**Review Questions**

***Chapter 8: Synaptic Plasticity***

1. Provide two ways to induce LTP, using LTP in the CA1 area as an example.

(1) Stimulate CA3 pyramid cell axon with brief, high frequency stimuli.

(2) Stimulate CA3 pyramid cell axon with low frequency stimuli, and stimulate axon terminates to the nearby spine on the same CA1 pyramid cell.

2. What is long-term depression (LTD), and how is it obtained experimentally?

**LTD**: It is to describe the decrease of EPSP strength on postsynaptic membrane respond to exciting presynaptic stimuli, which last for a long time.

Stimulate axon at a low rate for a long period.

3. Providing three lines of evidence in support of LTP’s role in memory formation.

(1) Using of LTP can engineer a memory. (R. Malinow’s Lab Nabavi et al., 2014 Nature)

(2) Enhancing of LTP in mice can improve their memory. (Tsien’s Lab: Tang et al., 1999)

(3) Knockout of key signaling elements in LTP diminish mice memory. (Tonegawa’s Lab: Silva et al., 1992 Science)

4. How to reveal the presence of silent synapses electrophysiologically? How are silent synapses converted to active excitatory synapses?

**Reveal**: In the research of glutamatergic synapses, we can give stimuli to the presynaptic axons and determine the postsynaptic membrane potential. In this experiment, some postsynaptic neurons have no potential respond to presynaptic stimuli. Thus, we can speculate that these synapses are silent synapses.

**Conversion**: Clamp silent postsynaptic membrane potential to +60mV to remove Mg2+ in NMDA-R. At the same time, stimulate presynaptic terminal to induce LTP. LTP on postsynaptic trigger the AMPA-R inverting to postsynaptic membrane. With the presence of AMPA-R, the silent synapses can respond to glutamate signal normally so that they are converted to active excitatory synapses.

5. What are molecular events necessary for induction of LTP?

(1) High frequency stimuli make postsynaptic membrane potential depolarized.

(2) Depolarization of postsynaptic membrane potential remove Mg2+ ion in NMDA-R so that it can bind to glutamate and induce the increase of intracellular Ca2+ concentration.

(3) High Ca2+ concentration activate CaMKII.

(4) CaMKII phosphorylate downstream substrates include AMPA-R to strengthen the current respond to glutamate binding.

(5) Some substrates induce genetic change to maintain LTP.

6. Why LTP is suitable as a cellular mechanism of associative memory?

There are two crucial conditions to induce an LTP which are **interaction between glutamate and NMDA-R**, and **depolarization of postsynaptic membrane potential**. These two conditions can be provided by two different synapses which have the same postsynaptic neuron. For instance, a dendrite spine A forms a synapse with an axon A, whereas another spine B close to spine A forms a synapse with another axon B, respectively. When we stimulate axon B with high frequency stimuli, spine B membrane potential will be depolarized and the depolarization can spread to spine A. In this case, low frequency stimuli are sufficient to induce LTP. Therefore, spine A’s LTP is the result of association of two synapses. So, LTP is suitable of associative memory.

Key terms

associativity

augmentation

habituation

long-term depression (LTD)

long-term potentiation (LTP)

posttetanic potentiation (PTP)

potentiation

sensitization

spike timing-dependent plasticity (STDP)

synaptic depression

synaptic facilitation