

How genetic parasites persist despite the purge of natural selection

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Mobile genetic elements, such as transposons, plasmids, and viruses, are ubiquitous in cellular life forms. Although the selfish nature of these genetic elements is undeniable, the actual cost that they impose on their host and the mechanisms by which they counteract natural selection remain unclear. We combined mathematical models and comparative genomics to disentangle the roles of selection, horizontal gene transfer, gene duplication, and gene loss on the spread and persistence of mobile genetic elements (Figure 1). By quantifying the mean contribution of transposons, conjugative plasmids, prophages, and toxin-antitoxin modules to the fitness of microbial hosts, we provide evidence that these genetic elements are deleterious at evolutionary timescales [1]. Moreover, the transfer rates experienced by selfish genetic elements exceed the minimum rates required for their long-term survival (Figure 2), which fully characterizes these elements as parasites [2].

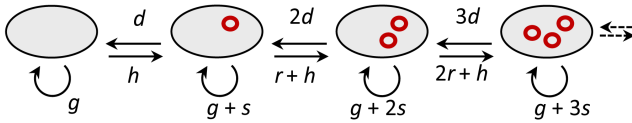


Fig. 1. Copy number dynamics of a family of mobile genetic elements in a population of hosts. Gray ovals represent host genomes, small circles indicate the parasite copy number. Mobile genetic elements are subject to gene duplications at rate r (per copy), loss at rate d (per copy), horizontal transfer at rate h , and host-level selection, with selection coefficient s . Adapted from [2].

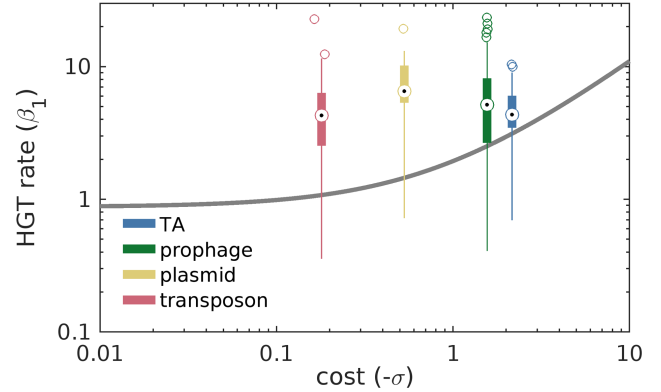


Fig. 2. Critical value of the intra-population horizontal gene transfer (HGT) rate required for long-term persistence of genetic parasites, as a function of the parasite cost. Both the HGT rate and the fitness cost are normalized by the loss rate, such that $\beta = h/d$ and $\sigma = s/d$. The boxplots indicate the empirical HGT rates of different classes of mobile genetic elements inferred from comparative genomics. Adapted from [2].

[1] J. Iranzo, J.A. Cuesta, S. Manrubia, M.I. Katsnelson and E.V. Koonin, *Disentangling the effects of selection and loss bias on gene dynamics*, PNAS **114**, E5626 (2017).

[2] J. Iranzo and E.V. Koonin, *How genetic parasites persist despite the purge of natural selection*, EPL **122**, E5626 (2018).