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Autore	Paloma Koprovski Menguer
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In all living organisms, essential micronutrients are cofactors of many ubiquitous proteins that participate in crucial metabolic pathways, but can also be toxic when present in excessive concentrations. In order to achieve correct homeostasis, plants need to control uptake of metals from the environment, their distribution to organs and tissues, and their subcellular compartmentalization. They also have to avoid deleterious accumulation of metals and metalloids such as Cd, As and Al. These multiple steps are controlled by their transport across various membrane structures and their storage in different organelles. Thus, integration of these transport systems required for micronutrient trafficking within the plant is necessary for physiological processes to work efficiently. To cope with the variable availability of micronutrients, plants have evolved an intricate collection of physiological and developmental processes, which are under tight control of short- and long-range signaling pathways. Understanding how plants perceive and deal with different micronutrient concentrations, from regulation to active transport, is important to completing the puzzle of plant metal homeostasis. This is an essential area of research, with several implications for plant biology, agriculture and human nutrition. There is a rising interest in developing plants that efficiently mobilize specific metals and prosper in soils with limited micronutrient availability, as well as those that can selectively accumulate beneficial micronutrients in the edible parts while avoiding contaminants such as Cd and As.

However, there is still an important gap in our understanding of how nutrients reach the seeds and the relative contribution of each step in the long pathway from the rhizosphere to the seed. Possible rate-limiting steps for micronutrient accumulation in grains should be the primary targets of biotechnological interventions aiming at biofortification. Over the last 10 years, many micronutrient uptake- and transport-related processes have been identified at the molecular and physiological level. The systematic search for mutants and transcriptional responses has allowed analysis of micronutrient-signaling pathways at the cellular level, whereas physiological approaches have been particularly useful in describing micronutrient-signaling processes at the organ and whole-plant level. Large-scale elemental profiling using high-throughput analytical methodologies and their integration with both bioinformatics and genetic tools, along with metal speciation, have been used to decipher the functions of genes that control micronutrients homeostasis. In this research topic, we will follow the pathway of metal movement from the soil to the seed and describe the suggested roles of identified gene products in an effort to understand how plants acquire micronutrients from the soil, how they partition among different tissues and subcellular organelles, and how they regulate their deficiency and overload responses. We also highlight the current work on heavy metals and metalloids uptake and accumulation, the studies on metal selectivity in transporters and the cross-talk between micro and macronutrients. Thus, we believe a continued dialogue and sharing of ideas amongst plant scientists is critical to a better understanding of metal movement into and within the plant.