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## Designs, applications, and limitations of genetically encoded fluorescent sensors to explore plant biology

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摘要	<p>The understanding of signaling and metabolic processes in multicellular organisms requires knowledge of the spatial dynamics of small molecules and the activities of enzymes, transporters, and other proteins in vivo, as well as biophysical parameters inside cells and across tissues. The cellular distribution of receptors, ligands, and activation state must be integrated with information about the cellular distribution of metabolites in relation to metabolic fluxes and signaling dynamics in order to achieve the promise of in vivo biochemistry. Genetically encoded sensors are engineered fluorescent proteins that have been developed for a wide range of small molecules, such as ions and metabolites, or to report biophysical processes, such as transmembrane voltage or tension. First steps have been taken to monitor the activity of transporters in vivo. Advancements in imaging technologies and specimen handling and stimulation have enabled researchers in plant sciences to implement sensor technologies in intact plants. Here, we provide a brief history of the development of genetically encoded sensors and an overview of the types of sensors available for quantifying and visualizing ion and metabolite distribution and dynamics. We further discuss the pros and cons of specific sensor designs, imaging systems, and sample manipulations, provide advice on the choice of technology, and give an outlook into future developments.</p>
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