«Здоровый и больной мозг: от молекулярной физиологии к патологии, клинике и лечению»

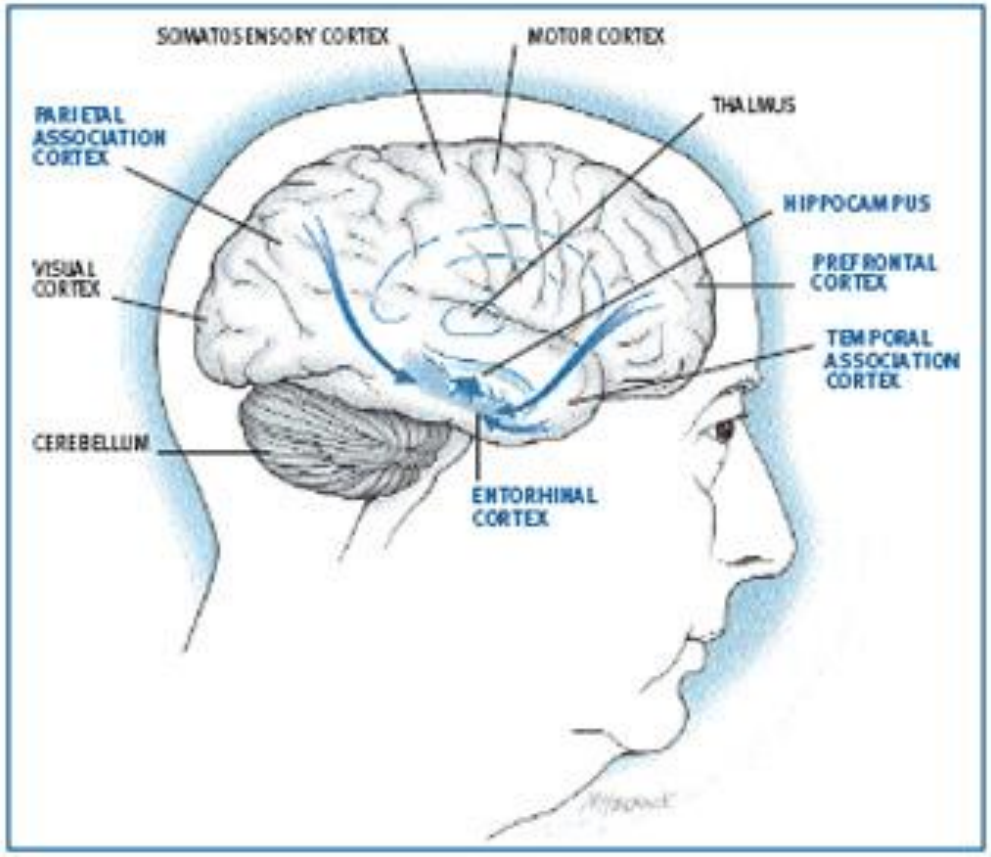
Наиль Бурнашев

II Интегративная деятельность мозга

1. Структурно-функциональная организация коры головного мозга и гиппокампа. Локальные нейронные сети в ЦНС в развитии.

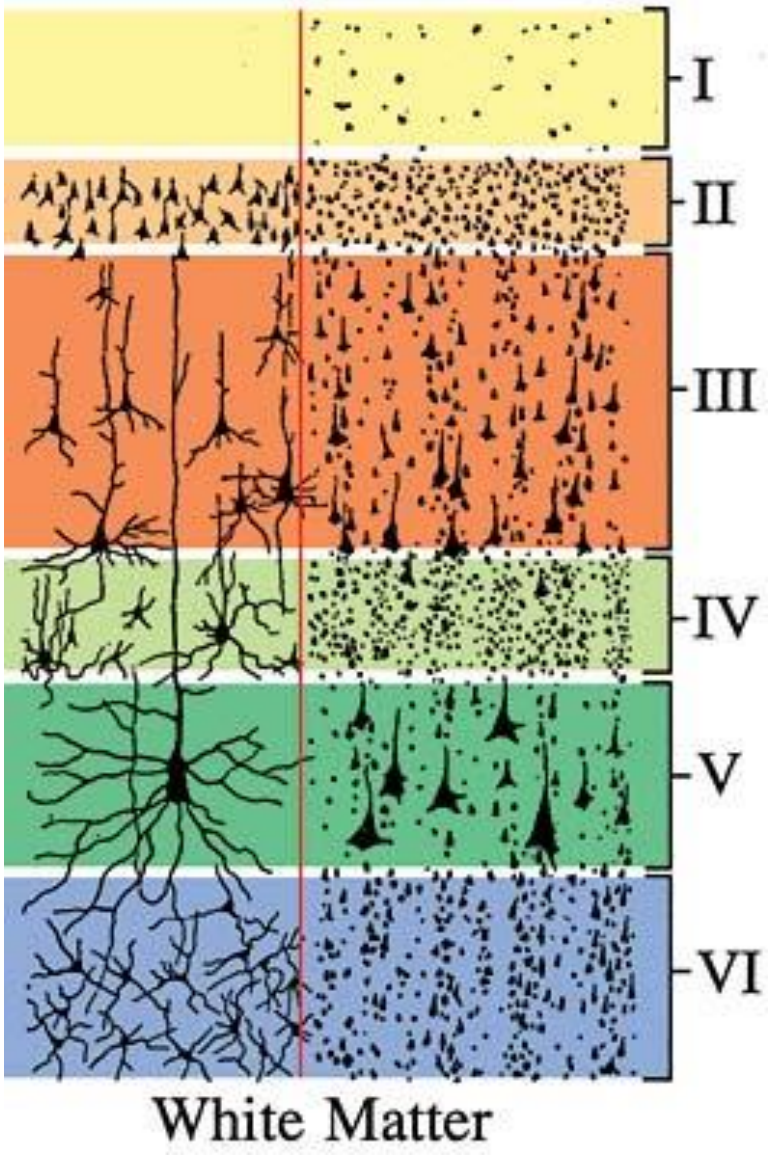
2. Нейронные механизмы обучения и памяти. Нарушения памяти.

Неокортекс: Кортикальные колонны

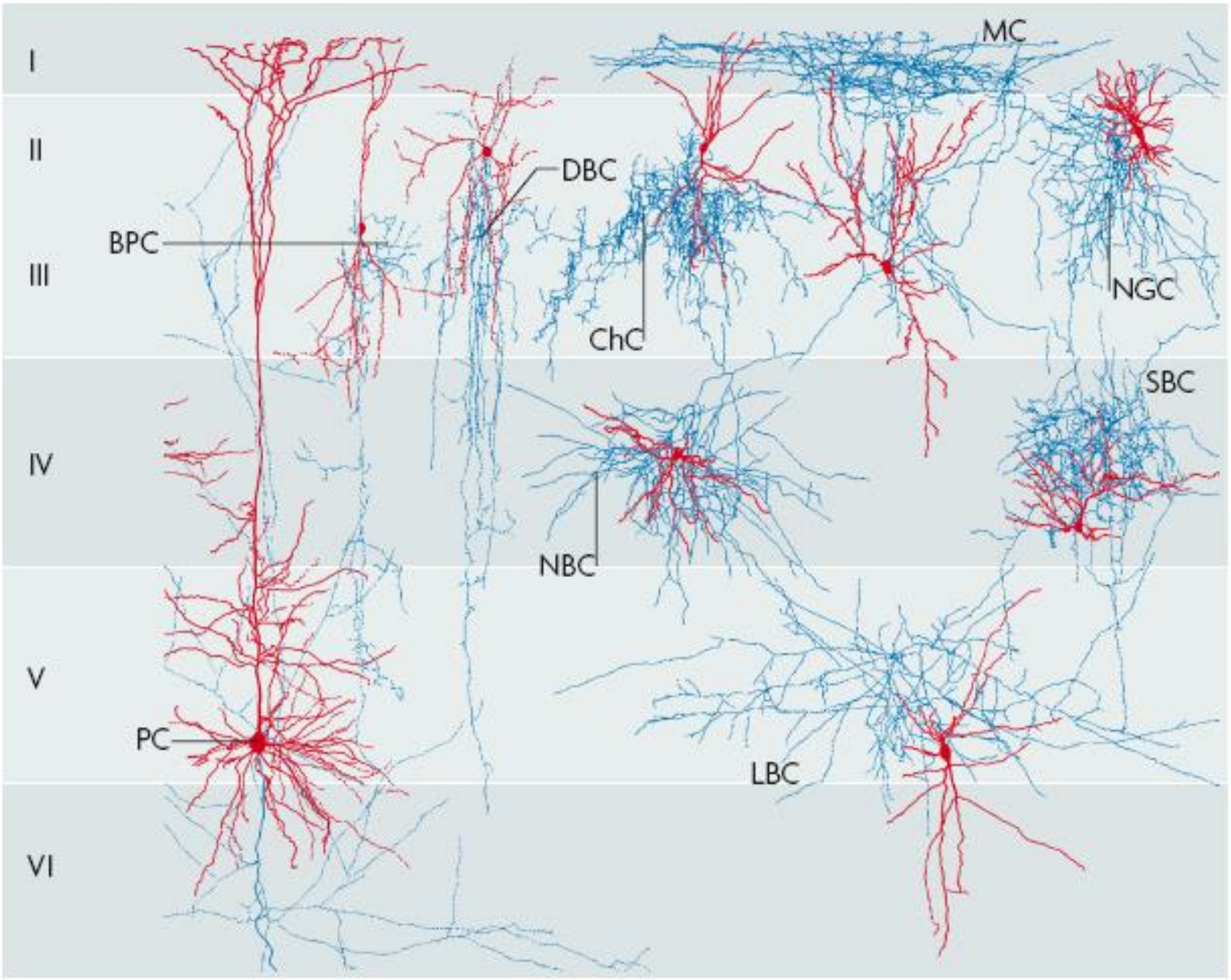

SOMATOSENSORY CORTEX
MOTOR CORTEX
PARIETAL ASSOCIATION CORTEX
THALAMUS
HIPPOCAMPUS
VISUAL CORTEX
PREFRONTAL CORTEX
TEMPORAL ASSOCIATION CORTEX
CEREBELLUM
ENTORHINAL CORTEX

В коре полушарий различают 6 слоев

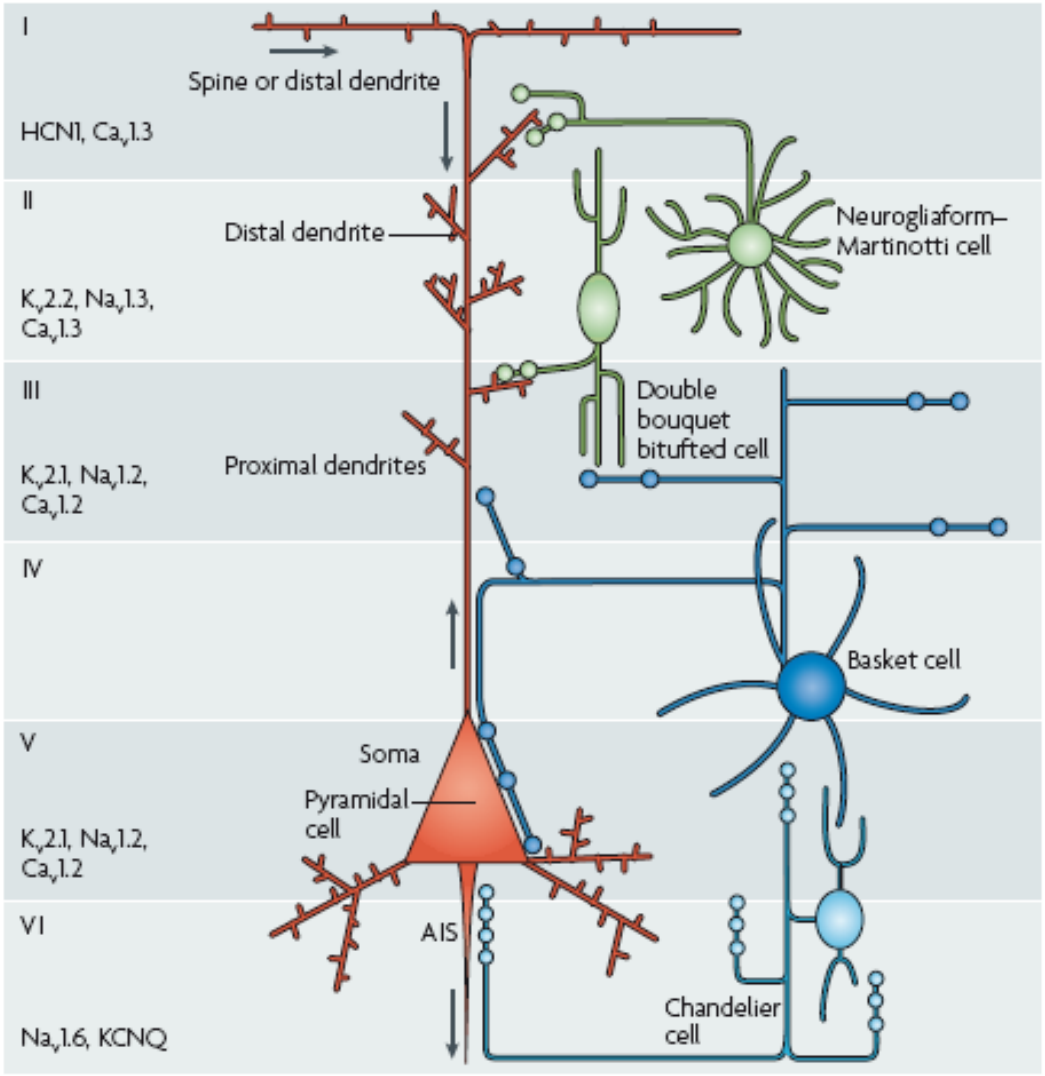
1. **Молекулярный**
2. **Наружный зернистый**
3. **Наружный пирамидный**
4. **Внутренний зернистый**
5. **Внутренний пирамидный**
6. **Полиформный**



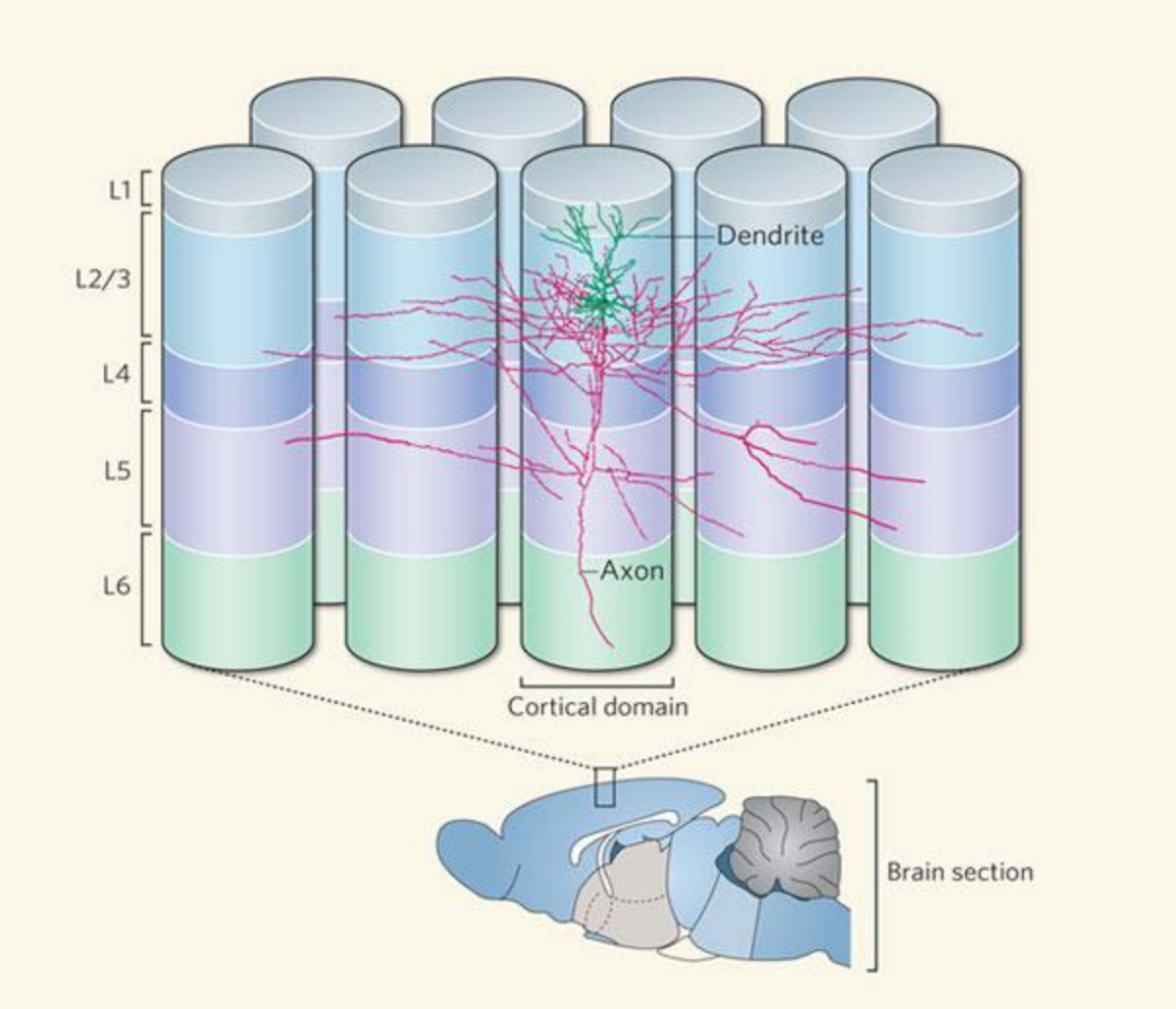
Многообразие кортикальных нейронов



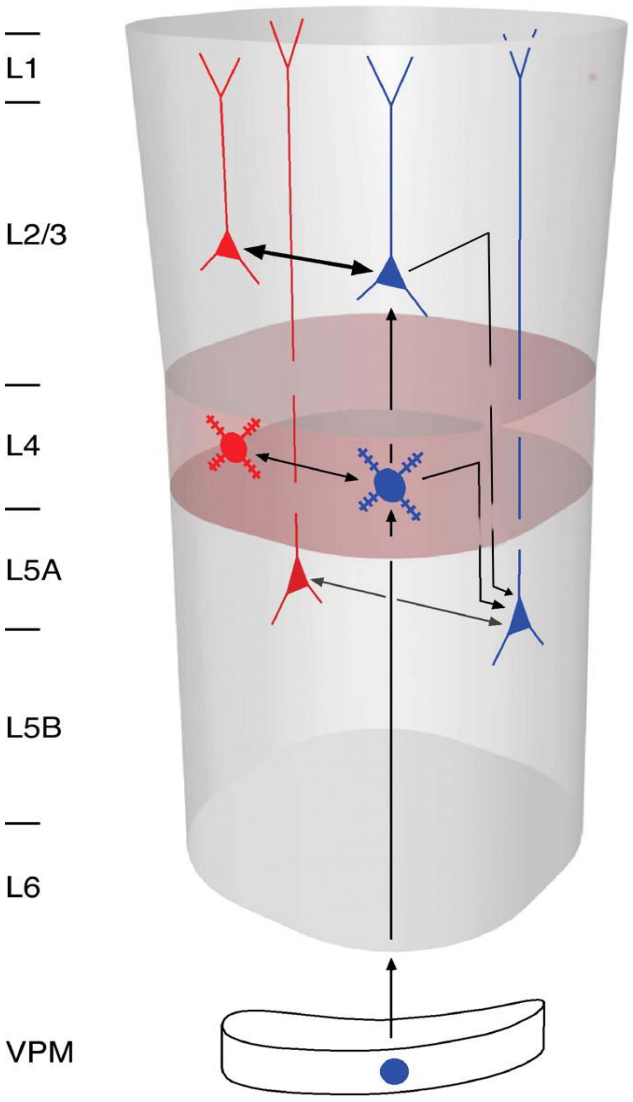
Организация клеток в неокортексе

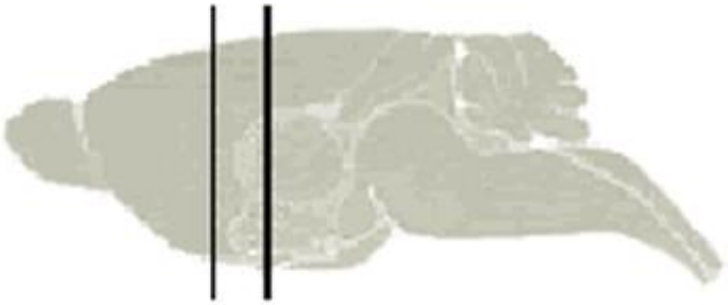


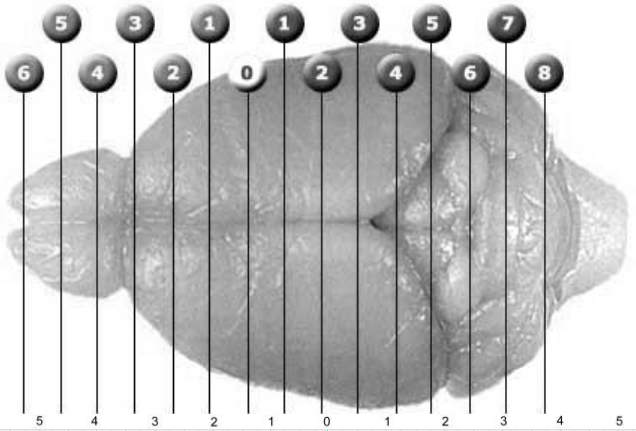
Кортикальные колонны

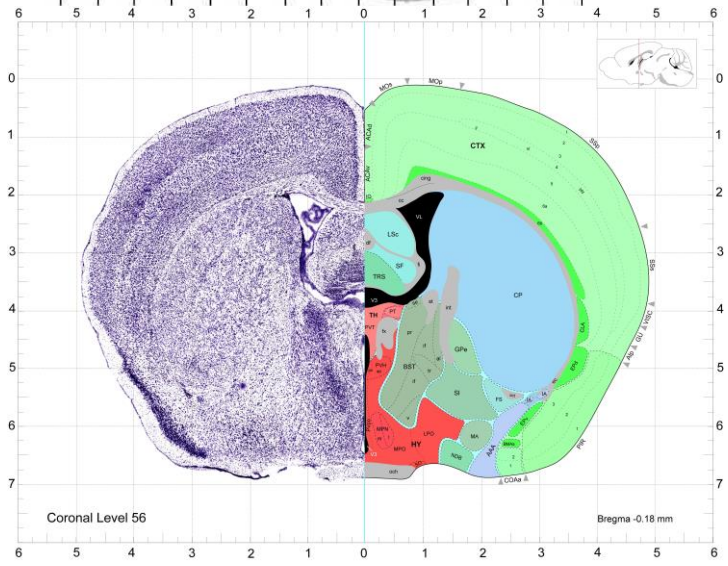


Кортикальная колонна



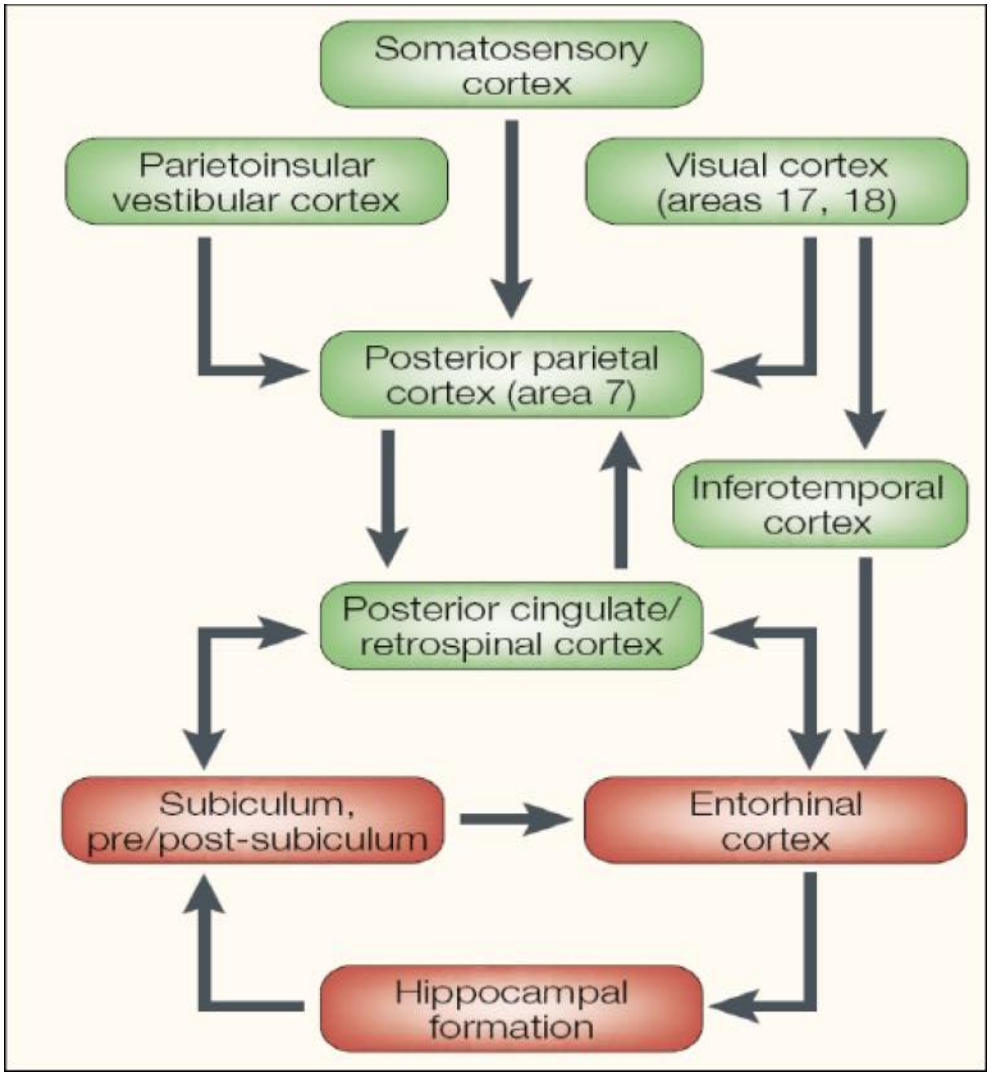


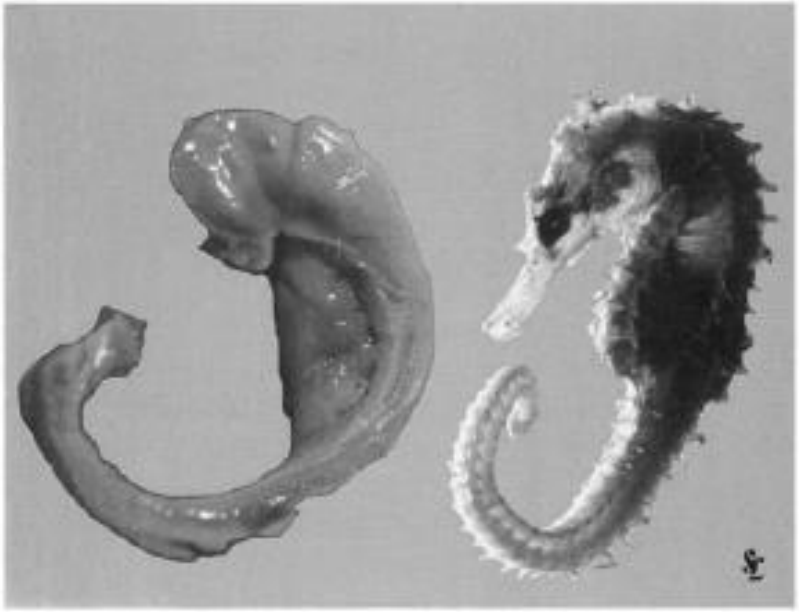




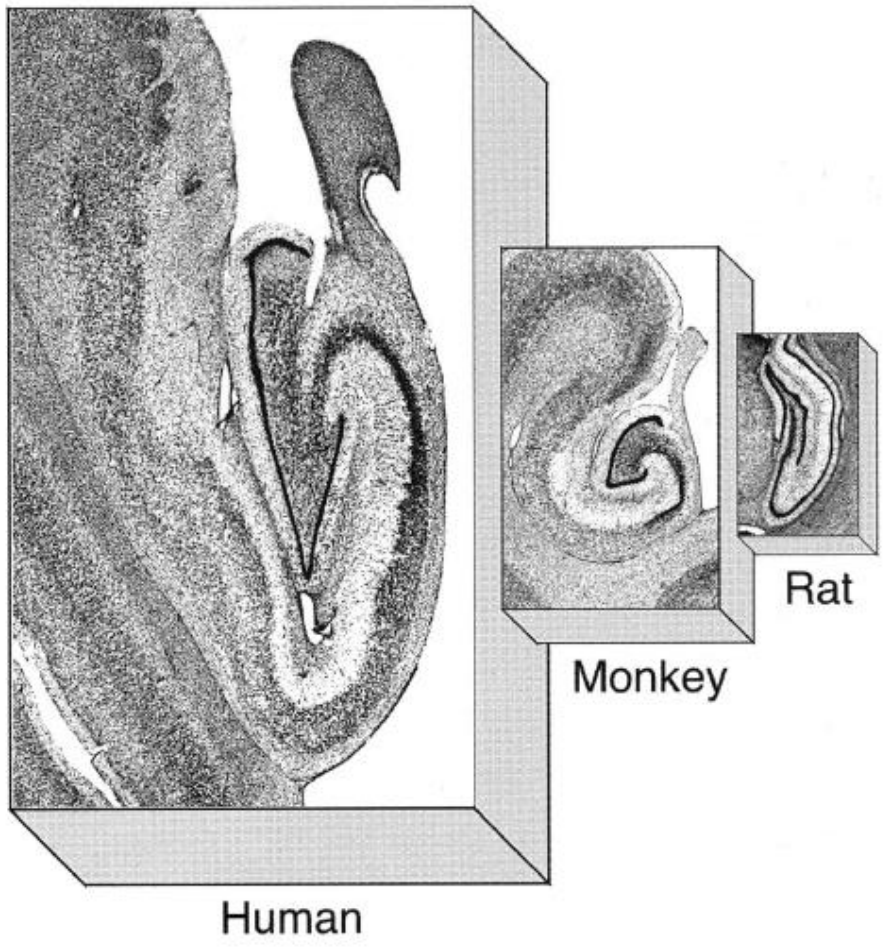
Гиппокамп: синаптическая триада

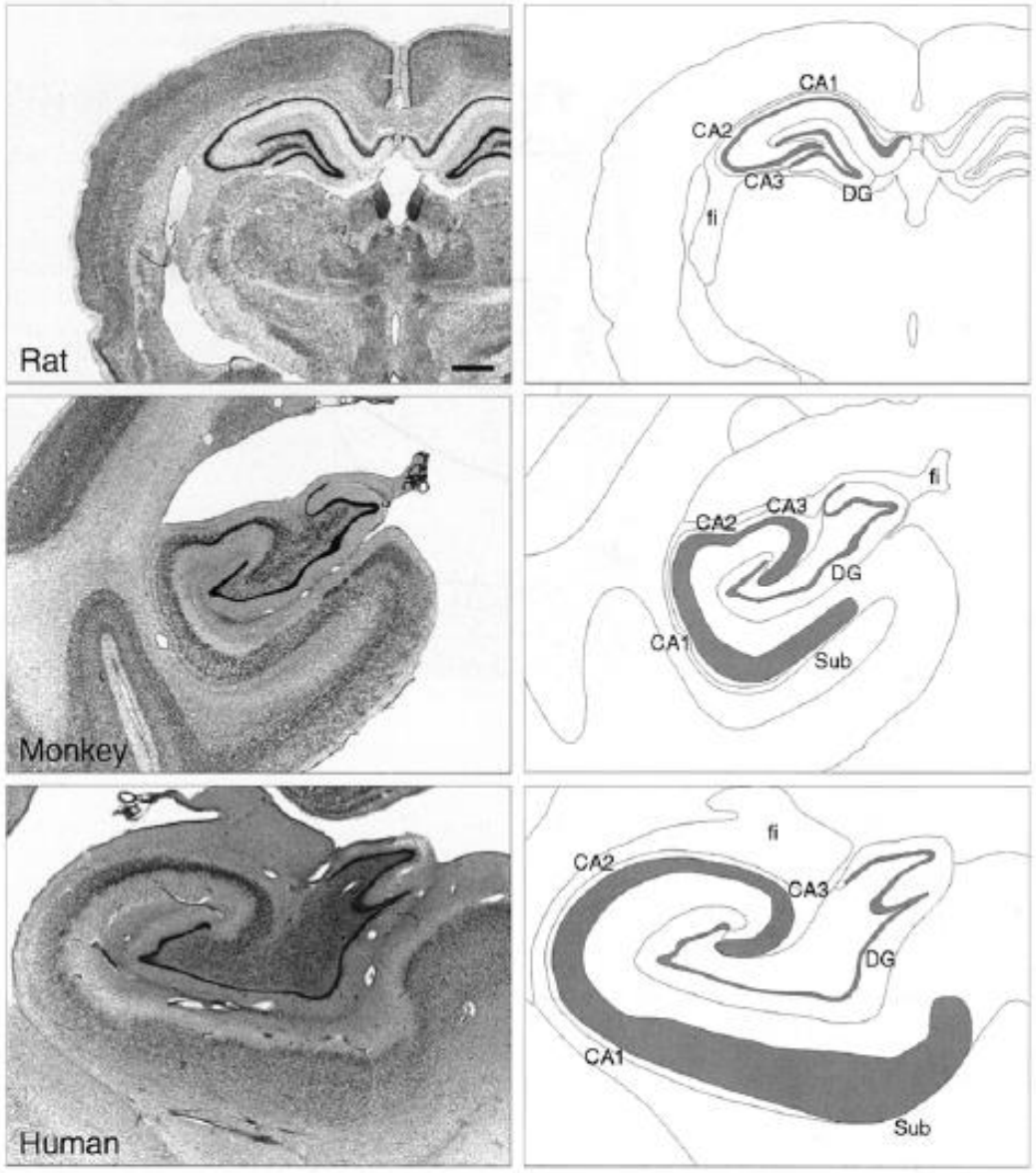
Обработка семантической информации





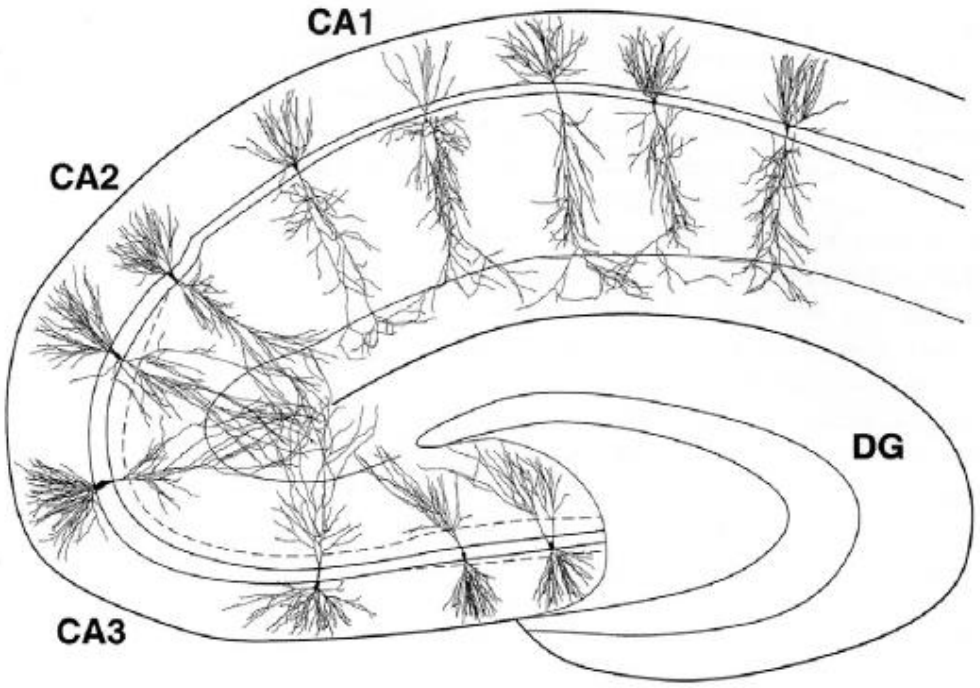
Dissected human hippocampus
and the *Hippoampus leria*


Rat
Monkey
Human

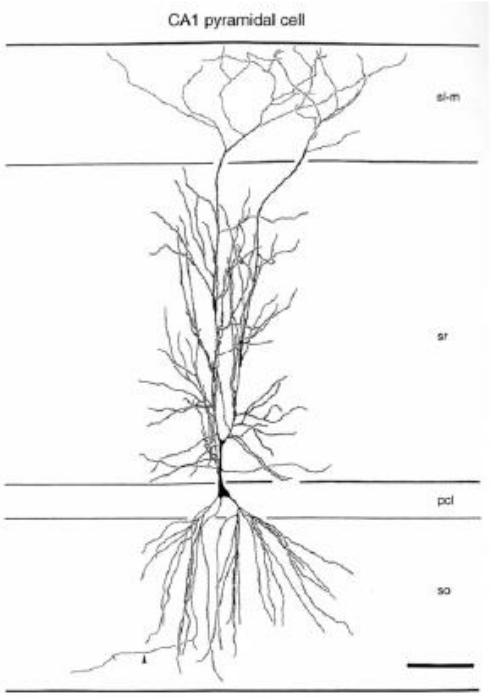

Rat
CA1
CA2
CA3
DG
fi
Monkey
fi
CA2
CA3
DG
CA1
Sub
Human
fi
CA2
CA3
DG
CA1
Sub

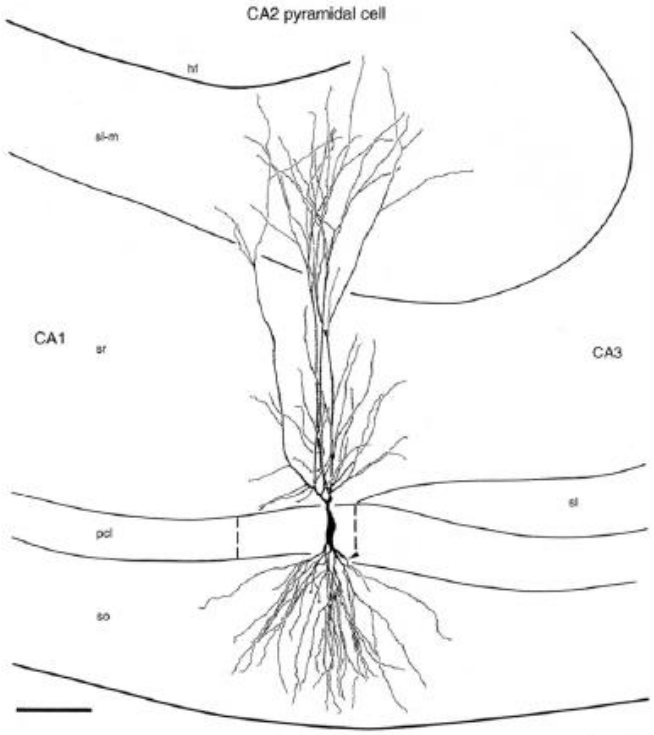
Drawing of the hippocampus in
Histologie de Système Nerveux, 1911

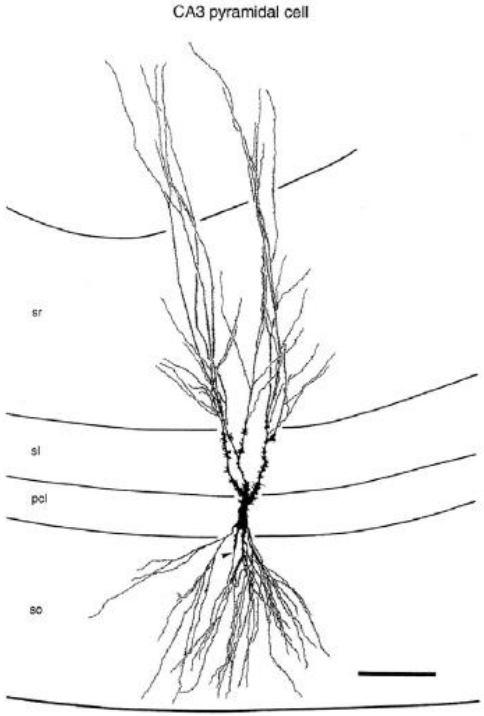
Organization of hippocampal pyramidal cells



Пирамидальные нейроны

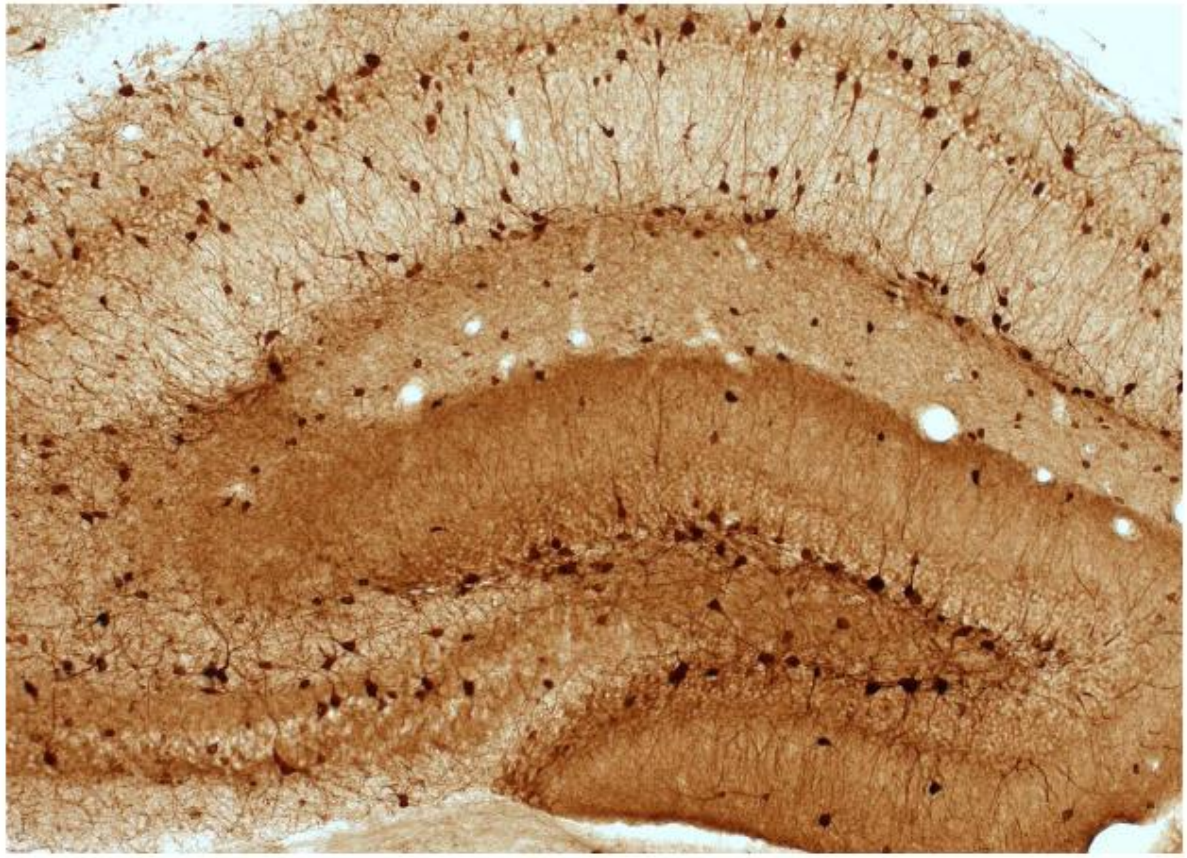




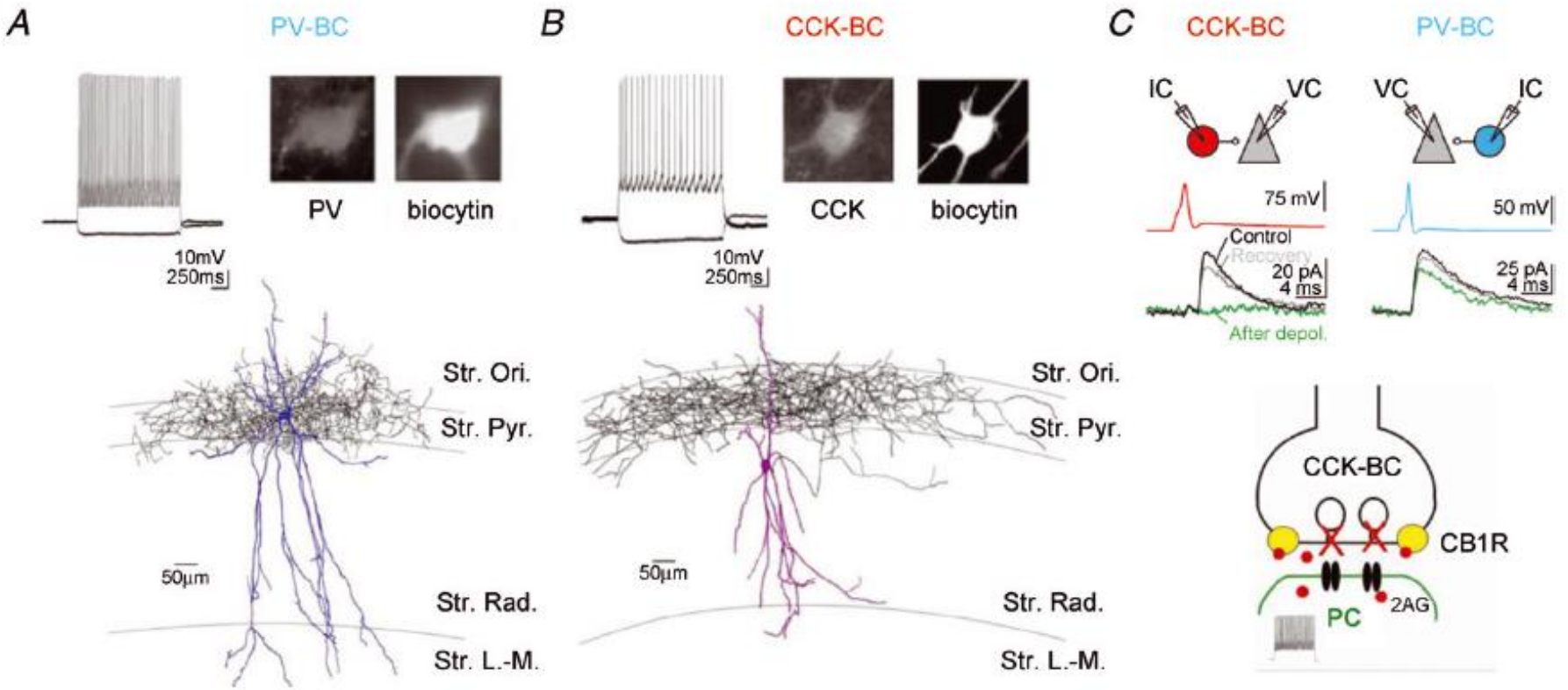


Интернейроны

GAD_{67} immunoreactivity



Интернейроны



Синапсы интернейронов

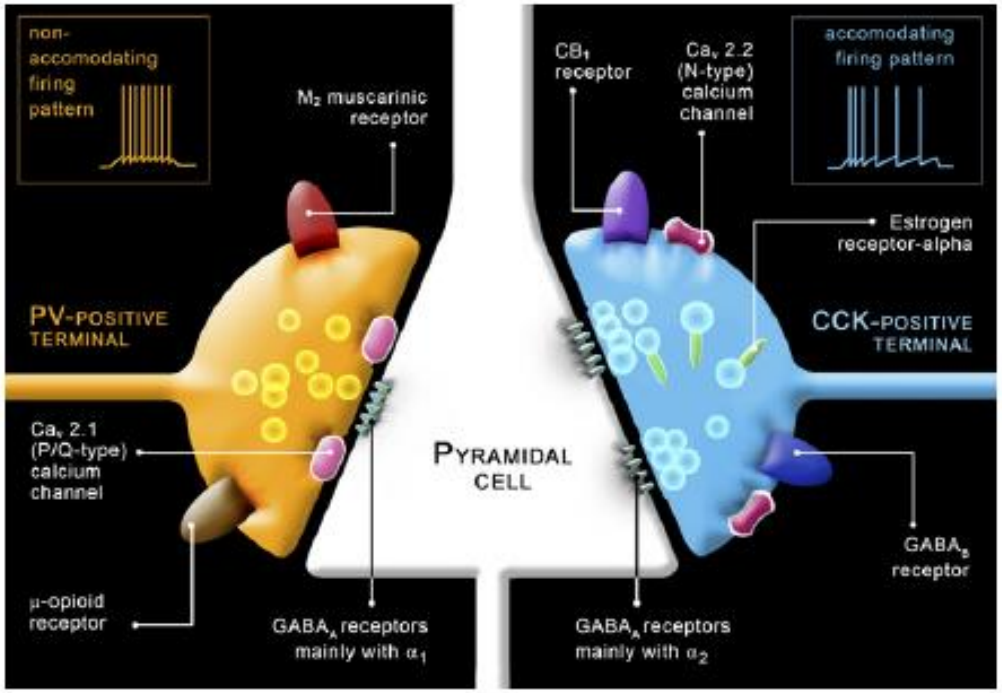


Figure 2. Field Guide to Hippocampal Basket Cells: Output

A plethora of distinct molecular, morphological, and physiological features distinguish the boutons formed by the two GABAergic basket cell types on cell bodies of cortical pyramidal neurons. Action potentials with a nonaccomodating firing pattern arrive from the cell body of fast-spiking parvalbumin (PV)-positive interneurons to the terminals, where they open $Ca_v2.1$ (P/Q-type) calcium channels. These channels are concentrated at the active zone to ensure precisely timed univesicular release. In contrast, action potentials with an accomodating firing pattern arrive from the soma of regular-spiking cholecystokinin (CCK)-positive interneurons to their terminals, where they exclusively open $Ca_v2.2$ (N-type) calcium channels. These channels are distributed throughout the bouton, but not at the active zones, resulting in loose coupling between the Ca^{2+} source and the Ca^{2+} sensor of exocytosis. Furthermore, these axon terminals have several active zones that allow multivesicular release in an asynchronous manner. The two axon terminal types differ also with regard to presynaptic regulation, as PV-positive axon terminals have receptors for acetylcholine (M_2 muscarinic) as well as for enkephalins or β-endorphin (μ-opioid receptor). In contrast, GABA release from CCK-positive axon terminals can be efficiently controlled by endocannabinoids (predominantly 2-AG) through the CB_1 cannabinoid receptor and by autocrine $GABA_B$ receptors. Finally, estrogen may mobilize the vesicle clusters to the active zone upon activation of estrogen receptor-α located on the vesicle membranes within a third of the CCK-positive axon terminals. Note that axon terminals are enlarged for clarity, and their relative sizes are not in scale with the pyramidal cell body. (Artwork by Dr. Gábor Nyíri.)

Синапсы интернейронов

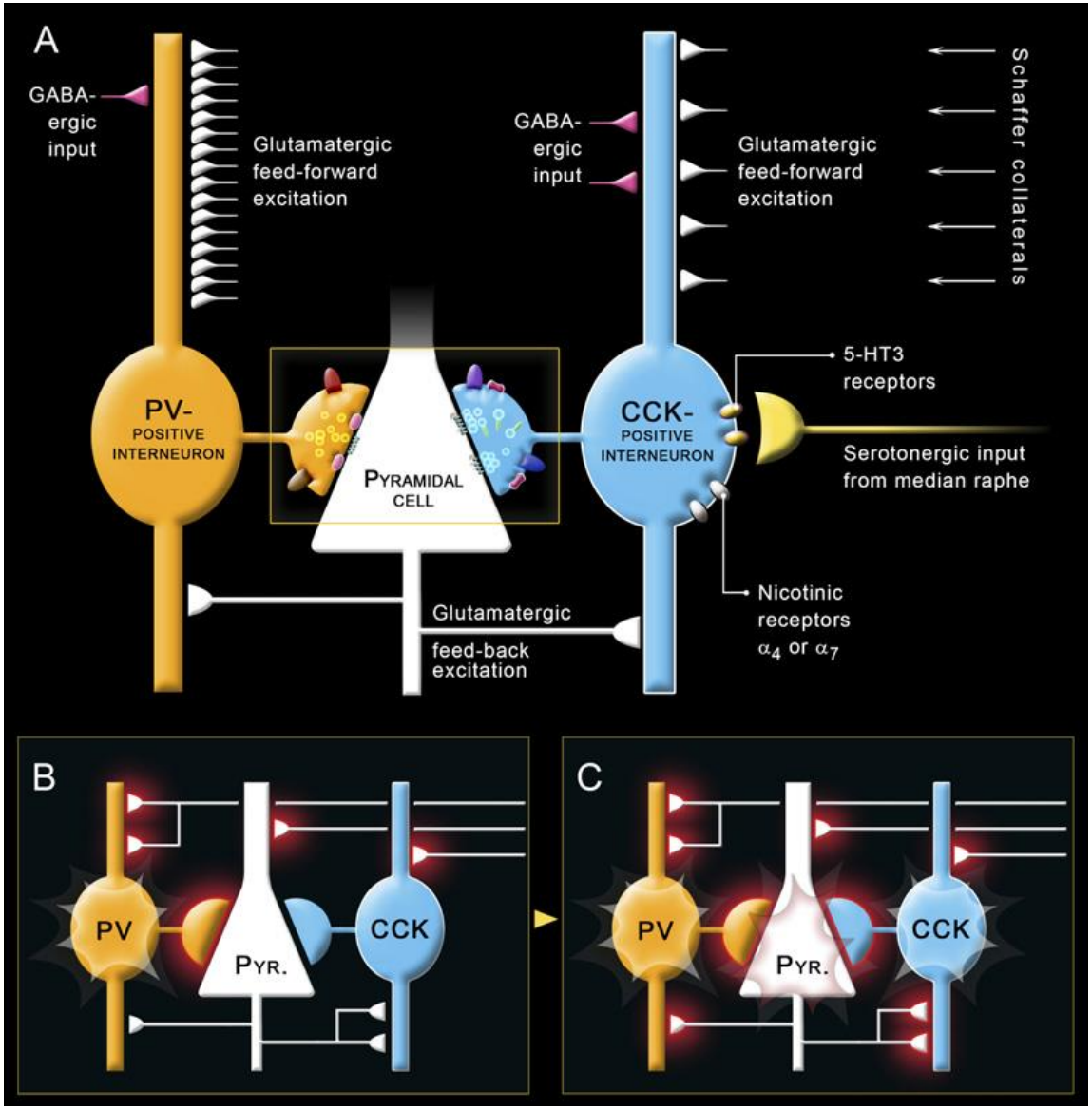


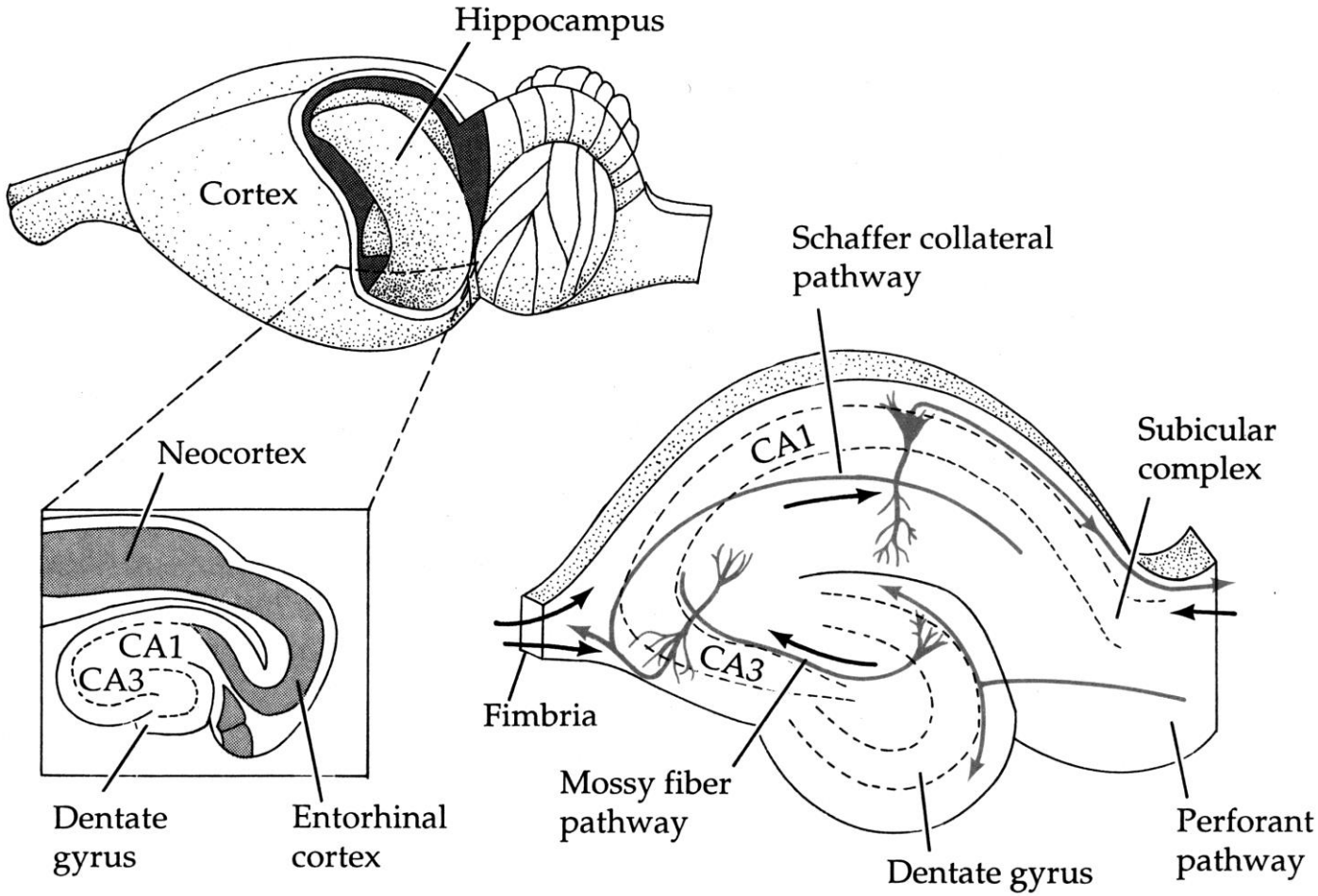
Figure 1. Field Guide to Hippocampal Basket Cells: Input

(A) Major distinguishing features of the PV and CCK basket cells on the input side are the following: PV cells have at least three times more glutamatergic synaptic (mostly Schaffer collateral) inputs than CCK cells, whereas the latter receive serotonergic input from the median raphe and express 5-HT_3, nicotinic $\alpha7$ and $\alpha4$ receptors. This is consistent with a predominantly local excitatory drive for PV cells and a massive subcortical contribution in case of CCK cells. GABAergic input of CCK cells is about twice as dense as that of PV cells. The white outline of the CCK cells indicates a longer membrane time constant.

(B) Stimulation of Schaffer collaterals readily discharges PV cells, which are predominantly feed-forward driven.

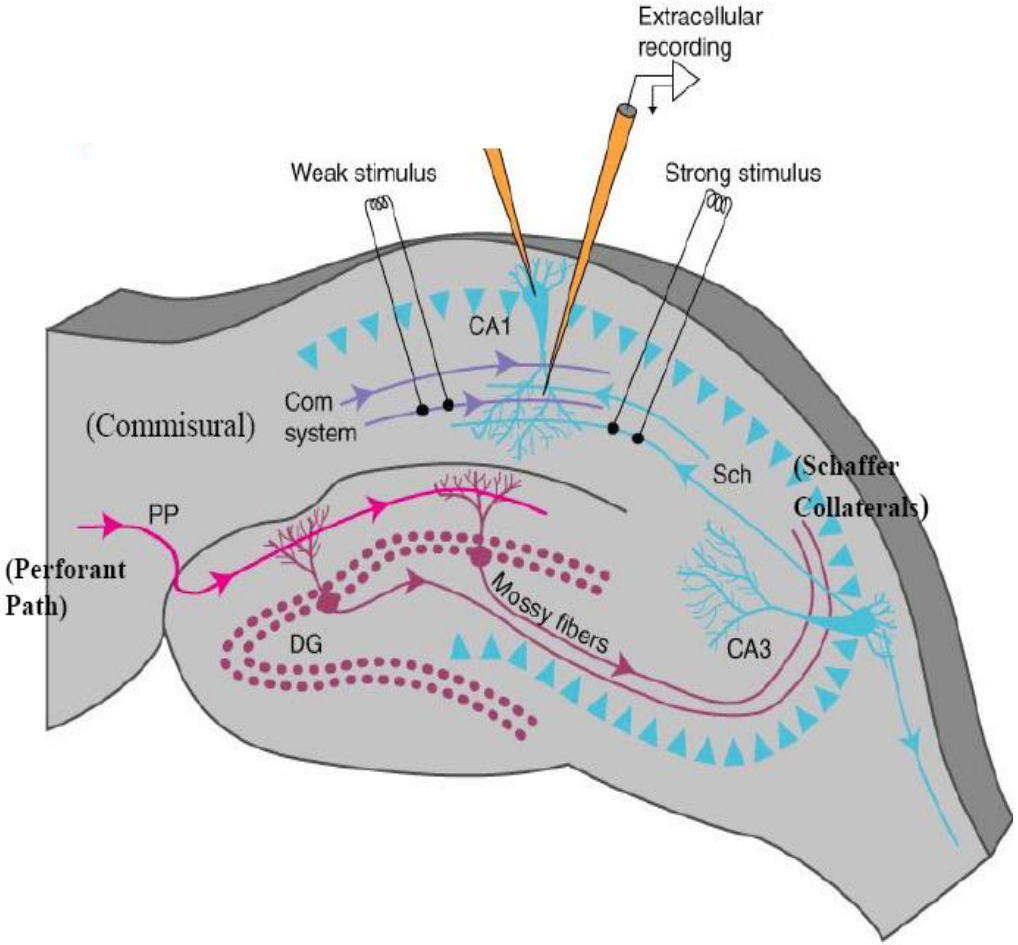
(C) On the other hand, due to their longer time constant, CCK cells have a unique ability to summate feed-forward and feed-back inputs, and will fire only when local pyramidal cells are also activated (Glickfeld and Scanziani, 2006). The red halo around axon terminals indicates activation and transmitter release from the boutons, whereas action potential discharge in cell bodies is signified by translucent stars. (Artwork by Dr. Gábor Nyíri.)

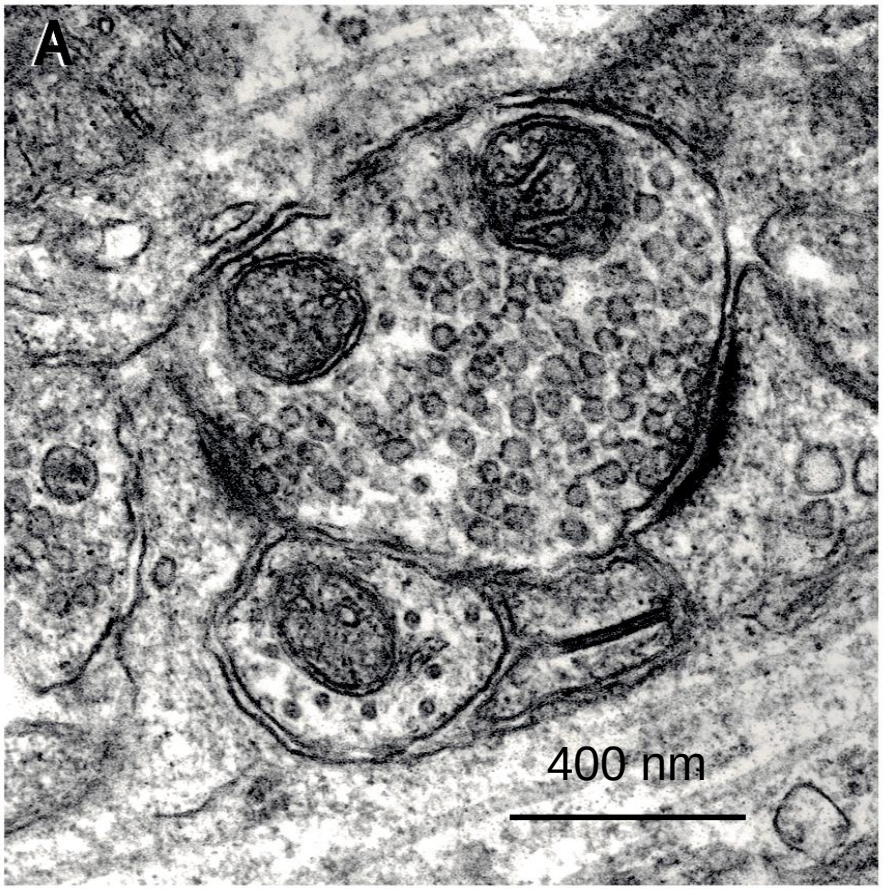
Синаптическая триада



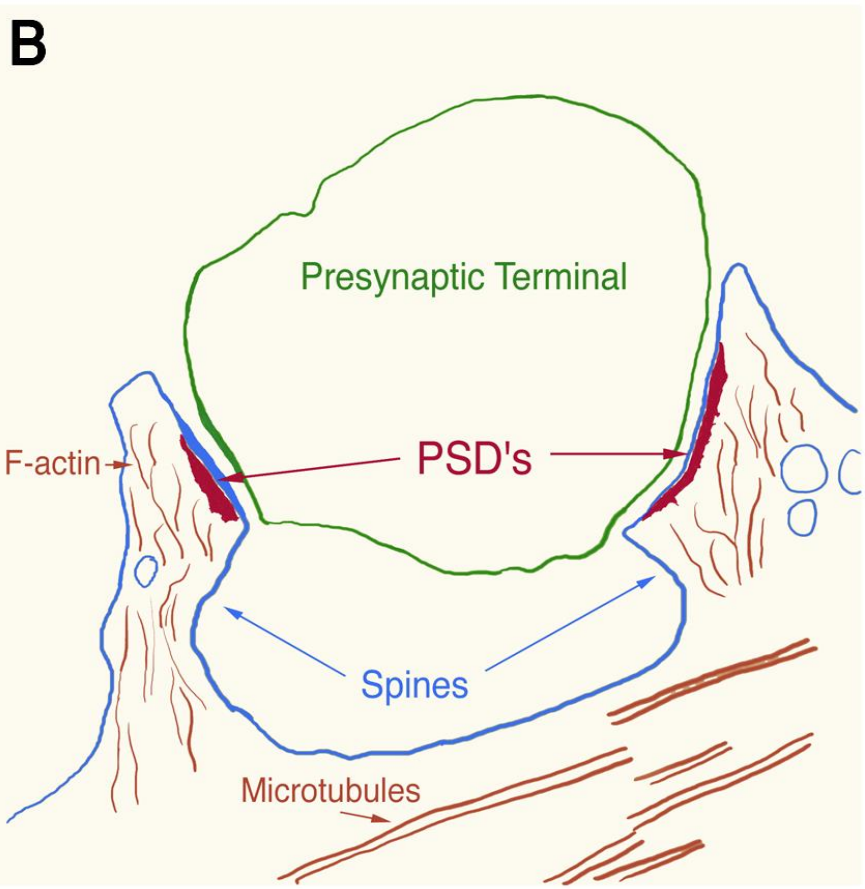
The “tri-synaptic pathway”

LTP может быть получена в срезе гиппокампа

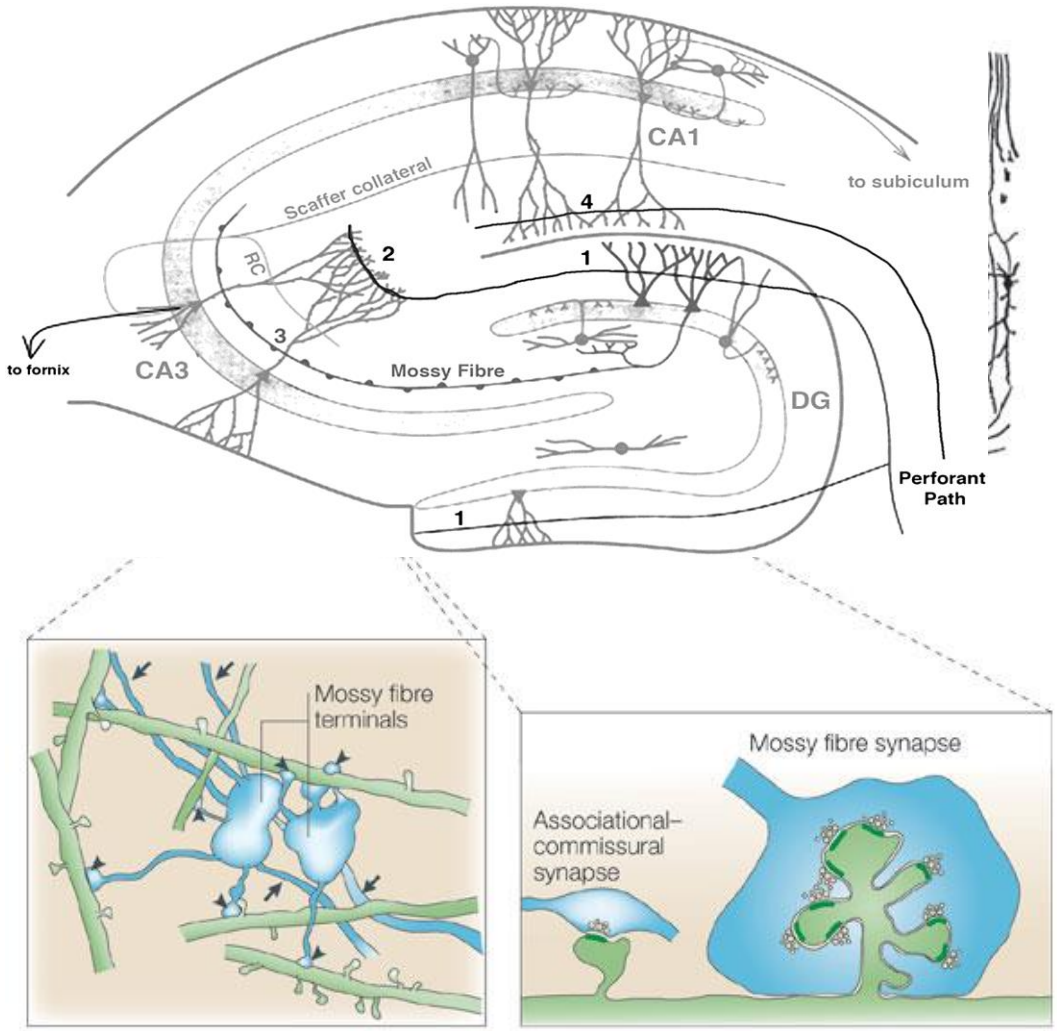


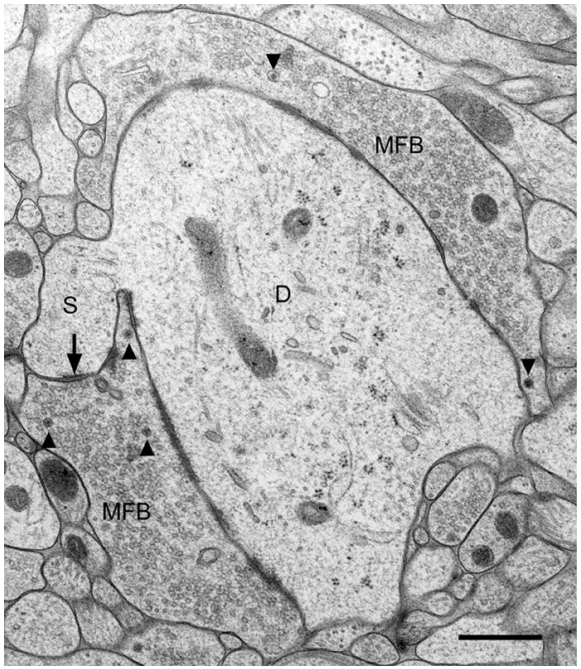


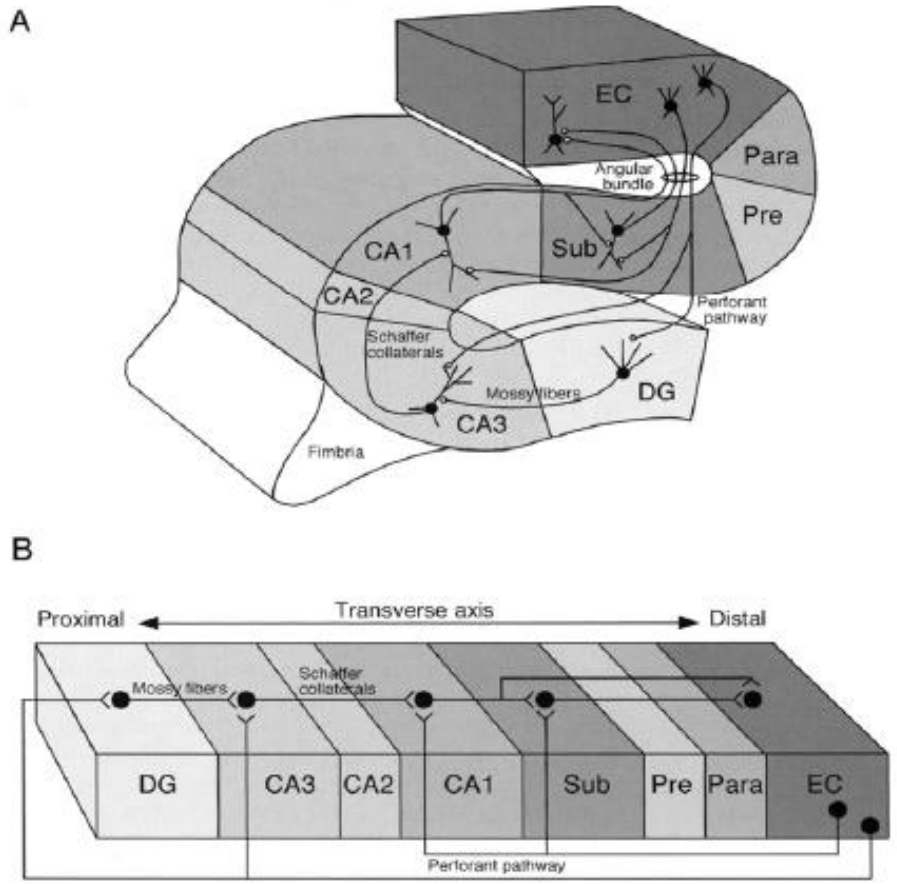
Electron micrograph of hippocampal synapse



“Map” of micrograph to the left

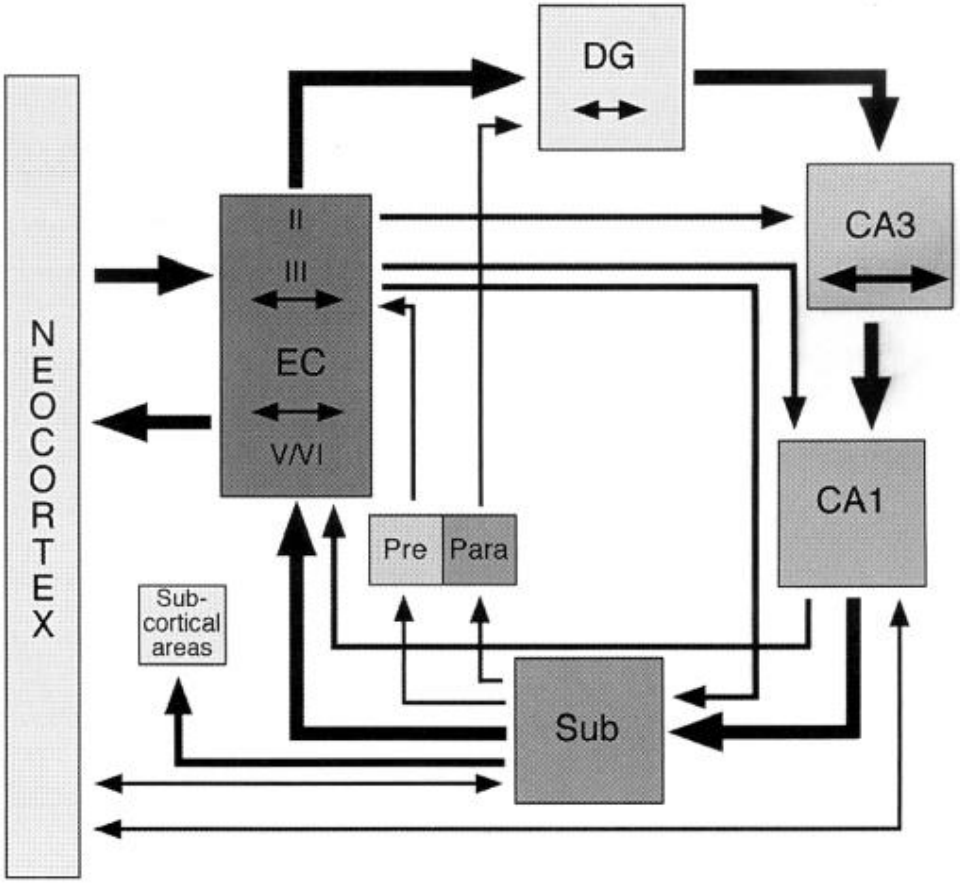






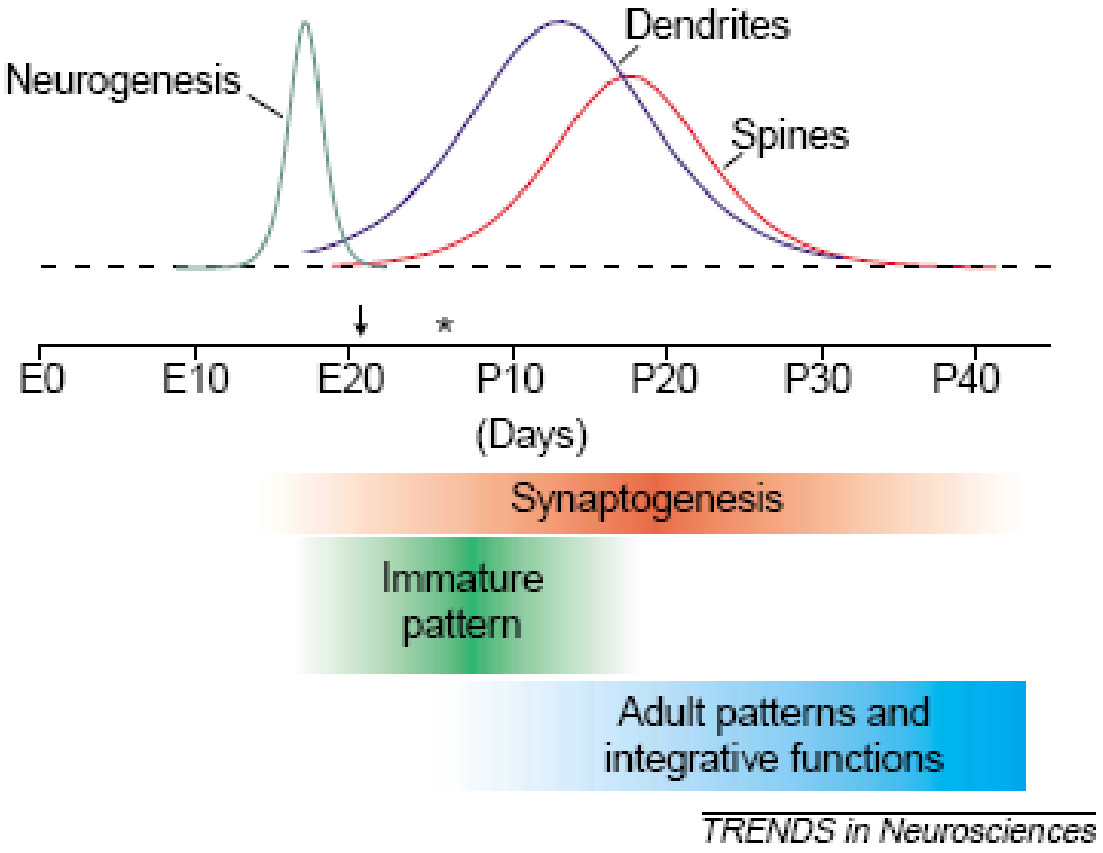
- Unidirectional passage of information through intrahippocampal circuits
- Receives highly processed, multimodal sensory information from a variety of neocortical structures

Summary of the serial and parallel pathways

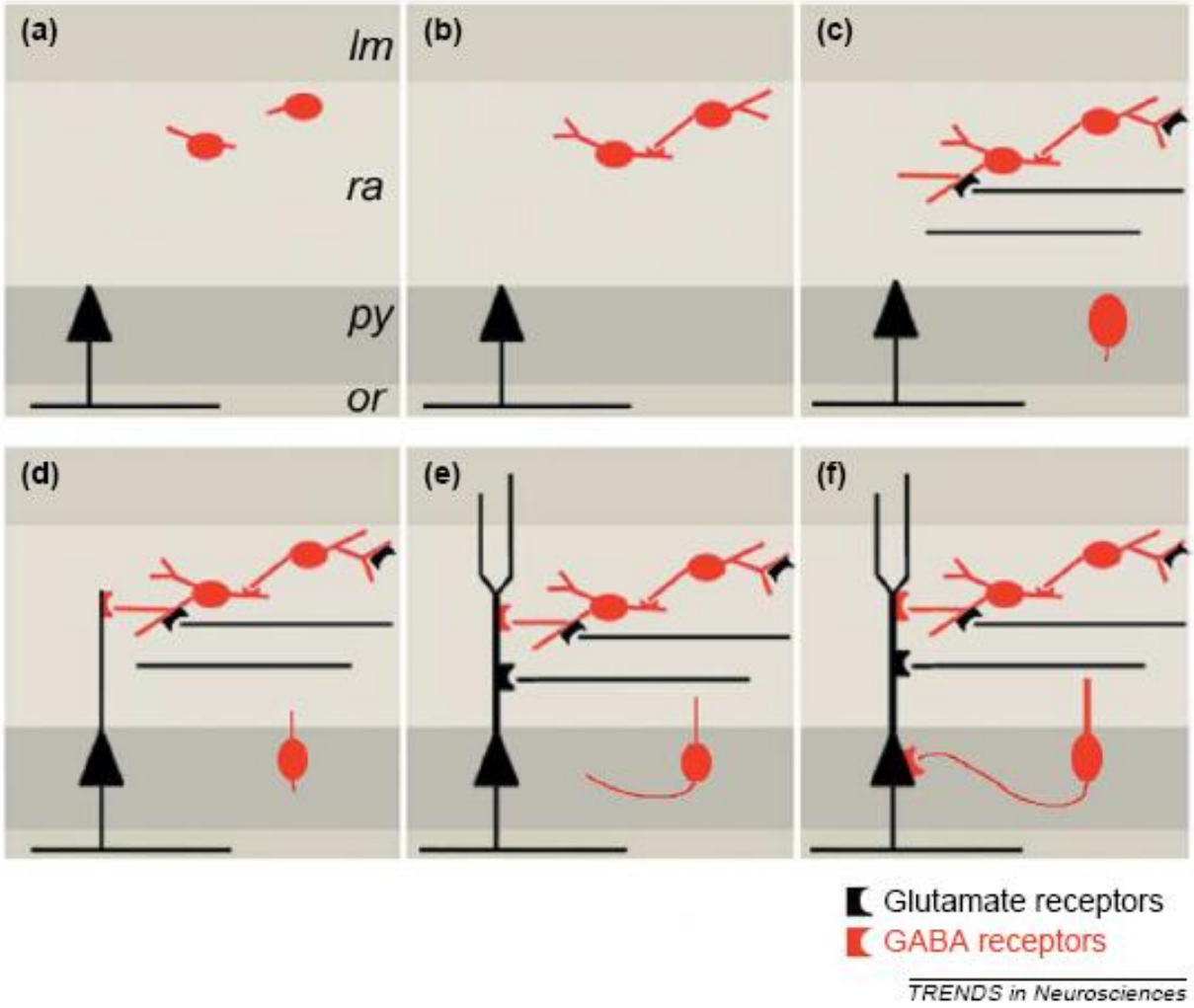


Формирование локальных нейронных сетей в ЦНС в развитии

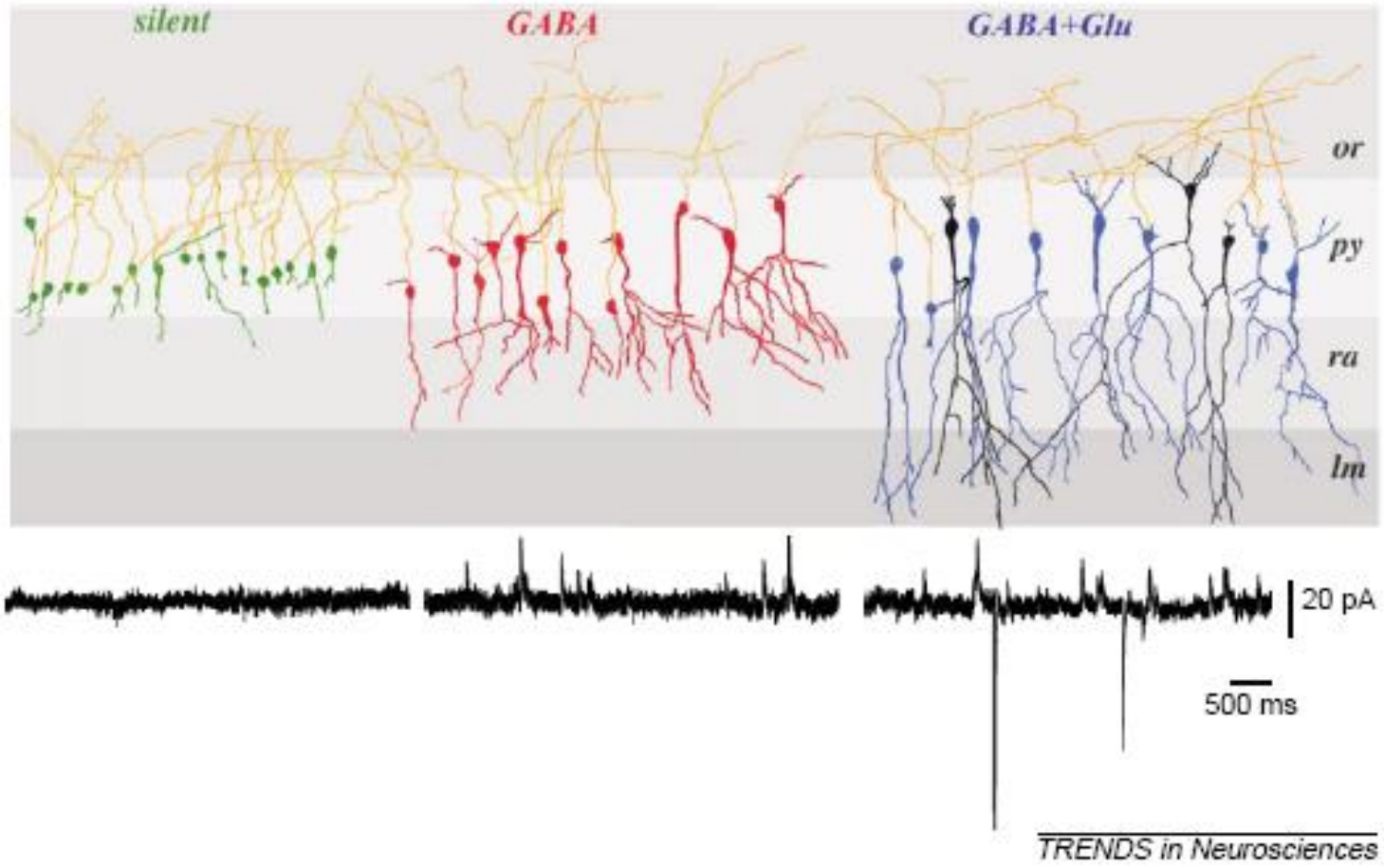
Основные события в формировании нервных сетей гиппокампа



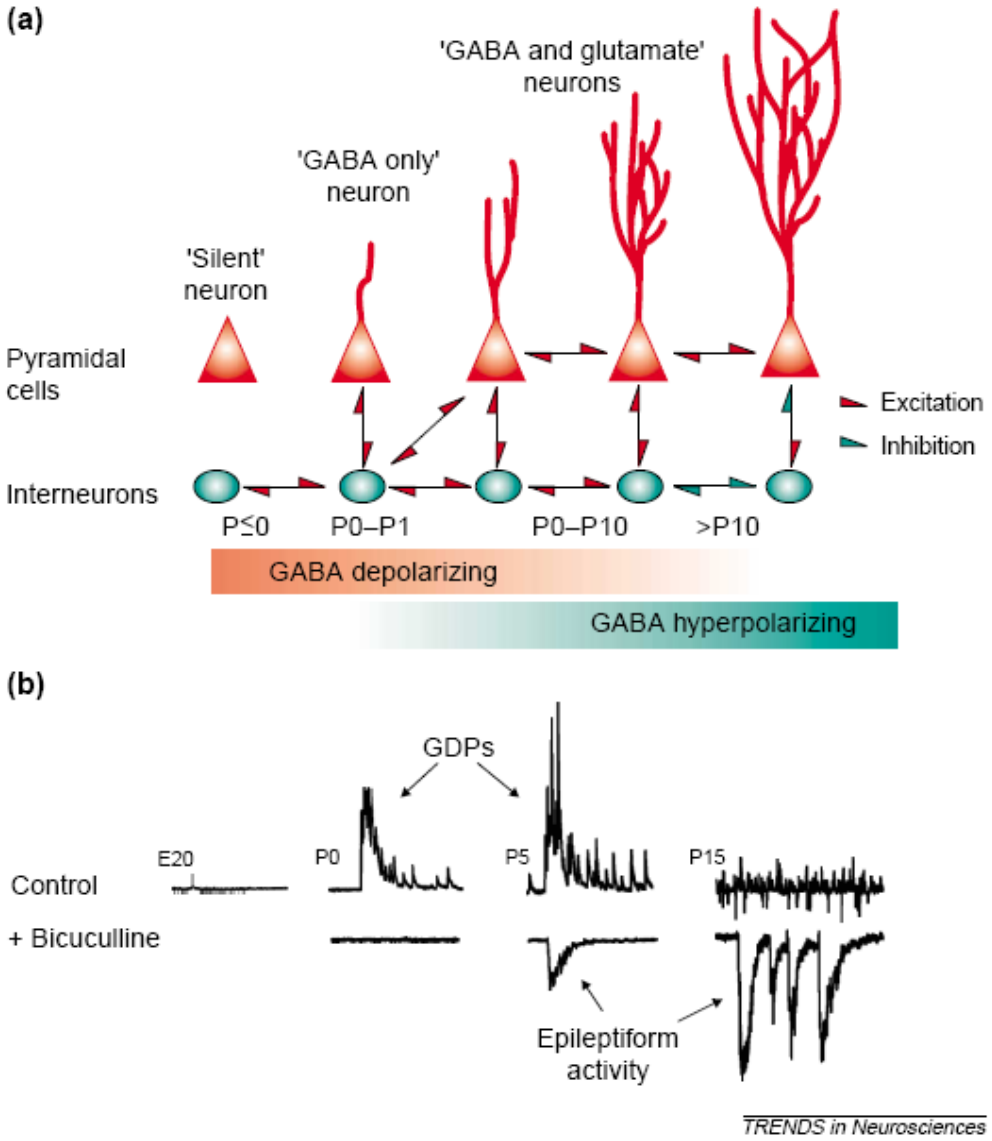
Основные события в формировании нервных сетей гиппокампа



Box 2. Sequential maturation of GABA and glutamate



Основные события в формировании нервных сетей гиппокампа крыс



Основные события в формировании нервных сетей гиппокампа человека