Biology of Learning and Memory [1]

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Learning is defined as a process that leads to a relatively permanent change in behavior. In this article, we will venture on the biological theories and brain structures associated to learning and memory.

Biological Theories

There are two theories that explain the cellular basis of learning and memory. First, the Nucleotide Rearrangement Theory states that chemical changes in the body are linked to learning. Learning and memory enhance in trained rats as their cortical RNA increases. More and harder training results to lower possibilities of forgetting and memory deterioration. However, when RNA synthesis is inhibited, memory becomes impaired.

The second biological theory of learning and memory is the Cellular Modification Theory proposed by Kandel, et.al. It focuses on habituation, sensitization and conditioning in relation to learning and memory. The researchers found out that the increase in the release of neurotransmitters result to faster response rates of the sensory-motor neurons synapses. This, in turn, leads to conditioning and sensitization. However, low levels of neurotransmitters result to slower synaptic responses, leading to habituation. The synaptic responsivity is facilitated by the serotonegic interneurons that prolong the closure of K+ ion channels in order to increase action potential’s duration in sensory neurons.

Hippocampus

The hippocampus in the medial temporal lobe plays important roles in learning and memory.

The clinical studies on Patient H.M in 1953 showed the significant functions of the medial temporal lobe. Patient H.M. underwent surgical removal of the medial temporal lobes. This resulted to anterograde amnesia (difficulty of forming new memories) and neologism (forming and/or using new words). However, procedural memories, semantic memories, speech, reading and writing were all left unaffected.

Situated in the medial temporal lobe, the hippocampus is responsible for the consolidation of short term memory and long term memory. In particular, the hippocampus is responsible for the formation of new memories related to experiences events, also known as autobiographical or episodic memories. Declarative memories, those that can be verbalized more explicitly than episodic memories, are formed but not stored in the hippocampus. These memories as well as past events are believed to be stored in the frontal and temporal lobes.

There are two hippocampi in the brain, one in the left hemisphere and the other one on the right. When one of these hippocampi are damaged and the other one is left intact, the person can still experience almost normal memory functioning. However, severe damage or removal of both hippocampi as in the case of Patient H.M. results to anterograde amnesia.

A process called long-term potentiation (LTP) occurs in the hippocampus. LTP refers to the increase in neural responsivity. Recent research studies proved that LTP is involved in spatial learning.

Mediodorsal Thalamus

The thalamus is referred to as the relay center of the brain. When its mediodorsal region is damaged, declarative memories are lost. However, procedural memories are left unharmed. Korsakoff's syndrome experienced by chronic alcoholic patients may result from damage of the mediodorsal thalamus. This is the reason why one of the symptoms of Korsakoff's syndrome is the loss of declarative memories.
