KING'S College LONDON

INSTITUTE OF PSYCHIATRY,
PSYCHOLOGY & NEUROSCIENCE

Module:

Biological Foundations of Mental Health

Week 4:

Biological basis of learning, memory and cognition

Dr Deepak Srivastava

Topic 2:

From the dynamic synapse to synaptopathies

Part 2 of 4

Topic list

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

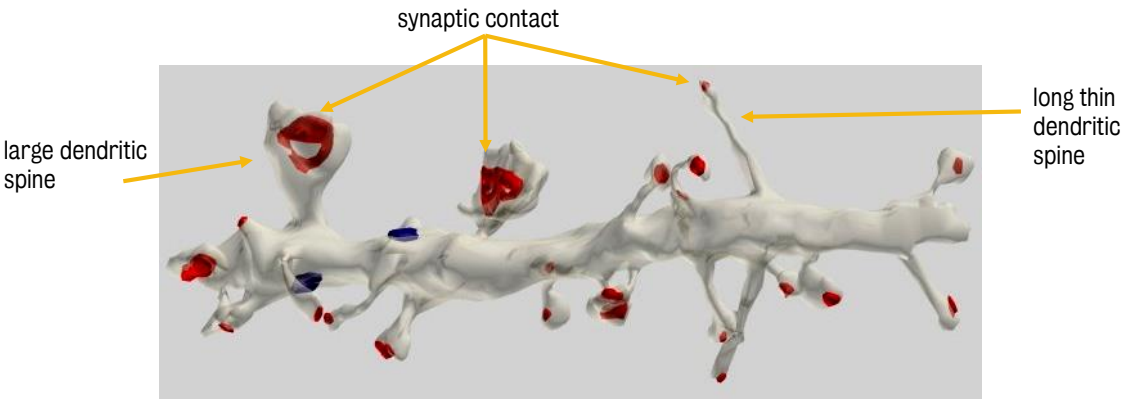
- Topic 1: Learning, memory and synaptic plasticity
- ***Topic 2: From the dynamic synapse to synaptopathies***
- Topic 3: The effects of activity, experience and deprivation on the nervous system

Click **Next** to continue

Part 2

A myriad of morphologies

The shape and size of a dendritic spine can provide information on its function.



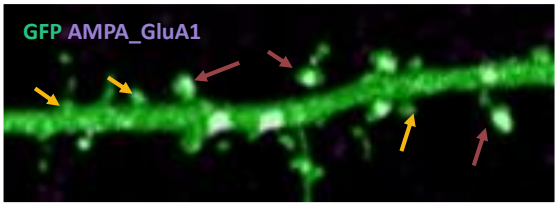
Larger dendritic spines have larger synaptic connections, while smaller or thinner spines have smaller connections.

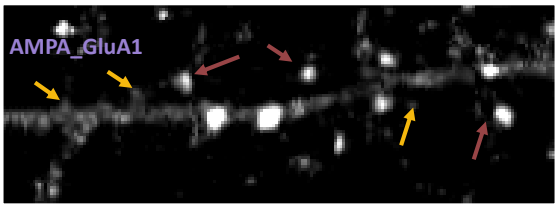
Fiala et al., 2002

Spine structure and synaptic function

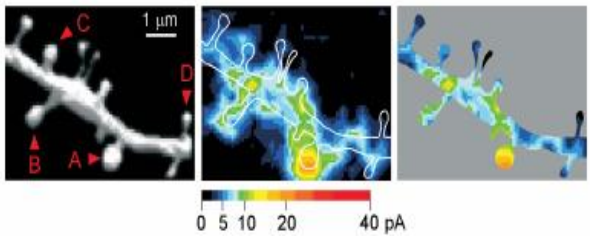
Dendritic spine structure is linked to synaptic function.

AMPA receptors are enriched in dendritic spines.





Functional AMPAR content is correlated with spine geometry.

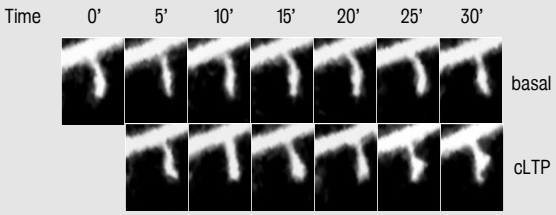


Matsuzaki et al., 2001; Xie et al., 2007

Structural plasticity

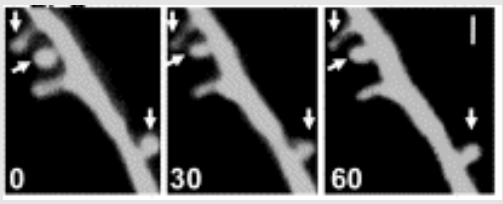
Dendritic spines can change shape in response to different stimuli.

Long term potentiation (LTP)



Dendritic spines increase in size.

Long-term depression (LTD)



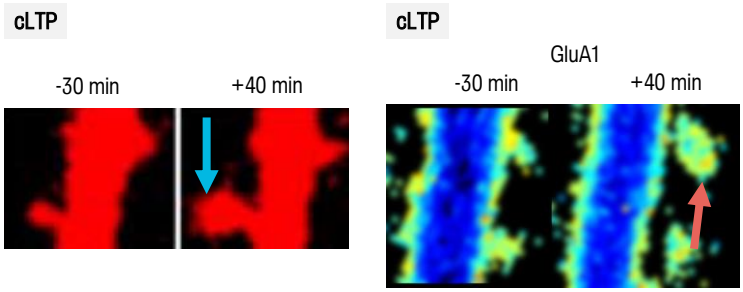
Dendritic spines decrease in size.

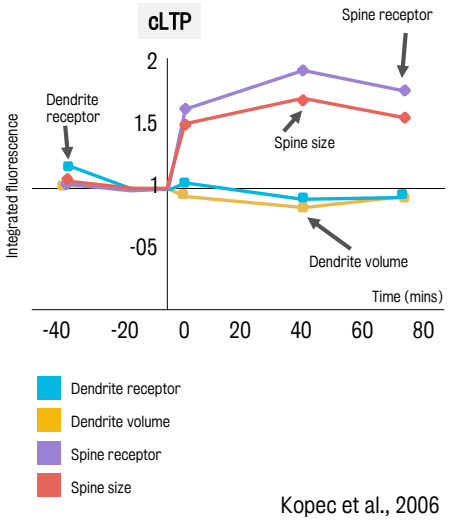
Structural plasticity

Xie et al., 2007; Zhou et al., 2004

Are structural and functional plasticity linked?

Kopec and colleagues tested the idea that an LTP-like stimulus would not only change dendritic spine size, but also increase the amount of AMPA receptors.



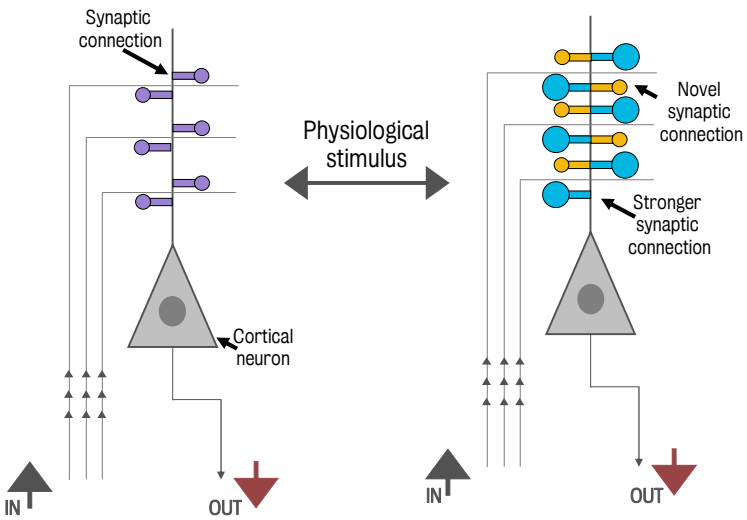


They found that the induction of chemical LTP (cLTP) caused the spines to increase in size and the amount of GluA1 also increased. As spine size increased, the amount of AMPA receptors also increased.

This shows us that structural and functional plasticity are linked.

Kopec et al., 2006

From structural plasticity to refinement of neural circuitry



A physiological stimulus can change:

- the number of dendritic spines
- the size of dendritic spines

This results in a change in the amount of AMPA receptors within the spines, resulting in a change of synaptic strength.

Structural and functional plasticity are connected and can be changed, resulting in refined neural circuitry.

Kopec et al., 2006

References

[1] Fiala, J. C., Spacek J., & Harris, K. M. (2002). Dendritic spine pathology: cause or consequence of neurological disorders?. Brain research reviews, 39(1): 29-54.

[2] Kopec, C. D., Li, B., Wei, W., Boehm, J., & Malinow, R. (2006). Glutamate receptor exocytosis and spine enlargement during chemically induced long-term potentiation. Journal of Neuroscience, 26(7): 2000-2009.

[3] Matsuzaki, M., Ellis-Davies, G. C. R., Nemoto, T., Miyashita, Y., Iino, M., & Kasai, H. (2001). Dendritic spine geometry is critical for AMPA receptor expression in hippocampal CA1 pyramidal neurons. Nature neuroscience, 4(11): 1086.

[4] Trachtenberg, J. T., Chen, B. E., Knott, G. W., Feng, G., Sanes, J. R., Welker, E., & Svoboda, K. (2002). Long-term in vivo imaging of experience-dependent synaptic plasticity in adult cortex. Nature, 420(6917), 788.

[5] Xie, Z., Srivastava, D. P., Photowala, H., Li, K., Cahill, M. E., Woolfrey, K. M., Shum, C. Y., Surmeier, D. J., & Penzes, P. (2007). Kalirin-7 controls activity-dependent structural and functional plasticity of dendritic spines. Neuron, 56(4): 640-656.

[6] Zhou, Q., Homma, K. J., & Poo, M. (2004). Shrinkage of dendritic spines associated with long-term depression of hippocampal synapses. Neuron, 44(5): 749-757.

End of part 2