Seeing the big picture: novel imaging tools to study spatial coordination of signalling processes in plants and algae

Supervisory team:
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Please submit applications for this project to the University of Bristol

Project description:
Communication between cells is essential to coordinate the physiology of photosynthetic organisms. Multicellular plants must respond in a coordinated manner to sensory inputs from individual cells, whilst unicellular algae must also communicate to coordinate population responses such as defence against pathogens or predators. Current imaging tools enable us to study signalling at the single cell or population level, but struggle to combine the two.

This project will utilise new and exciting imaging technology to address the spatial coordination of cellular signalling by plants and algae. The Mesolens microscope (http://www.mesolens.com/) enables imaging of a large field of view at subcellular resolution, allowing us to examine how single cell responses contribute to the response of a whole population of cells. The MBA hosts one of only a very few Mesolens microscopes in the world, offering a unique opportunity to develop methodologies with this emergent technology.

Diatoms are unicellular algae that play a major role in marine ecosystems, contributing an estimated 20% to global photosynthesis. Calcium-dependent signalling processes allow diatoms to sense and respond to changes in their environment, such as nutrient availability, osmotic stress or the presence of toxic metabolites. We have recently shown that diatoms possess unique mechanisms for calcium signalling, including a novel class of calcium channels that are not found in other eukaryotes. The project will use Mesolens imaging, alongside other fluorescent imaging approaches, to examine cellular signalling in the model diatom Phaeodactylum tricornutum in response to a range of environmental stimuli. Transgenic strains expressing fluorescent biosensors for calcium and reactive oxygen species will be used to monitor the spatial coordination of these responses within a population, for example determining how cellular signals propagate following wounding of individual cells. Targeted gene knockout via CRISPR-Cas9 techniques will be used to identify the role of specific ion channels in these signalling responses.

The project will also examine the applicability of Mesolens imaging to the spatial coordination of signalling in land plants, focusing on the calcium-dependent signalling mechanisms that control the opening and closing of stomata. The extraordinary resolution of the Mesolens enables us to examine how signalling processes in individual stomatal guard cells are coordinated across an entire leaf.
The project will provide insight into the cellular mechanisms of signalling in plants and algae and aid the development of novel imaging methodologies. The student will receive comprehensive training in fluorescent microscopy, image processing, plant and algal physiology, and molecular genetic approaches.