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IN BRIEF

BACTERIAL PHYSIOLOGY

How to keep your plasmids

Plasmids have important roles in bacterial physiology, but owing to segregational loss and the fitness costs associated with carrying them, little is known about how these extra-chromosomal elements are maintained over time in bacterial populations. Although horizontal gene transfer (HGT) is thought to be a major contributor to plasmid maintenance, approximately half of known plasmids are not transmissible by HGT, indicating that other factors participate in this process. To study these, San Millan *et al.* combined mathematical modelling and an experimental system that involved *Pseudomonas aeruginosa* and its small non-transmissible plasmid pNUK73, which confers resistance to kanamycin and neomycin. They show that in the absence of antibiotics, *P. aeruginosa* initially rapidly loses pNUK73, but the rate of decay in plasmid carriage slows down over time owing to the acquisition of mutations (termed compensatory mutations) that lower the costs associated with plasmid carriage. In addition, the authors found that rare events of antibiotic selection are sufficient to maintain pNUK73 in the population. Interestingly, their analysis also revealed that positive selection increases the frequency of compensatory mutations, suggesting that the two mechanisms interact to stabilize plasmid carriage.

Gullberg *et al.* analysed how the pUUH239.2 plasmid — which confers resistance to multiple antibiotics and heavy metals — is maintained in *Escherichia coli*. By competing isogenic *E. coli* strains, with or without the plasmid, the authors found that the concentrations of antibiotics and heavy metals necessary to maintain pUUH239.2 in the population were much lower than the minimum inhibitory concentration of the plasmid-free strain. Furthermore, some combinations of antibiotics and heavy metals showed synergistic effects on plasmid selection. These results indicate that sublethal levels of antibiotics and heavy metals are sufficient to drive positive selection of multidrug resistance plasmids.

ORIGINAL RESEARCH PAPERS San Millan, A. *et al.* Positive selection and compensatory adaptation interact to stabilize non-transmissible plasmids. *Nature Commun.* http://dx.doi.org/10.1038/ncomms6208 (2014) | Gullberg, E. *et al.* Selection of a multidrug resistance plasmid by sublethal levels of antibiotics and heavy metals. *mBio* http://dx.doi.org/10.1128/mBio.01918-14 (2014)

ARCHAEAL EVOLUTION

Acquiring genes from bacteria

The mechanisms that drive the evolution of high taxonomic groups of bacteria and archaea are largely unknown. Here, Nelson-Sathi *et al.* examined 267,568 protein-coding genes from 134 archaeal genomes and compared them with their homologues from 1,847 reference bacterial genomes. Notably, about one-third of the archaeal genes had bacterial homologues; phylogenetic analysis of these genes suggested that they were acquired by archaea from bacteria. A phylogenetic tree based on these imported genes closely mirrored a reference tree comprising archaea-specific genes from 13 higher taxa, suggesting that these gene acquisitions from bacteria drove higher taxa evolution in archaea. Methanogenic archaea were the main recipients of bacterial genes, and most imported genes are associated with metabolic functions, suggesting that the acquisition of new metabolic pathways from bacteria was one of the key drivers of the evolution of high archaeal taxa.

ORIGINAL RESEARCH PAPER Nelson-Sathi, S. *et al.* Origins of major archaeal clades correspond to gene acquisitions from bacteria. *Nature* http://dx.doi.org/10.1038/nature13805 (2014)