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Short Communication

Signaling Routes between Chloroplasts and the Nucleus

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DESCRIPTION

Chloroplast-to-nucleus (Retrograde) signaling is an important part of plant's capacity to sense and act upon changes in their environment, especially those that require eventual adjustments to photosynthetic capacity. The ability to co-ordinate immediate and longer-term responses to environmental perturbations occurs at the cellular, tissue and whole plant (systemic) level [1]. A particularly active area within this research sphere is the quest to identify the precise signaling routes between chloroplasts and the nucleus. Several signaling pathways and signal initiators and transducers have been identified and continue to attract attention, although there are undoubtedly many more to be uncovered. The close association of a proportion of a cell's chloroplast complement with its nucleus is a feature of all plant species so far examined. More recently, this relationship has received growing attention since the juxtaposition of a subset of chloroplasts with the nucleus is suggested to be a crucial feature in the communication and coordination of highly complex processes between these organelles in response to developmental and environmental cues. Since some signaling molecules could originate from multiple cellular sources, the close association between the nucleus and a subset of chloroplasts may provide the necessary specificity for retrograde signal transduction. Conversely, if no discrimination between the origins of such molecules was accommodated, then using them as signal transducers from the chloroplast would not provide any specificity. The molecule where this argument is most pertinent and will be the example used in this essay is Hydrogen Peroxide (H_2O_2) whose origin from different subcellular sources produces differential gene expression patterns, which implies that there is an associated signaling specificity [2]. Observations suggest that H_2O_2 can also be the transducing signal from chloroplasts to the nucleus. In higher plants, the movement of H_2O_2 between chloroplasts and the nucleus has been studied in *Nicotiana benthamiana* (Nb) epidermal pavement cells. This tissue is readily accessible for monitoring changes in the oxidation state of transiently expressed genetically encoded H_2O_2 reporting fluorescent biosensor proteins using confocal laser scanning microscopy. Important for interpretation of responses to some environmental stresses is that Nb epidermal pavement cells are photosynthetic. The H_2O_2 that accumulates in Nb chloroplasts in these studies arises in response to increased light intensity or to pathogen effector triggered immunity. However, a wide range of environmental challenges cause changes in H_2O_2 levels in other subcellular compartments including the peroxisome, mitochondrion, cytosol and the plasma membrane. Therefore, chloroplast-nucleus association is proposed to be relevant in determining how H_2O_2 secreted from chloroplasts could be specific in the transduction of an oxidizing signal to the nucleus.

Stromules

Stromule formation may be associated with a suppression of photosynthesis, which occurs in *Arabidopsis thaliana* challenged with elicitors. Photo-inhibition may also be an important step, which stimulates stromule formation in the absence of pathogen infection such as in senescing leaves. Stromules appear to promote chloroplast-to-chloroplast contacts but also that of chloroplasts-to-nucleus and are suggested to be conduits for H_2O_2 and selected proteins to transfer to the nucleus although this remains under debate.

Nuclear envelope

The outer membrane of the nuclear envelope is continuous with the Endoplasmic Reticulum membrane (ER) and consequently, 50 nm wide perinuclear spaces between the inner and outer nuclear membrane is contiguous with the ER lumen. Chloroplasts, like many other organelles that form physical interactions with the ER, are tethered to the outer ER/nuclear membrane typically at 10–30 nm distances. The ER outer membrane is thus frequently in very close association with the outer chloroplast envelope membrane [3]. A long-observed phenomenon is the avoidance response of chloroplasts whereby they move away from high fluence blue light, which is controlled by phototropins and uses the actin cytoskeleton to guide movement. Interestingly, the nucleus, which has no capacity to move independently, is towed by its attached chloroplasts. Undoubtedly, many proteins are involved in the combined tethering of chloroplasts to nuclei and their repositioning in the cell, as well as being involved in other functions such as

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anchoring of plastids to the plasma membrane and chloroplast division.

H_2O_2 Aquaporin (AQPs) and the route to the nucleus

The development of H_2O_2 across membranes is considered to happen by dispersion down a concentration gradient worked with by layer characteristic proteins. Nonetheless, H_2O_2 dissemination into red platelets isn't worked with by AQPs yet by an obscure layer protein or through the lipid portion raising the chance of AQP-autonomous method for shipping H_2O_2 between cell compartments. This is notwithstanding the physico-chemical contemplations reasoning that straightforward dispersion of H_2O_2 across layers can be dismissed. All things being equal, all AQPs that transport H_2O may likewise transport H_2O_2, in spite of the fact that there are contrasts in the productivity of how individual AQP isoforms separate between these two atoms [4]. The probability of extremely close contact between the chloroplast envelope and the external nuclear envelope could remember a limited expanded fixation for micro-domains at or close to MCS and, assuming that there is the closeness of additional AQPs in the external nuclear film, this would work with the exchange of H_2O_2 to the perinuclear space. Mitochondrial-ER MCS in animal cells shapes a climate where H_2O_2 really does for sure focus in micro-domains on one or the other side of the mitochondrial envelope. It tends to be deduced that a similar to the course of action around chloroplast-external nuclear/ER layer could exist and surely, H_2O_2 micro-domains have been noticed related with Nb epidermal chloroplasts.

CONCLUSION

One can visualize two chat situations: (a) expanded H_2O_2 from the ER lumen enlarging H_2O_2 coming from chloroplasts and intensifying a pressure responsive sign; or the inverse: (b) the construction of a retrograde sign now by expanded and exceptionally restricted cell reinforcement movement. This could give a method for mediating retrograde signaling to fit a harvest plant's reaction to natural pressure. This might end up being a simpler choice than attempting to control a H_2O_2 signal whenever it has shown up in the core considering the exchange of oxidizing counterparts is reasonable through a broad and profoundly portable organization of intermediate redox transporters to plenty of beneficiary redox-sensitive administrative proteins.

REFERENCES

1. Exposito RM, Laissue PP, Yvon DG, Smirnoff N, Mullineaux PM. Photosynthesis-Dependent H2O2 Transfer from Chloroplasts to Nuclei Provides a High-Light Signalling Mechanism. Nat Commun. 2017; 8: 49-51.
2. Devireddy AR, Zandalinas SI, Fichman Y, Mittler R. Integration of Reactive Oxygen Species and Hormone Signalling during Abiotic Stress. J Plant. 2021;105: 459–476.
3. Kangasjärvi S, Neukermanns J, Li S, Aro EM, Noctor G. Photosynthesis, Photorespiration, and Light Signalling in Defence Responses. J Exp Bot. 2012;63: 1619–1636.
4. Biswas MS, Mano J. Lipid Peroxide-Derived Short-Chain Carbonyls Mediate Hydrogen Peroxide-Induced and Salt-Induced Programmed Cell Death in Plants. Plant Physiol. 2015;168: 885–898.