Transient Hypermutagenesis Accelerates the Evolution of Legume Endosymbionts following Horizontal Gene Transfer

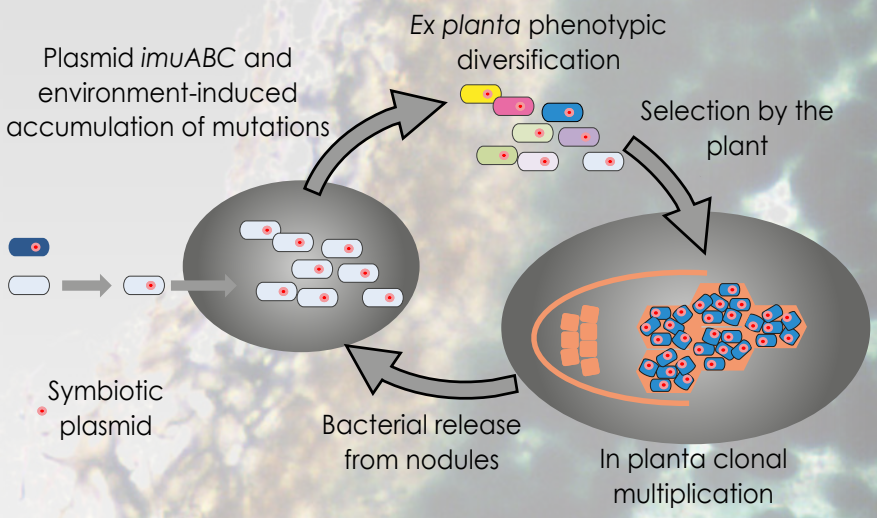

Fig.: Model for symbiotic and mutagenic plasmid-driven evolution of rhizobia. Following horizontal transfer of a symbiotic plasmid to a soil bacterium, the recipient genome accumulates environment-induced mutations that lead to phenotypic diversification. The most beneficial variants are selected by the plant and clonally multiply within nodules before being released. Rounds of ex planta phenotypic diversification/plant selection/clonal multiplication may have driven the adaptation process in natura. **Background:** Mimosa nodule induced and colonized by *R. solanacearum* evolved symbiote (stained bacteria in dark blue/green)

Horizontal gene transfer has an extraordinary impact on microbe evolution and diversification, by allowing exploration of new niches such as higher organisms. This is the case for rhizobia, a group of phylogenetically diverse bacteria that form a nitrogen-fixing symbiotic relationship with most leguminous plants. While these arose through horizontal transfer of symbiotic plasmids, this in itself is usually unproductive, and full expression of the acquired traits needs subsequent remodeling of the genome to ensure the ecological success of the transfer. Here we uncover a mechanism that accelerates the evolution of a soil bacterium into a legume symbiont.

We show that key symbiotic genes are co-transferred with genes encoding stress-responsive error-prone DNA polymerases that transiently elevate the mutation rate in the recipient genome. This burst in genetic diversity accelerates the symbiotic evolution process under selection pressure from the host plant. A more widespread involvement of plasmid mutagenesis cassettes in rhizobium evolution is supported by their overrepresentation in rhizobia-containing lineages. Our findings provide evidence for the role of environment-induced mutagenesis in the acquisition of a complex lifestyle trait and predict that co-transfer of complex phenotypic traits with mutagenesis determinants might help successful horizontal gene transfer.

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