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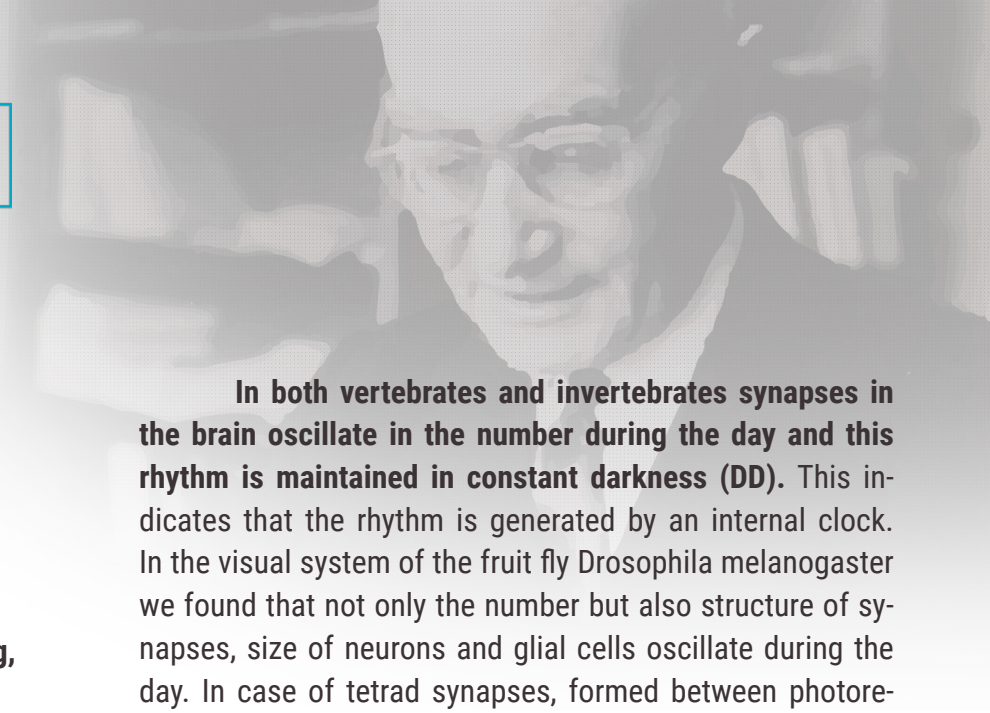

Circadian plasticity of synapses

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In both vertebrates and invertebrates synapses in the brain oscillate in the number during the day and this rhythm is maintained in constant darkness (DD). This indicates that the rhythm is generated by an internal clock. In the visual system of the fruit fly Drosophila melanogaster we found that not only the number but also structure of synapses, size of neurons and glial cells oscillate during the day. In case of tetrad synapses, formed between photoreceptors and the first order interneurons, their number increases twice during the day, in the morning and in the evening while feedback synapses contacting L2 interneurons back to the photoreceptor terminals are most numerous at night. It means that different types of synapses show a specific daily pattern in the frequency changes. Tetrad synapses are also sensitive to light and their number increases at any time of the day after a short light pulse. In contrast feedback synapses are not sensitive to light. In addition to synapse numbers, synaptic proteins also oscillate in abundance in the course of the day. The number of synapses, levels of synaptic proteins, structure of neurons and glial cells do not oscillate in mutants of clock genes and mechanisms responsible for daily remodeling of the brain include circadian expression of genes and proteins involved in TOR kinase signaling and autophagy.

Similar cyclic changes in the number of synaptic contacts were also found in the mouse brain, in somatosensory cortex. In the layer IV (barrel cortex) where there are cortical representations of vibrissae, excitatory synapses peak during the day when mice sleep while inhibitory synapses increase in the frequency at the beginning of night when mice are highly active in locomotor activity. While excitatory synapses oscillate in the number only in light/dark conditions (LD), inhibitory synapses oscillate not only in LD but also in DD, which confirms that their number is controlled by the circadian clock. Moreover, dendritic spines, which carry postsynaptic elements of synapses change their morphology. During the day there is more one-synapse dendritic spines but at night more double-synapse spines. The results, which have been obtained so far in both flies and mice, clearly indicate that brain is remodeled in the course of the day.

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