KING'S College LONDON

INSTITUTE OF PSYCHIATRY,
PSYCHOLOGY & NEUROSCIENCE

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Topic 1:

Learning, memory and synaptic plasticity

Part 1 of 4

Module:

Biological Foundations of Mental Health

Week 4:
Biological basis of learning, memory and cognition

Topic list

This week, we will be looking at the following topics:

- ***Topic 1: Learning, memory and synaptic plasticity***
- Topic 2: From the dynamic synapse to synaptopathies
- Topic 3: The effects of activity, experience and deprivation on the nervous system

Click **Next** to continue

Part 1

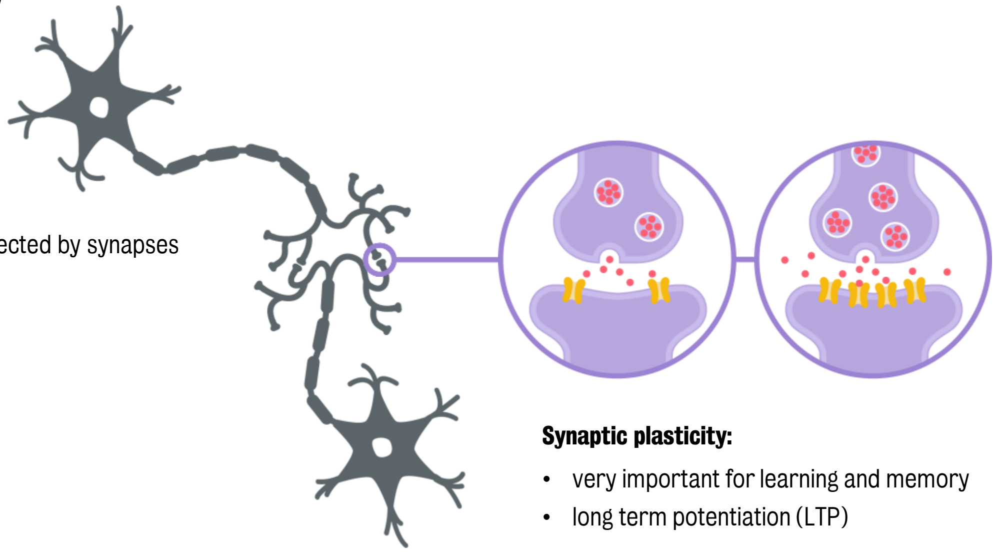
Introduction

How the brain stores and forms memory

Part 1: Overview

Synaptic plasticity

Neurons are connected by synapses



Synaptic plasticity:

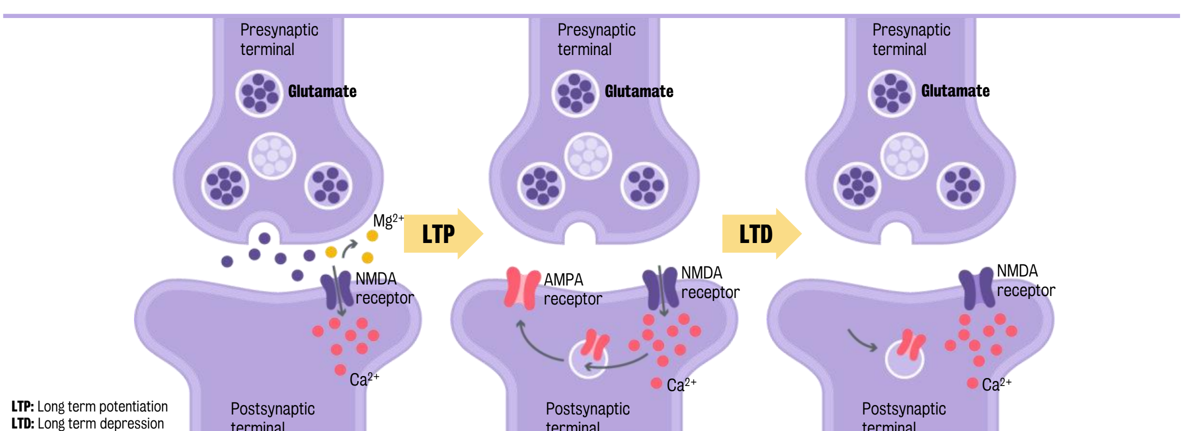
- very important for learning and memory
- long term potentiation (LTP)

Definition of synaptic plasticity

Synaptic plasticity:
History-dependent change in synaptic transmission

- can increase and/or decrease
- can be short-lasting or long-lasting
  - Long term potentiation (LTP)
  - Long term depression (LTD)
  - Short term potentiation
  - Short term depression

Plasticity of excitatory synaptic transmission



LTP: Long term potentiation
LTD: Long term depression

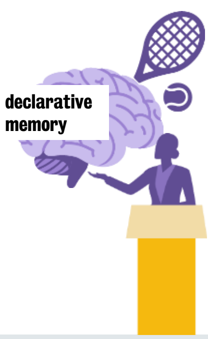
Measurement of synaptic plasticity

The famous case of the H.M. patient
Patient who suffered from severe epilepsy

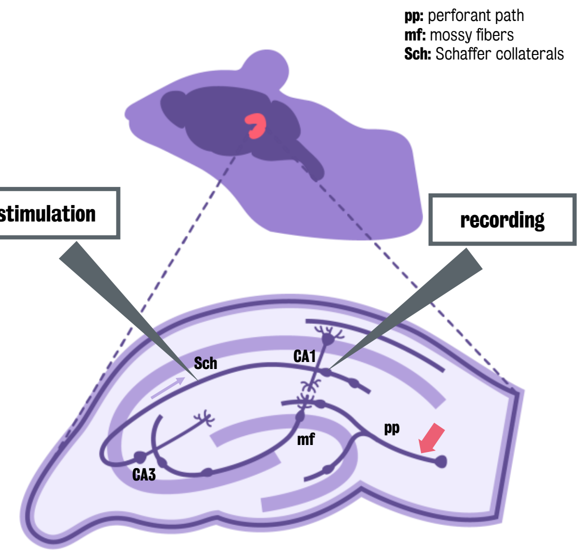
Method:
Surgeons in the 1950s decided to remove the focus of the epilepsy by lesioning the area of the brain that produces it, which includes the hippocampus.

Outcome:
The lesion worked for the treatment of epilepsy but resulted in severe memory impairment.

Conclusion:
The hippocampus is important for learning and memory, particularly for declarative memory.



How do you study synaptic plasticity in the hippocampus?
By using an electric stimulation electrode that simulates and records synaptic currents.

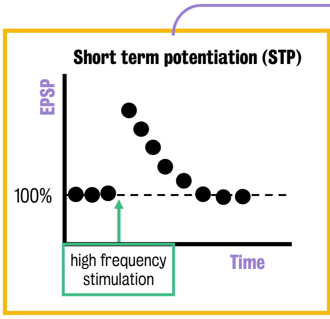


O'Keefe and Nadel (1978)

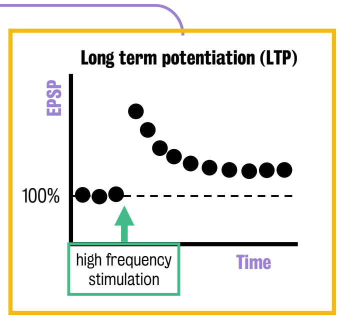
Different forms of synaptic plasticity

EPSP: Excitatory postsynaptic potential
(measure of excitatory synaptic transmission)

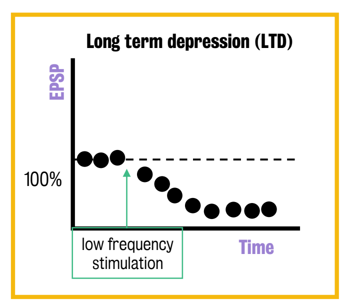
Difference between STP and LTP:
A higher frequency stimulation is required



Duration:
Normally lasts for about 30 minutes

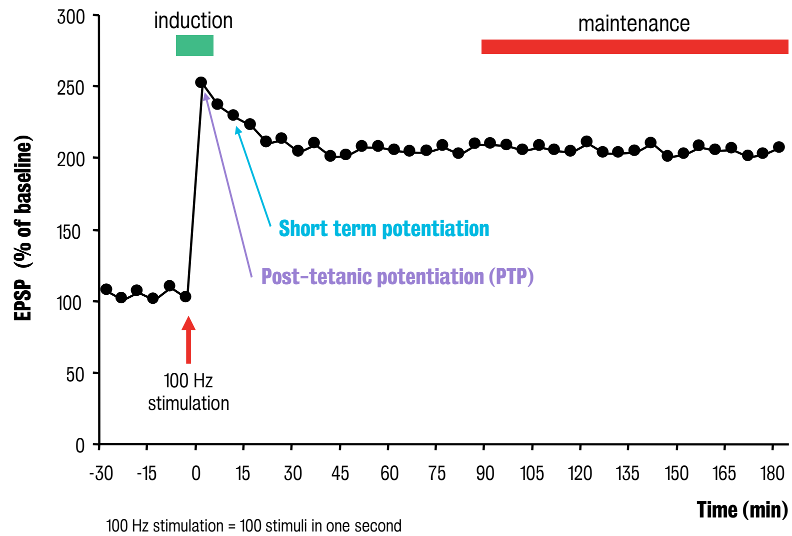


Duration:
Can last for several hours or even up to a year *in vivo*



Properties of LTP (1)

Long-term potentiation was thought to be a mechanism of information storage in the brain.



100 Hz stimulation = 100 stimuli in one second

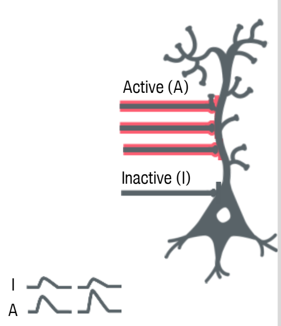
Properties of LTP (2)

Long lasting

(long lasting enhancement of synaptic transmission)

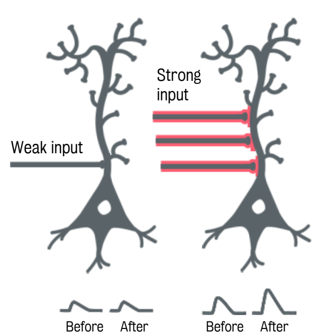
Input specific

(specific to the activated synapses only – doesn't affect neighbouring synapses)



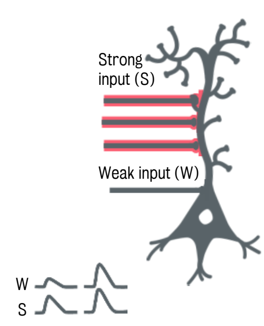
Cooperativity

(need a threshold stimulation to induce long term potentiation – only signals of relevance induce long term potentiation)



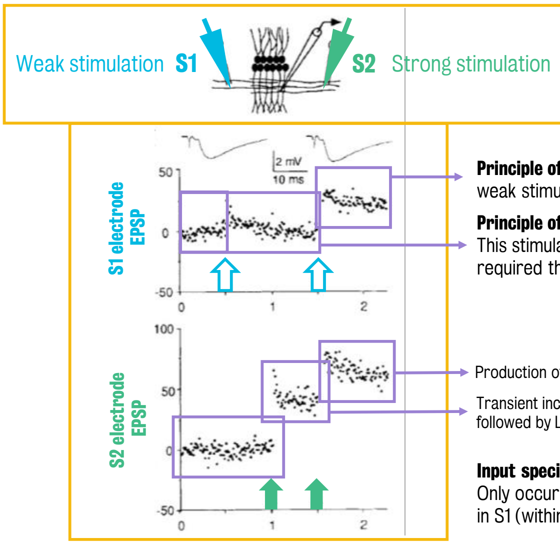
Associativity

(applies to long term potentiation at two different synapses – neighbouring synapse experience)



Properties of LTP (3)

A synaptic model of memory: Long-term potentiation in the hippocampus



EPSP: Excitatory postsynaptic potential (measure of excitatory synaptic transmission)

FEPSPs: Field excitatory postsynaptic potentials

Principle of associativity:
weak stimulation + strong stimulation = production of LTP

Principle of cooperativity:
This stimulation did not reach the required threshold to induce LTP

Production of long lasting synaptic transmission

Transient increase in synaptic transmission (PTP and STP) followed by LTP that is long lasting and stable

Input specific phenomenon:
Only occurs in the S2 pathway and not in S1 (within the same timeframe)

Pavlovian conditioning (Pavlov's dog):

Principle of **associative learning**

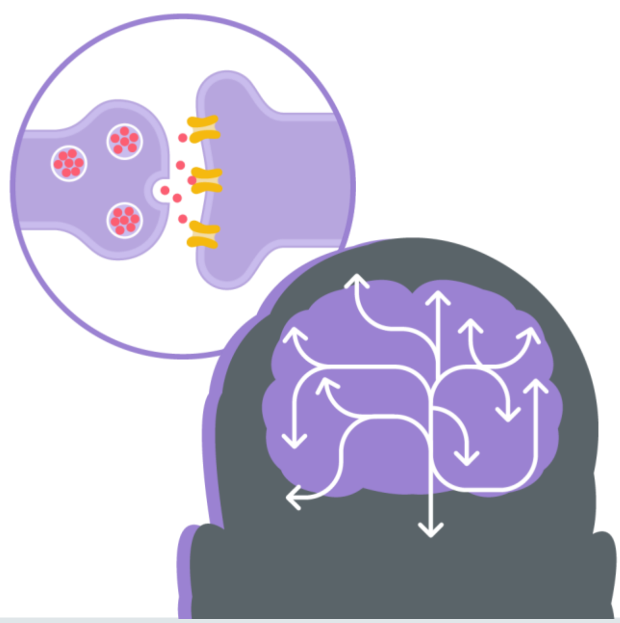
Bliss and Collingridge (1993)

Part 1: Summary

Phenomenon of long-term potentiation

In the next part, we will explore:

- the underlying molecular mechanisms of LTP
- its role in learning and memory



End of part 1