Signaling and Communication in Plants

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Gasotransmitters in Plants

The Rise of a New Paradigm in Cell Signaling

Springer

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Preface

Gasotransmitters were born as cytotoxic compounds; however, there is enough evidence accumulated in many laboratories worldwide during the last quarter of century demonstrating their potential capacity as cytoprotective molecules and, thus, as essential components of cell homeostasis.

Research is, after all, a rediscovery; and gasotransmitters have emerged in plant research for rediscovering many, yet incompletely deciphered, signal transduction pathways of central physiological processes all along the plant life cycle.

Even if the term gasotransmitter refers to gaseous signaling molecules formed endogenously by uni- or pluricellular organisms, the influence of exogenously supplied gases that can be perceived by cells and are also able to transmit signals from the environment, ending in physiological changes in organisms, is not excluded.

More than a decade ago, the term “gaseous transmitter” was used to introduce hydrogen sulfide (H_2S) as one of the three more important gaseous molecules together with nitric oxide (NO) and carbon monoxide (CO) in regulating essential features linked with the cell physiology (Wang 2002).

These endogenously generated gaseous molecules may potentiate or antagonize each other through actions that (1) alter the activity of the specific enzymes involved their biosynthetic pathways or (2) rely on a direct chemical interaction among themselves. They are, in addition, able to share similar features since various cellular components are common targets of all the three gasotransmitters. The latter aspect highlights the potential existence of complementary functions among gasotransmitters and is reminiscent of a certain level of redundancy for ensuring that cell metabolism works even under environmentally induced threatening circumstances.

The actions and biological functions of gasotransmitters do not require a receptor or an enzymatic activity mediating their chemical effect on cellular targets. The half-life of gasotransmitters is short in general; CO is more stable and supposed to be capable of acting at long distances from the site of production. In contrast, the half-life of NO and H_2S is shorter and supposed to be acting near the site of production. In spite of their ubiquity, the endogenous concentration of gasotransmitters is regulated at many levels and the richness of their chemical reactivity and the formation of more stable intermediates for their storage and translocation, which can result in the appearance of high gasotransmitters concentration in some specific cell locations, must be considered.

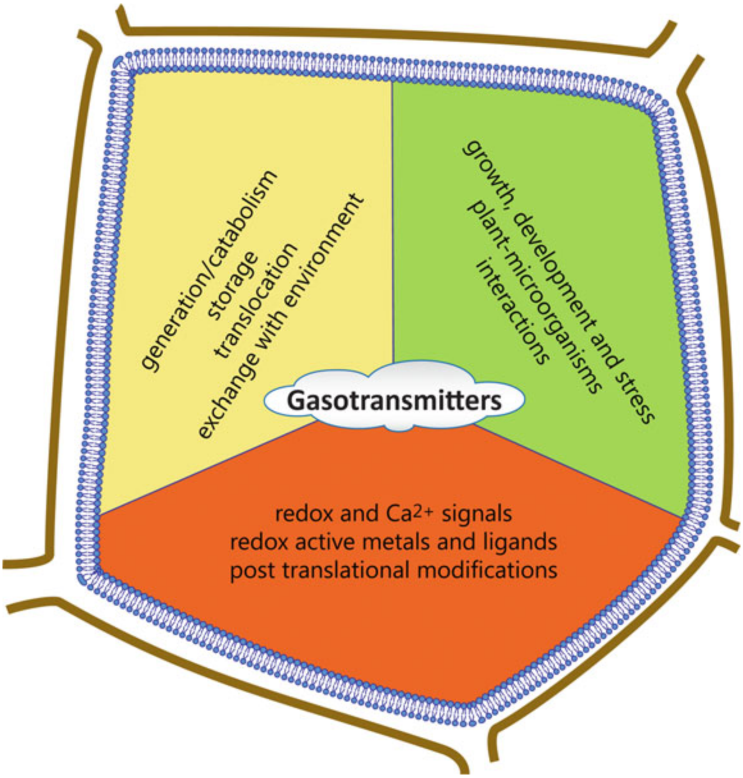
The exogenous administration of gasotransmitters, as well as their endogenous manipulation through pharmacology or through the use of genetically modified organisms, has unambiguously proved their cytoprotection activity in many experimental models.

Besides their cytoprotective action, gasotransmitters have been shown to be essential for cell homeostasis through the regulation of many cell functions, in particular those associated with the maintenance of cell redox balance during adaptive responses for changing physiological conditions derived from exogenous or endogenous stimuli.

The redox chemistry of NO and H_2S is rich and complex, allowing the formation of derivatives with specific physical features and chemical reactivities. Thus, any biomolecule containing active metal or residue with redox activity constitutes a potential target for the biological activity of these gasotransmitters.

As stated, as yet unexplored key element is the influence of the interaction between the gasotransmitters themselves and the generation of unidentified intermediate molecules operating on the cell physiology. This point is strongly linked to the necessity of developing new measuring techniques and technologies required for an accurate dosage of the gasotransmitters and intermediate molecules in living cells.

Figure 1 summarizes the main topics addressed in this book related to gasotransmitters signaling in plant biology, involving the generation pathways, metabolism, functions, and molecular mechanisms underpinning their functions.



This book compiles the current trends of gasotransmitter research in plants that will constitute the foundations for the upcoming research in the next decades. Research leaders in the field have carefully addressed the history and the main trending topics of the gasotransmitters in plants nowadays, as well as the main streams sharing the current and future proposals that might be expected. The strengthen, weakness, and spotlights of the most important issues concerning gaseous compounds as emerging cell signaling molecules deserve special attention in this book.

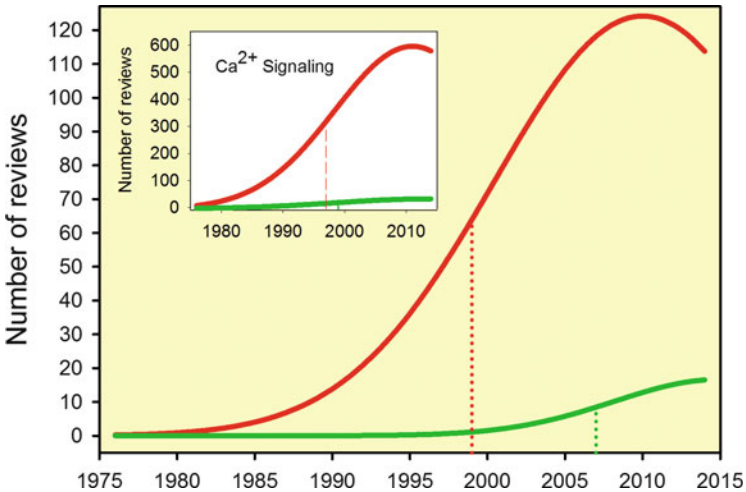
The book is organized into 14 chapters, containing 46 figures, 6 tables, and 11 schemes, which proportionally represent the relative relevance of the research on nitric oxide (NO), carbon monoxide (CO), and H_2S in the plant kingdom.

Thus, the book highlights key roles of NO as signaling molecule regulating reversible posttranslational modifications of proteins through the S-nitrosylation/ denitrosylation, the participation of NO in plant interactions with microorganisms, and finally, the strong evidence supporting the involvement of NO in hormone signaling and the preferential linkage to non-symbiotic hemoglobin contributing to N assimilation and plant growth and developmental processes.

In the last decade, a large amount of results addressing the functions and effects of H_2S in plant life have positioned this gas as the new “Cinderella” of plant research. Moreover, the findings reported in the last 2 years, concerning the richness of the NO/H_2S chemical reactivity, are thoroughly addressed in this book, highlighting the necessity of considering the intermediate reactive molecules generated by both gases when analyzing unexpected experimental results.

The book also dedicates a chapter with a detailed and updated reviewing of the more relevant findings concerning the actions of CO in plant biology.

Finally, Fig. 2 indicates the value of the opportunity and convenience of editing the book nowadays. Figure 2 shows the total number of reviews written on gasotransmitter signaling in all kingdoms of life vs. those addressing just plant issues, between 1970 and 2014. The analysis of Fig. 2 highlights two important aspects: the first is a 10 years lag between the year reaching the 50 % of the maximum between general gasotransmitter reviews and those addressing plant issues and the second one is that reviews in plants represent barely 10 % of the total reviews. The inset in Fig. 2 shows the same analysis for Ca^{2+} signaling; in this case, the proportion of reviews addressed to plants vs. the total number of reviews is similar to that found in gasotransmitters. However, while the number of reviews in plant Ca^{2+} signaling reached a plateau in the last decade, the reviews in plant gasotransmitter signaling present a fast-growing curve in the last 3 years.



Overall, this book seeks to call the attention of plant researchers to the relevance of the gasotransmitters in cell signaling as a fast-growing field in plant biology that influences, probably, every aspect of the plant life.

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Reference

Wang R (2002) Two's company, three's a crowd - can H_2S be the third endogenous gaseous transmitter? FASEB J 16:1792–1798

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