PhD in Evolutionary Biology and Ecology

Università di Roma Tor Vergata

EVOLUTION AND FUNCTION OF PHYTOCHELATIN SYNTHASE IN CYANOBACTERIA AND VIRIDIPLANTAE

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The enzyme phytochelatin synthase (PCS) is a cytosolic γ-glutamylcysteine dipeptidyl (trans)peptidase (EC 2.3.2.15), belonging to the clan CA of the papain-like cysteine proteases, known as a key enzyme for heavy-metal detoxification in plants. The PCS catalyzes the prompt enzymatic formation of some peculiar thiol-peptide compounds, the so-called "phytochelatins", starting from the reduced glutathione (GSH) via a transpeptidase reaction. Phytochelatins (PCs) are thiol-peptides whose general structure is (γ-glutamate–cysteine)$_n$–glycine, with *n* usually ranging from 2 to 5. Due to the thiol group of the cysteine residues, PCs can bind cadmium (Cd) and other thiophilic metals and prevent them from circulating in the cytosol. It is now well known that higher plants, as well as a number of marine and freshwater algae (*Chlorophyta*, *Chrysophyta*, *Phaeophyta*, *Rhodophyta*), some fungi, lichens and even some animal species do actually produce PCs in response to metal stress, in particular Cd. PCS is of particular interest from an evolutionary prospect due to its constitutive expression and its widespread presence in nature. Recently, the constitutive presence of functional PCS leading to full PC synthesis was confirmed in bryophytes and in lycophytes. Moreover, some PCS-like enzymes, sharing significant sequence homologies with plant PCSs, were identified in cyanobacteria and in some gamma- and beta- proteobacteria. Why would organisms spend so much energy in producing protective proteins even when they are not exposed to the respective stressors? This may suggest that conceiving a role of PCS and PCs exclusively addressed to toxic metal detoxification could be reductive; by contrast, we could hypothesize that PCS performs other, still largely unknown, essential functions. Recent studies have demonstrated the presence of a basal transpeptidase PCS activity even in absence of Cd and an increased *in vitro* activity of PCS in the presence of iron and zinc (Fe, Zn) in very ancient land plants. This allows to hypothesize a primeval role of the PC pathway in the control of the homeostasis of trace metal micronutrients (e.g. Fe and Zn). Given all the above, this PhD project aims to investigate: i) the presence of a constitutive and functional PCS in cyanobacteria and in other basal organisms; ii) the production of PCs in charophytes, bryophytes, lycophytes and other ancient lineages of Viridiplantae; iii) the roles of the PCS and in particular its possible involvement in the homeostatic regulation of metal micronutrient requirements justifying its ubiquitous presence and constitutive expression.