Heavy metals – about the role of the vacuole in detoxification, phytoremediation and safe food

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Every living organism needs essential heavy metals such as iron and zinc. However, if plants grow on soils containing high concentrations of these metals or of non-essential, toxic metals and metalloids such as cadmium or arsenic they may accumulate them at concentrations toxic for their growth as well as for animals and humans feeding these plants. For plants, one of the major steps to survive in heavy metal contaminated soils consists in depositing heavy metals safely into the large central vacuole. To be efficiently stored in this metabolic nearly inactive compartment, complexing agents such as carboxylates, nicotianamine or phytochelatins have also to be transported concomitantly with heavy metals into the vacuole in order to avoid that they can be transported back to the cytosol. Our laboratory is interested since many years in heavy metal resistance and especially in the role of the vacuole in heavy metal detoxification. On one side this knowledge will provide us with basic knowledge how plants deal with abiotic stresses, on an other side this knowledge can be exploited to learn which strategies should be applied in plant breeding and which are the most promising approaches allowing to produce plants that can clean up the environment and that accumulate less toxic metals in the edible parts. In the first part of my talk I will show how we succeeded to identify two vacuolar ABC transporters acting as the long-sought phytochelatine transporters. These transporters play a central role in providing resistance to plants against arsenic, mercury and cadmium. In the second part I will discuss how we identified the corresponding transporter in rice. Due to the complex anatomy this transporter plays mainly a role in nodes, which are the crossroads for the delivery of inorganic nutrients to the different parts of this crop. Absence of this transporter results in an increased arsenic content in grains. Finally I will discuss two biotechnological approaches. The first one was carried out with poplar. The goal was to produce plants that can be used for phytoremediation/phytostabilisation. The second approach deals with arsenic in rice fields. This is extremely important in India and Bangladesh, where rice is a staple food. Paddy fields of these countries contain very high amounts of arsenic due to irrigation with arsenic-containing water in former times. Rice growing on these soils takes up high arsenic concentrations which is transferred to grains and enters in the food chain. This has a toxic effect for the population. Therefore we have the goal to produce rice plants that accumulate much less heavy metals in rice grains.