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 1 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

Learning outcomes

- be able to describe the components of an excitatory synapse and the different morphologies that dendritic spines can adopt
- understand that dendritic spines play a key role in synaptogenesis
- understand that abnormal dendritic spine density has been linked with different neurodevelopmental, psychiatric and neurodegenerative disorders
- be able to describe how studying specific genes associated with disease can help us understand how dendritic spine dysfunction may play an important role in the pathophysiology of disease.

Part 1

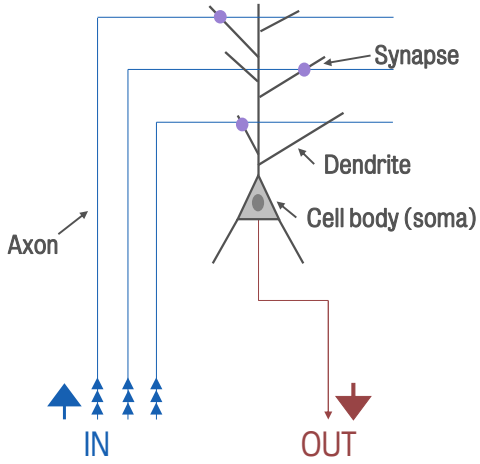
Basic function of synapses

Structure and function of dendritic spines

Synapses

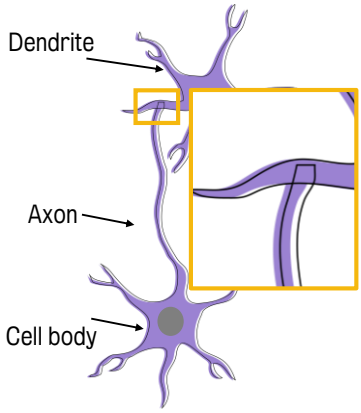
Synapses are sites of synaptic communication, occurring though transfer of chemical messages between CNS cells.

- responsible for cognitive function, social behaviour, learning and memory and motor behaviours
- can occur from sensory organs and neurons, between neurons and from neurons to target organs
- unidirectional flow of information, from the pre-synaptic neuron to the post-synaptic neuron
- disruption of synapse structure and/or function is strongly linked with brain dysfunction



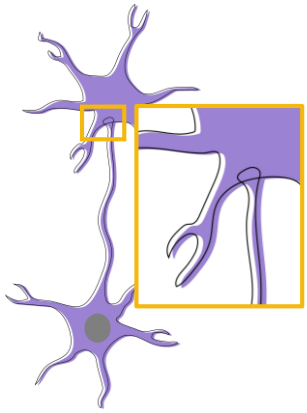
Types of synapses

Axodendritic



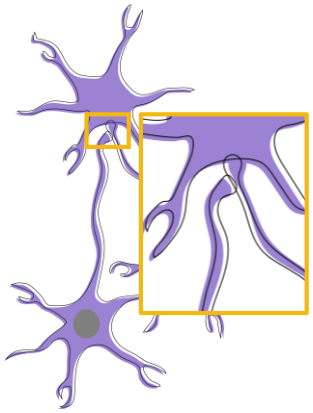
- axon to dendrite
- excitatory, inhibitory or neuromodulatory

Axosomatic



- axon to cell body
- inhibitory or neuromodulatory

Axoaxonic

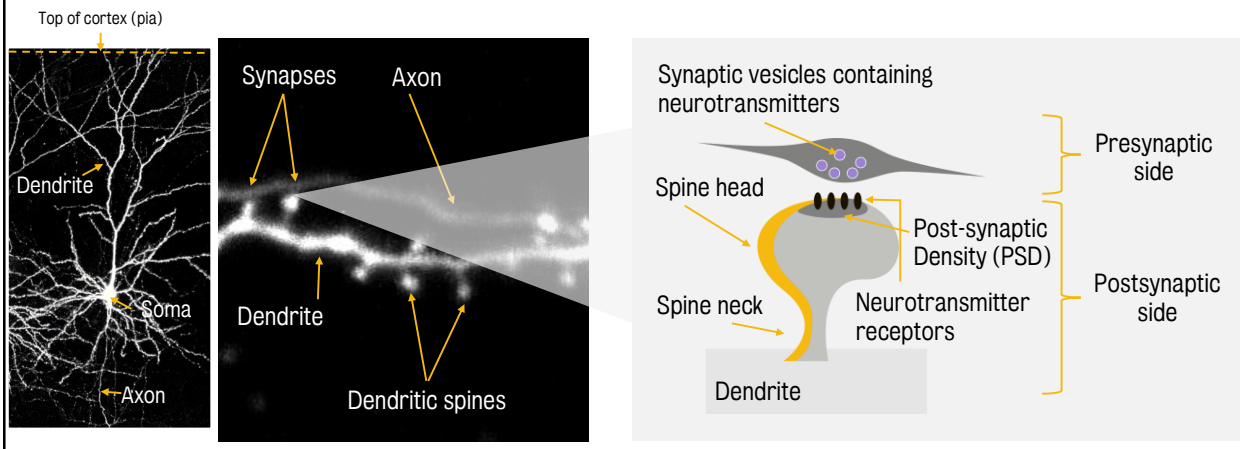


- axon to axon

Bear et al., 2007

Dendritic spines

Many synapses occur on highly specialised dendritic protrusions called dendritic spines.

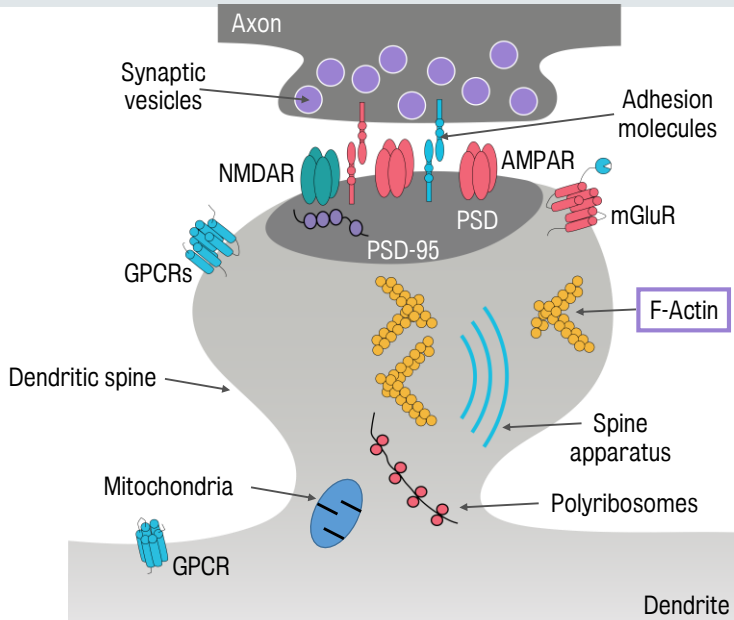


Srivastava et al., 2011; 2013

What is in a dendritic spine?

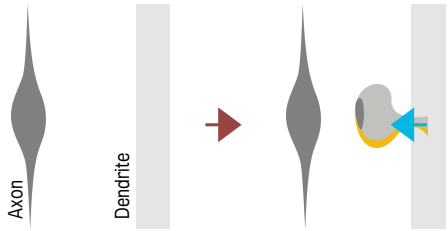
Why have dendritic spines?

1. Increasing surface area and synaptic connections
2. Able to compartmentalise electrical and biochemical signals from the cell
   - Spines have specialised shapes and vast numbers of proteins
   - F-actin allows dendritic spines to change shape

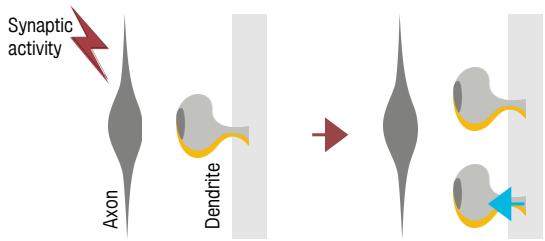


Physiological role of dendritic spines

Synapse formation



Structural encoding of information

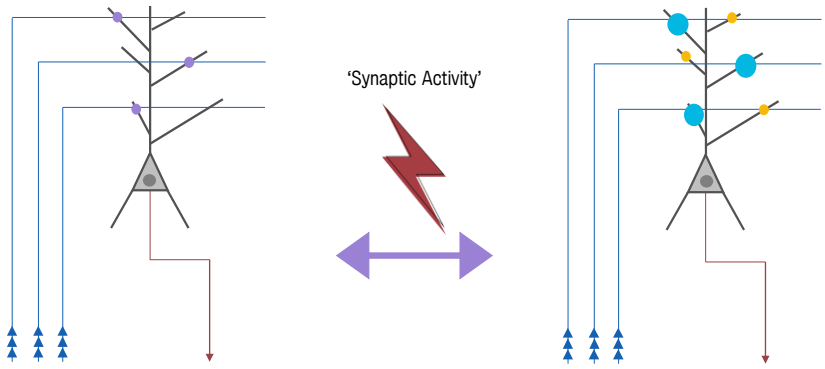


Changes in synaptic connectivity can occur in a bi-directional manner.

Physiological role of dendritic spines

Neural circuit remodelling

Changes in dendritic spine *Number + Shape*

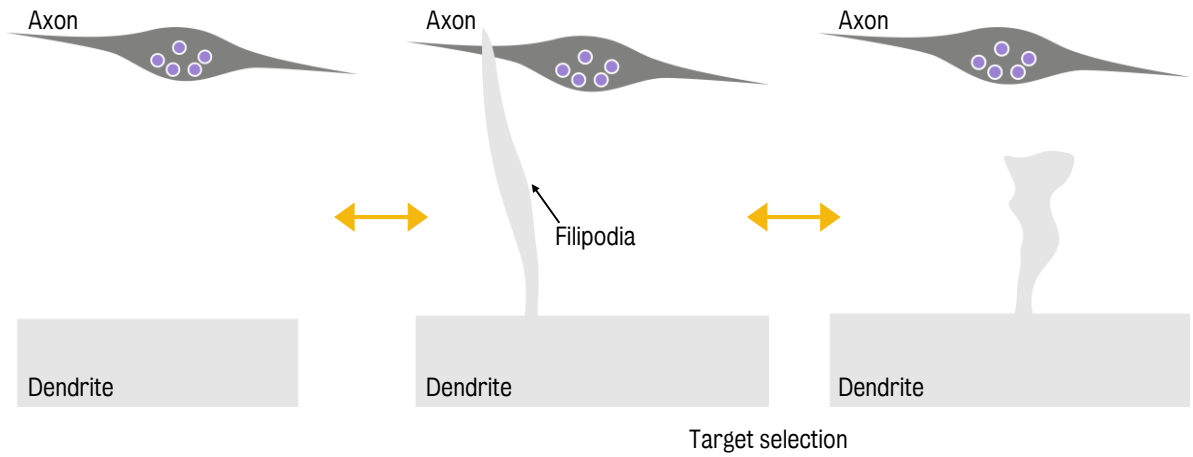


- Larger dendritic spine
- New dendritic spine

Making synapses: spinogenesis

The filipodial model can be broken down into spinogenesis and synaptogenesis.

Spinogenesis

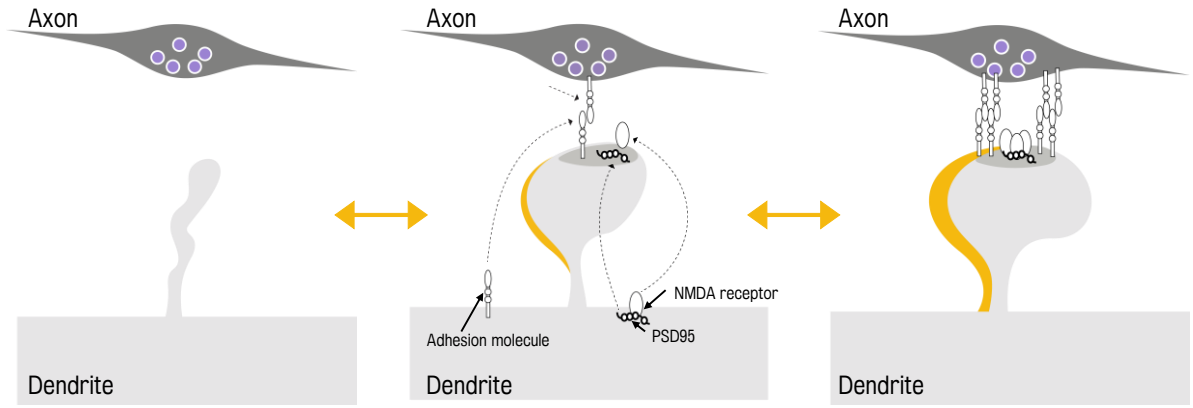


Target selection

Making synapses: synaptogenesis

The filipodial model can be broken down into spinogenesis and synaptogenesis.

Synaptogenesis



Synapse assembly

Synapse stabilisation

References

[1] Bear, M. F., Connors, B. W., & Paradiso, M. A. (Eds.). (2007). Neuroscience (Vol. 3). Lippincott Williams & Wilkins.

[2] Srivastava, D. P., & Penzes, P. (2011). Rapid estradiol modulation of neuronal connectivity and its implications for disease. Frontiers in endocrinology, 2 (77): 1-17.

[3] Srivastava, D. P., Woolfrey, K. M. & Penzes, P. (2013). Insights into rapid modulation of neuroplasticity by brain estrogens. Pharmacological Reviews, 65(4): 1318-1350.

End of part 1