many cook stove designers are striving to develop improved, low emission cook stoves, but they need diagnostic tools to enable them to make knowledgeable design decisions. In this project, the emissions from an improved cook stove, the Berkeley-Darfur Stove (BDS), and single blocks of wood were examined using laser extinction. Laser extinction is a nonintrusive, in-situ technique that measures the opacity of emissions from fires, indicating the amount of released pollutants. The pollutant production was compared between the single wood block and the BDS to gain a deeper understanding of combustion in the stove while providing initial steps towards a nonintrusive diagnostic tool for measuring pollutant production in cook stoves.

Research activities:
The initial focus of my work at The University of Adelaide was examining the pollutant production from the combustion of wood in the BDS. My original proposal was adapted to use a simpler, more robust diagnostic technique, laser extinction, to better suit the complexities of examining pollutant production in cook stoves. Using laser extinction allowed for greater flexibility in the experimental setup, reducing the amount of optical access needed for the trials. After measuring the pollutants from the BDS, we decided examining the pollutants from a single small block of wood would help explain the fundamental phenomena occurring in the BDS fires. Comparing the two cases, we saw some definite trends that require further exploration. The research conducted during my brief stay in Adelaide got the project off the ground, fostering continued collaboration between the research groups in Adelaide and Berkeley.

Perspective of research after the program:
Although the time I spent in Adelaide was short, the experience was exceptional. Not only did I gain many new skills and contribute to my doctoral research, but an international collaboration vital to my graduate studies was initiated which would not have occurred without the EAPSI program. Through this program, I began learning laser diagnostic techniques, while also developing friendships and networks in Australia and around the globe through other visiting scholars. The knowledge I gained by working with the Australian scientific community has better equipped me for future collaborations and research on an international level.

Australian advisor's remarks:
It was an absolute pleasure hosting Kathleen. The task of improving the health of half the world's population through developing less polluting cook stoves is a global problem. Kathleen brought with

her passion and expertise in the operation of the Berkeley-Darfur stove, specifically designed for displaced persons in Sudan. Her skills complemented our advanced laser diagnostics laboratory which is typically used for the study of fundamental and industrial combustion processes. This project has the potential to greatly reduce deaths directly attributable to poorly designed and operated cook stoves used throughout the developing world. During this brief visit Kathleen has initiated beneficial collaborations, which has already resulted in two conference papers. Further collaborative research has been identified for future projects. The EAPSI program has enabled good outcomes in a short visit, and we look forward to developing a positive long-term partnership.

Participant: Jocelyn Lavallee, Colorado State University

Australian research advisor: Professor Michael Bird

Australian host organisation: James Cook University

Title of research proposal: *Disentangling temperature controls on turnover of old, nitrogen-rich soil organic matter*

Research description:
We aim to understand how temperature affects the cycling of soil organic matter. In particular, we are interested in old, nitrogen-rich soil organic matter that has very long turnover times. We collected soils from several sites in the United States and studied the rates of carbon turnover in relation to site temperature, management, and physical soil properties. In Australia, I went a step further to isolate black carbon in those soils and measure the rate of turnover of that black carbon using stable carbon isotopes. This will allow us to determine whether black carbon, which is thought to be highly stable over long time periods, is affected by site temperature and management.

Research activities:
I spent my time at James Cook University performing hydrogen pyrolysis on my samples to isolate black carbon. This method employs a highly specified instrument of which there are only a few in the world. Once all of my samples had been pyrolysed, I prepped them to be run on the Elemental Analyser and Mass Spectrometer, and am currently analysing the output from those instruments.

Perspective of research after the program:
My experience at James Cook University was extremely productive. I pyrolysed 200 samples in less than two months, which had never been done previously. My host, my home advisor and I are excited to analyse the resulting data, and expect at least one publication to come out of my work. Hydrogen pyrolysis is a cutting edge technique, and we are using it to answer highly relevant questions related to global climate change and soil carbon dynamics. This was a positive collaborative research experience for both sides, and we already have an additional set of soil samples that we hope to pyrolyse in the future.

Australian advisor's remarks:
It was a pleasure to host Jocelyn in my research group at James Cook University (Cairns campus). Jocelyn enthusiastically engaged with her project from the outset and quickly became a 'regular' research group member. She worked hard and very independently on her project and completed a surprisingly large number of analyses in the fairly brief time available. I anticipate this will result in at least one paper in a top international journal. On behalf of James Cook University I'd like to thank the EAPSI program for providing the opportunity to host Jocelyn in my lab. I found it a most enjoyable and fruitful experience.

Participant: Emily Marshall, Vanderbilt University

Australian research advisor: A/Professor David Wood

Australian host organisation: Monash University

Title of research proposal: *Circumference and path width of highly connected graphs*

Research description:
For several graphs H, we examined certain structural properties of graphs G which do not contain H as a minor. In particular, we looked at the path width of H-minor-free graphs. It is known that H-minor-free graphs have bounded tree width if, and only if, H is a planar graph. To bound the pathwidth of such graphs, we increased the connectivity. When H is a cycle of length t, we showed that two connected H-minor-free graphs have path width bounded by a function of t. When H is k disjoint cycles of length t, we showed that (k+1)-connected H-minor-free graphs have path width bounded by a function of k and t.

Research activities:
While at Monash, I attended the Discrete Mathematics Research Group seminars. The group met weekly for research talks or informal problem sessions. I had the opportunity to present some of my own research and also participated in the problem sessions. In working on our main research project, I met frequently with my host researcher, A/Professor David Wood.

Perspective of research after the program:
Our research topic presents a new direction for problems concerning path width of graphs. We have a result for two families of graphs H but similar results can be explored for other families.

Australian advisor's remarks:
It was a pleasure working with Emily. She is intelligent and hard-working. She diligently worked on the project, always following my suggested research directions. The paper that we are writing is highly innovative and opens up a new direction for research that I hope other mathematicians will follow.

Participant: Tyler Massaro, University of Tennessee, Knoxville

Australian research advisor: Dr Daniel Spring

Australian host organisation: Monash University

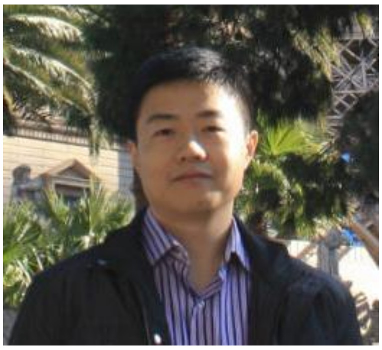
Title of research proposal: *Resource allocation for bushfire containment and response strategies on high fire index days in Victoria*

Research description:
Ultimately, the goal of fire management is the preservation of life and property. On high fire index days in Victoria, it is critical for fire managers to successfully contain a bushfire before it has a chance to begin spotting and starting fires elsewhere. We are looking at two ways to improve first attack success: (1) introducing a remote surveillance network of heat sensors; and (2) increasing the number of airborne helicopters as fire index increases. Using a system of coupled partial differential equations, we model the propagation of a bushfire through different fuel layers. Then, we simulate containment of these fires through a combination of each of the two strategies. Since each strategy has an associated cost, we search for the optimal combination, subject to a fixed budget.

Research activities:
My research activities included visits to local forests; discussions with fire managers and researchers; and testing and simulating the equations.

Perspective of research after the program:
We have explored numerous avenues for mathematically describing a bushfire containment program. Our current path is the one which is mathematically accessible, and, more importantly, the most realistic for fire managers to implement.

Australian advisor's remarks:
Tyler demonstrated himself to be a highly capable researcher with original ideas and a keen willingness to learn. He made substantial progress during his visit on his dissertation project involving optimal early response to bushfire. On a personal level, Tyler was a pleasure to work with. Tyler's visit was highly productive, with important research papers likely to arise from our collaboration on the control of contagion processes.



Participant: Lingyun Miao, University of Rochester

Australian research advisor: A/Professor Paul Stoddart

Australian host organisation: Swinburne University of Technology

Title of research proposal: *Optical delivery for ultra-high density magnetic hard drives*

Research description:
Heat-assisted magnetic recording is one of the most promising future technologies for nano-scale magnetic recording and ultra-high density magnetic hard drives. It requires the use of a focused laser beams to define magnetic recording feature, where high efficiency optical coupling and delivery of highly focused optical beams at low cost are key challenges. This research collaboration seeks to design nano-sized metallic structures that greatly reduce the spot size of incident optical beams. Such properly engineered structures can generate highly focused optical spots on the scale of tens of nanometers, which facilitates magnetic recording density beyond one terabyte per square inch.

Research activities:
The majority of this research was based on nano-antenna design and numerical simulation. Unlike the conventional gold nano-antenna approach, in this work we designed the near field transducer based on aluminium. The advantages of using aluminium over gold include lower material cost and higher optical efficiency. Both aspects are of great importance to the specific application of heat-assisted magnetic recording.

The simulation results indicate that our design can achieve 35 nanometer spot size with doubled efficiency compared with previously reported results. Thus, this work has demonstrated the feasibility of using aluminum nano-antenna for use in heat-assisted magnetic recording applications. This research will benefit the development of next generation ultra-high density magnetic hard drives.

Perspective of research after the program:
Many exciting research opportunities were discussed during my stay at Swinburne University of Technology. On top of the successful accomplishment of this collaboration there are plenty of relevant and non-relevant topics that can be carried out beyond this work. Thus, the EAPSI program has greatly expanded my research perspective. I truly believe my future research will benefit a lot from this program.

Australian advisor's remarks:
At the start of Lingyun's visit we were able to crystalise some specific, exciting research opportunities that drew on the expertise of both research groups. Lingyun decided to perform numerical simulations to validate the concept first and this was a good decision, as attempts to fabricate and characterise nano-antennas would have been impossible to progress to an advanced stage during a short visit. Lingyun very efficiently learned the Lumerical code for finite difference time domain simulation and was able to develop important numerical results. He was also interested in the opto-mechanical effects of light interaction with chiral plasmonic nanoparticles and started

studying this topic. He presented his progress at weekly group meetings and joined in discussions with other students about their results. He was a good team member and displayed professionalism, maturity and independence. The work that was initiated during Lingyun's visit is being written up for publication. Moreover, we intend to continue the collaboration in order to achieve an experimental implementation. It was a pleasure to have Lingyun join our group during his visit and we wish him well in his future research career.

Participant: Jeffrey Pigott, Ohio State University

Australian research advisor: Professor Kate Wright

Australian host organisation: Curtin University

Title of research proposal: *Calculation of the energetics of water incorporation in majorite granite*

Research description:
The aim of the research was to determine the thermodynamics for water incorporation into the mineral, majorite, as a function of pressure in order to determine the likely water content within the deep Earth. By calculating and comparing the defect energies associated with charge-balanced substitutions of hydrogen for magnesium or silicon, I determined that the hydrogarnet defect has the lowest energy and is therefore predicted to be the most favourable in the majorite structure. The mechanism by which water is incorporated into mantle garnets has major implications for the interpretation of global-scale mantle processes, such as subduction and plume ascent which are ultimately linked to surface processes through plate tectonics. The presence of aluminium should have an effect on the energetics of hydrogen defects in majorite and will be considered in simulations run at my home institution in the United States.

Research activities:
To achieve the above aim, the project required the development and testing of force field parameters for the computer simulation of majorite garnet via energy minimisation. This included the study of both bulk properties, such as elastic behaviour and wave velocities, in addition to the calculation of defect energies for vacancies and impurities within the mineral structure. The defect formation energy associated with hydrogen incorporation in tetragonal majorite garnet was calculated using classical atomistic simulations based on the Born model of solids using the General Utility Lattice Program (GULP). Interatomic potential functions were used to describe the total lattice energy in terms of the atomic positions. Our parameterisation of the potential model was tested against the experimentally determined structure and elasticity of a range of hydrated aluminosilicate minerals. The optimised crystal structure and lattice energy of majorite were calculated using the full unit cell, which consists of 160 atoms. Intrinsic defect energies related to both bound and unbound cation and oxygen vacancies were calculated to determine the most energetically favourable defect structure. The energies associated with protonating each of the six unique oxygen sites were calculated, both individually and as charge-balanced hydrogen defect complexes. The resulting defect energies were coupled with balanced chemical reactions to determine the most favourable incorporation mechanism. In addition, simulations using a 2 x 2 x 2 supercell were run to account for a more realistic concentration of hydrogen within the system.

Perspective of research after the program:
It was an amazing opportunity to be involved as a participant in the 2013 EAPSI program. After additional calculations that include the effect of aluminium, verification of the empirically-derived calculations with additional ab initio calculations, and determination of the effect of hydrogen defects on seismic wave speeds, this research project will be a useful contribution to the deep-Earth geophysical community. Interaction with the computational chemistry group, participation in group

meetings, and presentation of experimental research during their seminars allowed me a chance to cast my research in the context of the broader implications that are relevant to a group with diverse research interests and also to receive critical feedback that I otherwise might not have received. The research that was conducted in Australia will allow for continued collaboration between myself and Professor Kate Wright, Professor Julian Gale, as well as potentially other members of the Curtin University computational chemistry research group, both as this project is wrapping up and in potential future projects.

Australian advisor's remarks:
Jeffrey started the project with only limited prior experience of the techniques required to conduct the research. Despite this he soon developed all the skills needed to be an effective researcher in the field of force field simulation of minerals. He also rapidly integrated into the group and was a strong contributor to group seminars and discussions, which benefited everyone through the exposure to the broader perspective of someone involved in both experimental and theoretical work. Although the project faced some technical challenges, mainly from the sensitivity of the results to force field discontinuities that arise from the standard form of the ionic model with added three-body interactions, Jeffrey was able to obtain some valuable results regarding the thermodynamics of water incorporation into majorite that will hopefully lead to an understanding of such defects impact on seismic measurements. Therefore the project was a definite success, through Jeffrey's hard work and preference, and we thank the Australian Academy of Science and National Science Foundation for the opportunity to have conducted this work.

Participant: Page Quinton, University of Missouri Columbia

Australian research advisor: Dr Ian Percival

Australian host organisation: Geological Survey of New South Wales

Title of research proposal: *Constraining global sea surface temperature trends during the late Ordovician period in New South Wales, Australia*

Research description:
The project is an attempt to establish the first high-resolution sea surface temperature record of the Australian continent during the Late Ordovician (a time period from 454 to 443-million years ago) using conodont (the teeth-like structures located in the gills of a small marine animal) elements collected from New South Wales, Australia. The results will have implications for the role of atmospheric carbon dioxide on climate evolution, the timing of Ordovician glaciation, and the relationship between glaciation and the mass extinction event at the end of the Ordovician Period.

Research activities:
Research activities while in Australia included the collection of rock samples from various locations in central New South Wales. After all sample were collected, individual samples were processed in the acid prep laboratory at the WB Clarke Geoscience Centre. Processing involved the dissolution of the limestone samples in dilute acetic acid and the collection of microfossils (conodont elements) from the remaining residue.

Perspective of research after the program:
The research project was a success because of the flexibility of my host researcher and the fossil collections made available to me.

Multiple microfossil elements are necessary to perform the type of analysis I do. Though we tried to lower the risk of failure by selecting collection locations that had high yields in the past some samples did not produce enough elements. This type of risk is inherent in a study of this nature so it is always good to have a fall back plan. My host researcher had such a plan and allowed me to use existing collections from the Geological Survey of New South Wales, the Australian Museum, and Geoscience Australia.

Australian advisor's remarks:
This was my first experience of hosting a graduate student under such a fellowship, and I believe it was positive and beneficial for both Page and myself. The topic of her research (investigating the application of conodonts as palaeoenvironmental proxies in assessing seawater temperatures in the Late Ordovician) was something that had not previously been examined in eastern Australia. This project involved a week of fieldwork to collect limestone samples from central New South Wales, followed by six weeks processing the samples in the laboratory. Page has taken the picked residues back with her to the University of Missouri, where analytical work on the specimens will take place. The project faced some practical difficulties in that it depended on high specimen yields from selected horizons within considerable thicknesses of limestone. We collected from those horizons

known (from previous studies) to have highest potential for specimen yields, but even then it was not always possible to duplicate these results, Fortunately, we had a Plan B, which was to use the existing collections held by the Geological Survey of New South Wales, the Australian Museum, and Geoscience Australia (Canberra). This ensured that Page obtained suitable numbers of specimens to enable her analysis to proceed back home in Missouri.

As for logistics, it was fortunate that Page was able to obtain accommodation for five weeks of her stay as a house-sitter, as the prices for suitable short-term accommodation in the Sydney market would otherwise have used up her allowance well before she had completed her fellowship.
The prospects for future co-operation that have arisen from Page's visit to Australia are very good. We took the opportunity while doing the field sampling to collect from a wider time interval, covering much of the Ordovician, which will enable the results of the initially-conceived project to be related to the palaeoclimate prevailing prior to the onset of glaciation episodes in the Late Ordovician. Depending on successful results being obtained from the analysis of the conodonts, a paper (with Page as senior author) is planned, as well as a presentation to an international conference in 2014.

I wish to express my appreciation to Page for her conscientious dedication to ensuring the project achieved its aims, and to the Australian Academy of Science and the National Science Foundation for making her visit possible.

Participant: Jamie Smith, Ohio University

Australian research advisor: Professor Peter Albion

Australian host organisation: University of Southern Queensland

Title of research proposal: *Technological pedagogical content knowledge development in science teacher preparation: A mixed methods case study in Queensland, Australia*

Research description:
This study seeks to identify key characteristics that impact the development of technological pedagogical content knowledge (TPACK) in the science teacher preparation program at a large university in Queensland, Australia. TPACK is a conceptual framework of a body of knowledge from which teachers draw upon to influence practice; it is a dynamic and emergent form of knowledge that informs the employment of technology for teaching specific subject matter. While previous research has attempted to describe and measure TPACK in pre-service and in-service teachers, little is known about what experiences and factors influence its development. This study employs a mixed methods case study approach, including delivery of a TPACK survey instrument, class observations, student interviews, and document analyses, to identify the key characteristics that influence the development of TPACK among pre-service science teachers. The research addresses a specific need cited in the literature, identifying TPACK impact factors, and lays a foundation for the conception of a theoretical model of TPACK development.

Research activities:
Research activity began prior to the site visit. The host researcher was contacted and a proposal for research was presented for approval. This study will serve as the whole of my dissertation, with the data collection phase occurring during my stay in Australia. Thus, after receiving notification of the EAPSI fellowship award, I prepared a full proposal (including introductory, literature review and methodology chapters) and successfully defended it to my committee. My survey instrument was adapted for the context of the current study from a well-tested and endorsed pre-existing questionnaire. I developed my interview protocol and piloted it for revisions at my home institution. I obtained ethical clearance for my research from Ohio University prior to my departure.

Upon arrival at the University of Southern Queensland, I had one week to meet with my host and key university personnel prior to the semester holiday. I completed the necessary ethics review procedures and gained approval for the study with the assistance of my host researcher. After adapting documents to satisfy the requirements of both my home and host institution, I submitted amendments to my original proposal and was cleared for research before the start of the following term. During the university holiday, I contacted lecturers to gain access to online courses, establish observation times for on-campus courses, and gain permission to speak with prospective participants. As my focus is on pre-service secondary science education teachers, I visited any courses in the Faculty of Education in which they might be enrolled for the term.

In the first few weeks of the new term, I attended as many courses as possible, taking field notes during observations and collecting course documents for analysis. I met with prospective participants and collected consent forms. I had designed the questionnaire for online deployment via Qualtrics and sent a unique link to all consenting individuals. After the questionnaire was completed, I followed up with a request to submit a lesson plan and to establish an interview time. The lesson plan was used as a discussion point in the interview and will be part of a document analysis. Complete cases consist of questionnaire, document and interview data for each secondary pre-service science teacher. Additional analyses of policies, program and course documents will serve to provide contextual information and triangulate data across cases.

Due to the university holiday, I had made plans to extend my time in Australia to complete my research. The site visit was to serve only as an opportunity for data collection, and this was completed successfully. I will finish collecting online documents and observational notes, transcribe interviews and complete data analysis after my return to the US and intend to complete and defend my dissertation by the end of the current academic year. I also plan to share results from this study at various international conferences and parse my dissertation into one or more scholarly journal articles upon completion.

Perspective of research after the program:
The EAPSI experience has impacted me both personally and professionally in ways beyond what I can likely immediately assess. I have no doubt that this experience has altered my future as an academic and a global citizen. This was my first opportunity to study abroad, and the experience has left me with a deep appreciation for international travel and collaboration. The ability to live in a foreign country for nearly three months (as I extended my stay to complete data collection) was invaluable. I learnt a great deal from everyone I encountered, and I grew not only as a researcher, but as a person.

I view this study as a springboard to a line of research on the development of TPACK in teacher preparation programs. I am interested in exploring this topic across diverse settings where facets of TPACK are addressed and integrated in a variety of ways. There is much room for improvement in teacher preparation as we strive to prepare educators to meaningfully integrate modern technologies and embrace new pedagogies, and examining various approaches to TPACK development on a global scale can help inform and improve the process for all stakeholders.

Australian advisor’s remarks:
I was pleased to be able to host Jamie at the University of Southern Queensland. Although I have conducted research based on the TPACK framework I am not involved in teaching science education courses, so my role in hosting Jamie was primarily through assisting her with obtaining approvals and accommodation at the university and with making necessary contacts with the academics responsible for the relevant science education courses.

Jamie's approach to the project was very professional throughout. She arrived well prepared for the data collection work she had planned, skilfully negotiated the necessary adjustments to ethics documents to meet the requirements of both host and home institutions, and established very effective working arrangements with the academics and professional staff she worked with. The experience has been beneficial for all concerned and I expect that there is potential for future interaction that will benefit research at both institutions.

Participant: Amy Truitt, Portland State University

Australian research advisor: Dr Jeremy Brownlie

Australian host organisation: Griffith University

Title of research proposal: *The role of symbiotic bacteria in providing viral resistance in butterflies; the potential implications on conservation in the face of climate change*

Research description:
Wolbachia, a fascinating obligate endosymbiotic bacteria, is increasingly being investigated for a variety of reasons including the four reproductive phenotypes they present in their hosts: feminisation, male killing, parthenogenesis, and cytoplasmic incompatibility (Werren 1997; Werren et al., 2008). The most commonly observed phenotype in Lepidoptera causes cytoplasmic incompatibility (CI; Werren 1997 and Werren et al., 2008). While the mechanisms for CI are not well understood, it is clear that the sperm of infected males are incapable of fertilising either the eggs of uninfected females or the eggs of females infected with a different strain of Wolbachia because development of embryos is inhibited unless the infected sperm combines with an egg infected with the same strain (Werren et al. 2008). The result of infection by this phenotype is a substantial reduction to the relative fitness of uninfected females and some Wolbachia strains significantly reduce the lifespan its host. Hence, Wolbachia is different in respect to many other symbionts that spread through host populations by enhancing the fitness of their host; Wolbachia can spread by reducing the fitness of its host. However, in some cases Wolbachia provides a direct fitness benefit to the host by providing viral resistance (Brownstein et al. 1998; Hedges et al. 2008; Brownlie & Johnson 2009).

Lepidoptera are susceptible to a suite of detrimental viral infections. Nuclear polyhedris virus (NPV) infects a broad range of Lepidoptera and has a very high mortality rate. Larvae ingest NPV occlusion bodies from either the scree of infected individuals or virus contaminated surfaces. NPV is extremely virulent, spreading rapidly between species (Smith & Xeros 1953). If an endangered or threatened butterfly population contracted an NPV infection, it is quite possible the population would be driven to extinction as a result of NPV. In addition to NPV, we will investigate whether Wolbachia induces protection against flock house virus (FHV). FHV is a pathogen well known to infect and replicate in a broad range of insects including Lepidoptera (Dasgupta 2007). There is a paucity of information regarding Wolbachia infection status of NPV and FHV infected butterflies, therefore, this study will attempt to fill gaps in the knowledge by determining whether Wolbachia is capable of conferring viral resistance to its butterfly host against NPV or FHV.

While much research has been conducted investigating Wolbachia-mediated viral resistance in several species of drosophila and mosquitoes, the universality of this effect (beyond Diptera) is unknown. To our knowledge, this would be the first study investigating bacteria driven viral resistance in butterflies. Therefore, by employing viral techniques and bacterial injection methods, this project seeks to discover whether Wolbachia confers viral resistance in butterflies and if so, to elucidate the effects on the hosts. Different strains of Wolbachia have been shown to confer varying levels of anti-viral protection in drosophila species (Osborne et al. 2009; Longdon et al. 2012).

Therefore, we will conduct experiments to determine if different strains of Wolbachia have more or less of an effect on its butterfly host's longevity. We will be using three butterfly species that are common and available as caterpillars at the time of the project.

Research activities:
Upon arrival to Griffith, Dr Brownlie and I discussed the difficulty of working with a lepidoptera species in the short period time I was to spend in his lab. The life cycle of lepidoptera and the timing of the experiment were not conducive to using a lepidoptera species for this experiment. Therefore, we decided to proceed with Drosophila melanogaster as a model system. While it has previously been shown that Wolbachia provide viral resistance in adult drosophila hosts, it has not been determined whether they provide viral resistance at the larval stage. Many insects contract viral infections at the larval stage, which led us to investigate whether Wolbachia would also provide anti-viral protection during larval development. To conduct this experiment I first practiced microinjection techniques on drosophila larvae injecting them with PBS. Once I obtained a 95 % post injection survival rate, I began to inject larvae with the Drosophila C Virus (DCV). I injected a Wolbachia negative fly line as a control and two fly lines infected with different Wolbachia strains for the experiment. Wolbachia positive flies were infected with either wMel or wMelpop. Larvae were injected with volumes of 2.3 nl, 4.6 nl, and 9.2 nl at a concentration of 0.84 viral particles per nanoliter. Vials were set up as follows for each injection volume:

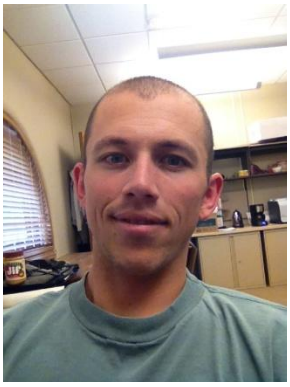
20 uninfected larvae per vial x 2 with PBS
20 uninfected larvae per vial x 2 with DCV
20 wMel larvae per vial x 2 with PBS
20 wMel larvae per vial x 2 with DCV
20 wMelpop larvae per vial x 2 with PBS
20 wMelpop larvae per vial x 2 with DVC

In addition to learning microinjection techniques, I was trained in quantitative polymerase chain reaction (qPCR) techniques.

Perspective of research after the program:
While the results from the experiment are inconclusive due to the duration of the experiment and malfunctions with the incubators, preliminary results from this experiment were a bit surprising. We had originally predicted that the wMelpop lines would exhibit increased viral resistance as compared to the wMel lines. However, based on this small study, it appears as though the wMel lines confer increased viral resistance as compared to wMelpop. To our knowledge this is the first study investigating Wolbachia's abitlity to confer viral resisitance in larvae, as all of the previous studies have injected viruses into adult flies. Therefore, there are several possibilities for these results. It may be that the titre levels of wMel and wMelpop are different at the larvae stage, with wMelpop over replicating and compromising the host's immune systems and inhibiting recovery. It is possible that wMel and wMelpop localise in different organs in the larvae, which could be potentially have a strong effect on immune system function and the ability of Wolbachia to inhibit viral replication. Additional experiments and viral injections could potentially yield interesting results that may influence both insect pest biocontrol protocols as well as vector disease control methods.

Although I was unable to conduct the originally proposed research project, I plan to conduct the experiment in the near future. My perspective remains steadfast that it is an important question to answer. I value the training provided by Dr Brownlie during my visit to his lab. I look forward to working with the many scientists I met in Australia and am excited to begin the research as soon as possible.

Australian advisor's remarks:
It was an absolute pleasure to have Amy join my research group for just six weeks. I was concerned about what could be achieved in such a relatively short period of time, however I have come to realise that the scheme allows students the opportunity to learn techniques, work, think and reflect on their projects and establish an international network. In all facets, Amy has excelled. She quickly learnt a number of techniques that will support her future research projects this year, as well as determining that some future experiments initially planned to be conducted in remote Central America may not be feasible. Amy attended the annual general conference of the Genetics Society of AustralAsia, where she actively networked with a range of local and international researchers. Pleasingly one of these connections has led to a Fulbright Fellowship application that would allow her to continue her research at Macquarie University. She also met with other world-leading research groups at Monash University and The University of Queensland during her time at Griffith University. In addition to Amy learning techniques and establishing a network, she brought invaluable insight and advice on projects and issues within my research group, in some cases providing a mentoring role for the junior students. To that end, I, and others in my research group and within the department, have learnt from Amy just as much as she has learnt from us.



Participant: Benjamin VanderJagt, Ohio State University

Australian research advisor: Dr Arko Lucieer

Australian host organisation: University of Tasmania

Title of research proposal: *Remotely measuring snow depth with an unmanned aerial vehicle (UAV)*

Research description:
Snow is an extremely important hydrologic variable in many areas of the world, and thus there is significant interest in developing methods to accurately quantify the amount of snow over large spatial areas, with little human effort. While there are existing satellite methods dedicated towards remote snow measurement, they suffer from coarse measurement resolution, and the accuracy of snow retrievals from such measurements is typically poor, especially in areas with complex terrain (such as mountains). Unmanned aerial vehicles (UAVs) provide an interesting solution to this problem. Specifically, they provide high resolution measurements, while simultaneously requiring little to no human effort. Therefore, the goal of this EAPSI fellowship was to make the first remote measurements of snow depth using an unmanned aerial vehicle with low cost sensors.

Research activities:
The first three weeks were spent assembling the UAV, mounting the sensors, conducting test flights and datasets, and waiting for snow to fall. The sensors included a digital camera, a laser scanning system (also known as LiDAR), and an on-board navigation system. Southern Tasmania received a large snowstorm in early July, and we were able to collect an excellent dataset to test our methodology. The snow surface was measured using reflected laser pulses which after subsequent processing provide a three dimensional surface. After the snow melted, we measured the ground surface using reflected laser pulses, produced another 3D surface, and differenced the two surfaces to produce an effective snow depth, at centimetre level resolution.

Perspective of research after the program:
Through the EAPSI fellowship, I was not only able to conduct state of the art research, but I also gained confidence in my own scientific abilities through frequent encouragement and support from my Australian colleagues. They were very accommodating, and provided excellent feedback on many of the ideas which I proposed. I now have a network of Australian collaborators, as well as other international colleagues, whom I met during my stay in Tasmania.

Australian advisor's remarks:
Ben's visit was a valuable experience for us. Ben was very enthusiastic about the project and showed great initiative and drive. During his stay here he has been very productive. We had an opportunity to go out in the field together and operate our UAV prototype. It was a good opportunity for us to test a new UAV airframe and to carry a laser scanner and DSLR camera simultaneously. Ben's visit gave us the opportunity to test the operation and data collection capacities of the prototype. Initial data analysis has already demonstrated that the project has been successful. We will have to go back to the study site in early Spring to collect more data when the snow has melted. This will give Ben

the opportunity to write up the experiments in a journal paper. It's the first time that anyone has collected LiDAR data of snow depth from a UAV.

Ben adjusted very quickly to a new environment and he fit very well into our research group. It was a pleasure to interact with him both professionally as well as socially during coffee and lunch breaks. In the last week Ben gave a presentation to summarise his research results. He is an excellent communicator and clearly explained and demonstrated his innovative ideas. I look forward to a continued collaboration and wish him all the best for the future.