

Adaptive response by state-dependent inactivation

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Many membrane channels and receptors exhibit adaptive, or desensitized, response to a strong sustained input stimulus. A key mechanism that underlies this response is the slow, activity-dependent removal of responding molecules to a pool, which is unavailable to respond immediately to the input. This mechanism is implemented in different ways in various biological systems and has traditionally been studied separately for each. Here we highlight the common aspects of this principle, shared by many biological systems, and suggest a unifying theoretical framework. We study theoretically a class of models, which describes the general mechanism and allows to distinguish its universal from system-specific features. We show that under general conditions, regardless of the details of kinetics, molecule availability encodes an averaging over past activity, and feeds back multiplicatively on the system output. The kinetics of recovery from unavailability determines the effective memory kernel inside the feedback branch, giving rise to a variety of system-specific forms of adaptive response: precise or input-dependent, exponential or power-law, as special cases of the same model.

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