A HORIZONTAL GENE TRANSFER AT THE ORIGIN OF PLANT PHENYLPROPANOID METABOLISM

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Phenylpropanoid metabolism, Phenylalanine Ammonia Lyase, land plants, Horizontal Gene Transfer

The pioneering ancestor of land plants (Embryophytes) that conquered terrestrial habitats around 500 million years evolved from the Charophyceae, a small group of freshwater green algae, differentiating afterwards from simple structure (Bryophyte) to complex organisms showing an extraordinary array of organs and tissue systems (vascular plants). However, early land plants had to face a harsh environment characterised by important stresses including desiccation, UV radiation, and microbial attack. Beneficial associations between fungi (mycorrhizal symbioses), and soil bacteria (N₂ fixing), might have greatly helped the first stages of phototrophs terrestrialization.

A key step during plants colonisation of land and diversification was represented by the origin and evolution of the phenylpropanoid pathway; the complex set of phenylpropanoid compounds are in fact involved in many stress response pathways (pathogens, grazing, ROS scavenging, UV screening, etc) as well as in other fundamental traits such as biosynthesis of lignin, the structural polymer able to guarantee stem rigidity and xylem (water conducting tissue) formation.

Despite its importance, the origin and evolution of the phenylpropanoid pathway, as well as the first advantageous physiological roles of its products are still unclear.

Phenylalanine Ammonia Lyase (PAL) is responsible for the first committed step of plant phenylpropanoid pathway. Although the complete phenylpropanoid metabolism appears to be a specific and ubiquitous feature of land plants, PAL homologs have been identified and characterized in fungi such as Aspergillus oryzae - whose genome shows to contain several phenylpropanoid pathway genes – and, although phenylpropanoids are largely absent in prokaryotes, in Streptomyces maritimus and Photorhabdus luminescens where they are involved in the production of antimicrobial compounds. A PAL homologue was also recently discovered in two cyanobacterial species of the order Nostocales

PAL is homologous to Histidine ammonia lyase (HAL), which is involved in histidine degradation and it is present in prokaryotes and eukaryotes. It is thus commonly suggested that PAL evolved from HAL in fungi and plants.

To shed some light on these issues, we have carried out an extensive phylogenetic analysis of PAL and HAL homologs.

The phylogenetic data lead us to propose a new evolutionary scenario involving two horizontal gene transfers: PAL originated in soil bacteria with an antimicrobial role, and was transferred (possibly from Nostocales species) very early to fungi via lichen-like symbioses and
then to early land plants *via* ancient arbuscular mycorrhizal symbioses, enabling the further development of the phenylpropanoid pathway and the radiation of plants on land.