Biological control of crop pathogens using predatory bacteria

Contact Professor David Whitworth for more information: dew@aber.ac.uk

Pathogenic organisms are a threat to food security and sustainability as they reduce crop yields and increase food spoilage. Due to the emergence of antimicrobial resistance (AMR), alternatives to chemical pesticides are increasingly sought to target and control those pathogens. Bacterial predators such as myxobacteria can be thought of as living antibiotics, as they are able to kill pathogens, potentially preventing disease of farmed food (whether animal, plant or insect).

This experimental project will investigate whether various myxobacterial predators can be used as a biological control to protect crops (e.g. tomatoes, crickets, …) from pathogenic microbes. Diverse experimental approaches are available and depend on your interests. We might optimise methods for applying myxobacteria, isolate novel predators, characterise the activity of their toxic secretions, and/or use genetic engineering to identify the genes responsible for their predatory activity.

Fungal entomopathogens emerging from locust cadavers

Isolation and characterisation of novel predatory bacteria

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With the problems of antimicrobial resistance (AMR), alternatives to antimicrobials are in great demand. Potential alternatives to antimicrobials include the use of predatory bacteria, which are being investigated as 'living antibiotics'. This experimental project aims to isolate novel predatory organisms from the environment. Once isolated, bacterial strains could be characterised using a variety of methods, including microscopy, physiological assays, phylogenetic methods, predation assays, etc. Particularly novel strains could be further characterised for description as new species, for example via genome sequencing and deposition in culture collections.
If you wanted, we might also start to investigate the antimicrobial activity of the new predators, trying to identify new enzymes, toxins and/or natural products.

The predatory bacterium
Herpetosiphon llansteffanensis

Bacterial genome evolution

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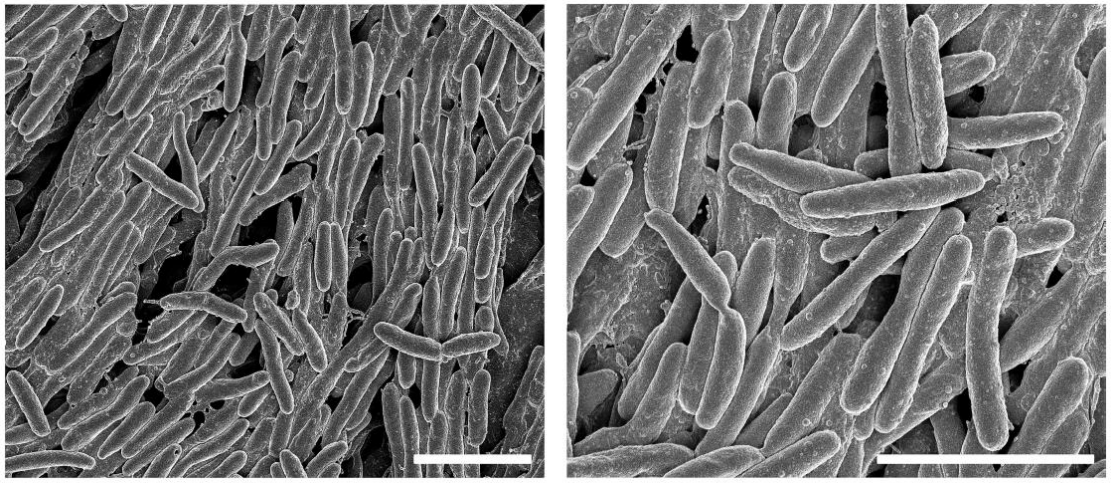
The ability of bacteria to evolve resistance and spread resistance genes between populations has led to the current crisis of AMR (antimicrobial resistance). This project investigates the processes associated with genome evolution in predatory myxobacteria and could be either experimental and/or computational, depending on your interests.

Experimentally, we might measure the rates of horizontal gene transfer and DNA uptake, monitor the amelioration of newly acquired DNA as it adapts to a myxobacterial host, promote genome streamlining under selection for fast growth, or develop methods for genome editing.

Computationally, we might assess the presence and transfer of AMR genes in myxobacterial strains, investigate the evolution of gene clusters producing novel natural products, or investigate the spatial organisation of the core vs accessory pan-genome.

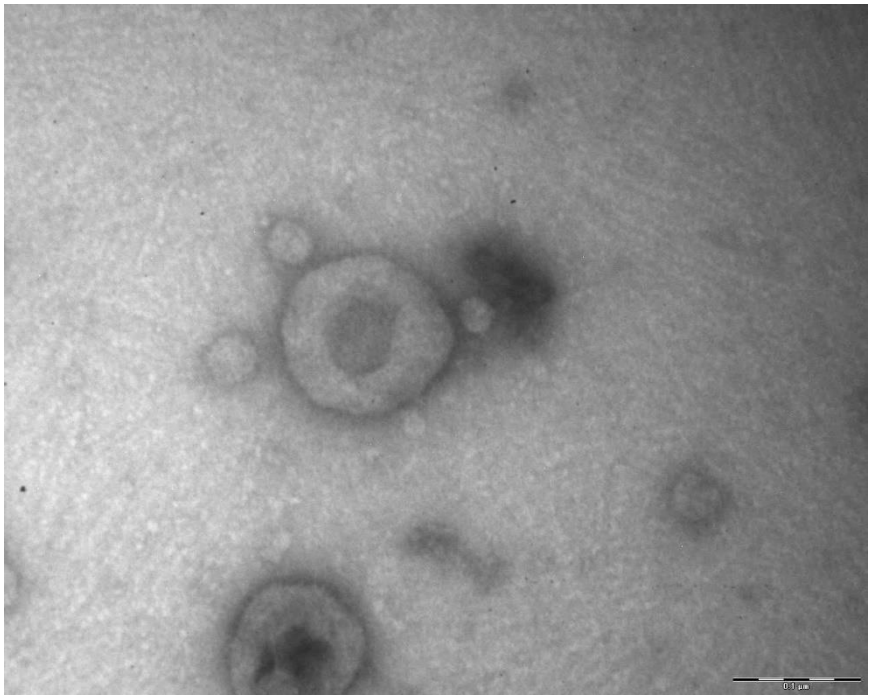


Electron micrographs of predatory *Corallococcus spp*.

Understanding helminth extracellular vesicles

Contact Dr Russ Morphew for more information: rom@aber.ac.uk

Parasitic helminth extracellular vesicles (EVs) are enriched with pathogen molecules, which could potentially be utilised for improved control of helminths. Helminth EVs are now known to function in numerous ways such as promoting or inhibiting host immunity, transporting molecules to recipient cells and even to detoxifying anthelmintic drugs. Therefore, understanding EVs from helminth parasites will aid our understanding of host parasite interactions whilst potentially leading to novel control options such as vaccinations or improved diagnostics. Projects in this area will develop skills in classical parasitology, EV purification and analysis, and a variety of omic technologies such as proteomics and peptidomics.



Invasive Chinese mitten crabs as food and behavioural enrichment for zoo animals

Contact Dr Joe Ironside for more information: jei@aber.ac.uk

The Chinese mitten crab *Eriocheir sinensis* is one of the most damaging invasive non-native species in Europe. In the River Dee, North Wales, efforts are being made to trap mitten crabs as they migrate downstream to breed. This raises the problem of how to dispose of the captured crabs in a sustainable way. As invasive non-native species, they cannot be sold commercially. This project would investigate whether mitten crabs trapped in the River Dee are suitable to feed to zoo animals, in terms of contamination and food quality. It might also be possible to investigate whether whole, dead mitten crabs provide behavioural enrichment to zoo animals who would normally eat crabs (e.g. Asian short-clawed otters). Students would gain experience in laboratory analysis of food quality and behavioural enrichment studies of zoo animals.

Origins of invasive non-native species

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Discovering the origins of new introductions of invasive species in Wales is a research priority, as it can inform efforts to control the spread of non-native species through biosecurity measures. This project will use population genetic methods to investigate the origins of recently established priority invasive non-native species in Wales. These may include (for example):

American slipper limpet in Cardigan Bay

Chinese mitten crab in the River Conwy

Carpet sea squirt in Milford Haven

Students will gain experience in molecular laboratory work and may also have opportunities for marine and/or freshwater fieldwork.

Toxicity of mercury to the fungal symbionts of leaf-cutting ants

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The use of mercury in artisanal gold mining is a major source of pollution in tropical rainforests. Leaf-cutting ants are among the most abundant and ecologically important organisms in neotropical rainforest ecosystems. They depend entirely upon symbiotic fungi which they farm in underground nests and feed with leaves cut in the surrounding rainforest. This project will aim to establish whether the fungi cultivated by leaf-cutting ants are harmed by exposure to the levels of mercury encountered in rainforests adjacent to artisanal gold mines. Students will gain experience in laboratory culture of fungi and ecotoxicological methods

Potential drugs from Seaweeds

Contact Dr Ifat Parveen Shah for more information: ifp@aber.ac.uk

As many as 40 to 50 % of drugs currently used to treat human maladies are derived from terrestrial organisms. However, there is a requirement to encompass even greater biological biodiversity to tap into novel biochemical variation which will include many new compounds with pharmaceutical potential. The sea represents an almost untapped resource as it contains over 80 % of all life forms on Earth.

Preliminary research on Bladder Wrack (*Fucus vesiculosus*) has identified a range of (poly)phenolics. These often have antioxidant and UV-absorbing properties which are recognised by the pharmaceutical, nutraceutical and cosmetic industries. The novelty of seaweed species opens up the possibility of new IP, process developments and product differentiation. In this project, we propose to begin to assess the pharmaceutical potential of four locally sourced seaweed species; Bladder Wrack (*Fucus vesiculosus*); Knotted wrack (*Ascophyllum nodosum*), Toothed Wrack (*Fucus serratus*) and Gutweed (*Enteromorpha intestinalis*). The student will extract natural products from seaweed and extensively characterise these by HPLC, MS and NMR. The extracts will be assessed for anti-helminthic and anti-inflammatory activities. Extracts will be fractionated and defined anti-helminthic and anti-inflammatory activity related to discrete biochemicals.

Innovation and cognition of invasive and native crustacea

Contact Dr Sarah Dalesman for more information:
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Innovation and cognitive ability are thought to be key traits associated with successful invasion potential of species, the ability to adapt behaviour to access new resources and new environmental challenges. However, work to date has focused on vertebrates, including birds and mammals. The proposed project will compare these traits in native and invasive crustaceans. The student will gain experience in experimental design, laboratory work, data analysis and presentation in comparative cognition.

Could snails be sentient?

Contact Dr Sarah Dalesman for more information:
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There is a growing interest in the potential for sentience in invertebrates, which may impact on how we treat these animals from a welfare perspective. Cephalopods are currently protected in research under home office regulation, and decapod crustaceans have recently been recognised as sentient by the U.K. government. Gastropods are a very large phylogenetic group, used in both farming and research; however, we lack the evidence needed to determine whether this group could be considered sentient. The student will have the opportunity to explore areas of interest within this general area, for example if we can demonstrate support for 'pain' in gastropods, or whether they are capable of more complex cognitive processes generally assumed to be indicators of sentience.

Towards a companion diagnostic for breast cancer screening.

Contact Professor Luis Mur for more information: lum@aber.ac.uk

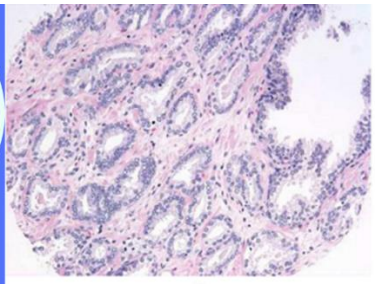
The current UK breast cancer screening has been very successful. In 2022-23 it screened 64.6 % of 1.93 million women for breast cancer by mammography and (in England) detected 18,942 cancer cases. Despite the considerable successes of the current breast screening modalities (e.g. mammogram, magnetic resonance imaging and ultrasound) in detecting the breast cancer, they also have their own limitations.

As part "Omics Approaches to Improve the Diagnosis, Management and Treatment of Breast Cancer" clinical study which has been ethically approved for 10 years (BECA, IRAS ID: 306872, Rec ref no.:21/SC/0411), (https://www.clinicalhubaberystwyth.com/beca) has been working with consultant mammographers who have highlighted how the current imaging tools can provide overlapping features observed in both benign (non-cancerous) and malignant (cancerous) disease that could result the false positive or false negative diagnosis.

BECA has identified of novel biological indicators (also known as biomarkers) in urine that could provide an early and accurate diagnosis of breast cancer. These could be used in a companion diagnostic test to improve the detection of malignant growths in breast cancer.

The BECA biomarkers could also be used be screen for breast cancer in low-risk women. The risks of breast cancer rise in post-menopausal women so that screening starts when women reach 50 years of age. However, there is a sizeable population of younger women (~18% of all cases in 2016-18) who develop breast cancer. There is a requirement to encourage younger, lower risk women to be tested. Our BECA biomarkers could be developed into a cost-effective test that could be used to screen younger women.

There are opportunities for master projects to help develop our understanding of changes in women at the earliest stages of breast cancer development and also changes seen with different types of breast cancer.



Developing a breakthrough technology for Prostate Cancer Screening

Contact Professor Luis Mur for more information: lum@aber.ac.uk

Globally, prostate cancer (PCa) affects over 1.4 million men, and causes over 375,000 deaths every year. The problem is set to get worse as the number of people with PCa is set to double by 2040 [1]. Presently, identifying patients with PCa depends on men coming forward to ask their doctor for testing. Testing usually involves determining the levels of prostate specific antigen (PSA) in blood, followed by a MRI scan and then prostate biopsies. One problem is that PSA-test gives a high number of false positives which can lead to unnecessary investigations, biopsies and treatment [2]

Aberystwyth University has established the OSCAR clinical study which is focused on defining key changes ("biomarkers") in the urine of men linked to PCa. Currently, 12 hospitals are recruiting to the OSCAR study thar are located across Wales and England. OSCAR has ethical approval to recruit 10000 men on to the study. This makes OSCAR the largest study in the UK that is focusing on screening urine for PCa biomarkers.

OSCAR has already found biomarkers that have far superior accuracies that the PSA test. The OSCAR biomarkers are better at detecting higher grade (more aggressive) PCa compared to healthy men. The biomarkers also better at distinguishing between benign prostate growth (benign prostatic hyperplasia [BPH]) from PCa.

There are opportunities for master's students to join scientists on the OSCAR study to test how the biomarkers change when the cancer is treated and what this can tell us about the underlying mechanism of tumours that respond well or badly to a particular treatment.

[1] James N, Tannock I, N'Dow J, Feng F et al Published Online April 4, 2024 https://doi.org/10.1016/S0140-6736(24)00651-2

[2] https://www.pulsetoday.co.uk/news/clinical-areas/cancer/six-different-proposals-for-prostate-cancer-screening-under-consideration/#:~:text=He%20said%3A%20'All%20PSA%2D,study%20from%20University%20College%20London.

Environmental DNA survey of freshwater snails on farmland to assess the risk of liver fluke transmission in areas where *G. truncatula* is absent.

Contact Dr Rhys Jones for more information:
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Galba truncatula is the main intermediate snail host of liver fluke *(F. hepatica*) and it is assumed that if it is absent from an area then liver fluke cannot transmit. Our current research shows that this snail is absent from areas commonly assumed to be fluke transmission sites by farmers which indicates that fluke transmission risk may be lower than anticipated on certain farms. However, other snails, including *O. glabra* and *R. balthica* can also transmit fluke, although their presence on farmland is somewhat uncertain. Using an eDNA metagenomic analysis approach, we will aim to identify which other amphibious snails are present on Welsh farmland with focus on those that may transmit fluke.

Balancing veterinary disease control with biodiversity: Surveying amphibian presence in liver fluke infection sites via environmental DNA metagenomic analysis.

Contact Dr Rhys Jones for more information: raj22@aber.ac.uk

As chemical control of liver fluke (*F. hepatica*) becomes increasingly difficult due to drug resistance and climate change, there is growing interest in using land management strategies to limit fluke infection opportunities. However, these strategies which may include draining, fencing, tree planting or avoidance of grazing may impact other wildlife species that also inhabit these sites. However, fluke infection risk areas are poorly defined and there is limited knowledge of their value to wildlife species and overall biodiversity. Using an eDNA metagenomic approach this project will identify which amphibian (or other groups) species are commonly present in such sites which will inform of how these areas should be managed in future.

Verification of potential genetic regulators of seedpod size in model plants and crops identified by machine learning (ML) programme DeepCanola.

Contact Professor John Doonan for more information:

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Background

Seed pod size has a critical relationship with yield in the UK's largest oil crop, *Brassica napus*, but is affected by temperature – and therefore climate change. The Lu and Doonan labs at Aberystwyth have developed the deep-learning program DeepCanola to automatically measure pod characteristics from images, which we have used on a GWAS experiment treated with different winter temperatures, and for which we have both genetic and transcriptomic data. This data presents several candidate genes for the control of this key trait: but are they real? To assess the accuracy of DeepCanola, we will analyse a selection of mutants in Arabidopsis and *Brassica rapa* – both identified from the GWAS experiment, and *a priori* targets known to modulate pod size and shape. These will be tested with DeepCanola, and for new targets, their molecular function characterised via standard molecular biology techniques, including transgenesis, qPCR, and protein [illegible] appropriate.

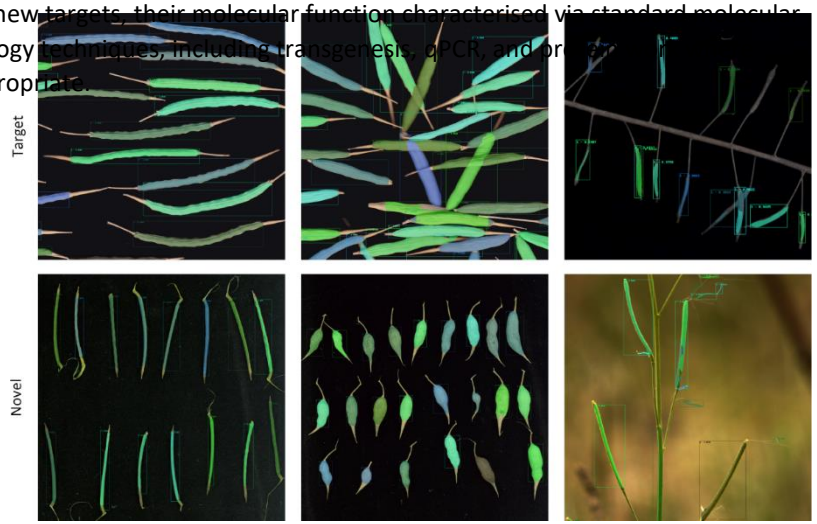

Figure 1. DeepCanola generalisation capability - Examples test images showing samples from varying domains from the target and novel species. From van Vliet, Atkins et al.

Aims

To identify candidate genes from GWAS, and assess their role in Arabidopsis and Brassica via analysis of mutants and transgenic analysis and comparison with known mutants with DeepCanola imaging. To molecularly characterise the function of identified targets.

Methodology, techniques and training

Transferrable: cloning (expression construct production), genotyping techniques (PCR and KASP), RNA extraction and high quality qPCR, fluorescent protein (confocal) microscopy, image analysis with DeepCanola. Depending on project progress, could include transcriptomics.

Plant specific: plant growth, genetics and mutant analysis of Arabidopsis models and *Brassica* crops. Production of transgenic Arabidopsis, phenotyping.

References

- DeepPod: a convolutional neural network based quantification of fruit number in Arabidopsis. Hamidinekoo *et al.* 2020. Gigascience. https://doi.org/10.1093/gigascience/giaa012
- Integrated Phenomics and Genomics reveals genetic loci associated with inflorescence growth in *Brassica napus. Williams* et al. 2023 BioRXiv. doi: https://doi.org/10.1101/2023.03.31.535149
- DeepCanola: Phenotyping Brassica Pods Using Semi-Synthetic Data and Active Learning. *Van Vliet, Atkins* et al., under revision to Computers and Electronics in Agriculture.

Lignocellulose degrading genes in fungi

Contact Professor Gareth Griffith for more information:
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A large number of fungal genomes have been sequenced in recent years. I have an interest in phenoloxidase genes which are important in the degradation of lignin, and in the defence of fungi against reactive oxygen species. Possible project areas include data-mining of the ca. 35 fungal genomes now available for genes involved in lignin and cellulose degradation.

Insect-fungus interactions

Contact Professor Gareth Griffith for more information:
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Insects are important vectors of fungal spores. We are investigating the way in which insects can mediated the dispersal of yeasts and other fungi in nature. Possible project areas include examination of insect populations on mushrooms, vectoring of yeast and fungal spores by insects, consumption of mushrooms by slugs.

Can fungal metabolites modify insect behaviour?

Contact Professor Gareth Griffith for more information:
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Secondary metabolites have very different effects on different animal species (e.g., theobromine in chocolate is toxic to dogs). Secondary metabolites in fungi may be toxic or psychoactive in humans but the effects of these compounds on other animals is less well -understood. this project will explore the effects of fungal metabolites on the behaviour of Drosophila melanogaster.

DNA barcoding of fungi

Contact Professor Gareth Griffith for more information:

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Many organisms can be difficult to identify based on morphological features alone. This project will use DNA extraction/PCR/DNA sequencing to identify fungi (choice of specific group is flexible). Such approaches can reveal cryptic speciation and sometime discover species new to science.

Spore survival in soil

Contact Professor Gareth Griffith for more information:
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Fungal spores deposited in soil often need to undergo a period of dormancy before germination and growth. In order to germinate at the appropriate time, fungal spores need to respond to environmental signals, notably external nutrient. The ability of fungal spores to survive in soil and to respond to nutrient stimuli will be examined using soil microcosms.

Lichens on Gravestones

Contact Professor Gareth Griffith for more information:

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Using historic photographs from 1970s, the diameter of lichen thalli (and thus growth rate over 40-year period) will be measured. Project requires car transport to reach field sites near Porthmadog

Indoor aerobiology

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Using simple air samplers, air spora in various indoor environments will be quantified and the abundance/diversity of fungal spores quantified. Comparisons will be made between difference room usage and may include farm buildings, horse stables etc.

Conservation management of grassland fungi

Contact Professor Gareth Griffith for more information:
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Waxcaps and other fungi found in nutrient-poor grassland habitats are a valuable and threatened component of European biodiversity, having declined drastically in abundance due to habitat loss. In order to be able to conserve these fungi more information is needed about their ecology, in particular what management regimes are conducive to their growth. This project will investigate the effect of different sward management regimes (e.g., hay cutting etc.) on the diversity of mushroom formation.

Effect of soil fungi on germination of seeds of invasive plants

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Seeds of many species of plant show differences in germination rate according to whether they are placed in sterile compost or native soils. It is believed that the presence of certain fungi are involved in mediating this phenomenon.

Investigating heat stress-induced breakdown of self-incompatibility in plants

Contact Dr Maurice Bosch for more information:
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Self-incompatibility (SI) is a key mechanism that prevents self-fertilization in many flowering plants, maintaining genetic diversity and reproductive success. However, environmental factors like heat stress can weaken SI, leading to unexpected self-fertilization. This project aims to investigate how elevated temperatures disrupt the SI response, focusing on the well-characterized *Papaver rhoeas* SI system. Specifically, it will examine how heat stress affects the interaction between the PrpS receptor and PrsS ligand, as well as key downstream signalling events, including Ca^{2+} signalling, reactive oxygen species (ROS) production, and programmed cell death (PCD) in pollen. Understanding these mechanisms is essential for predicting how climate change may impact plant reproduction and hybrid breeding strategies. The student will gain experience in controlled pollination experiments to determine the contributions of pollen and pistil to SI breakdown. The student will also carry out some cell biology studies to start evaluate the impact of increased temperatures to Ca^{2+} and ROS dynamics in pollen tubes. This research has important applications in crop breeding, fertility control, and climate resilience, providing insights into how SI breakdown could be managed to support sustainable agriculture.

Investigating the impact of environmental stress on forage grass cell walls and digestibility

Contact Dr Maurice Bosch for more information:
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Forage grasses form the foundation of UK livestock nutrition, but climate change is increasing the frequency of extreme weather events that can alter their growth and quality. A major factor influencing forage digestibility is the composition and structure of cell walls, which make up ~70% of plant dry weight. This project will examine how environmental stress affects cell wall integrity and digestibility, focusing on the role of reactive oxygen species (ROS) and oxidative cross-linking in stress-induced modifications. Understanding these changes is crucial for developing resilient forage crops that maintain nutritional value under variable climate conditions. The student will use fluorescent probes (DCFH-DA, Amplex Red) and confocal microscopy to track ROS accumulation in stressed plants, alongside spectrophotometric assays to quantify peroxidase activity and oxidative cross-linking. This research will provide valuable insights into how stress impacts forage quality, with implications for livestock productivity, sustainable agriculture, and climate adaptation strategies.