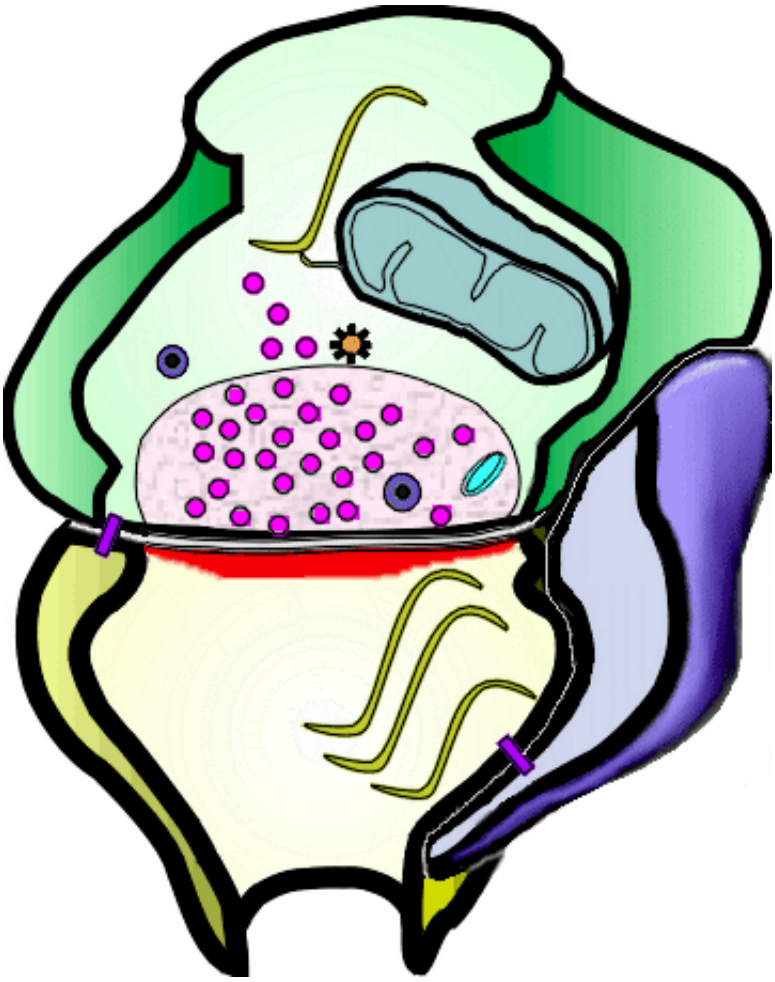
Structure of Chemical Synapses

by Karin Sorra

Functional communication between neurons occurs at specialized junctions called *synapses*. The most common types of synapses in the brain use chemicals, (more specifically, *neurotransmitters*,) to communicate between neurons. These are called *chemical synapses*.

Schematic of a Chemical Synapse



	Presynaptic Axon
	Postsynaptic Spine
	Postsynaptic Density
	Active Zone
	Astrocyte
	Coated Vesicle
	Dense Core Vesicle
	Double-Walled Vesicle
	Endoplasmic Reticulum
	Mitochondrion
	Punctum Adhaerens
	Synaptic Cleft
	Synaptic Vesicle

(Click on an object to view through the electron microscope.)

A presynaptic element, an axon, and a postsynaptic element, for example a dendritic spine, are in close apposition at the synapse but not in direct contact. The pre- and postsynaptic membranes are separated by a gap, the synaptic cleft. Chemical transmitters bridge this gap by diffusing from release sites on the presynaptic side to receptors on the postsynaptic side.

A variety of ultrastructural specializations occur at the synapse enabling unambiguous identification of the pre- and postsynaptic partners. Within the presynaptic axonal bouton, clouds of synaptic vesicles are prominent; mitochondria may be present, as well as tubules of endoplasmic reticulum. A characteristic

feature of the synapse is the accumulation of opaque material on the cytoplasmic face of the postsynaptic membrane. This material is refered to as the postsynaptic density. The density represents the aggregation of neurotransmitter receptors and signaling proteins essential for chemical synaptic transmission.

Since the late 1950s, the ultrastructural features of individual synapses have been studied extensively using snap-shots obtained via electron microscopy. Gray classified two types of synapses within the brain based on the ultrastructural characteristics of the presynaptic (vesicle-bearing) and postsynaptic partners (length of apposed membrane, membrane thickenings and synaptic cleft):

- Type 1
- Type 2

These two categories were further distinguished by their locations: Type 1 synapses were found on dendritic spines and dendrite shafts, whereas Type 2 synapses occurred primarily on dendrite shafts and neuronal cell bodies. Virtually synonymous with Gray's nomenclature are the terms:

- Asymmetric Synapse
- Symmetric Synapse

described by Colonnier. Colonnier extended the observations of Gray using aldehyde-fixed brain. In aldehyde-fixed tissue, asymmetric synapses include axons that contain predominantly round or spherical vesicles and form synapses that are distinguished by a thickened, postsynaptic density. In contrast, symmetric synapses involve axons that contain clusters of vesicles that are predominantly flattened or elongate in their appearance. The pre-and postsynaptic membranes are more parallel than the surrounding nonsynaptic membrane, and the synapse does not contain a prominent postsynaptic density. Click here (164K) to view Colonier's description of asymmetric and symmetric synapses.

The sterotypical and most abundant synapse in the central nervous system is the asymmetric synapse occurring between an axon and a dendritic spine. Other synaptic relationships exist and involve different parts of the neuron. For instance, axo-axonic, somato-axonic, somato-dendritic, dendro-axonic, and dendro-dendritic synapses can occur and provide alternate mechanisms for functional communication between neurons.

Structural and functional classifications of axons, dendrites and their synapses are still emerging. The use of electrophysiology, laser scanning, and serial electron microscopy, together with 3D computer-aided reconstruction, facilitate the study of neurons and the intricacies of their synapses within the brain. See "Synapses of S. Radiatum" for more details of the structure of synapses within area CA1 of the hippocampus.

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