

Cellular potlatch: The advantage of leakage of essential metabolites and resultant symbiosis of diverse species

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Microbial communities display extreme diversity. A variety of strains or species coexist even when limited by a single resource. It has been argued that metabolite secretion creates new niches and facilitates such diversity. Nonetheless, it is still a controversial topic why cells secrete even essential metabolites so often; in fact, even under isolation conditions, microbial cells secrete various metabolites, including those essential for their growth. First, we demonstrate that leaking essential metabolites can be advantageous. If the intracellular chemical reactions include multibody reactions like catalytic reactions, this advantageous leakage of essential metabolites is possible and indeed typical for most metabolic networks via "flux control" and "growth-dilution" mechanisms; the later is a result of the balance between synthesis and growth-induced dilution with autocatalytic reactions. Counterintuitively, the mechanisms can work even when the supplied resource is scarce. Next, when such cells are crowded, the presence of another cell type, which consumes the leaked chemicals is beneficial for both cell types, so that their coexistence enhances the growth of both. The latter part of the paper is devoted to the analysis of such an unusual form of symbiosis: "consumer" cell types benefit from the uptake of metabolites secreted by "leaker" cell types, and such consumption reduces the concentration of metabolites accumulated in the environment; this environmental change enables further secretion from the leaker cell types. This situation leads to frequency-dependent coexistence of several cell types, as supported by extensive simulations. A new look at the diversity in a microbial ecosystem is thus presented.