

ONE SYSTEM

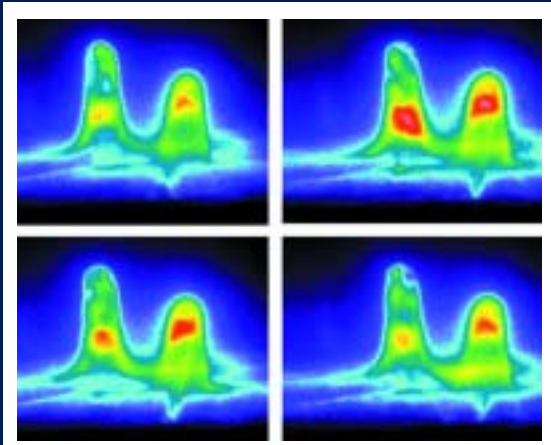
– two different relationships

A JIC combination of biological and mathematical approaches has provided a novel explanation for the mechanisms of multi-functionality in signalling pathways.

Plants have symbiotic relationships with micro-organisms, which benefit both partners. Leguminous plants, such as peas and beans, form nodules on their roots which house rhizobia, bacteria which are able to “fix” nitrogen. Many plants, including legumes, form another symbiotic relationship with a type of soil fungus, which helps the plants absorb nutrients, particularly phosphate. These arbuscular mycorrhizal fungi are very different to rhizobia, and produce very different reactions in the plants. Although both symbiotic relationships activate and use several of the same plant genes, it is only now that a JIC team, led by Giles Oldroyd and Allan Downie, have discovered how the one system can manage two different relationships.

Nitrogen-fixing rhizobia produce a chemical, known as Nod factor, which is detected by root hair cells in legumes. The legume root signalling pathway responsible for perception of Nod factor uses oscillations in calcium levels to transduce the signal in cells. The fact that several genes in this signalling pathway are also required for

mycorrhizal symbiosis suggested that mycorrhizal fungi were likely to activate calcium spiking in root hair cells. The researchers monitored calcium



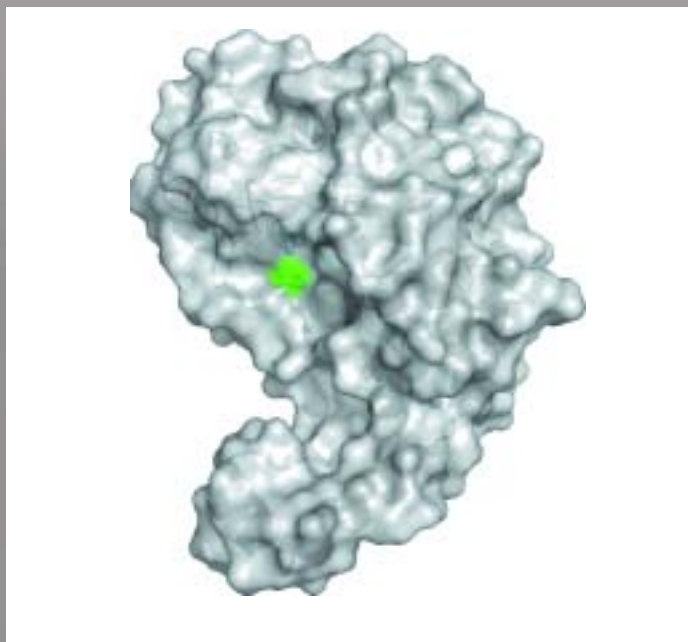
levels when *Calcium spiking in a Medicago root hair cell injected with a mycorrhizal calcium responsive dye* were

present and found, for the first time, that mycorrhizal fungi activate calcium spiking, but the pattern produced is different to that induced by Nod factor. This creates a quandary: how can the same signalling pathway be activated differentially to produce alternative calcium responses?

Computational and Systems Biologists Saul Hazledine and Richard Morris then analysed the mycorrhizal and Nod factor-induced calcium responses, and found that they were both chaotic in nature. Stochasticity and randomness are not the only explanations for the seemingly erratic and noisy signals observed in these calcium oscillations. Often a fairly simple set of equations can give rise to what is termed ‘deterministic chaos’, allowing the system to produce a vast range of different behaviours with minimal energetic effort. Chaotic systems are intrinsically flexible and are particularly sensitive to small changes in the nature of the input. Likewise, the symbiosis signalling pathway must be sufficiently flexible to allow differential responses to rhizobia and mycorrhizal fungi; such flexibility may be provided through this chaotic component within the signalling pathway. The chaotic nature of the signalling pathway implies that only minor differences between the means of activation would be necessary in order to produce the differential calcium responses observed.

NEW FUNDING FOR RESEARCH

How do cyclomodulins work?



Molecular surface of the structure of a cyclomodulin

Mark Banfield has won funding from BBSRC to investigate the structure and function of a protein, originally identified in the food-borne pathogens Enteropathogenic *E. coli* (EPEC) and Enterohaemorrhagic *E. coli* (EHEC), that is able to change the properties of the host cell during infection. This protein, ‘Cif’, interferes with progression of the host cell cycle, irreversibly stopping it in its tracks. Cell cycle arrest by Cif is not

achieved by activation of the DNA damage pathway but by a novel, as yet uncharacterised mechanism. Proteins that modulate the cell cycle are one of the most targeted set of molecules by the pharmaceutical industry. Investigating how a bacterially-derived protein interferes with the eukaryotic cell cycle is important for understanding the molecular details of this system, and in the long-term may identify new routes for novel therapeutics.