BIOSENSORS

Seeing MAPK activity

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Plant cells quickly adapt to changing conditions. Protein phosphorylation is the most common post-translational reversible modification during signal transduction. Kinases represent 4% of the total number of *Arabidopsis* genes. That includes 20 mitogen-activated protein kinases (MAPKs, also known as MPKs) involved in immunity, stress responses and development. The activity of a specific kinase is usually measured in a plant extract, but most of the spatiotemporal information is lost with such a crude and destructive approach. Kinase signalling is highly dynamic, constrained by available cofactors and intertwined with a network of other concomitant signalling and metabolic processes, and so should be observed in an intact biological context. With this goal in mind, Patrick Krysan and colleagues have developed a genetically encoded biosensor to visualize MAPK activity in living tissues.

The authors engineered a Förster resonance energy transfer (FRET)-based sensor built around a plant MAPK substrate. Phosphorylation induces conformational changes that modify the fluorescence properties of the protein. In vitro assays suggest that the sensor responds to the most prominent *Arabidopsis* MAPKs. The team then generated transgenic lines expressing nuclear or cytoplasmic versions of the biosensor. Biotic and abiotic MAPK activators generated a signal in cotyledons, similar to the usual transient MAPK activation observed with traditional approaches, but this time quantified with cellular resolution. A conditional loss-of-function double mutant was used to determine the dependency of the signal on MPK3 and MPK6. Observing individual pavement and guard cells revealed intriguing spatial and temporal heterogeneity after flagellin or chitin treatment.

At this stage, the design of a plant MAPK activity biosensor is an exciting proof of concept. An upgraded version, maybe with more input specificity, will certainly be part of our future toolbox to study unperturbed MAPK signalling in living tissues.

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