Synaptic plasticity

Synaptic plasticity, the property of a neuron or synapse to change its internal parameters in response to its history.

Since memories are postulated to be represented by vastly interconnected neural circuits in the brain, synaptic plasticity is one of the important neurochemical foundations of learning and memory.

Plastic change often results from the alteration of the number of neurotransmitter receptors located on a synapse.

There are several underlying mechanisms that cooperate to achieve synaptic plasticity, including changes in the quantity of neurotransmitters released into a synapse and changes in how effectively cells respond to those neurotransmitters.

Synaptic plasticity in both excitatory and inhibitory synapses has been found to be dependent upon postsynaptic calcium release.

The molecular mechanisms underlying various types of synaptic plasticity are historically regarded as separate processes involved in independent cellular events. However, recent progress in our molecular understanding of Hebbian and homeostatic synaptic plasticity supports the observation that these two types of plasticity share common cellular events, and are often altered together in neurological diseases. Here, we discuss the emerging concept of homeostatic synaptic plasticity as a metaplasticity mechanism with a focus on cellular signaling processes that enable a direct interaction between Hebbian and homeostatic plasticity. We also identify distinct and shared molecular players involved in these cellular processes that may be explored experimentally in future studies to test the hypothesis that homeostatic synaptic plasticity serves as a metaplasticity mechanism to integrate changes in neuronal activity and support optimal Hebbian learning [1)].

Synaptic plasticity, induced by the close temporal association of two neural signals, supports associative forms of learning. However, the millisecond timescales for association often do not match the much longer delays for behaviorally relevant signals that supervise learning. In particular, information about the behavioral outcome of neural activity can be delayed, leading to a problem of temporal credit assignment. Recent studies suggest that synaptic plasticity can have temporal rules that not only accommodate the delays relevant to the circuit, but also be precisely tuned to the behavior the circuit supports. These discoveries highlight the diversity of plasticity rules, whose temporal requirements may depend on circuit delays and the contingencies of behavior [2)].

1)

Li J, Park E, Zhong LR, Chen L. Homeostatic synaptic plasticity as a metaplasticity mechanism - a molecular and cellular perspective. Curr Opin Neurobiol. 2018 Sep 10;54:44-53. doi: 10.1016/j.conb.2018.08.010. [Epub ahead of print] Review. PubMed PMID: 30212714.

2)

Suvrathan A. Beyond STDP-towards diverse and functionally relevant plasticity rules. Curr Opin Neurobiol. 2018 Jul 26;54:12-19. doi: 10.1016/j.conb.2018.06.011. [Epub ahead of print] Review. PubMed PMID: 30056261.