School of Agriculture, Food & Wine

Summer Scholarship Projects 2018/2019

Biometry & Bioinformatics

Entomology & Plant Pathology

Project Title: *Pollinator diversity of lucerne (Medicago sativa) production areas of South Australia*

Supervisor: Dr Katja Hogendoorn and Dr Scott Groom
E-mail: katja.hogendoorn@adelaide.edu.au, scott.groom@adelaide.edu.au
Phone: 8313 6555
Location: Waite Building, Waite Campus. Keith and surrounding areas (~2.5hr from Adelaide).

Brief Project Outline:
The European honeybee (*Apis mellifera*) represents the predominant managed pollinator in Australian agriculture. However, a large proportion of the pollination required for crop production is provided free-of-charge by unmanaged species including feral honeybee colonies. In the lucerne production areas surround Keith in South Australia, this is especially true where established *Eucalyptus* trees are common and typically contain hives in their hollows. But the arrival of the parasitic *Varroa* mite in Australia, and its associated viruses, is largely expected to eliminate these feral honeybees. To mitigate some of this loss in pollination, we can look to ensure the health of the remaining pollinating species populations. But our understanding of exactly which species contribute to lucerne pollination is limited as is what resources they require outside of crop flowering periods. This project will look to identify native species of pollinators that contribute to lucerne pollination and highlight floral species of the surrounding landscape that likely support their persistence outside of crop flowering.
Techniques/Skills Learnt:

- Bee taxonomy and systematics
- Plant and pollen identification
- Slide preparation and microscopic examination
- Insect tissue processing and DNA extraction

Farming Systems

Food & Nutrition

Plant Biology & Biochemistry

Project Title: *Design of biomimetic coatings to understand plant-pathogen relations*

Supervisors: Dr. Bryan Coad and Dr. Alan Little
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Phone: 08 8313 7260
Location: Level 4, Wine Innovation Central building

Brief Project Outline:
Plant fungal pathogens have evolved highly sophisticated ways to infect crops and therefore are a threat to global food supply. On surfaces such as leaves, they first adhere to the surface and, interestingly, seem to know how to grow directionally towards ideal locations for infection before beginning surface penetration. If it were possible to better understand how the fungus senses and responds to the physical and chemical cues present on leaf surfaces, then we could develop strategies for interrupting infection, or develop plants which prevent adhesion or conceal inductive cues.
We propose that artificial surfaces can be constructed to model natural leaf surfaces. By designing surfaces with well-defined chemical and physical properties to which the fungus can respond, we will be able to understand the essential triggers for infection. Additionally, studying the adhesion on surfaces will allow us to understand how secreted chemicals prepare the surface before infection. The overall aim is to replicate essential components of the leaf and assemble these into a biomimetic model.
The goal of this research project is to make biomimetic surface coatings and investigate their biological response. This will involve using surface coating methods on materials such as glass slides, and to visualise the fungi using microscopy. This will provide an opportunity to learn about novel polymerisation techniques, characterisation of surfaces using surface analysis, and to visualise their biological effect.

Techniques/Skills Learnt:
- Surface coating techniques
- Surface analytical techniques
- Microscopy

Research Area: Biomaterials, interface science, bio-interfaces, plant-pathogen interactions.

Project Title: *Fungal penetration resistance in barley: development of a high-throughput screen.*

Supervisors: Dr. Neil Shirley and Dr. Alan Little
E-mail: alan.little@adelaide.edu.au
Phone: 08 8313 7260
Location: Level 4, Wine Innovation Central building

Brief Project Outline:

In plants, the cell walls are one of the first lines of defence protecting the cell from successful invasion and are a major factor in basal host resistance against fungal pathogens. As a defence response, plants reinforce the cell wall near the site of penetration by producing a dome-shaped apposition (papilla) between the epidermal wall and the plasma membrane. The polysaccharide composition of papillae that have been effective in preventing penetration by *Blumeria graminis* f. sp. *hordei* (*Bgh*) are traditionally believed to contain callose as the main polysaccharide component. However, recent evidence presented by our group demonstrated that effective papillae that are successful in preventing the penetration attempts of *Bgh* contain significantly higher concentrations of callose, arabinoxylan and cellulose (Chowdhury *et al*., 2014).

The current methods utilised for screening a cultivar's susceptibility to fungal infection involves standard disease resistance ratings by macroscopic and microscopic assays. This is time and labour intensive with long times required to generate symptoms on the leaves. The results can also be inaccurate due to the inherent variability of a subjective disease rating scale. This project aims to develop a quick and robust PCR method for quantitating the relative susceptibility of a barley cultivar to penetration by the powdery mildew causal agent, *Blumeria graminis* f.sp. *hordei* (*Bgh*). Once developed the assay will be utilised in a screen of barley germplasm and genetic analysis of potential resistance loci.

Techniques/Skills Learnt:

- Fungal infection assays
- RNA extraction
- Quantitative real time PCR

Project Title: *Genomic analysis of fungal nucleotide sugar interconverting enzymes.*

Supervisors: Dr. Julian Schwerdt and Dr. Alan Little
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Phone: 08 8313 7260
Location: Level 4, Wine Innovation Central building

Brief Project Outline:

The fungal cell wall is perhaps the most ideal target for the treatment of fungal pathogens. The fungal cell wall represents a considerable metabolic investment as it accounts for 15–30% of the cellular biomass. It plays such a momentous role to survival and maintaining homeostasis that up to 20% of genes in the fungal genome are associated with cell wall biogenesis. The enzymes and signal transduction pathways that govern the synthesis of these cell wall components are prime targets for antifungal drugs. Knowledge of the cell wall composition and its biosynthesis will allow more targeted and tailored approaches towards disease control.

To date, only a small percentage of fungal cell walls have been characterised. The ability of fungi to generate the necessary sugar nucleotide substrates for the synthesis of various cell wall components is determined by the presence of the nucleotide sugar interconverting enzymes. This project aims to characterise the distribution of each nucleotide sugar interconverting enzyme family across the available fungal genomes that have been fully sequenced. In doing so, we will generate a predictive map of what sugars each fungal species is capable of making and potentially incorporating into its cell wall.

Techniques/Skills Learnt:

- Bioinformatic analysis
- Cell wall biochemistry
- Fungal pathology

Project title: Accelerating biological discovery through Artificial Intelligence

Supervisors: Matthew Gilliham, Gustavo Carneiro, Rakesh David

Project outline:

The project aims to develop a computational platform that uses Artificial Intelligence (AI) to analyse scientific literature and integrate biological data from thousands of published studies. In our previous work, we applied a recursive neural network (RNN) to natural language processing of published scientific literature and demonstrated that RNN can successfully predict relationships between biological entities with high degree of accuracy (90%).

The current project aims to further develop the pipeline by optimising keys steps in the workflow which include entity extraction from scientific papers published in various file formats and automated annotation of biological entities and their relationships. Most biological databases rely heavily on expert curators in the field to manually extract and store data from the publications, making the process time-consuming and affecting scalability. Here, we will develop scripts for automatic annotation and in doing so address a key step in the processing of the training and testing data for the network classifier model.

The interdisciplinary project brings together biology labs across UA Faculties and Schools, expertise in AI from the School of Computer Science (CS) and an international industry partner with a proven track record in cognitive-based computing systems. The student undertaking the project will be jointly supervised by The Australian Centre for Visual Technologies (ACVT) at the School of CS and ARC Centre of Excellence in Plant Energy Biology at the UA School of Agriculture, Food and Wine (AFW).

Please contact A/Prof Matthew Gilliham (matthew.gilliham@adelaide.edu.au) (School of CS) to discuss the opportunity further.

Skills learnt:

- Cloud-based analytical skills in AI and NLP techniques
- Python based bio-curation techniques
- Interdisciplinary bioinformatics skills in literature retrieval and text mining

Plant Genetics, Genomics & Breeding

Project Title: *Understanding xylan degradation in barley plant cell walls*

Supervisors: Dr Natalie Betts & Dr Helen Collins
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Location: Bulone GlycoScience, Wine Innovation Central Building, Waite Campus
Supervisor research profiles:
https://researchers.adelaide.edu.au/profile/natalie.betts
https://researchers.adelaide.edu.au/profile/helen.collins

Brief Project Outline:

The cell wall is a defining characteristic of plant cells. It confers structural strength, provides protection against infection, and stores reserve carbohydrates. Recently, the barley genome has been sequenced, which has helped to identify many new genes involved cell wall metabolism throughout the plant. Many of these genes exist in large families, presumably with similar functions in different plant tissues. We have begun investigating the genes encoding proteins that degrade arabinoxylans, a key component of the plant cell wall.
This project will examine a new barley tissue collection to assess:

1. Xylanase gene expression in grain tissues during germination and development via quantitative PCR and analysis of existing RNAseq datasets
2. Enzyme activity in germinating grain and seedling tissues using biochemical assays.
3. How gene and enzyme data relate to changes in xylan content as determined via immuno-microscopy.

Results from this project will likely be included in a publication in 2019.

Techniques/Skills Learnt:

- Planting and collection of plant material
- Possibly RNA extraction and cDNA synthesis
- qPCR and/or RNAseq analysis
- Biochemical enzyme assays
- Immuno-histochemical microscopy

Waite Undergraduate Summer Research Scholarship Project

Project Title: *Improving pathogen resistance in barley plants*

Supervisors: Drs Natalie Betts, Helen Collins & Alan Little
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Location: Bulone GlycoScience, Wine Innovation Central Building, Waite Campus
Supervisor research profiles:
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https://researchers.adelaide.edu.au/profile/helen.collins
https://researchers.adelaide.edu.au/profile/alan.little

Brief Project Outline:

Barley is the fifth largest crop in the world. It is used for human food, animal feed and malting and brewing. Numerous genes are involved in plant growth and development, from the initial stages of grain germination through to the senescence of the plant prior to harvest.

This project will focus on grain and leaf resistance to pathogen attacks, specifically investigating:

1. The location and amounts of anti-microbial hordatines in grain tissues during germination using a newly developed chromatographic technique
2. The timing and roles of jasmonate hormones in directing plant resistance
3. Possibly, the effect of foliar application of hordatines on barley leaf resistance to *Blumeria graminis* infection
4. Genes that drive barley resistance, with the overall aim to find breeding targets using existing RNAseq datasets developed from barley grain tissues during development and germination. Genes of interest can be further explored using quantitative PCR (qPCR).

Results from this project will likely be included in a publication in 2019.

Techniques/Skills Learnt:

- Experimental design
- Plant tissue harvesting and sample preparation
- High performance liquid chromatography (HPLC)
- Possibly, barley plant growth, infection, and subsequent isolation of epidermal layers
- Correlation of results with gene expression from existing RNAseq datasets

Depending on results, primer design for quantitative PCR analysis

Project Title: *"Using imaging techniques in plant science – working on the Arabidopsis and rice CCC project"*

This project is open to 1 – 2 students

Supervisor: Stefanie Wege
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Phone: +61 8 8313 6665
Location: PRC, level 2, room 2.26a

Brief Project Outline:

CCC proteins are large (~1000 amino acids in length) membrane integral proteins of yet unknown function in plants and other organisms. Plants without functioning CCC proteins (knockout plants) have a severe phenotype: they are dwarfed, show extremely low fertility, complete loss of apical dominance, deformed leaves and alterations in seed coat composition. During the summer scholarship project, we will investigate the *Arabidopsis thaliana* (model plant) *ccc* knockout mutant further, and compare new findings to the *ccc* knockout phenotype in the crop rice (*Oryza sativa*). This will involve growing the plants in a range of different growth conditions and documenting and quantifying observed phenotypic aspects. Documenting of phenotypes will be done by a range of imaging techniques; mainly by microscopy, including fluorescence based microscopy like confocal LSM. The goal is to better understand the function of the CCC proteins in plants and to ultimately use this knowledge to design strategies for crop improvement.

Techniques/Skills Learnt:

- Scientific imaging, including advanced microscopy
- A large variety of different Arabidopsis and rice plant growth methods, including *in vitro* and pot/soil based methods
- How to transform a complex observation into a measureable output (e.g. from image to diagram)
- Basics in ImageJ and R

Project Title: *How do cyst nematodes hijack plant roots?*

Supervisor: Diane Mather

E-mail: diane.mather@adelaide.edu.au
Phone: 8313 7156
Location: Plant Genomics Centre

Brief Project Outline:

Nematodes (roundworms) are almost everywhere! It has been estimated that they account for about 80% of the individual animals on earth. Some are free-living and some are parasites. Cyst nematodes are parasites of plants. They invade plant roots and take over plant cells to form feeding sites. They 'trick' their host plants into providing a steady stream of nutrients. How do they do this?

We've been spying on these worms with a confocal microscope and now we think we've discovered some of their secrets. We have developed new hypotheses and are planning new experiments.

In this project, you'll have the opportunity to help us solve the mystery of how these tiny animals make themselves at home inside plant roots.

To find out more, please contact Diane by email.

Techniques/Skills Learnt:

- Inoculating seedlings and growing them a hydroponic system
- Preparing root tissue for microscopy
- Microscopy and image analysis

Project Title: *Molecular plant breeding*

Supervisor: Diane Mather
E-mail: diane.mather@adelaide.edu.au
Phone: 8313 7156
Location: Plant Genomics Centre

Brief Project Outline:

Do you like genetics? Would you like to learn how genetics is applied in plant breeding?
Our lab develops DNA markers for wheat, barley, chickpea and almond. We're interested in genes that help plants resist pathogens and parasites and in genes that improve grain and nut quality. Plant breeders use our markers to develop improved varieties for farmers and consumers.
In this project, you can be involved in one or more of our marker development efforts. You will help us solve some genetic puzzles and develop molecular tools for use in the plant breeding industry.
To find out more, and to discuss a specific project that suits your interests, please contact Diane by email.

Techniques/Skills Learnt:

- Using robots to extract and analyse DNA
- DNA sequence analysis
- Genetic mapping

Soil Science

Project Title: *Low-tech determination of soil water holding capacity*

Supervisor: Ron Smernik
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Phone: 8313 7436
Location: Prescott Building 304, Waite Campus

Brief Project Outline:
The ability of a soil to retain water that is accessible to plants is perhaps its most important attribute in an Australian agricultural context. From a soil physics perspective, plant available water is usually defined as the water held at matric suctions between 10 kPa (field capacity) and 1500 pKa (wilting point). Although these are routinely measured in soil physics labs, determination of wilting point water content in particular is time-consuming and requires expensive equipment. The aim of this project is to develop low-tech options for estimating plant available water that are cheap and quick, and can be used on-farm.

Techniques/Skills Learnt:
- Soil sampling
- Soil physical analyses, including particle separation and water content determination

Viticulture & Horticulture

Project Title: *Investigations with Yam Daisy*

Supervisor: Dr Kate Delaporte
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Phone: 8313 7405 or 0427-394-240
Location: Waite Precinct and PRC

Brief Project Outline:
We are looking at starting a small research program on the Australian native plant, Yam Daisy, **Microseris lanceolata.** The program will look to expand our current knowledge and understanding of the cultivation requirements of Yam Daisy for large scale production. It will also provide an opportunity to investigate the nutritional and bioactive potential of the tubers and also to piece together and expand on the life history knowledge and develop a breeding and selection matrix for specific characteristics.
Ultimately, we seek to develop new varieties with high nutritional/bioactive values that can be grown well under certain conditions to support a new indigenous food industry.

Techniques/Skills Learnt:

- Literature review: searching for and critical analysis of published literature to document known knowledge
- Experiment design: with guidance, develop a series of hypothesis and the experiments to test them.
- Experiment management: with guidance, devise experiments, manage them through set up and maintenance, data collection and analysis of results, discussion etc. Field or Glasshouse.
- Possible controlled pollination if plants are flowering during this period

Wine Science