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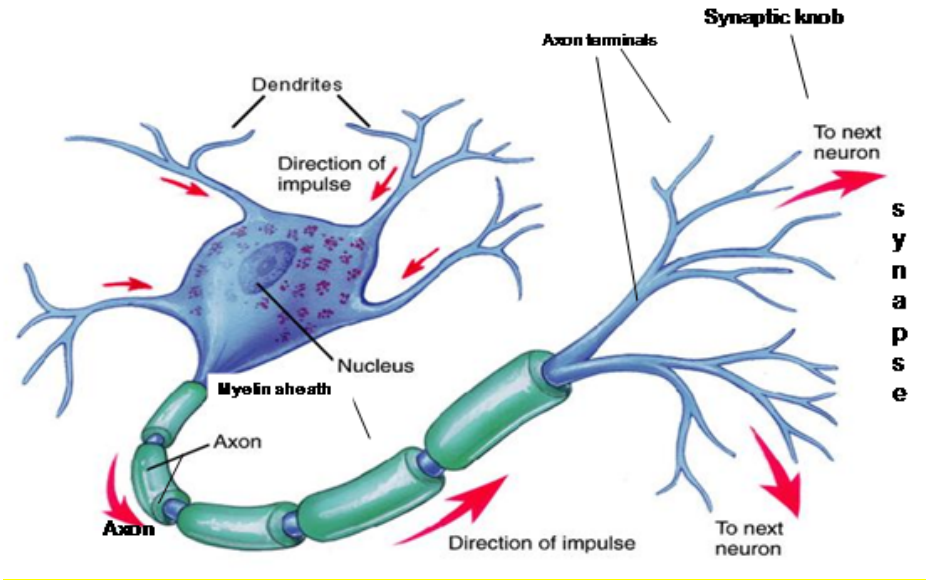
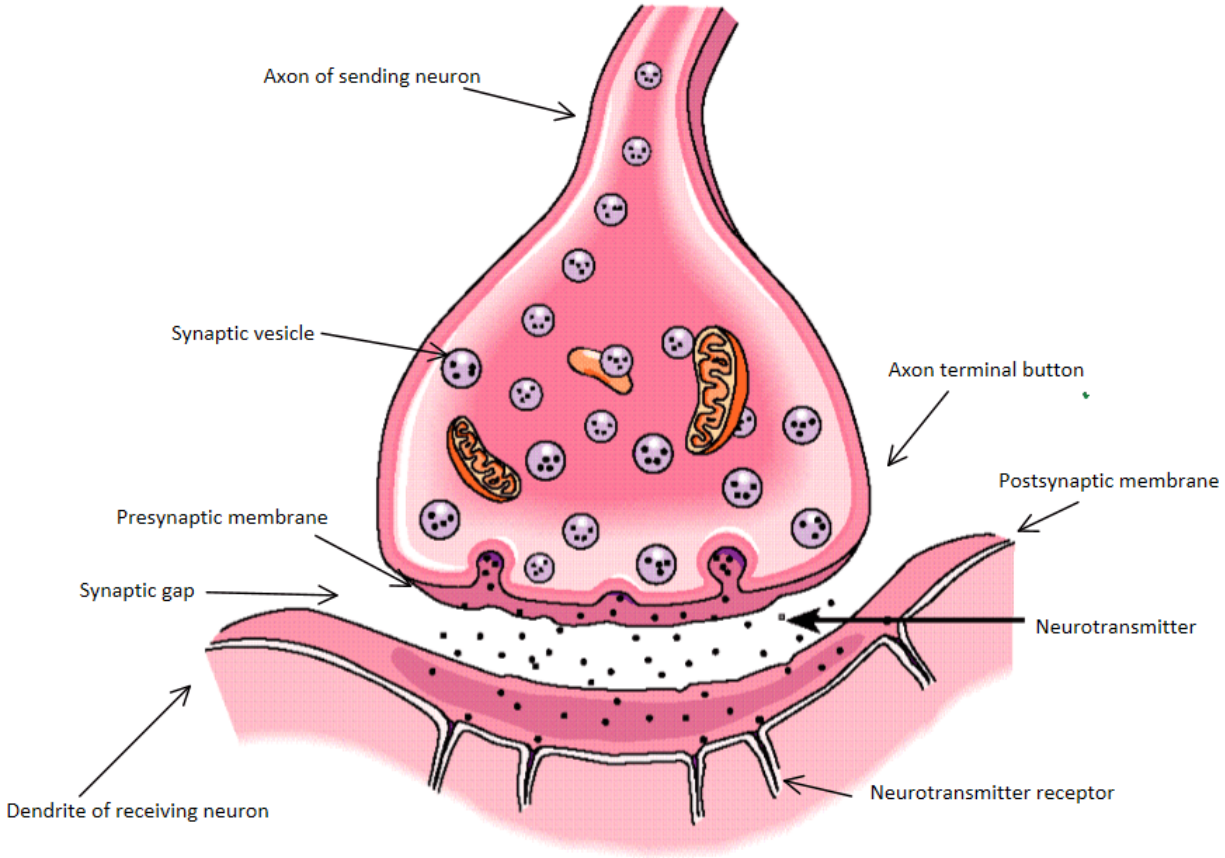
THE NEURAL MECHANISMS AND PATHWAYS INVOLVED IN LEARNING

When we learn, many processes are occurring at a rapid rate without our conscious knowledge. Existing neural connections are firing at a greater rate, new connections are being created, old connections are being strengthened and damaged areas are resolving their issues by fixing severed connections or re-wiring old ones.

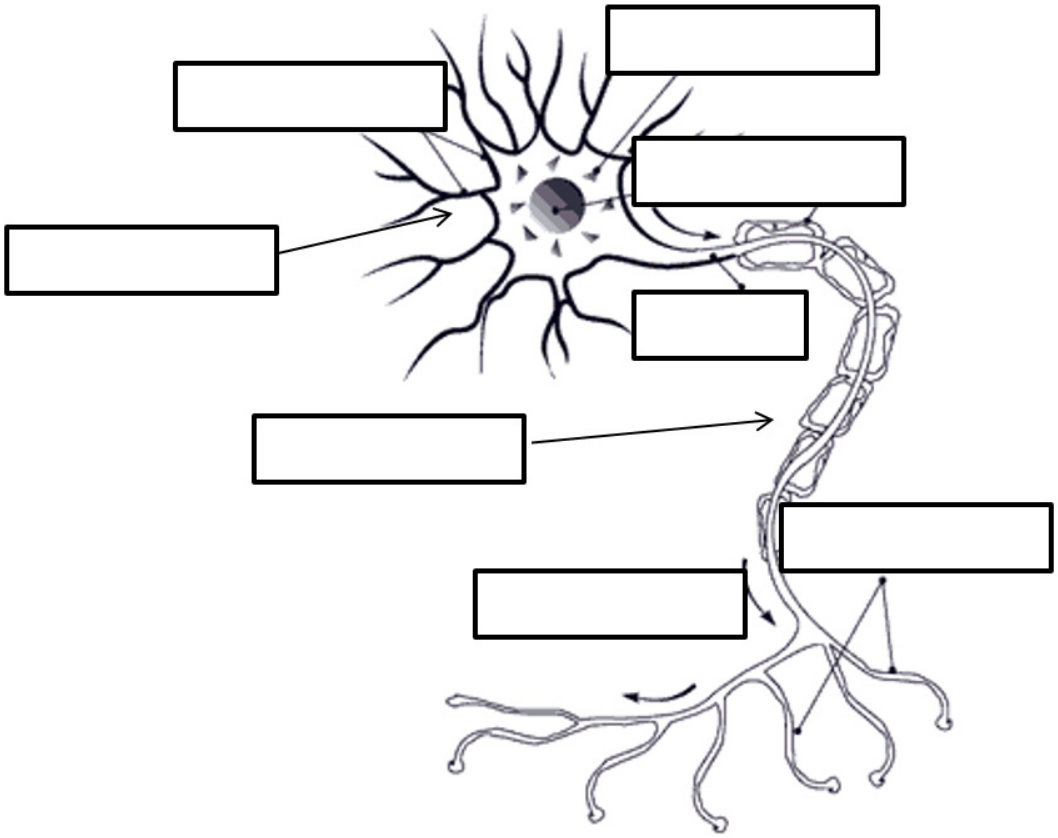
THE BASIC STRUCTURE OF A NEURON: NEURAL BASIS OF LEARNING





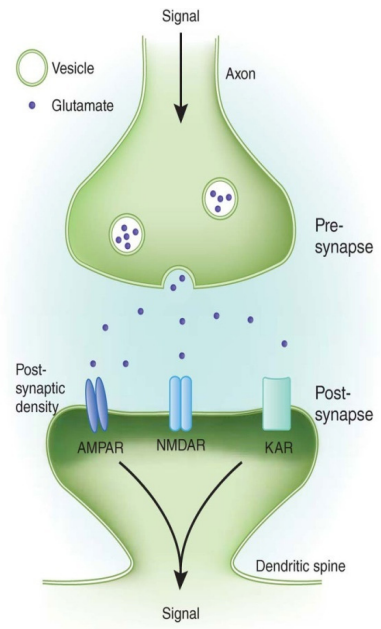
ACTIVITY 1

Label the following neuron.



A CLOSER LOOK AT NEURAL COMMUNICATION

NEURAL BASIS OF LEARNING & MEMORY

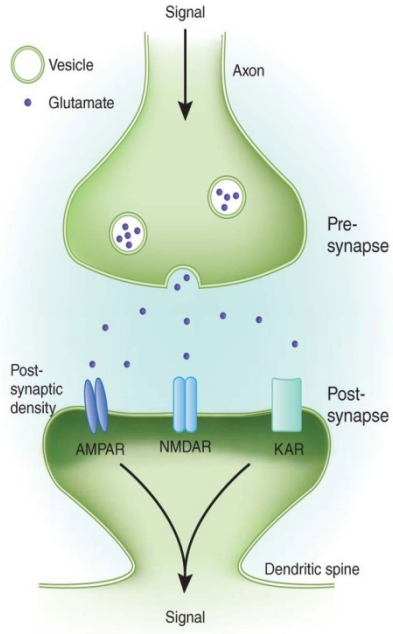


1. During learning, the axon terminals of the pre-synaptic (the sending) neuron release glutamate (a type of neurotransmitter) into the synaptic gap between the synaptic neuron and the dendrites of the neighbouring post-synaptic (the receiving) neuron.

2. This glutamate has an excitatory effect on the glutamate receptors, AMPA and NMDA in the post-synaptic neuron. An excitatory effect means that these receptors UNLOCK allowing the neurotransmitter, glutamate, to activate that neuron which makes it FIRE. It is this process that causes LONG LASTING changes at the synapse.

What do you mean by 'long lasting changes'?

Long lasting changes mean that new growths on the pre-synaptic and post-synaptic neurons occur. This means that new connections are made to adjacent and adjoining circuits of neurons.



So, what happens next?

3. The repeated glutamate stimulates the release of dopamine (another type of neurotransmitter) and it is THIS particular neurotransmitter that helps to generate new proteins.

   So, dopamine interacts with the genes of the neuron to generate new proteins. Thinking in general terms, in might help to remember that proteins are building blocks. When we want to build muscle at the gym, we might increase our intake of protein. A similar process can occur at the neural level where more protein means that more neural connections can be built.

4. Dopamine interacts with the genes of a neuron to generate new proteins.

5. This prompts the growth of new filigree appendages on the pre-synaptic neurons and dendritic spines on the postsynaptic neuron.

6. This means that postsynaptic neurons are now more sensitive to future firing by other neighbouring neurons.

In summary:

Behaviour will cause the release of glutamate from the pre-synaptic neuron into the synapse. Glutamate travels across the synapse and binds to the appropriate receptor sites on the post synaptic neuron. The glutamate stimulates the growth of dendritic spines. This makes the postsynaptic neuron more receptive to future bursts of glutamate and results in long lasting structural changes to the glutamate receptors of the post synaptic neurons. Dopamine is also released which interacts with the genes in the neuron to generate new proteins in the neuron (allowing for the growth of spines and appendages).

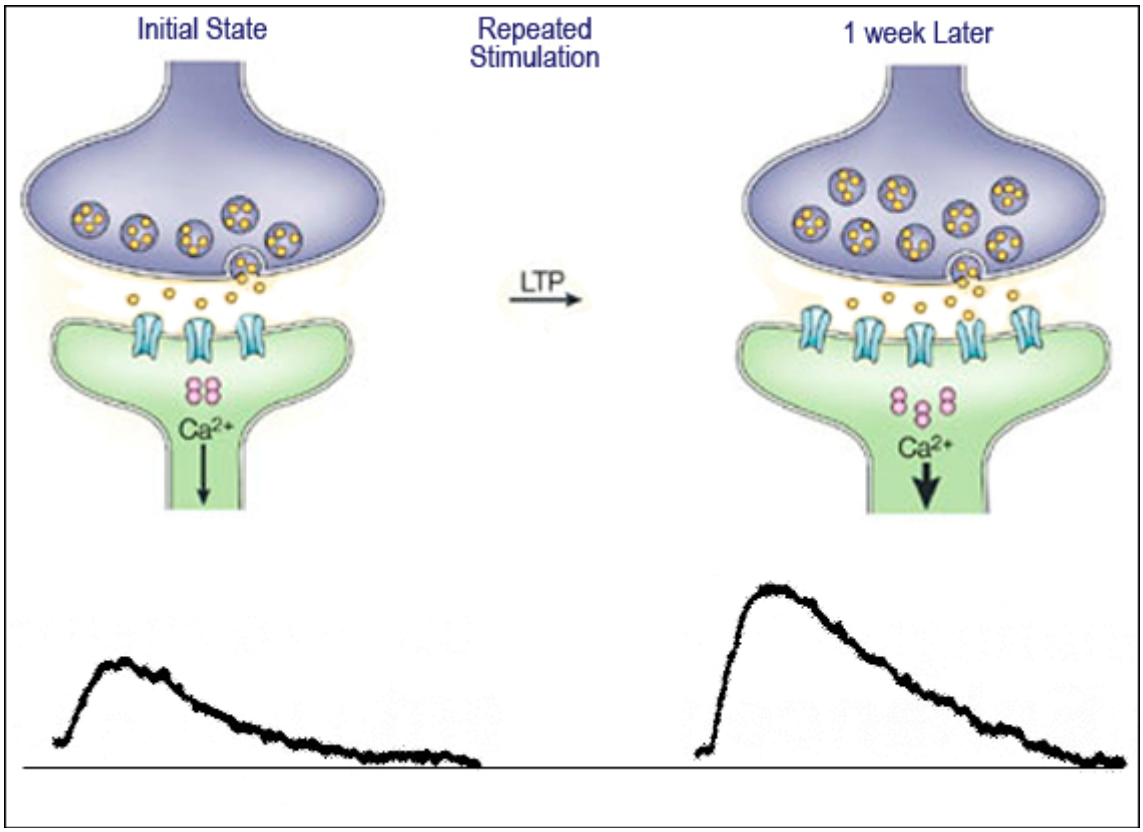
This all leads to:

- Repeated firing of neural circuits.
- Resulting in LONG LASTING structural changes to the glutamate receptors of postsynaptic neurons.
- The greater likelihood of pre-synaptic and post synaptic neurons firing AT THE SAME TIME and this causes LONG TERM POTENTIATION.

LONG TERM POTENTIATION

Refers to the long-lasting strengthening of the synaptic connections of neurons resulting in the enhanced or more effective functioning of the neurons, whenever they are activated.

So, Long Term Potentiation results from these structural changes at the neural level. In the diagram below you can see changes at the synapse where the post-synaptic neuron is more sensitive to firing.



HEBBIAN THEORY

Learning results in the creation of cell assembles or neural networks which is why the Hebb Rule is often associated with the rhyme: **'neurons that fire together wire together.'**

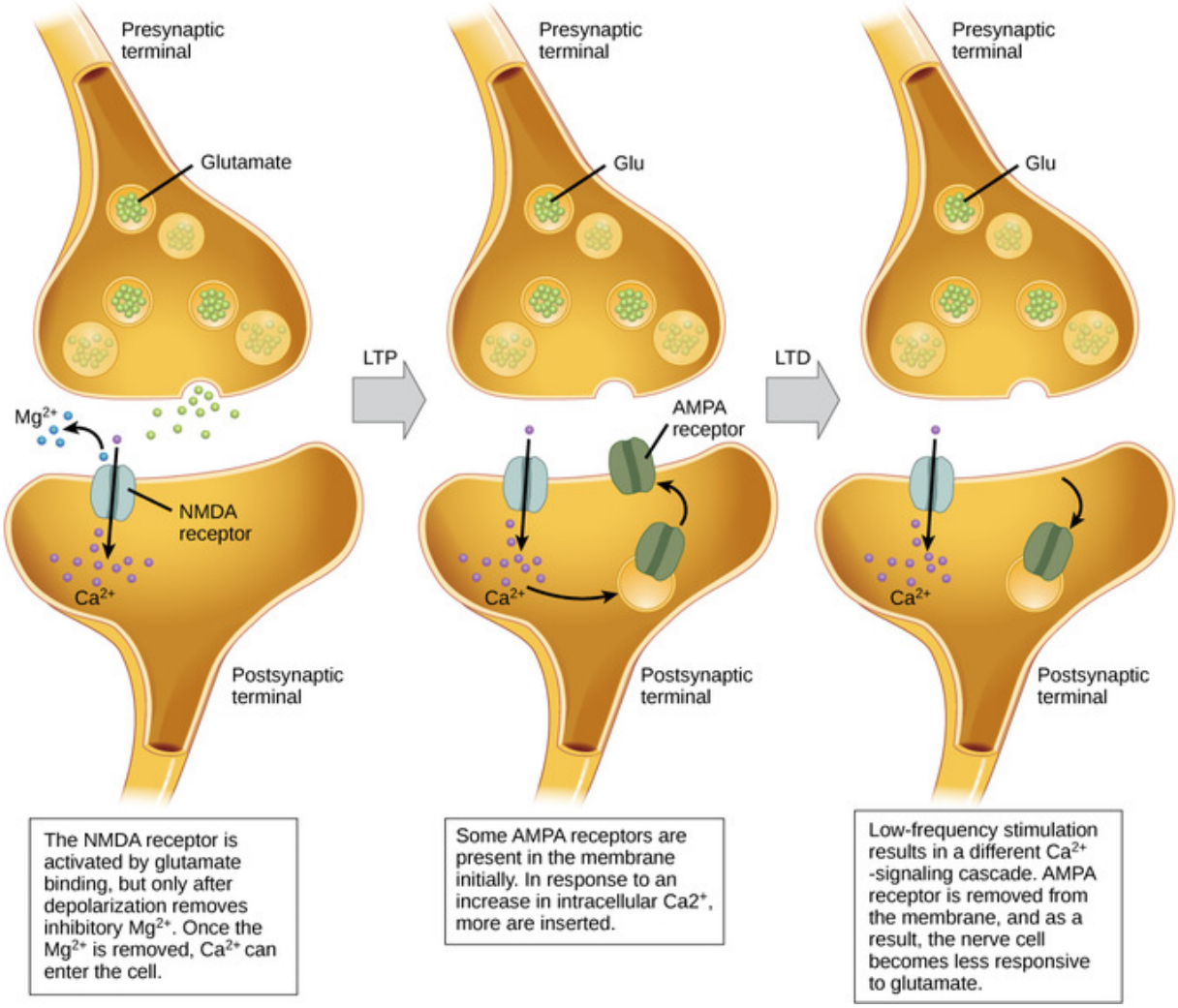
When a neurotransmitter is repeatedly sent across the synapse this can affect the strength of these connections. Neurons that do not fire together weaken their connections.

LONG TERM POTENTIATION AND NEURAL FORMATION IN BRAIN AREAS RELATING TO MEMORY

	Short-Term Memory	**Long-Term Memory**	**Brain Structures Involved**
Implicit (Procedural)	Temporary increased release of neurotransmitters from **PRE-synaptic** neuron.	Gene activated **growth** of new synaptic connections extending from the **PRE-synaptic** neuron.	Amygdala Cerebellum Reflex pathways (spinal cord, etc.)
Explicit (Episodic & Semantic)	Temporary increase in the number of receptor sites in **POST-synaptic** neuron.	Gene activated **growth** of new synaptic connections extending from the **POST-synaptic** neuron.	Hippocampus Temporal Lobe

LONG TERM DEPRESSION

Just as long-term potentiation can strengthen a synapse, a similar process can weaken an existing synapse, called **long-term depression.** Long-term depression occurs because a neuron may be firing out of synchronisation with other neurons. Researchers argue that long-term depression plays an important role in clearing the brain of old memories to make room for new information to be learnt and new memories to be formed or older memories to be modified.



NEUROHORMONES AND THE ROLE OF ADRENALIN IN THE CONSOLIDATION OF EMOTIONALLY AROUSING EXPERIENCES

Like neurotransmitters, neurohormones are chemical messengers that are manufactured by neurons and released from axon terminals. Unlike neurotransmitters, they are not released into the synaptic gap. Instead, they are released into capillaries (tiny blood vessels) where they are absorbed into the bloodstream and carried to target neurons or cells. For example, the hypothalamus in the brain has neurons that produce different kinds of neurohormones. These are secreted into the blood and travel to the pituitary gland where they exert their effect. When we experience stress for a prolonged time, it is the neurohormone TRH that signals the pituitary gland to produce ACTH which then enters the bloodstream and travels down to the adrenal cortex where it stimulates secretion of cortisol and other corticosteroids.

QUESTION 3
As a result of learning and new experiences, the brain modifies its neural pathways by:

A Increasing the number of neurons.
B Decreasing the number of neurons.
C Changing the structure of the axons within neurons.
D Changing the strength of the synaptic connections between neurons.

QUESTION 4
Which of the following is **true** regarding long-term depression as a neural process?

A Long-term depression refers to the long-lasting strengthening between synapses.
B Long-term depression only occurs in the cerebellum of the brain.
C Long-term depression involves the same neurotransmitters as the mental disorder depression.
D Long-term depression refers to the long-lasting reduction in synaptic transmission.

QUESTION 5
During learning, the dendrites of some nerve cells will:

A Release neurotransmitters into the synaptic gap.
B Receive neurotransmitters across the synaptic gap.
C Transmit impulses towards the synapses with other neurons.
D Integrate and process incoming information from other connecting neurons.

QUESTION 6
During learning, the role of neurotransmitters is to:

A Transmit electrical impulses along the axon of a neuron.
B Receive chemical messages from the synaptic gap between neurons.
C Transmit chemical messages across the synaptic gap between neurons.
D Inhibit transmission of electro-chemical impulses across the synapse between neurons.