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What we talk about when we talk about synapses - a short story of spines and densities

Electron microscopy is a widely used tool that has improved our knowledge of synapse ultrastructure and organization in the brain. Rearrangements of synapse structure following maturation and in synaptic plasticity have been broadly described and, in many cases, the defective architecture of the synapse has been associated to functional impairments. It is therefore important, when studying brain connectivity, to map these rearrangements with the highest accuracy possible to provide solid and reliable data about the structure of such a small complex. Dendritic spines initially identified as thin protrusions on the surface of Golgi-impregnated neurons were further characterized by Grey in 1959, through electron microscopy investigations, as the major postsynaptic target of excitatory synapses in the central nervous system. Several decades and numerous morphological and functional studies were needed to finally define dendritic spines as structures that not only increase the synaptic surface but also play an important role in the compartmentalization of biochemical processes within the restricted volume of a spine head. The heterogeneity in size and shape among different brain areas, developmental stages and animal species is a feature of dendritic spines. During synaptogenesis, thin filopodia, protruding from the dendritic shaft, start forming synapses with the axons from nearby neurons.The morphological changes that follow will determine the shape of the spine, in a highly mobile and plastic scenario where its final shape will depend on synaptic activity and strength. Dendritic spine number is equally highly variable as, not only at different ages synaptic establishment and pruning compete, but also experience can heavily affect formation of new spines, as well as spine maintenance and elimination. The overall result of all these developmental and plasticity-related events is the modulation of dendritic spines and synaptic density and ultimately the refinement of synaptic connectivity and neural wiring in the central nervous system. A crucial and plastic element of the dendritic spine is the postsynaptic density, an electron dense structure, tightly associated with the postsynaptic membrane, whose components are essential for neurotransmitter recognition, binding and local downstream signal transduction, and all biochemical processes that trigger plasticity like long term potentiation. The architecture of the PSD, in terms of size and shape is important to determine both synapse activity and maturation stage and its alterations can be considered hallmarks of pathological states. Our contribution to the research in this field will be presented during this seminar.

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