



**PETER PAZMANY
CATHOLIC UNIVERSITY**



**SEMMELWEIS
UNIVERSITY**



Development of Complex Curricula for Molecular Bionics and Infobionics Programs within a consortial* framework**

Consortium leader

PETER PAZMANY CATHOLIC UNIVERSITY

Consortium members

SEMMELWEIS UNIVERSITY, DIALOG CAMPUS PUBLISHER

The Project has been realised with the support of the European Union and has been co-financed by the European Social Fund ***

****Molekuláris bionika és Infobionika Szakok tananyagának komplex fejlesztése konzorciumi keretben**

*****A projekt az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával valósul meg.**



Nemzeti Fejlesztési Ügynökség

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TÁMOP – 4.1.2-08/2/A/KMR-2009-0006



BEVEZETÉS A FUNKCIONÁLIS NEUROBIOLÓGIÁBA

INTRODUCTION TO FUNCTIONAL NEUROBIOLOGY

By Imre Kalló

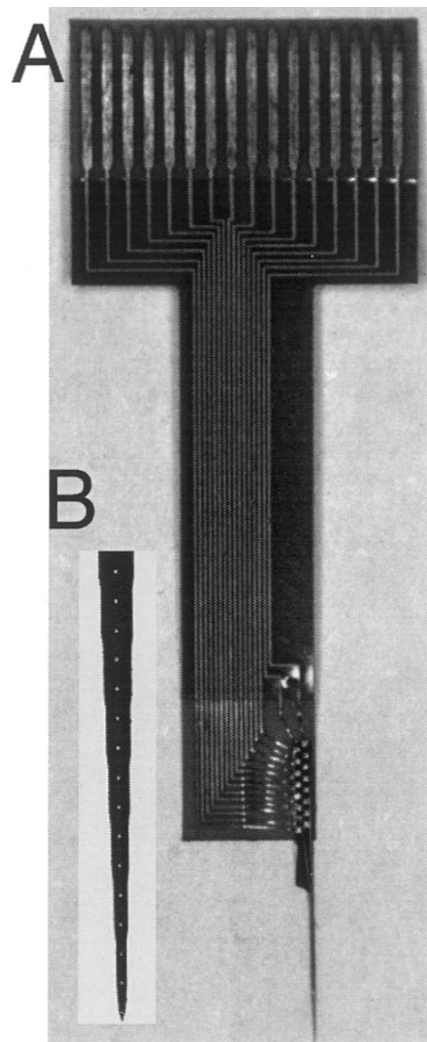
Contributed by: Tamás Freund, Zsolt Liposits, Zoltán Nusser, László Acsády, Szabolcs Káli, József Haller, Zsófia Maglóczky, Nórbert Hájos, Emilia Madarász, György Karmos, Miklós Palkovits, Anita Kamondi, Lóránd Eröss, Róbert Gábrriel, Zoltán Kisvárday, Zoltán Vidnyánszky

Electrophysiology_II.

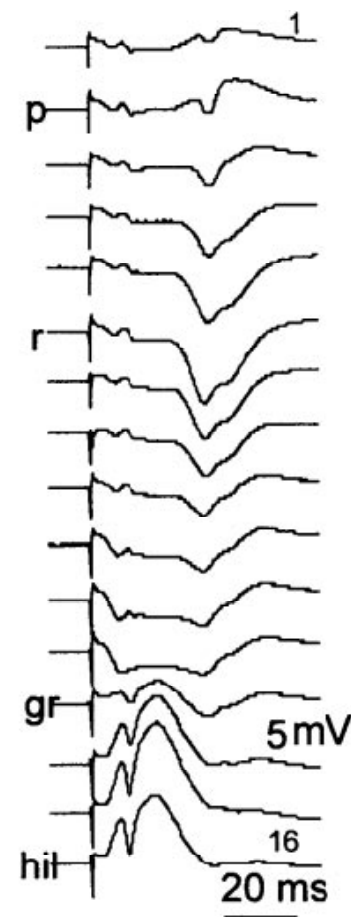
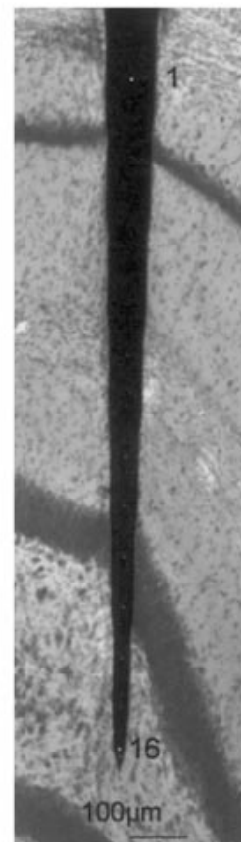
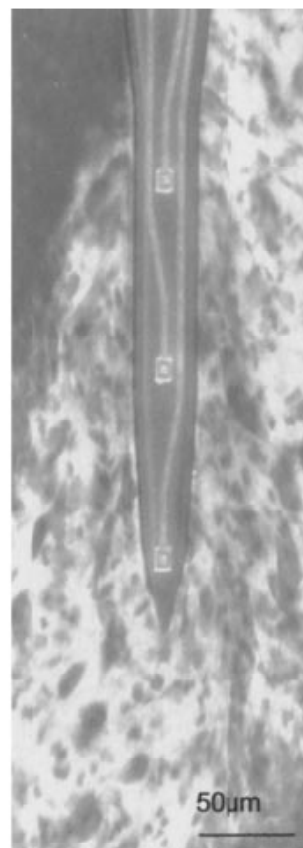
Imre Kalló & Norbert Hájos

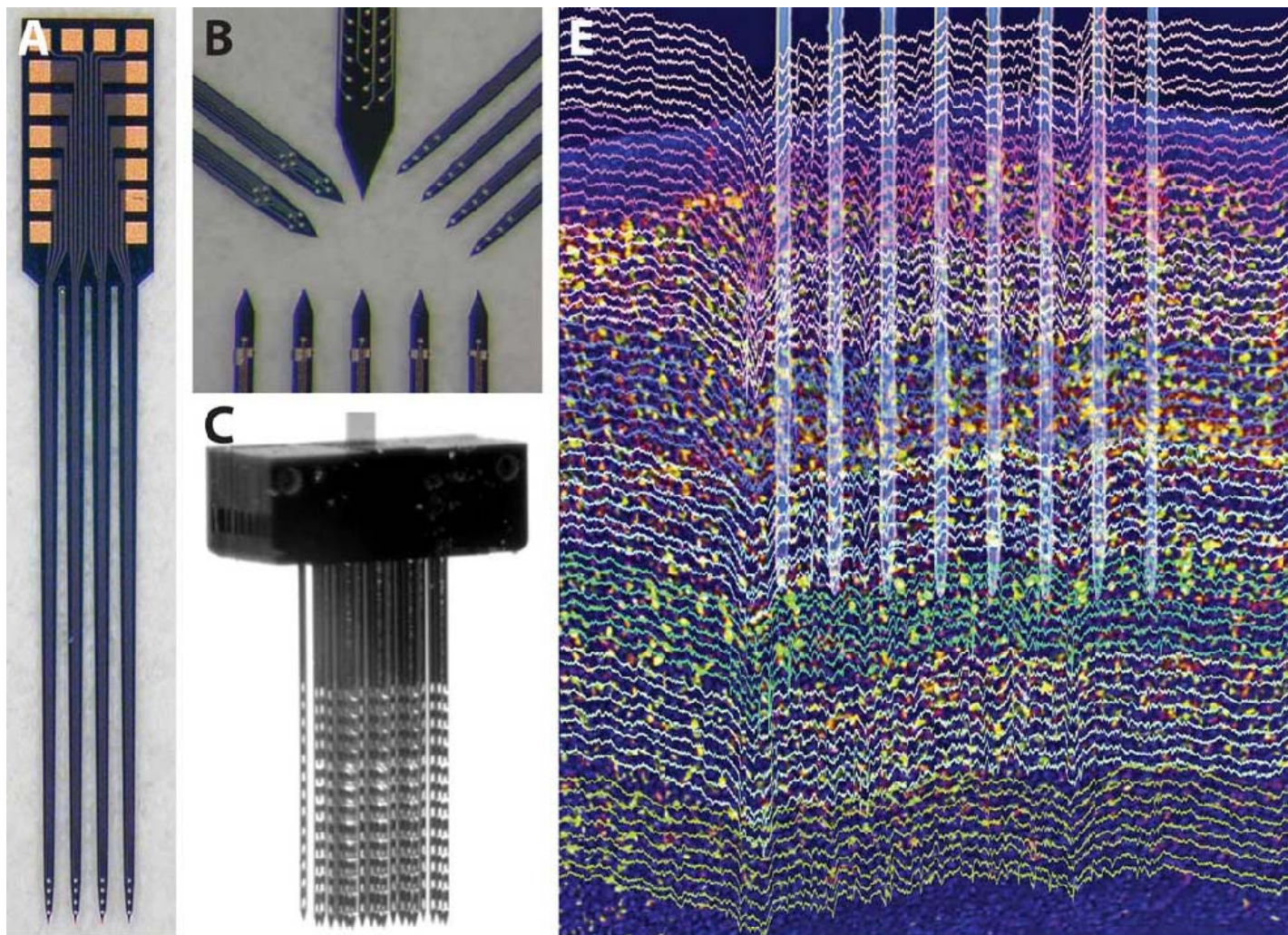
Pázmány Péter Catholic University, Faculty of Information Technology

- I. *In vitro* and *in vivo* recording techniques.
- II. Firing pattern of different cell types.
- III. Extracts from the studies on intercellular communications
(studies on gap junctions, dendritic action potentials, synaptic currents, noise-analysis, saturation of receptors by neurotransmitters, quantal analysis, paired recording of neurons, combination of electrophysiology with imaging techniques)

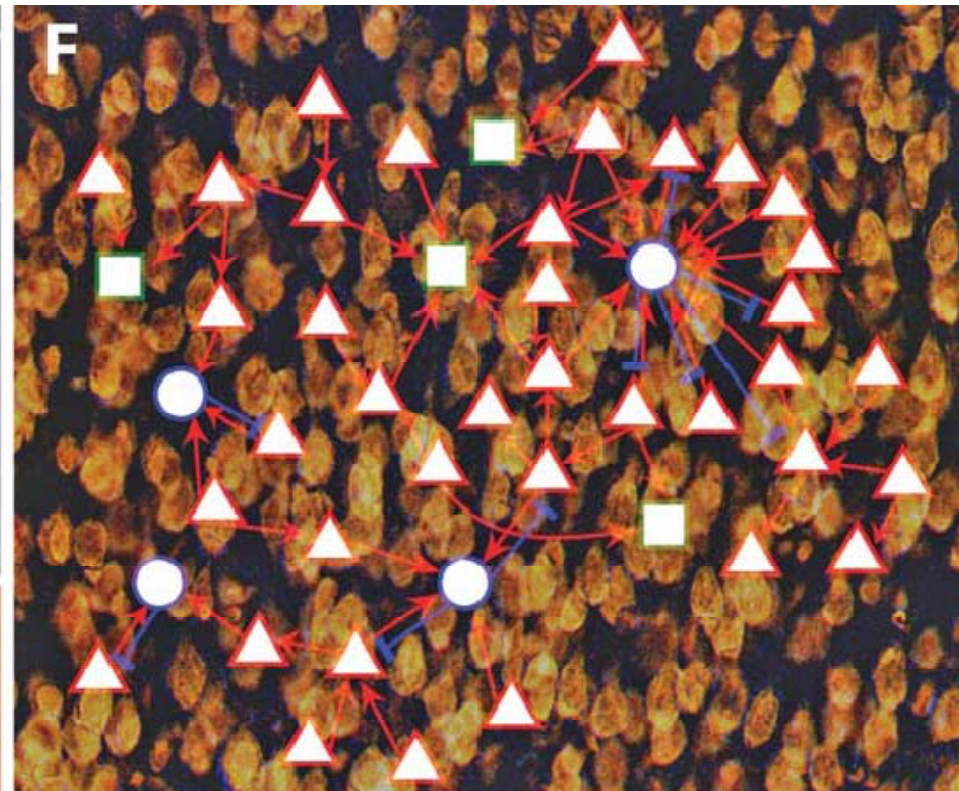
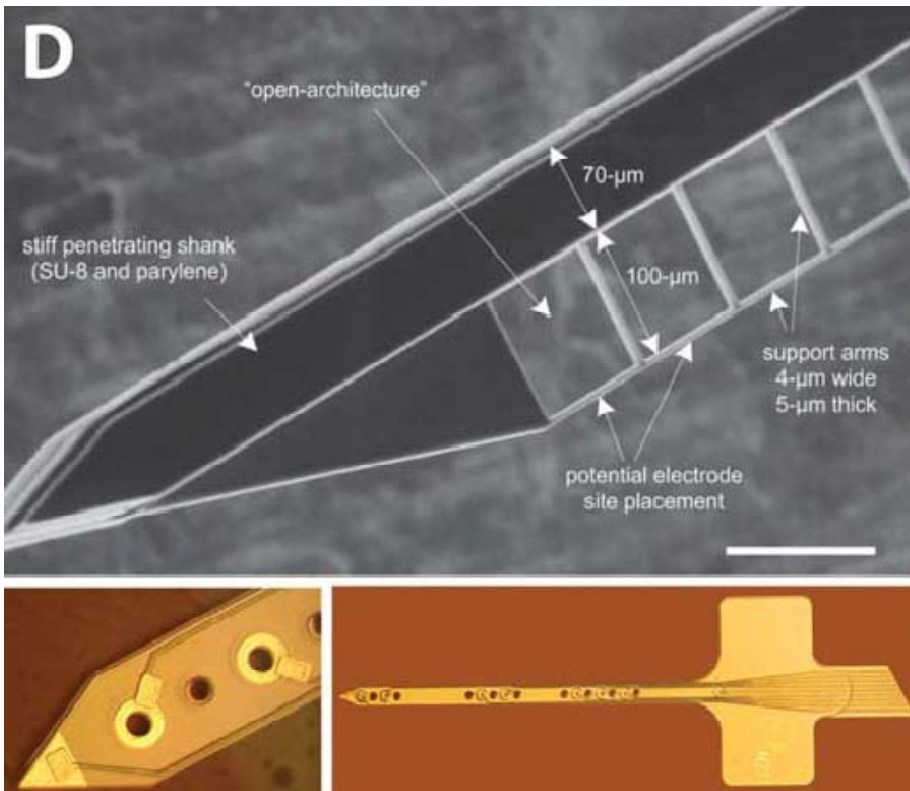


In vivo recordings

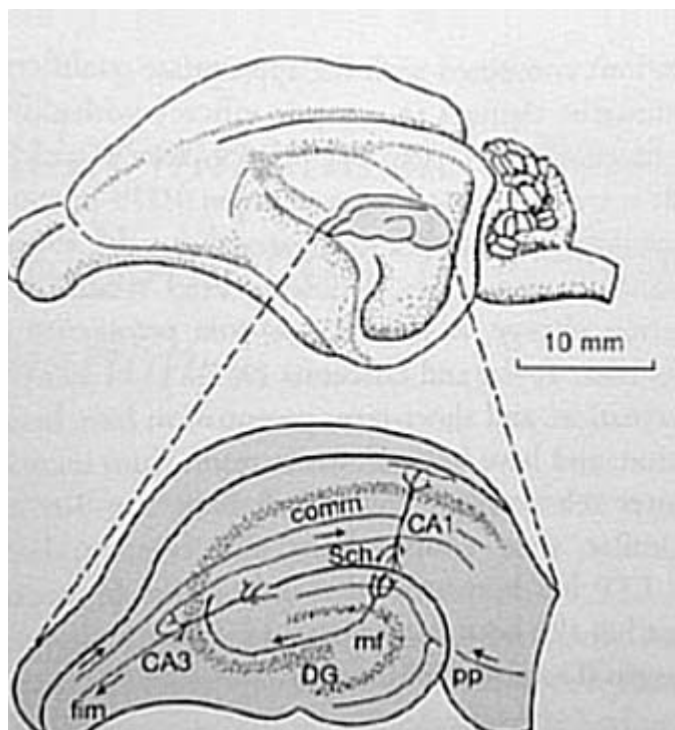




Ion concentrations and Equilibrium Potentials

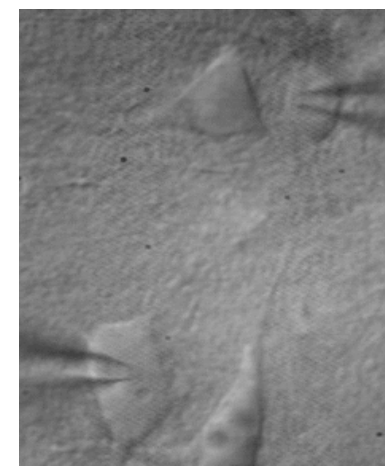
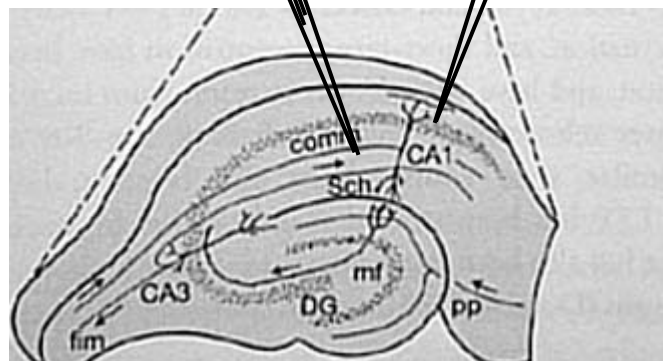


In vitro electrophysiological recording



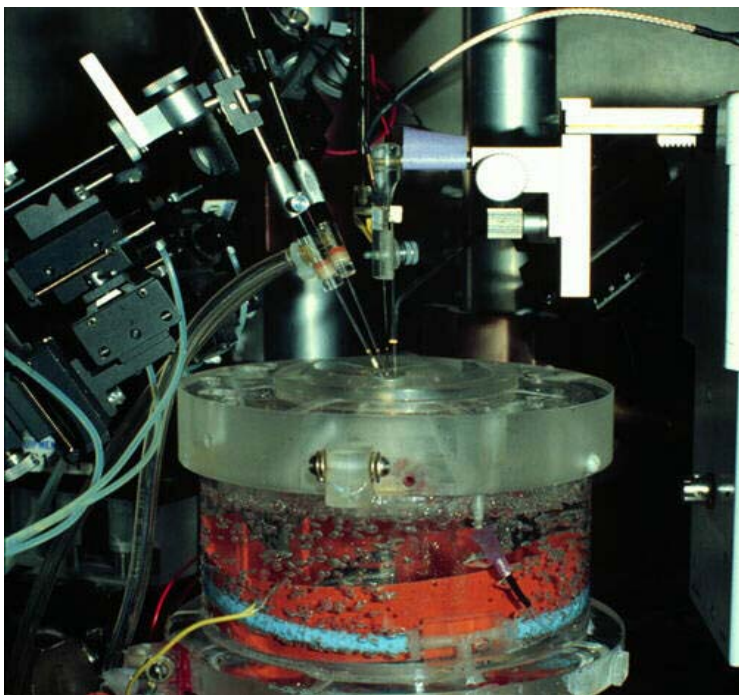
Stimulation

Whole-cell
Recordings

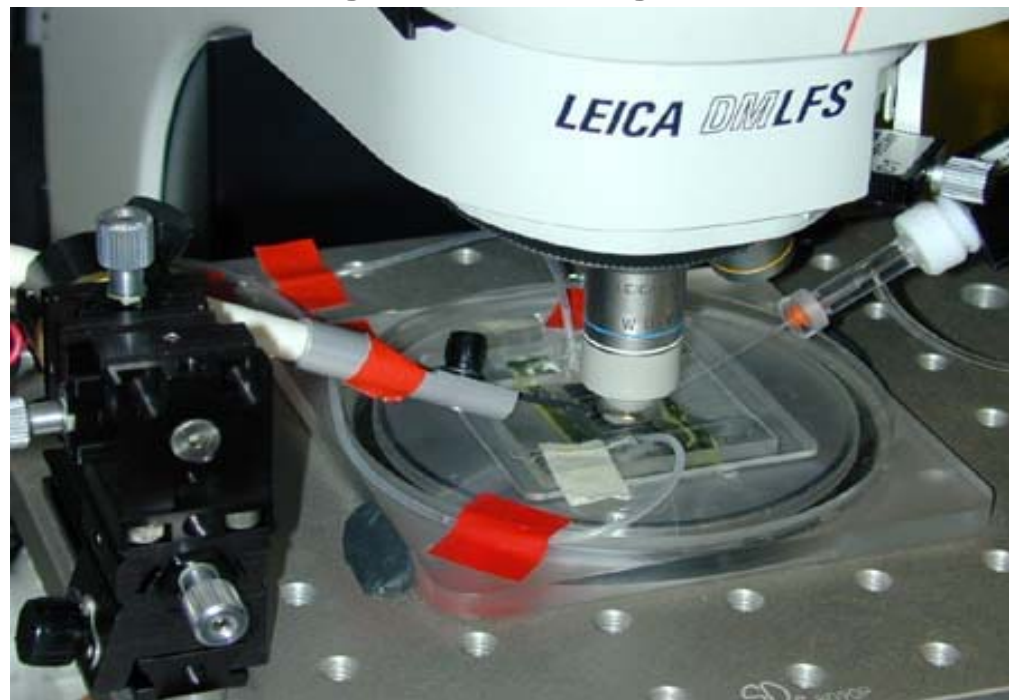


Equipment used

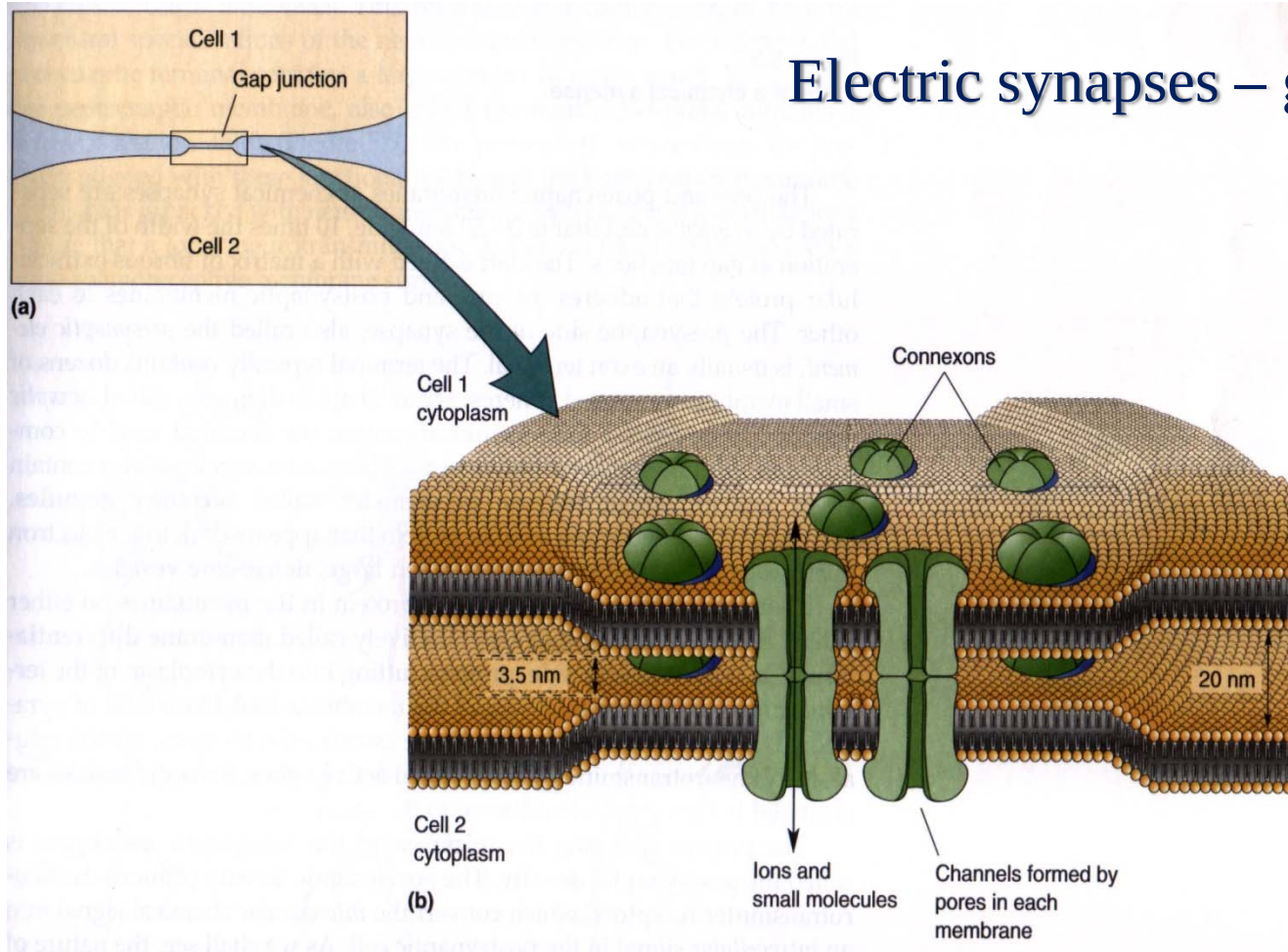
Interface recording chamber



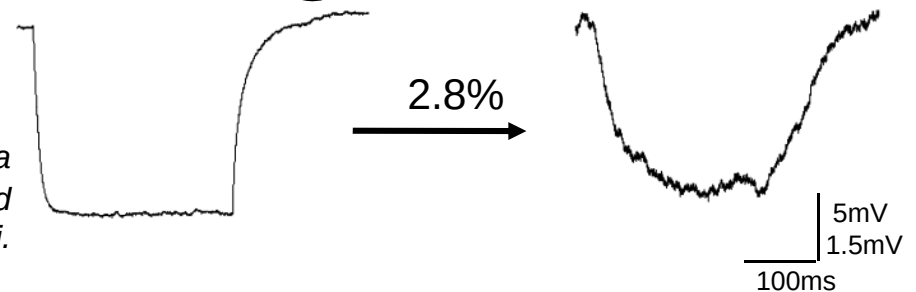
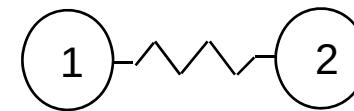
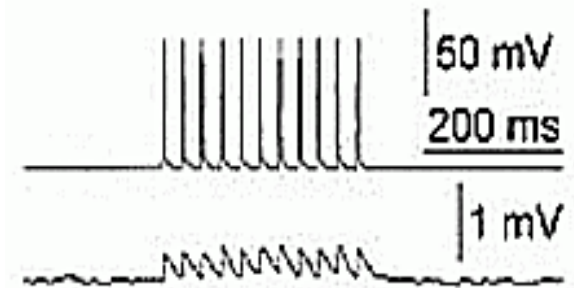
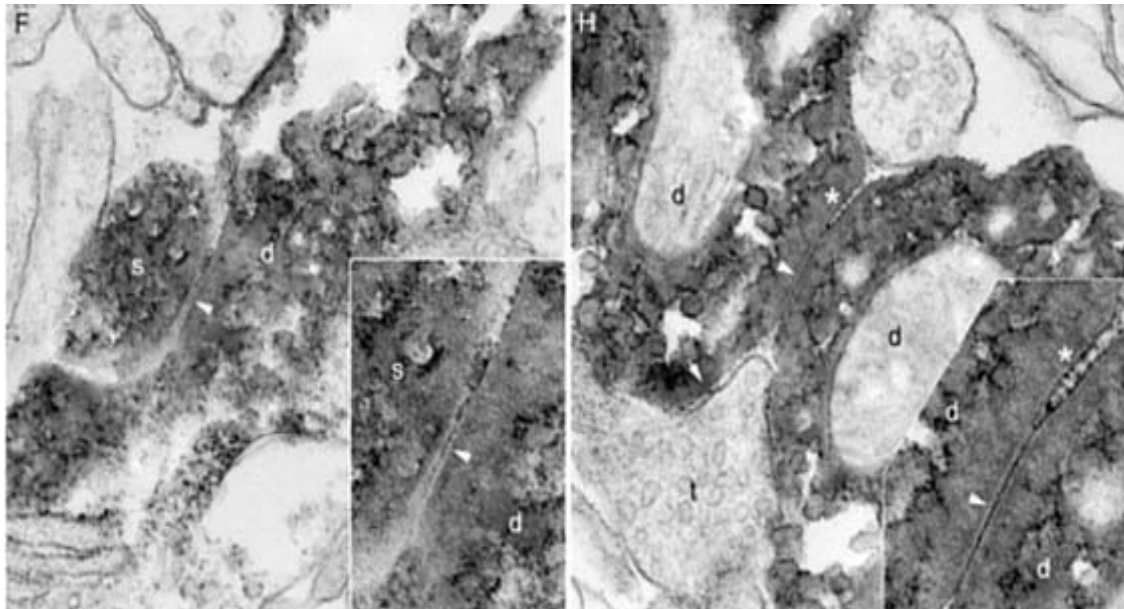
Submerged recording chamber



Electric synapses – gap junction

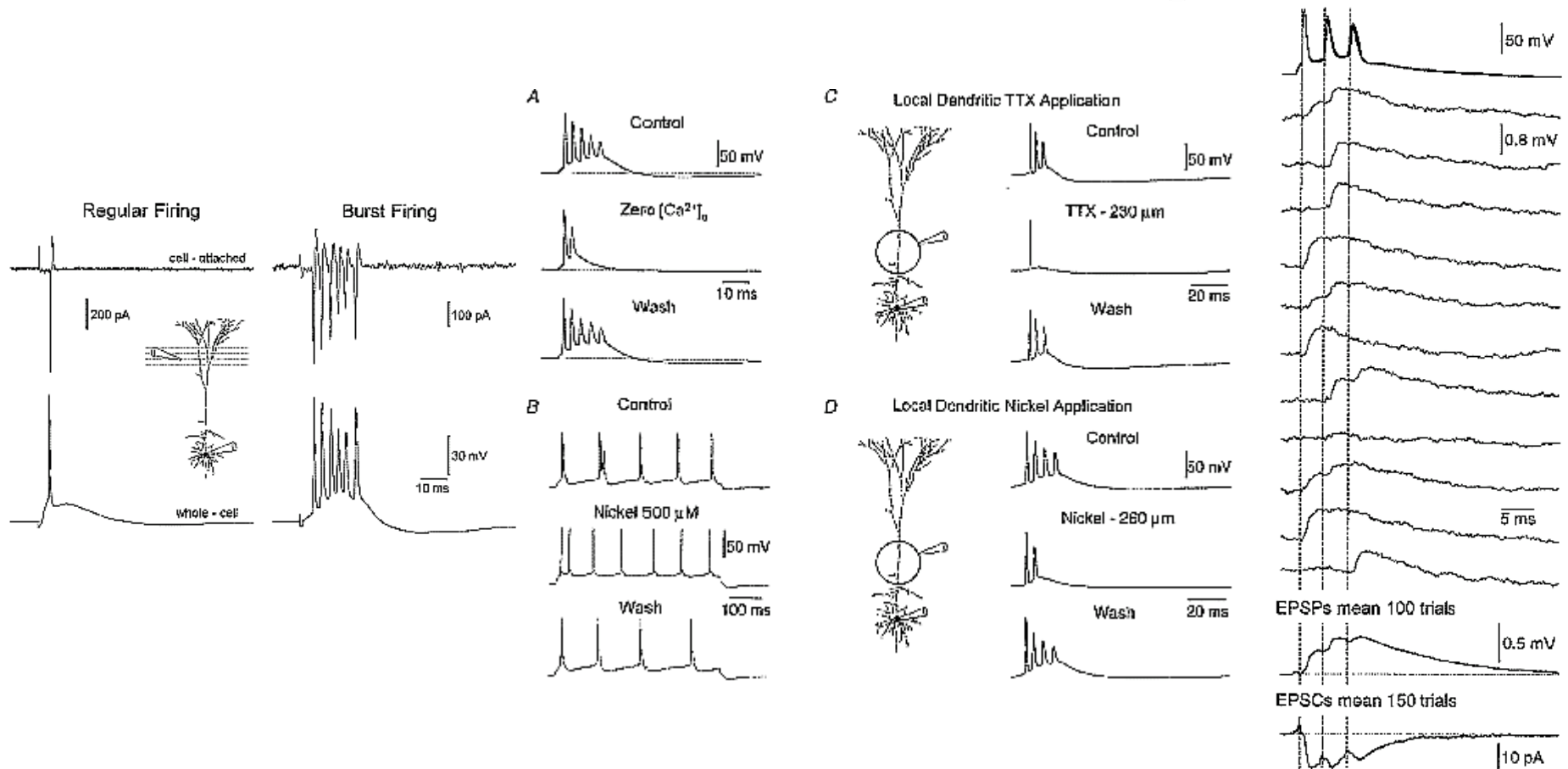


Electric synapses – gap junction

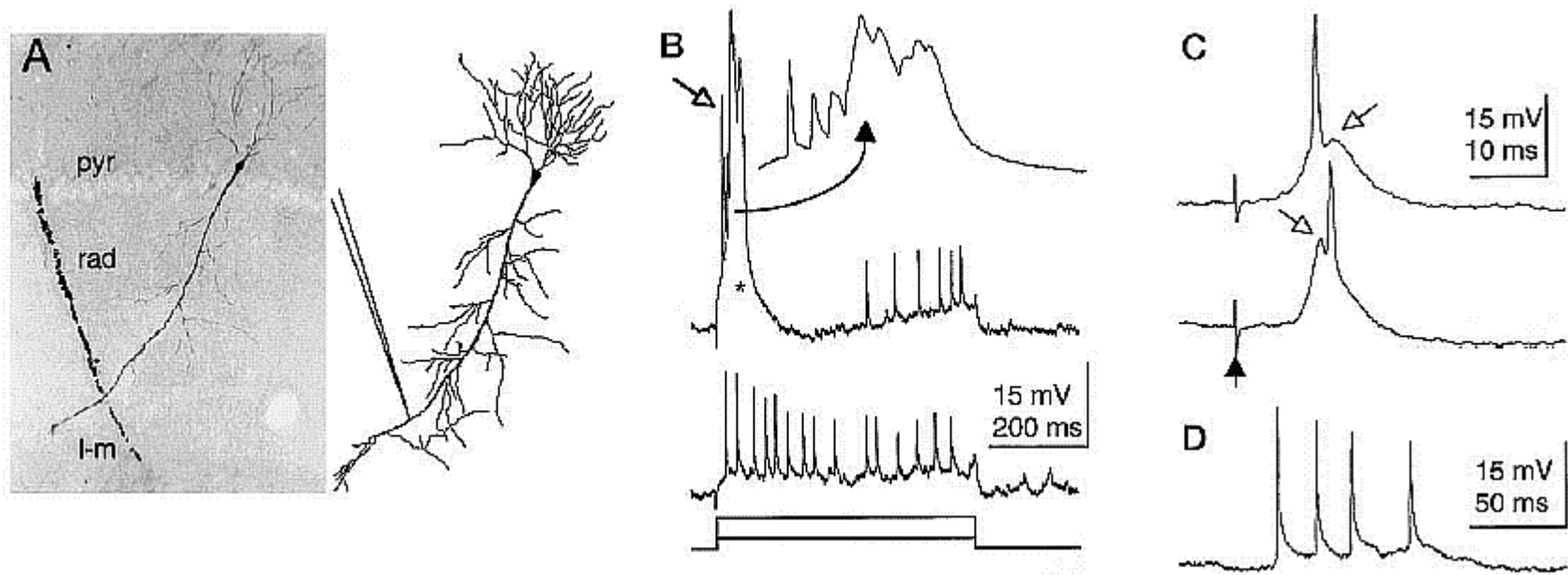


Ref: Szabadics J, Lorincz A, Tamás G. Beta and gamma frequency synchronization by dendritic gabaergic synapses and gap junctions in a network of cortical interneurons. *J Neurosci.* 2001 Aug 1;21(15):5824-31.

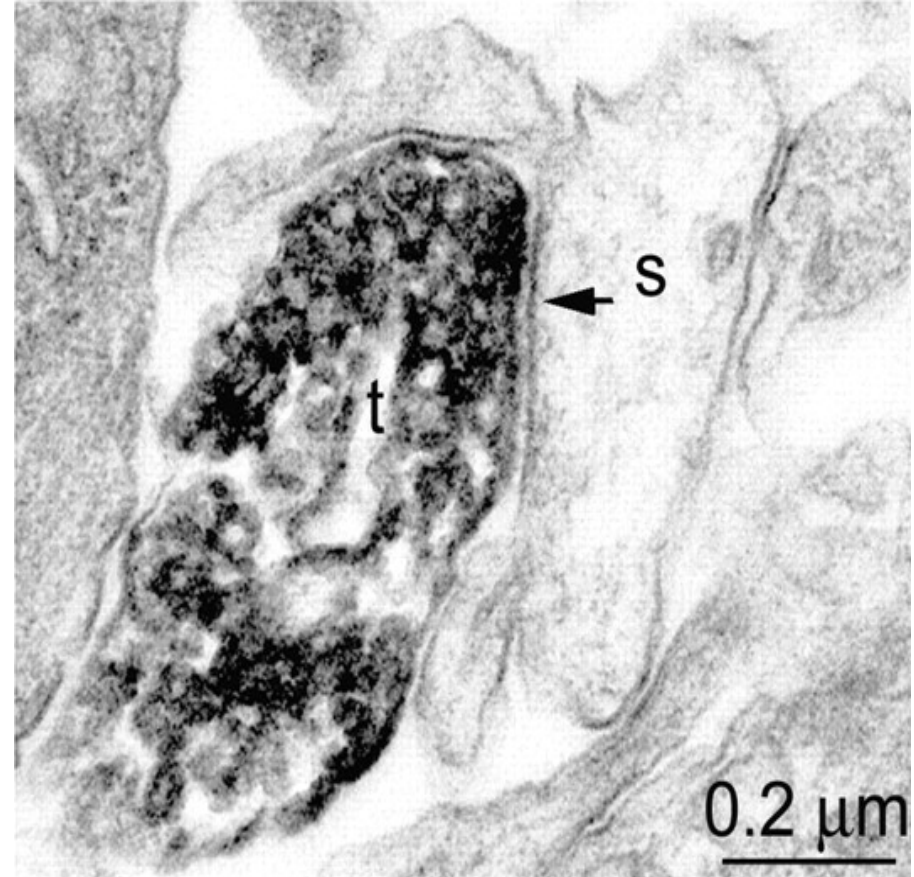
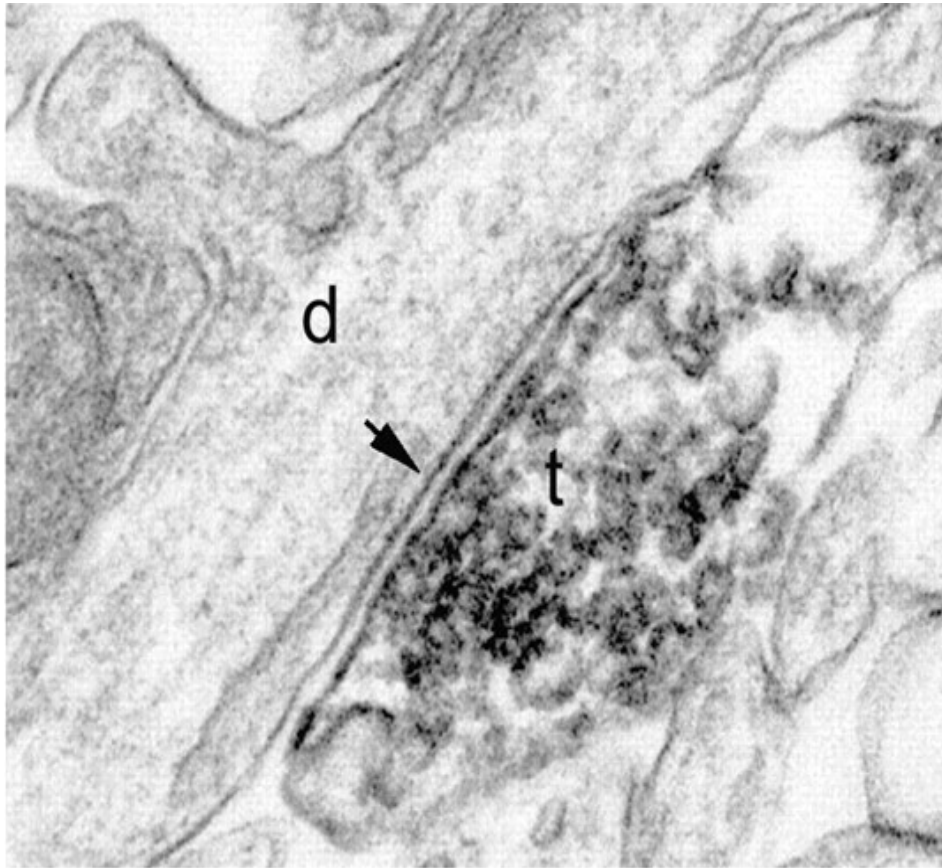
Active dendrites – *in vitro* recording



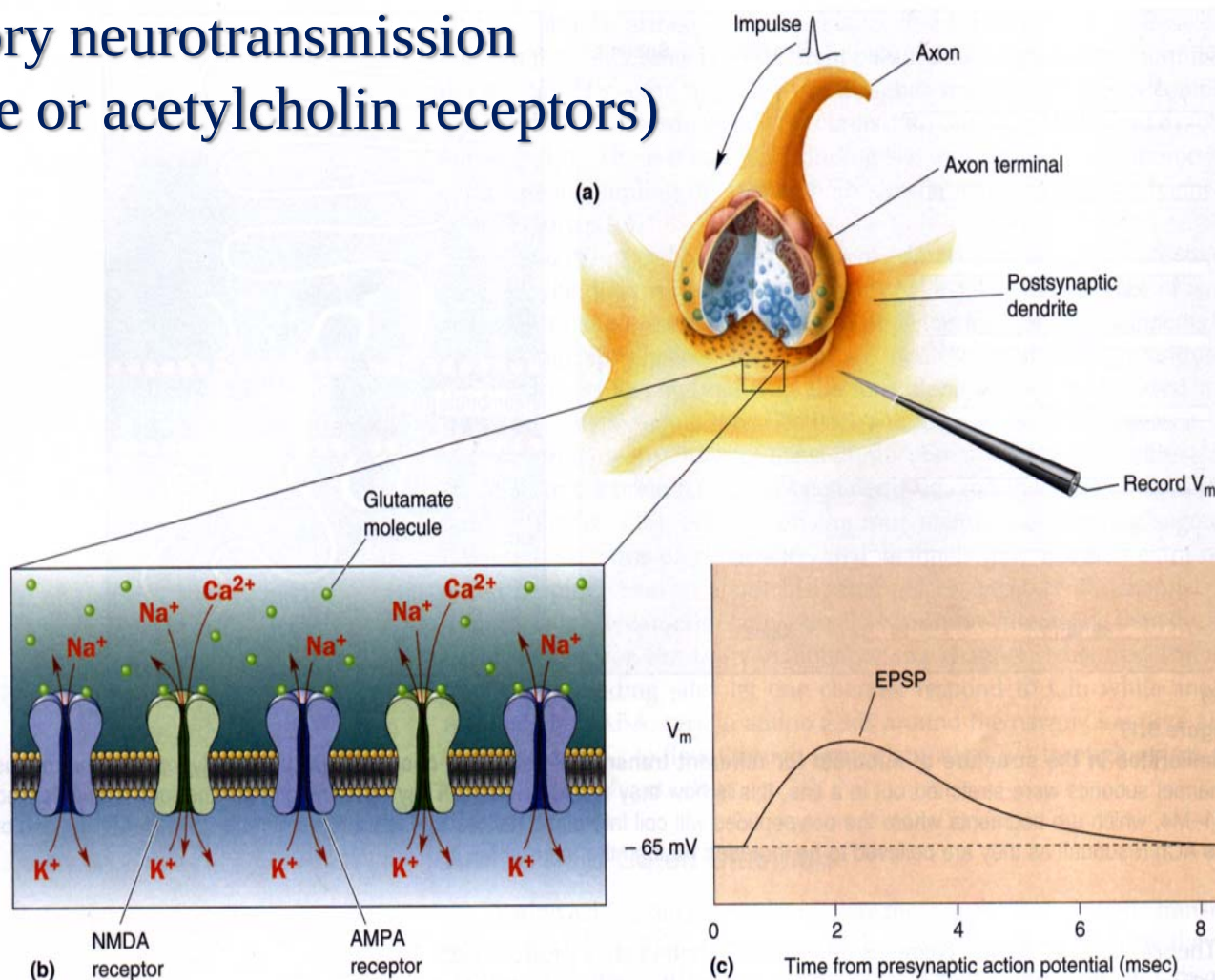
Active dendrites – *in vitro* recording



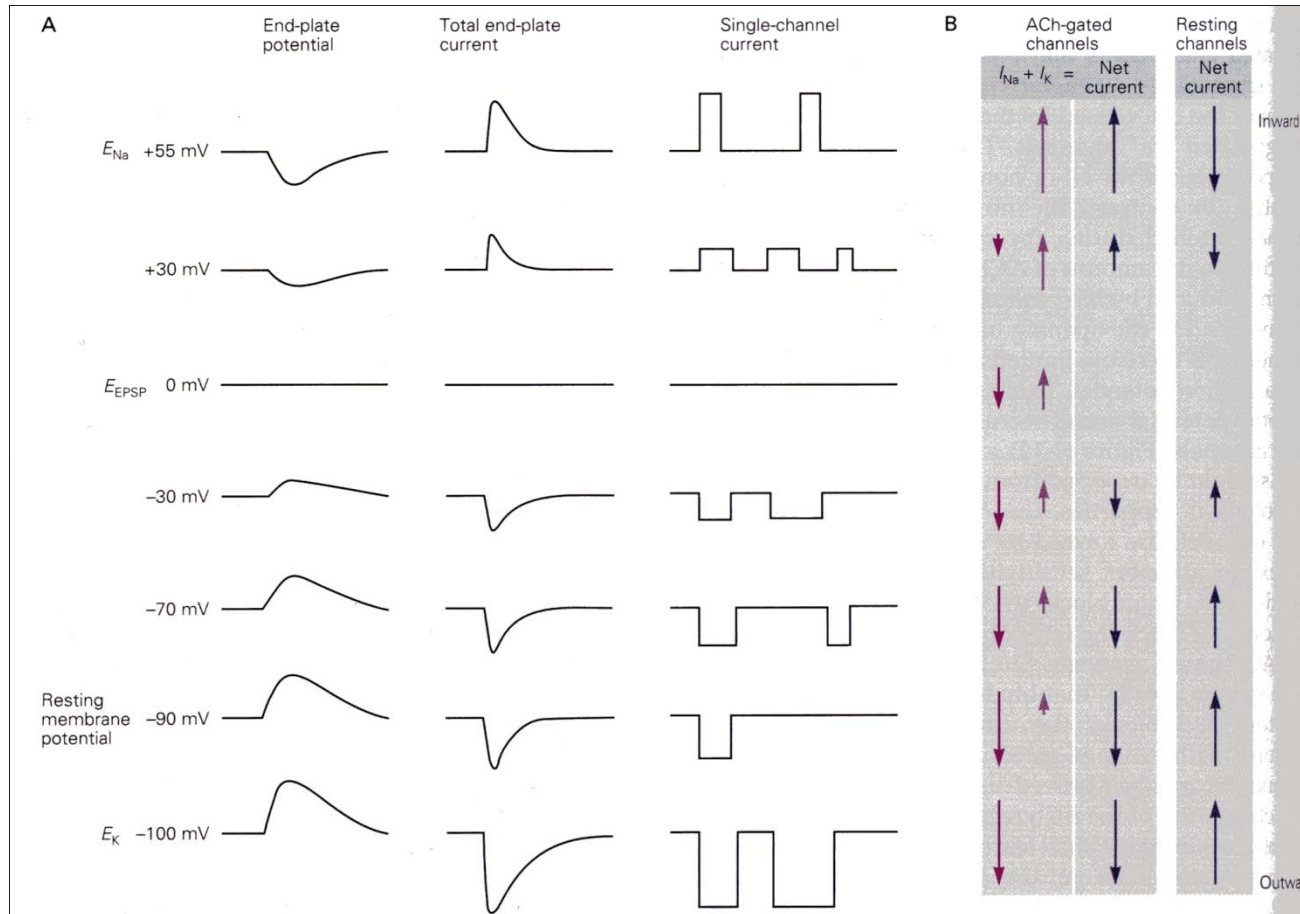
Synaptic connection



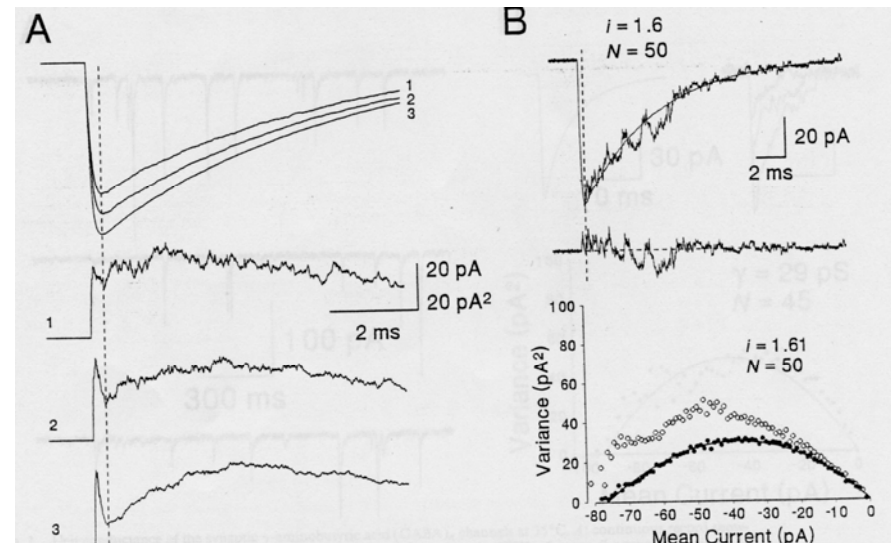
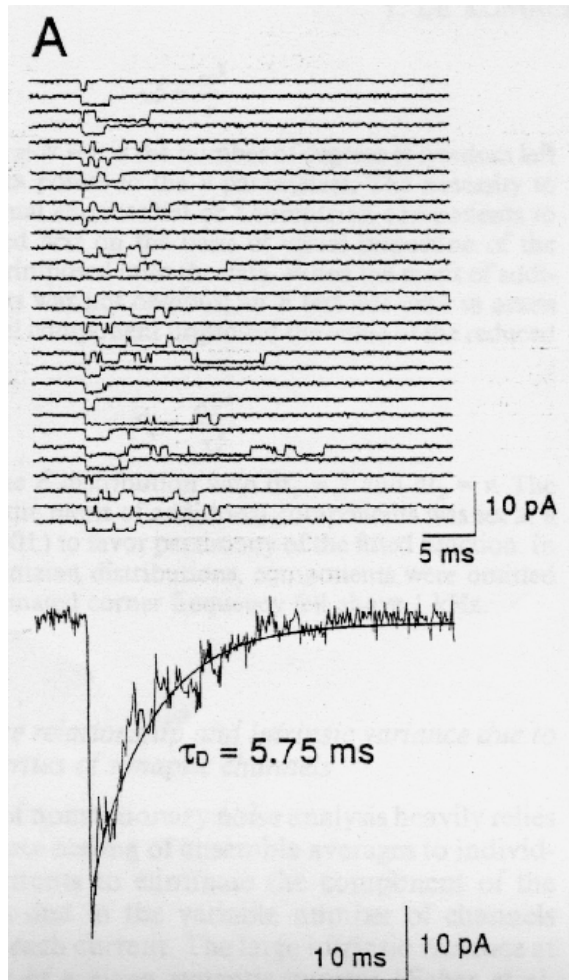
Excitatory neurotransmission (e.g. glutamate or acetylcholin receptors)



Synaptic transmission at the neuromuscular junction



Noise-analysis of synaptic currents



$$\sigma^2 = i * I_m - I_m^2 / N$$

σ^2 - variance

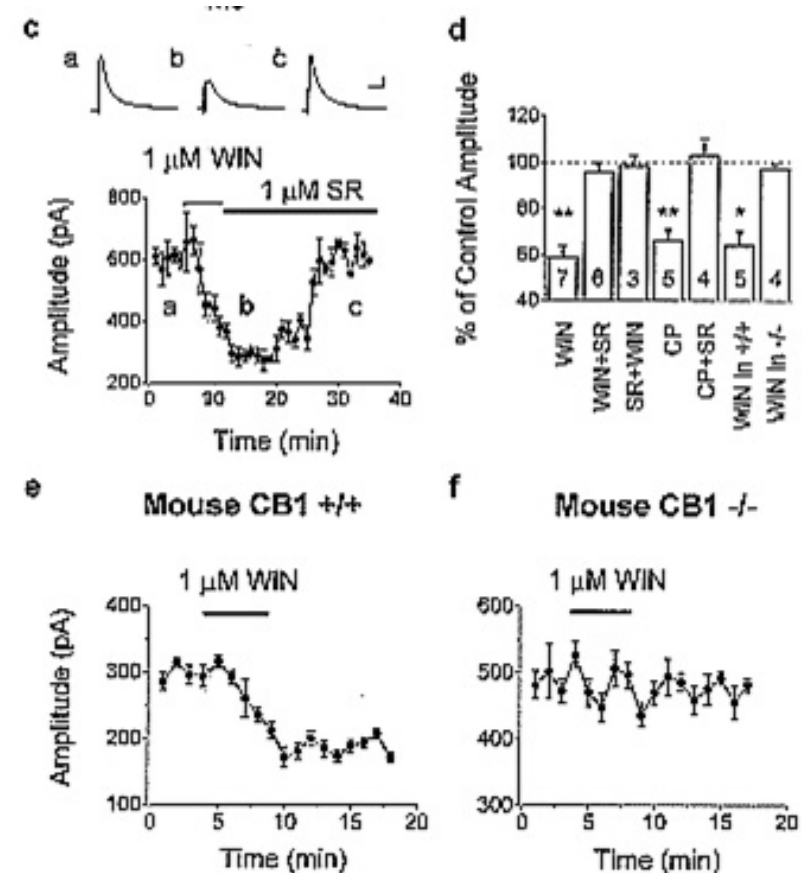
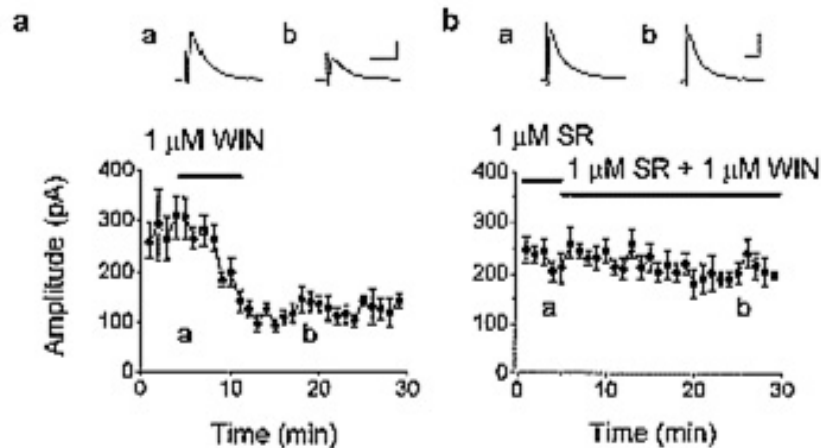
i – single channel current

I_m – mean current

N – number of channel, which generate current

Studies on synaptic transmission I.

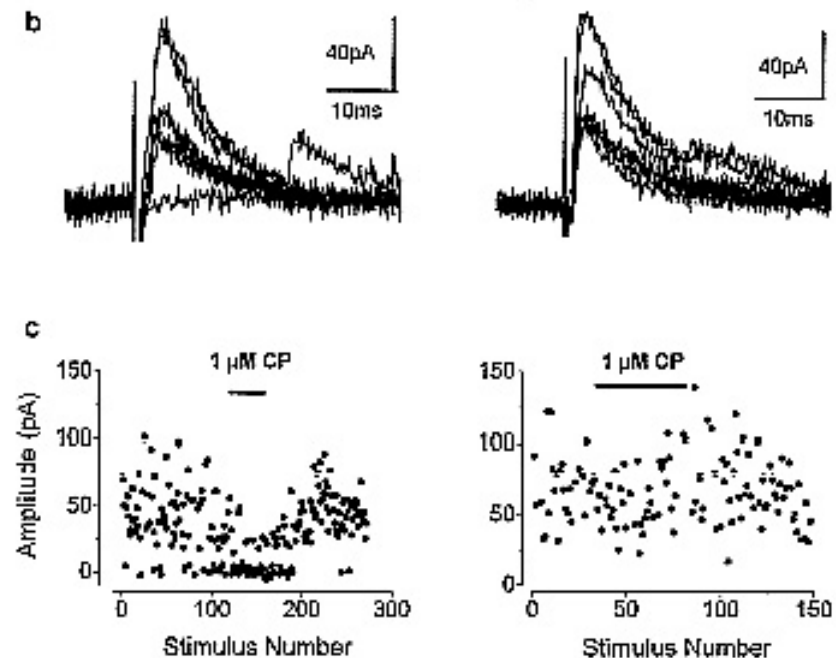
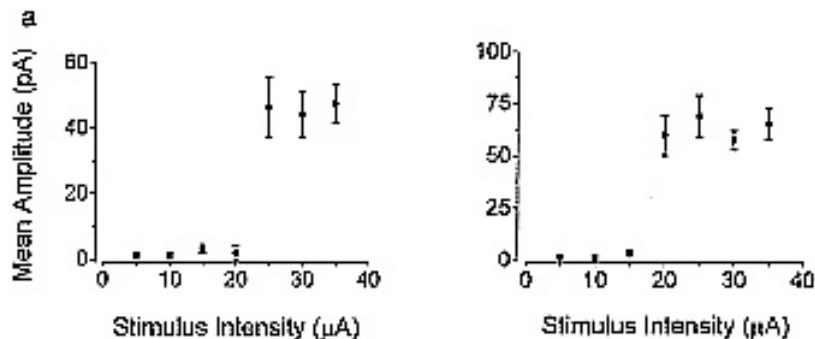
Electric stimulation experiments



Ref: Hájos N, Freund TF. Distinct cannabinoid sensitive receptors regulate hippocampal excitation and inhibition. *Chem Phys Lipids*. 2002 Dec 31;121(1-2):73-82. Review.

Studies on synaptic transmission I.

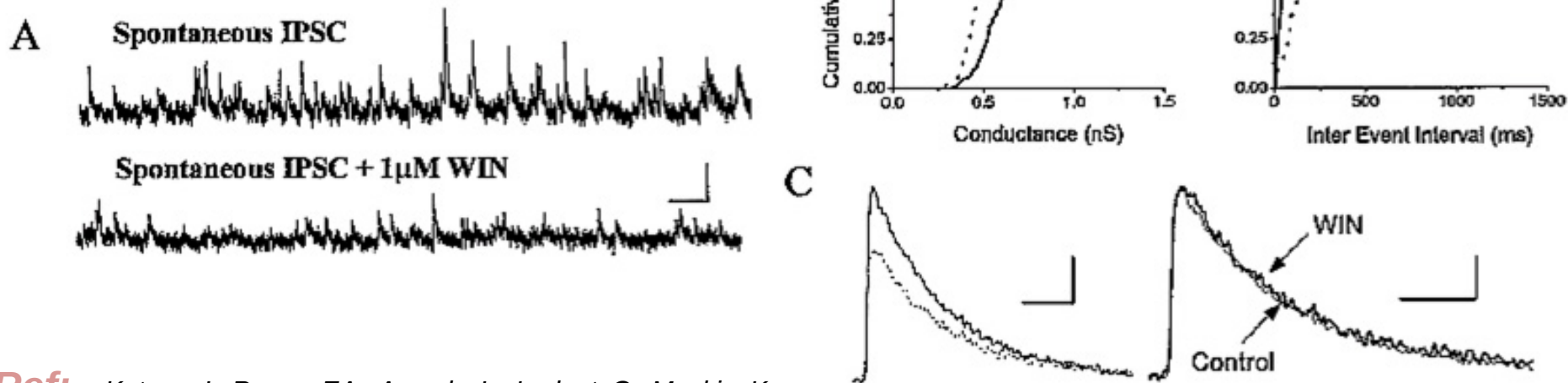
Minimal stimulation experiments



Ref: Hájos N, Katona I, Naiem SS, MacKie K, Ledent C, Mody I, Freund TF. Cannabinoids inhibit hippocampal GABAergic transmission and network oscillations. *Eur J Neurosci.* 2000 Sep;12(9):3239-49.

Studies on synaptic transmission II.

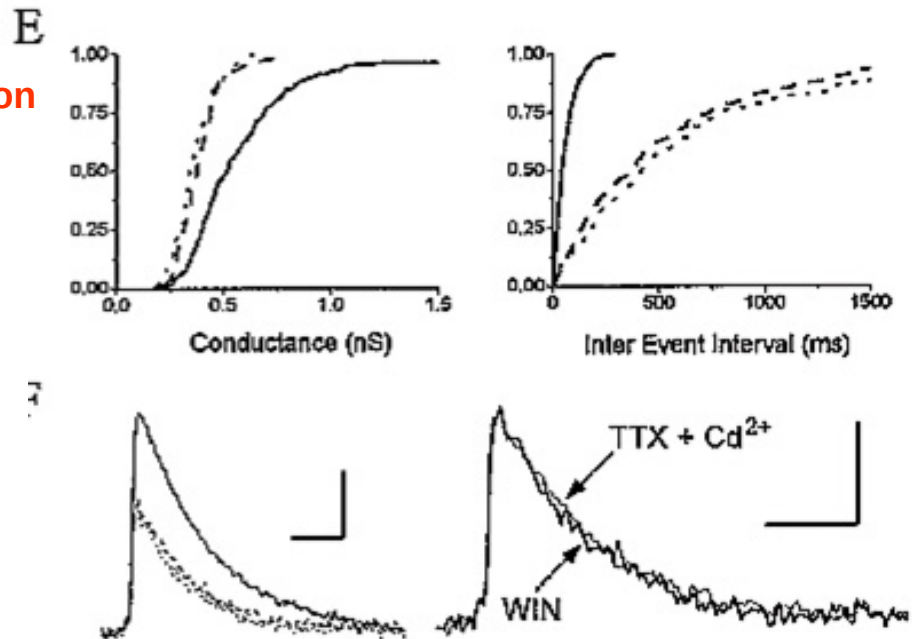
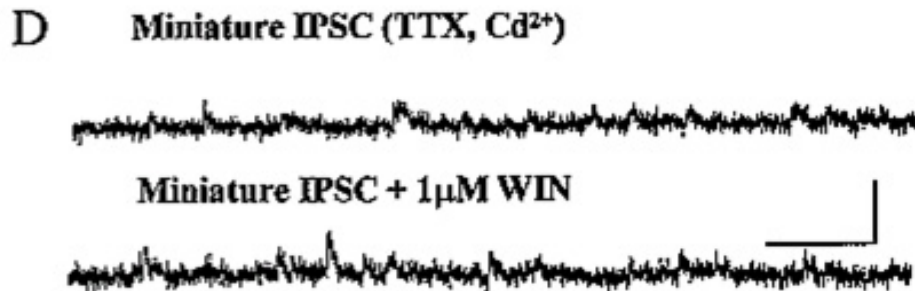
Action potential-dependent synaptic transmission



Ref: Katona I, Rancz EA, Acsady L, Ledent C, Mackie K, Hajos N, Freund TF. Distribution of CB1 cannabinoid receptors in the amygdala and their role in the control of GABAergic transmission. *J Neurosci*. 2001 Dec 1;21(23):9506-18.

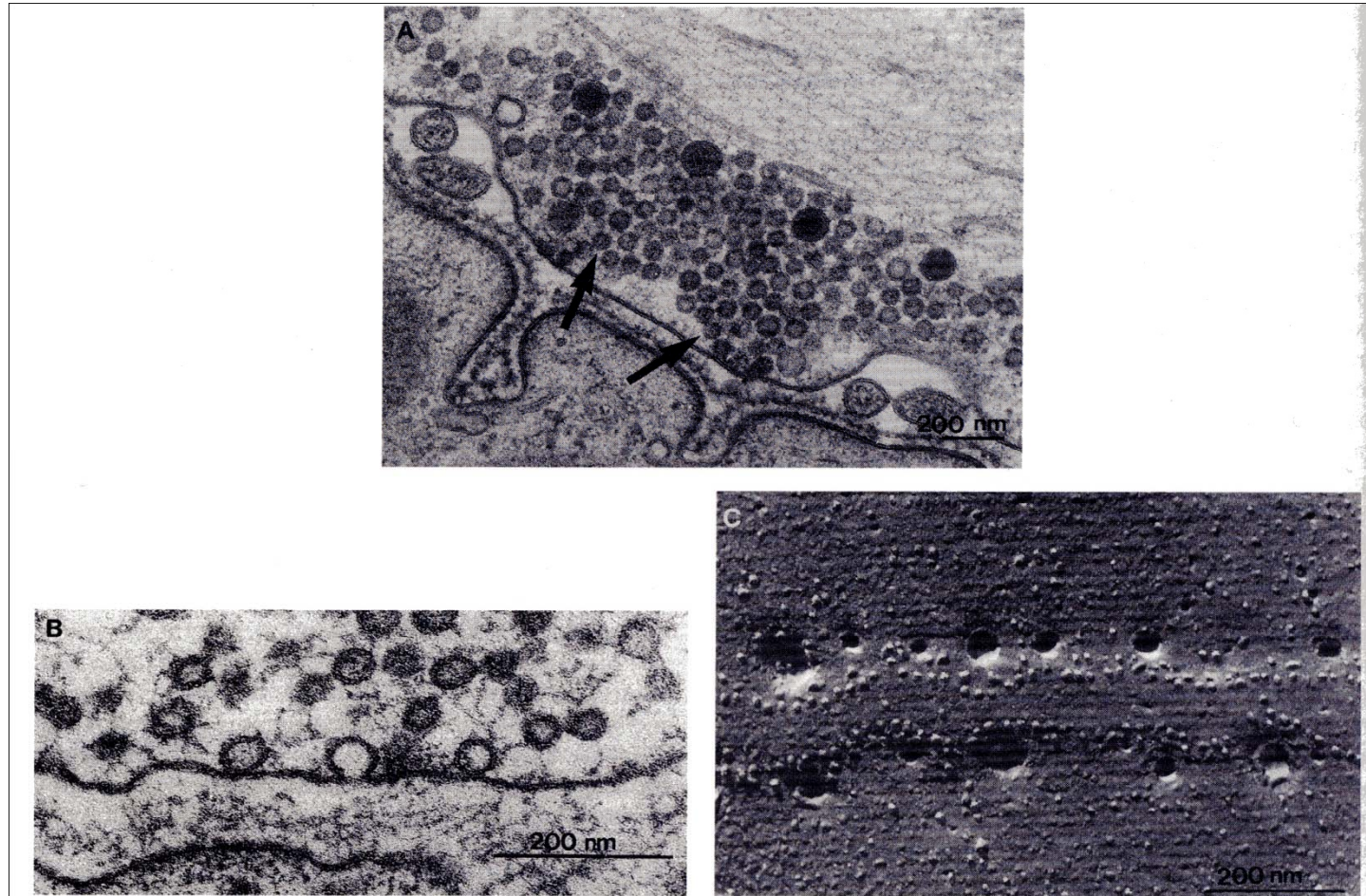
Studies on synaptic transmission II.

Action potential-independent synaptic transmission

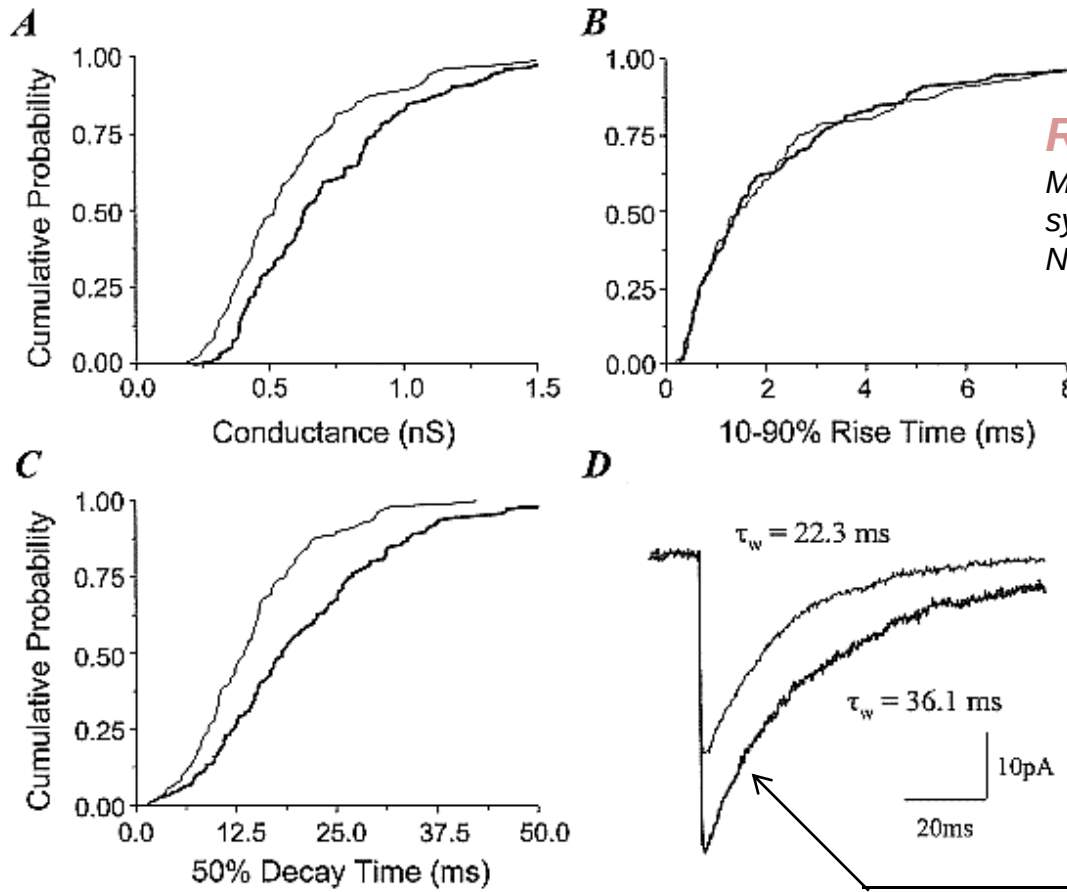


Ref: Katona I, Rancz EA, Acsady L, Ledent C, Mackie K, Hajos N, Freund TF. Distribution of CB1 cannabinoid receptors in the amygdala and their role in the control of GABAergic transmission. *J Neurosci.* 2001 Dec 1;21(23):9506-18.

Ultrastructure of axon terminals



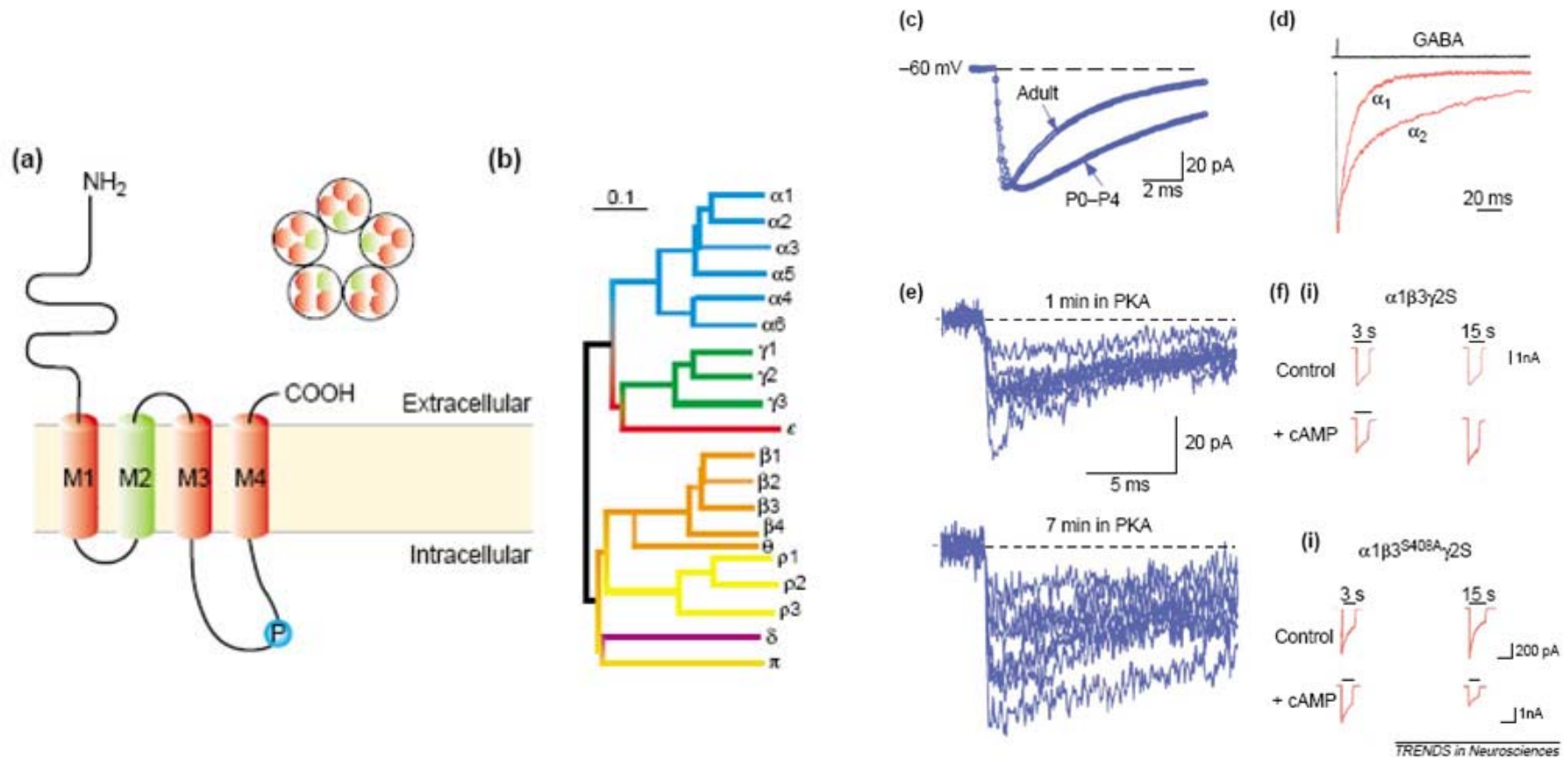
Saturation of synaptic neurotransmitter-receptors



Ref: Hájos N, Nusser Z, Rancz EA, Freund TF, Mody I. Cell type- and synapse-specific variability in synaptic GABAA receptor occupancy. *Eur J Neurosci.* 2000 Mar;12(3):810-8.

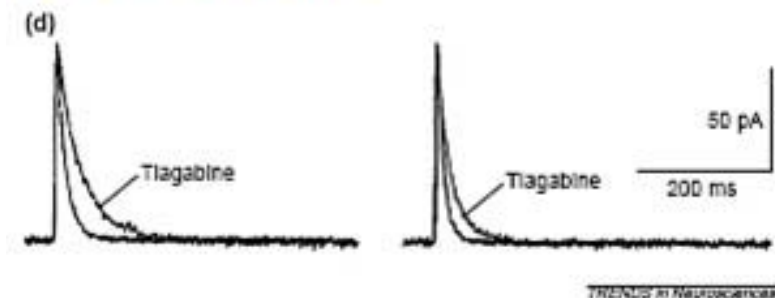
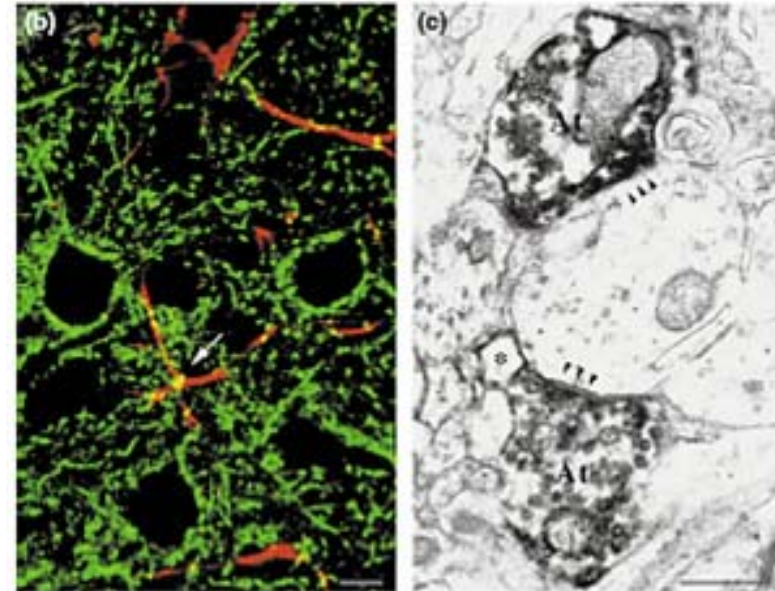
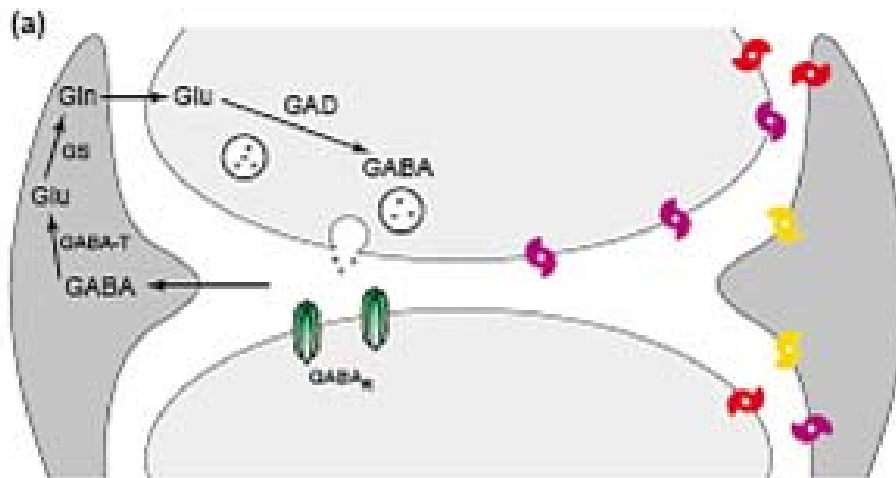
Zolpidem - egy benzodiazepine származék hatása

Large variety of neurotransmitter receptors: the GABA_A receptors as an example

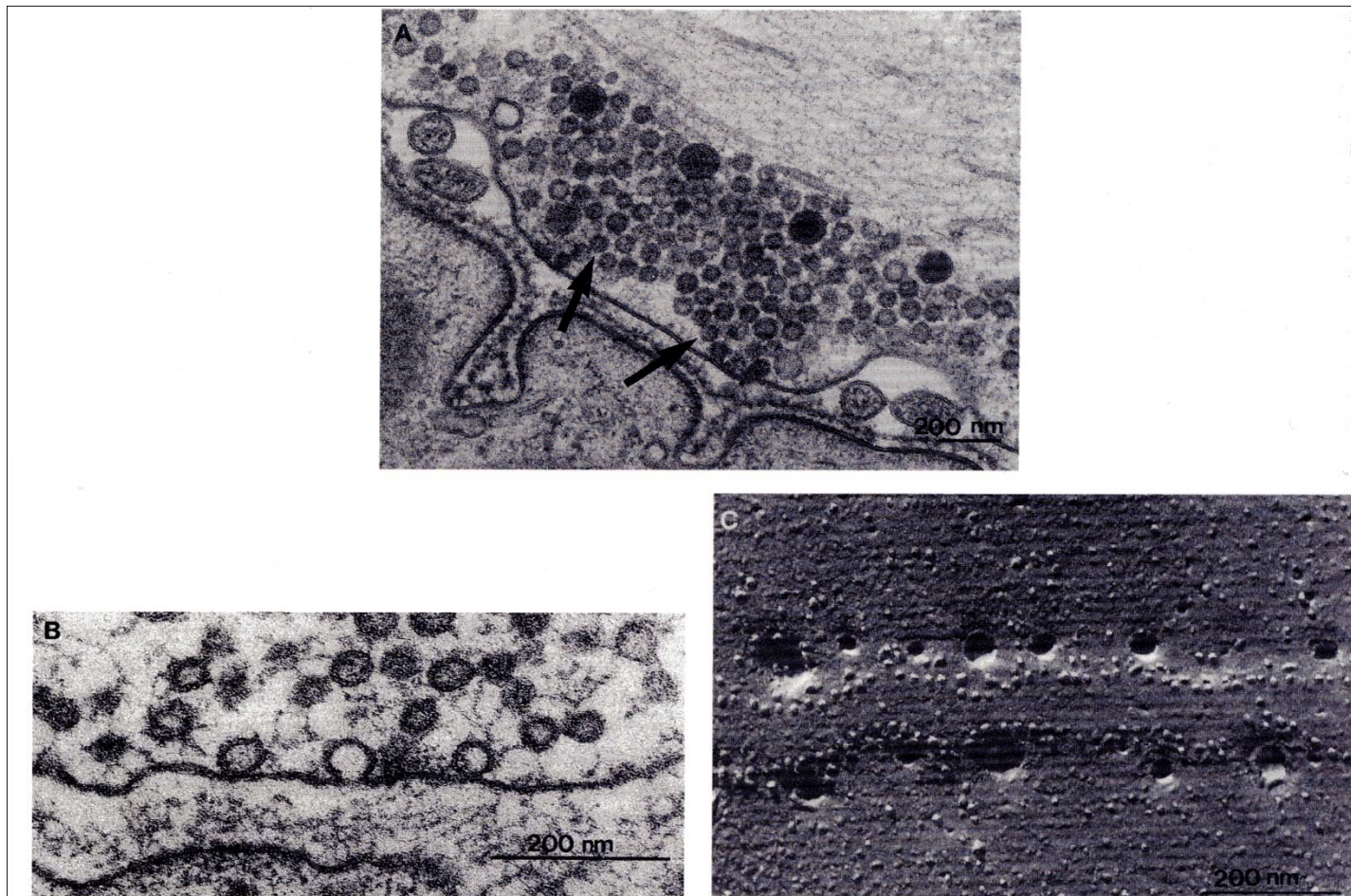


TRENDS in Neurosciences

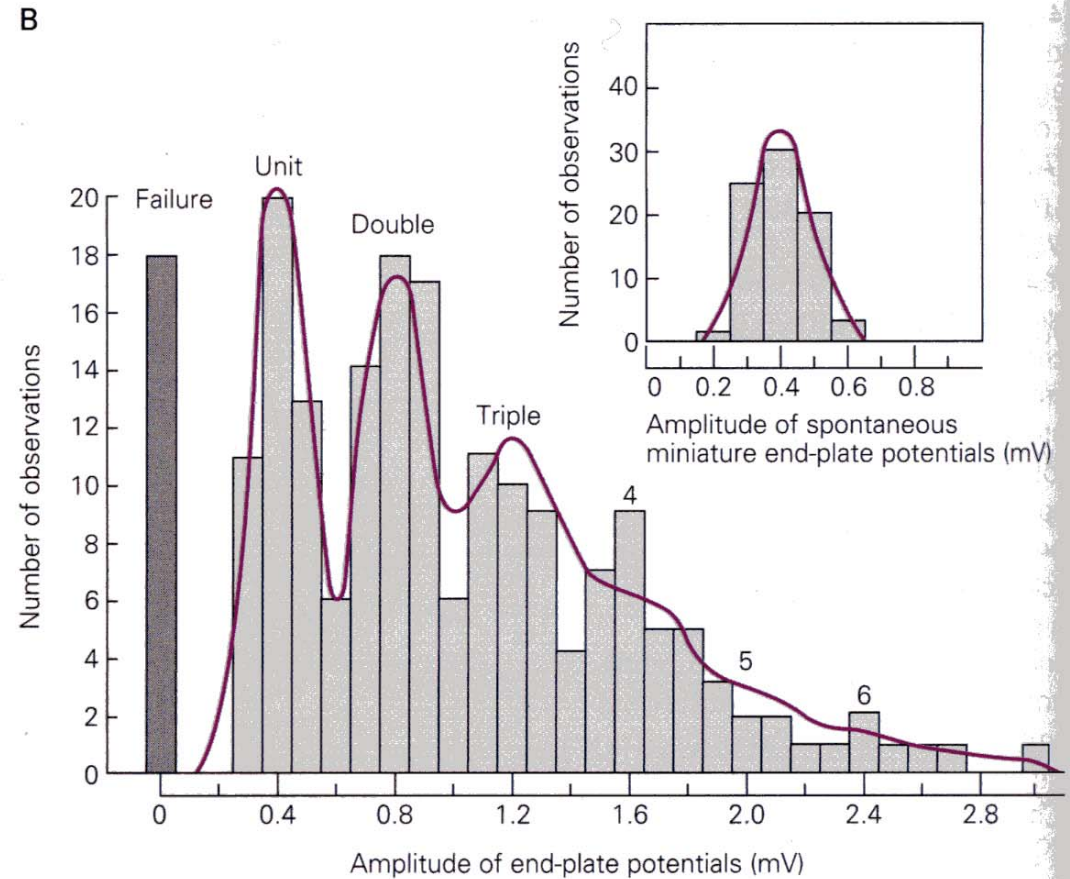
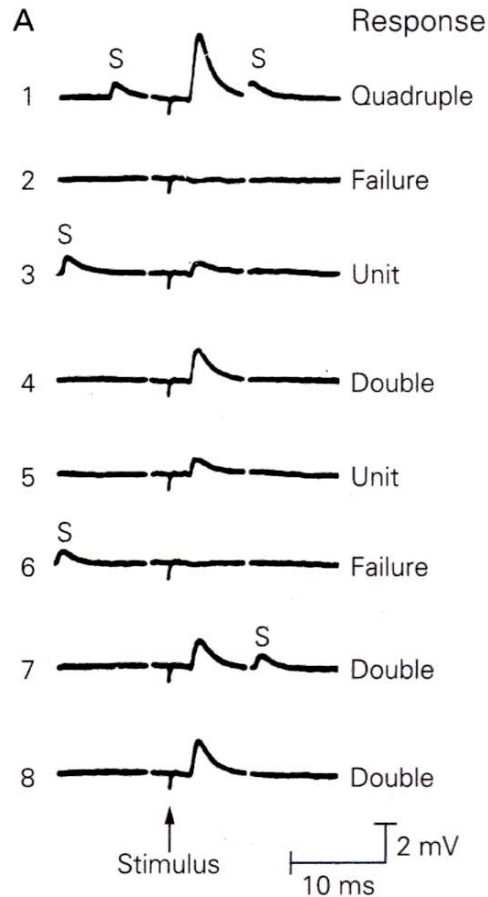
Large variety of neurotransmitter receptors: the GABA_A receptors as an example



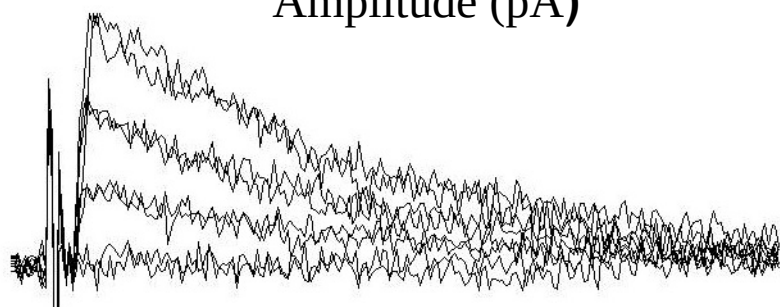
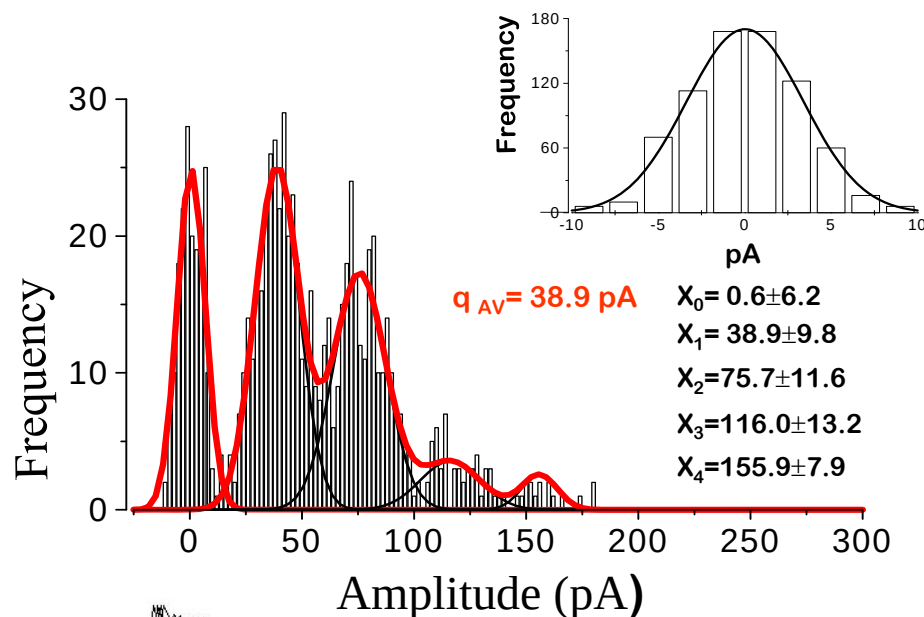
Ultrastructure of axon terminals



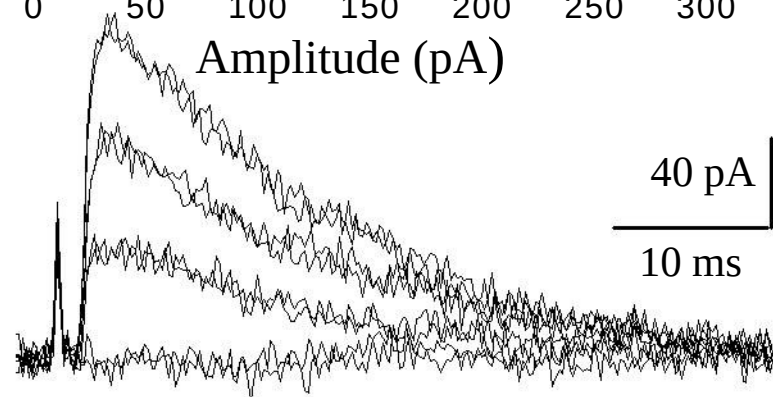
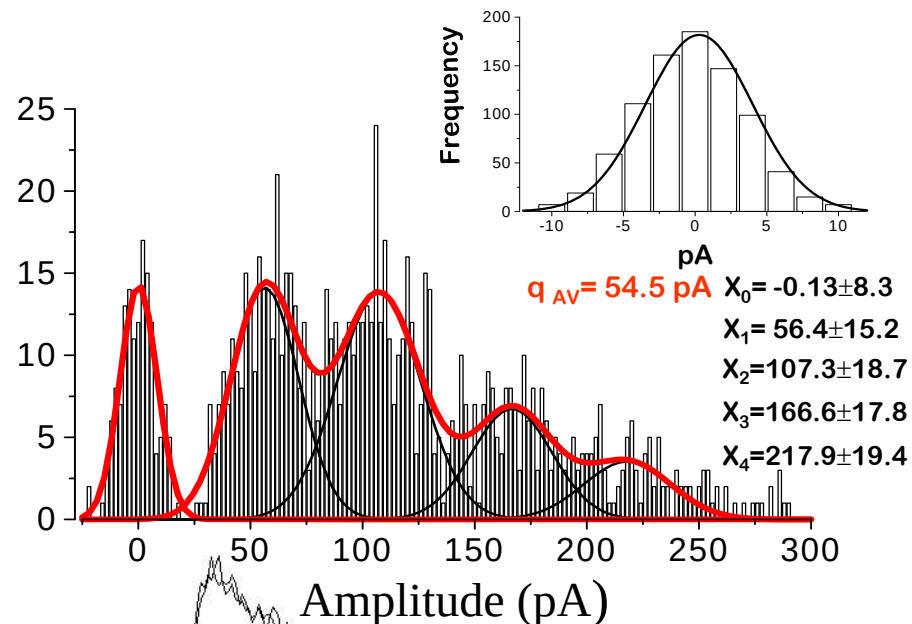
The release of transmitters is quantal



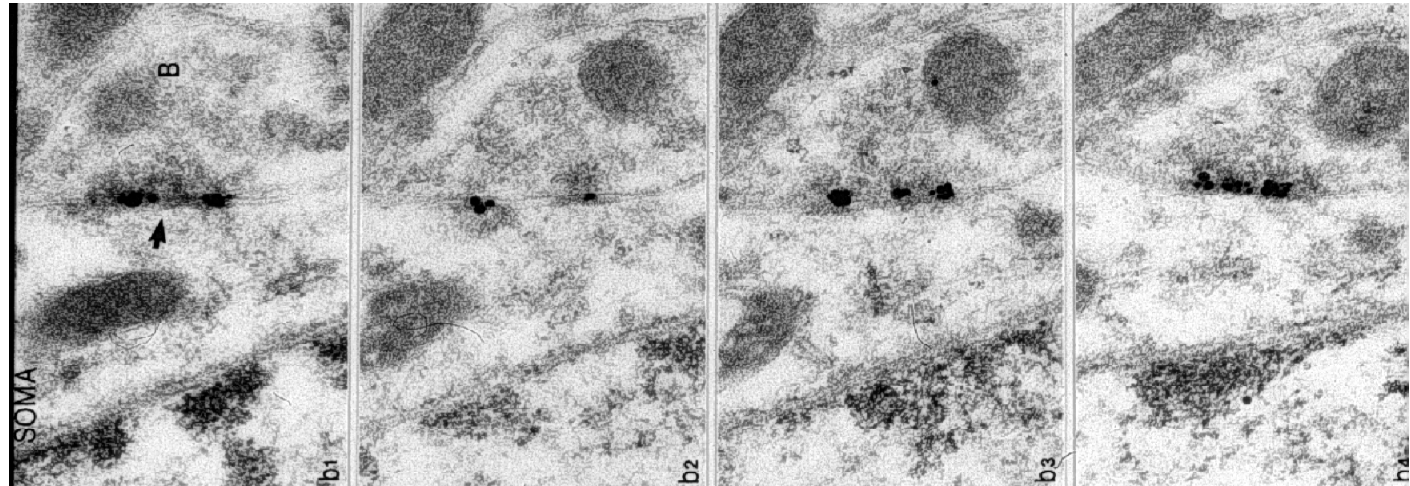
Control



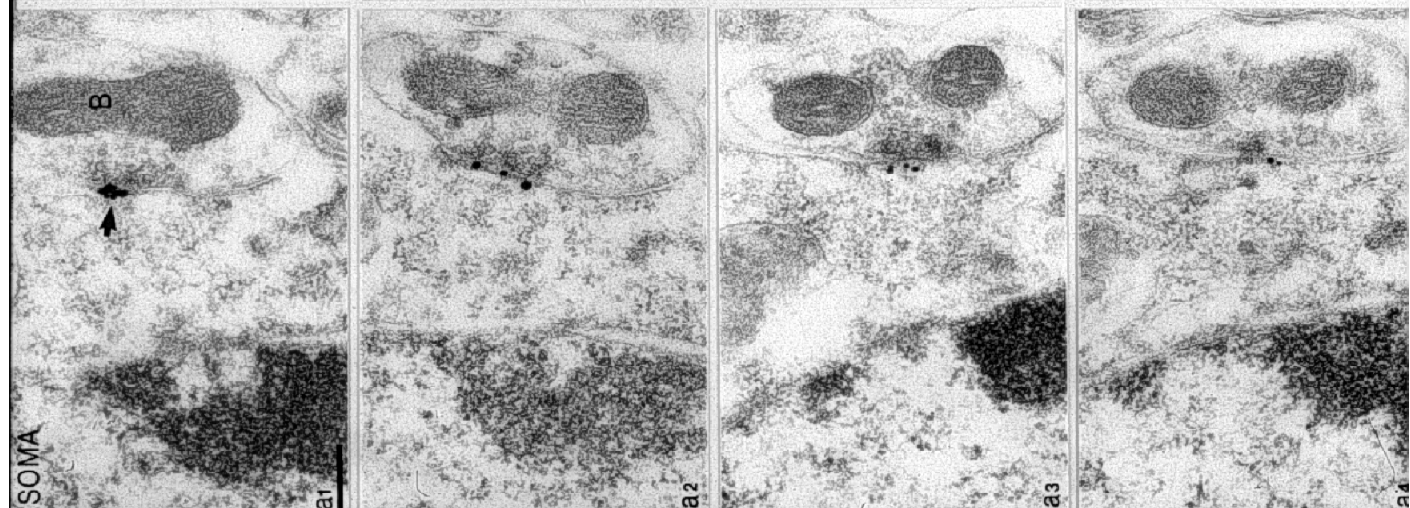
Kindled



Kindled

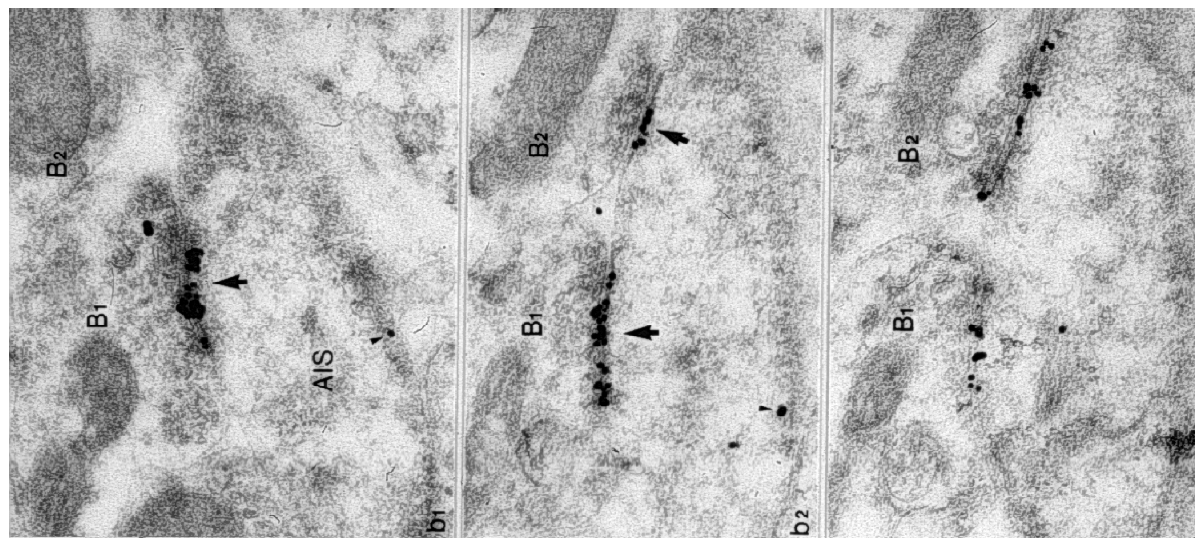


Control

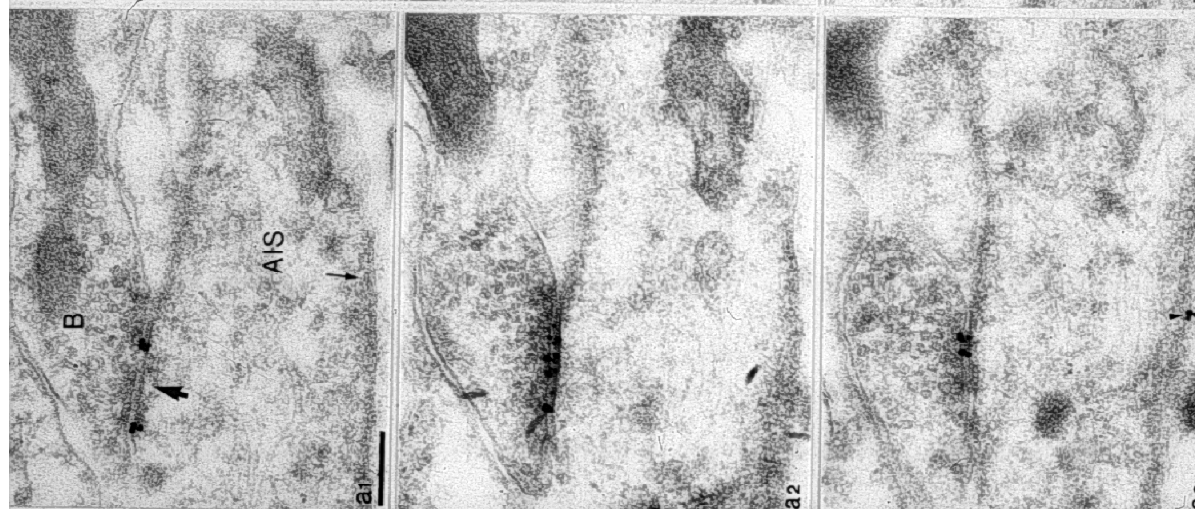


Ref: Nusser Z, Hájos N, Somogyi P, Mody I. Increased number of synaptic GABA(A) receptors underlies potentiation at hippocampal inhibitory synapses. *Nature*. 1998 Sep 10;395(6698): 172-7.

Kindled



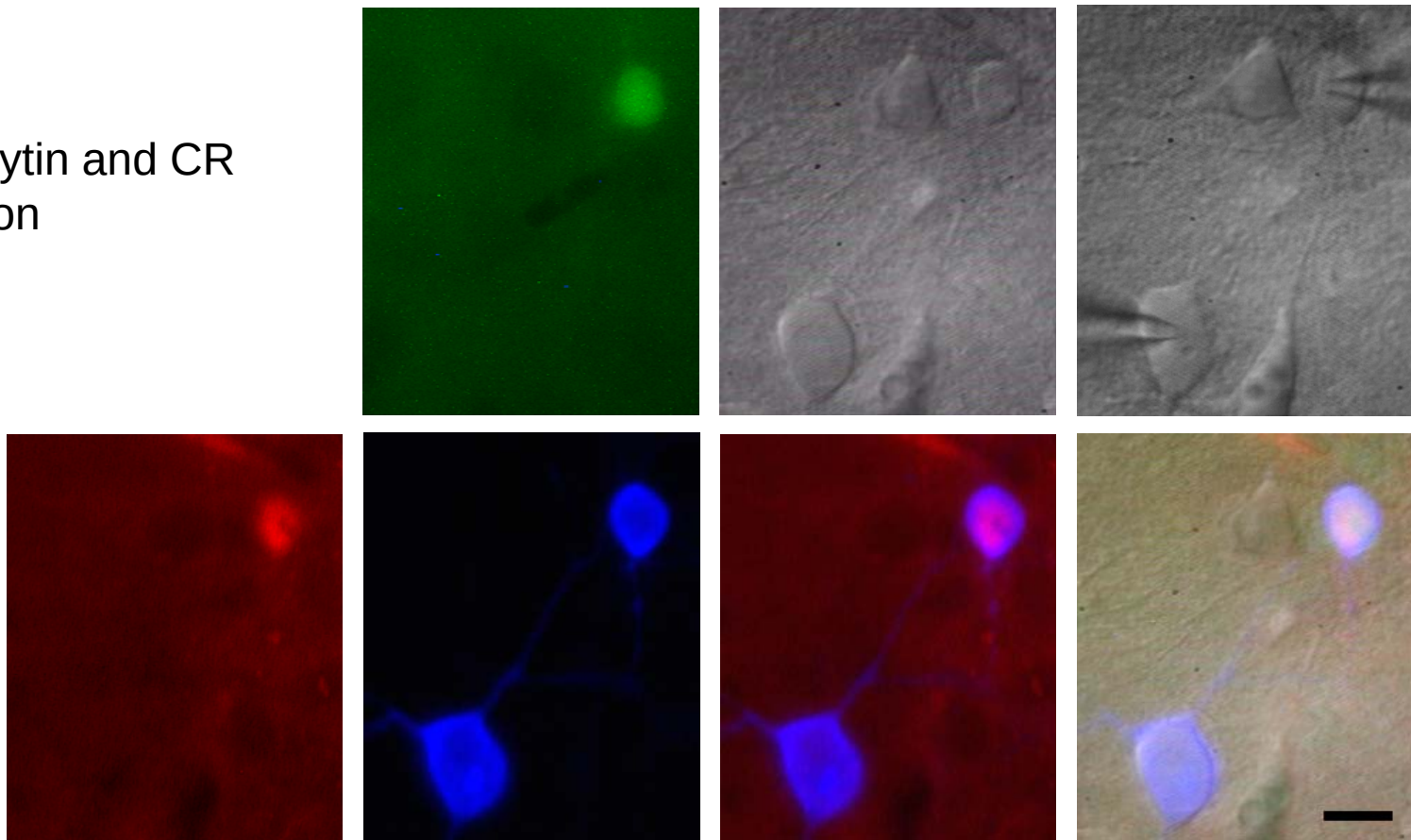
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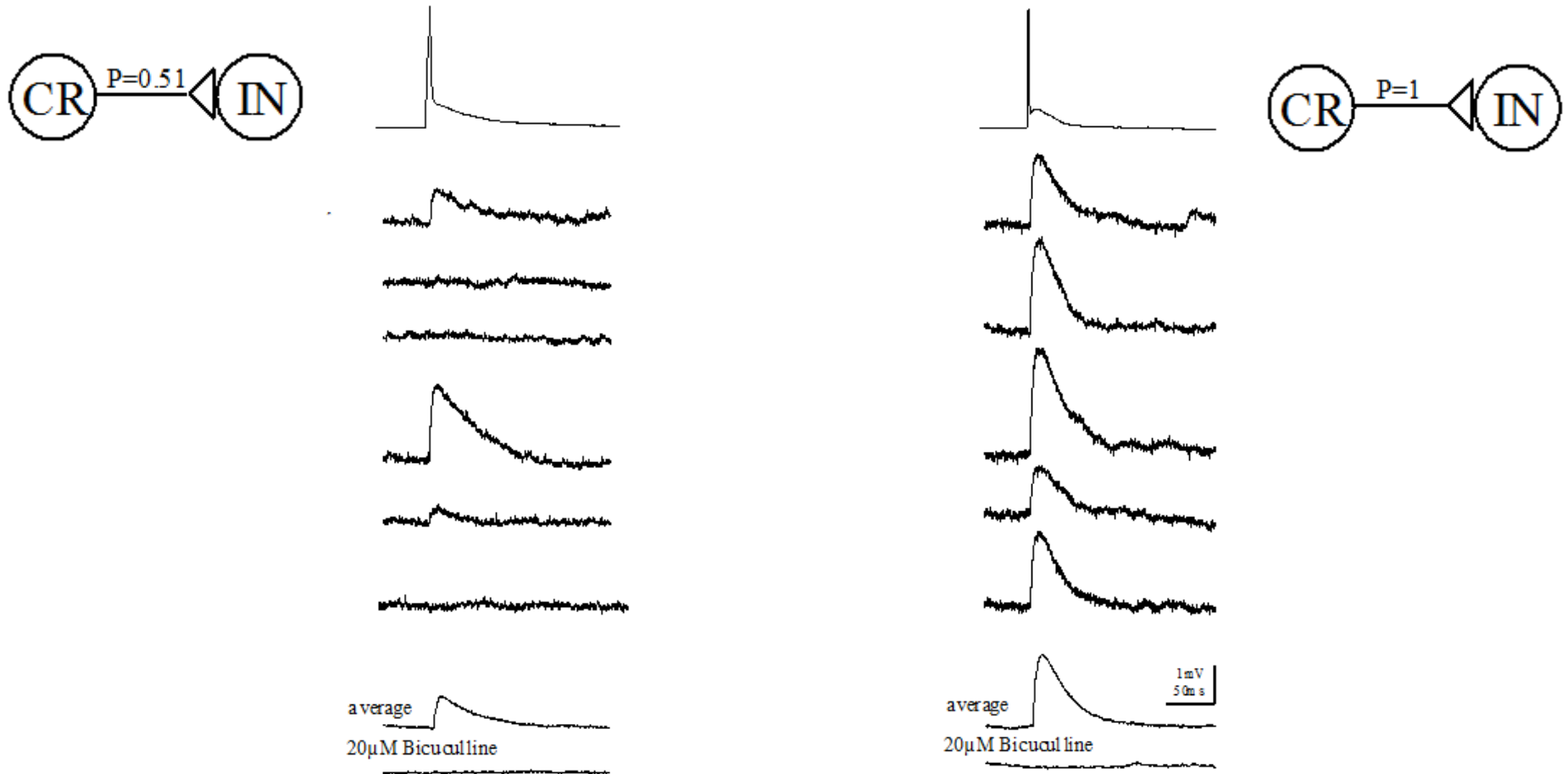
Ref: Nusser Z, Hájos N, Somogyi P, Mody I. Increased number of synaptic GABA(A) receptors underlies potentiation at hippocampal inhibitory synapses. *Nature*. 1998 Sep 10;395(6698): 172-7.

Paired recording of neurons

EGFP, Biocytin and CR
colocalization

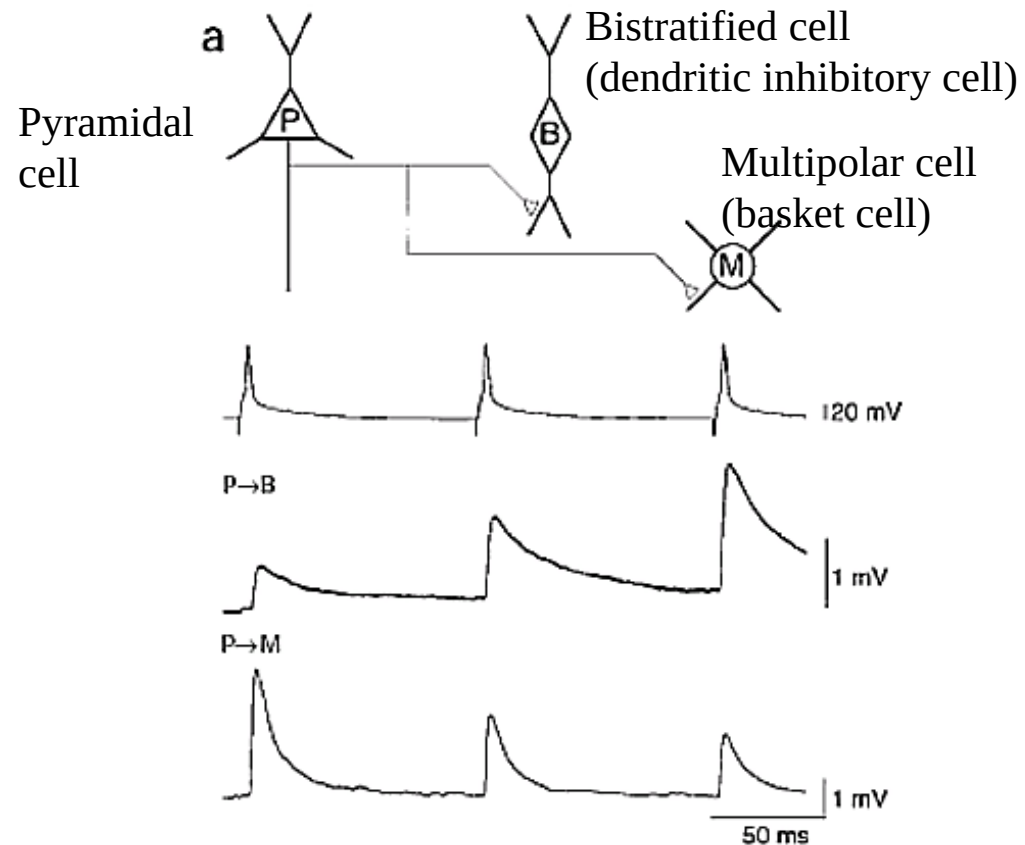
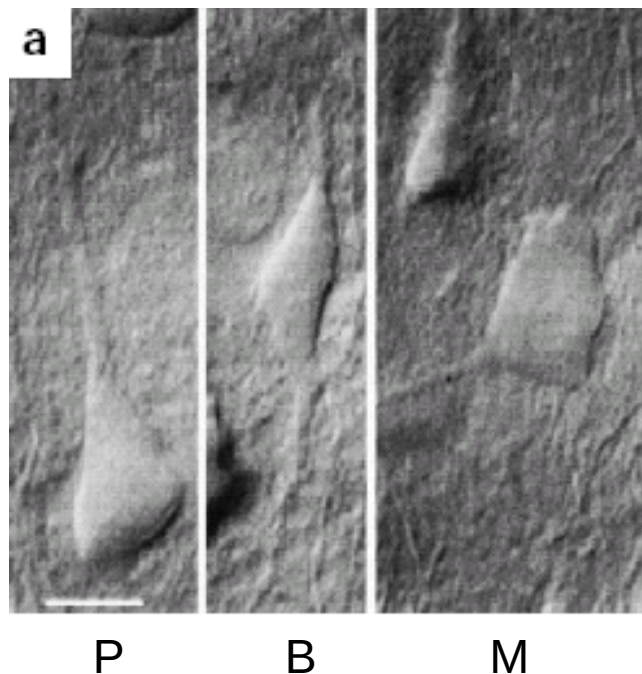


Paired recording of neurons

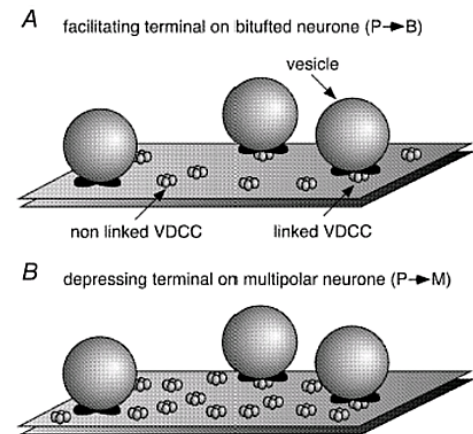
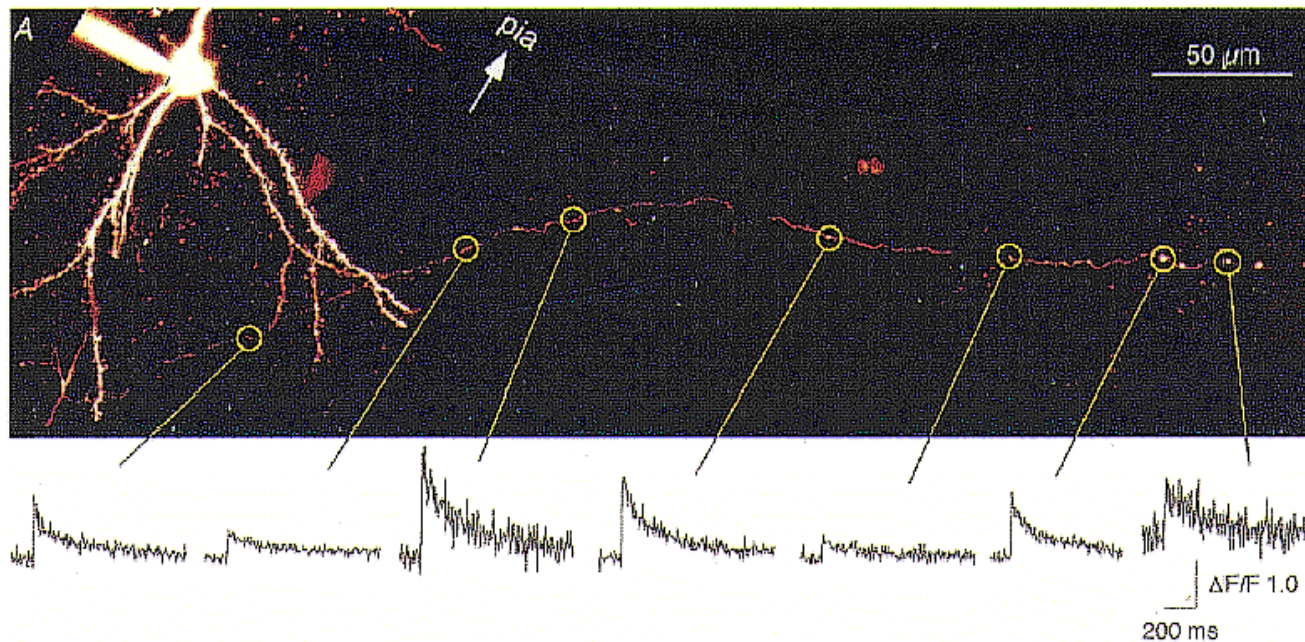


Paired recording of neurons (dual or triple recording)

The quality of neurotransmission is determined by the type of postsynaptic cell!!!

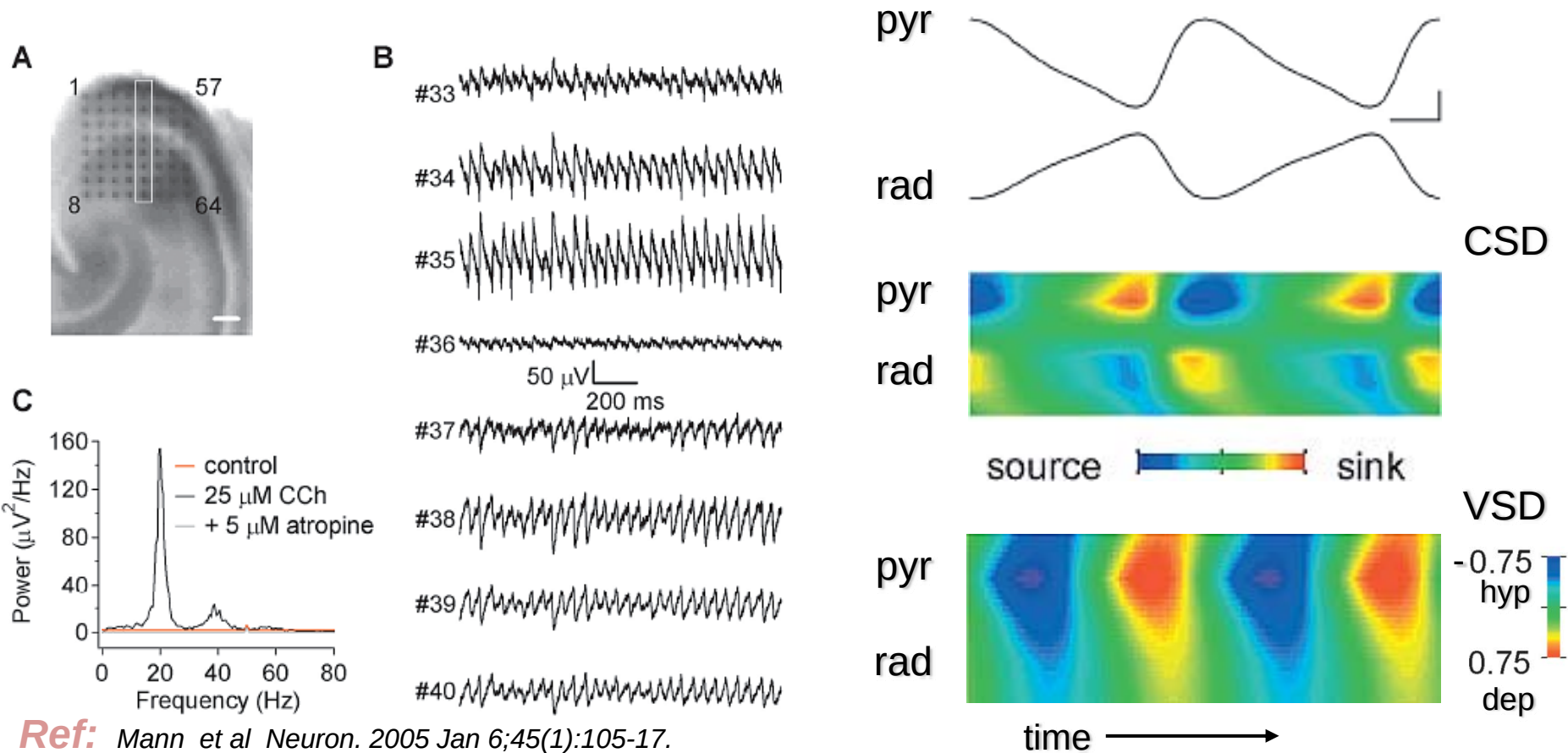


Difference of Ca^{2+} transients evoked by action potential is large in the axon terminals of pyramidal cells



Ref: Koester HJ, Sakmann B. Calcium dynamics associated with action potentials in single nerve terminals of pyramidal cells in layer 2/3 of the young rat neocortex. *J Physiol.* 2000 Dec 15;529 Pt 3:625-46.

Tracing of gamma oscillation in the CA3 region with voltage-sensitive fluorescent dyes



Ref: Mann et al *Neuron*. 2005 Jan 6;45(1):105-17.