Closing the Door: Understanding the Role of cGMP Signalling in Plant Immune Defence Against Pathogen Entry

Supervisory team:
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Project description:
Stomata, the pores on leaf surfaces, are vital for regulating CO2 uptake and water loss, playing a key role in plant responses to environmental stresses. However, these openings also serve as entry points for pathogens, making them targets for bacterial diseases that threaten global food production. To defend against such invasions, plants have evolved immune strategies, including cell surface receptors that recognize microbial structures like bacterial flagella and molecules like glutamate, released from wounds caused by environmental factors or the pathogens themselves. These molecules, known as elicitors, trigger defensive responses such as stomatal closure, effectively sealing off the plant from further pathogen entry. This project investigates a novel pathway through which plants respond to these attacks, focusing on the molecular mechanisms of stomatal immune responses, crucial for enhancing agricultural sustainability and crop productivity.

Stomatal closure relies on intracellular cyclic guanosine monophosphate (cGMP) signalling, and recent studies have identified phosphodiesterase (PDE1) as a key enzyme in cGMP turnover, regulating this critical biological process. Preliminary findings suggest that PDE1 plays a significant role in immune signalling by influencing cGMP levels, which are crucial for both stomatal closure and immune response. We hypothesize that PDE1 affects plant immunity primarily through its role in regulating stomatal closure, but it may also have additional functions in immune signalling independent of this process.

This proposal aims to elucidate how cGMP signalling influences plant immunity and to determine its role in plant-bacterial pathogen interactions. The specific objectives are: 1) Elucidate the role of PDE1 in plant immunity, 2) Investigate the broader role of PDEs in plant immunity, and 3) Identify how bacterial pathogens manipulate cGMP signalling.

The student will conduct infection assays by transiently overexpressing PDE1 proteins in Nicotiana benthamiana to evaluate their role in conferring immunity. Synthetic genes for selected PDE1 proteins will be cloned into binary expression vectors for agroinfiltration, and the infected tissue will be monitored for bacterial growth. Proteins that significantly alter bacterial growth will undergo further testing, including the creation of inactive mutants to assess the necessity of protein activity. Additionally, the student will monitor immune responses such as stomatal aperture, ROS burst, and thermal response to immunogenic peptides. Phosphodiesterase activity assays will be established using fluorogenic substrates to analyse PDE activity. Finally, we will screen for reduced PDE activity in plants infected with different Pseudomonas syringae strains to uncover bacterial manipulation of cGMP signalling.

Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.