

Electrophysiology

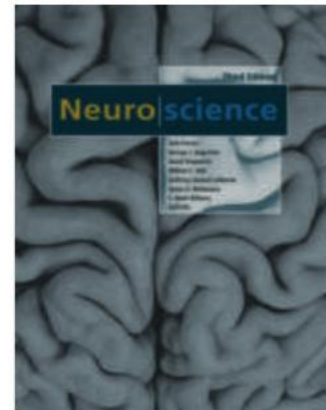
Techniques

How we know
what we know...

Topics I	Topics II
Introduction	Synaptic Transmission
Electrochemical Gradients	Electrophysiology Techniques
Passive Membrane Properties	Basic Circuits (Spinal Cord)
Action Potential	Sensory Systems Overview
Voltage-Gated Ion Channels	Synaptic Plasticity
Ligand-Gated Ion Channels	Recapitulation

Study Material

- NEUROSCIENCE Third Edition
 - Dale Purves
- Chapter 3
 - Page 48
- Chapter 4
 - Pages 70, 75, 82



THE COVER
Dorsal view of the human brain.
(Courtesy of S. Mark Williams.)

NEUROSCIENCE: Third Edition
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Aims for this Lecture

- Understand how electrical signals can be measured intra- and extracellularly.
- Field potentials – benefits and drawbacks.
- Whole cell recordings – benefits and drawbacks.
- A brief introduction to the patch-clamp technique.

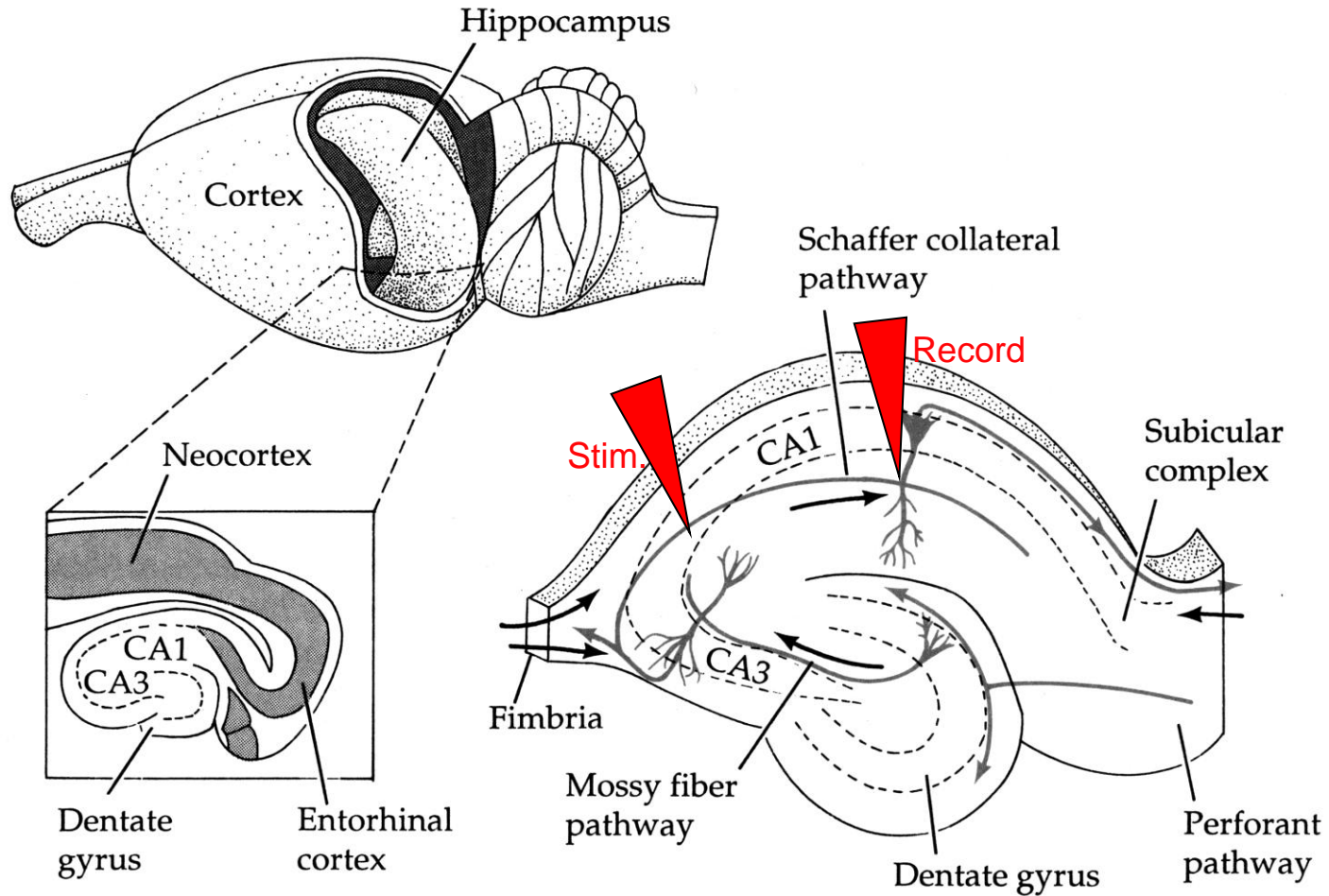
Recapitulation L8

- Synaptic transmission is a specialization of vesicular transport.
- The speed and calcium sensitivity are distinct features.
- The basic elements are the same, however
- At the core of the process is the SNARE complex.
- Clostridial (TeTx and BoNTx) toxins cleave components of the SNARE complex and so block synaptic transmission.

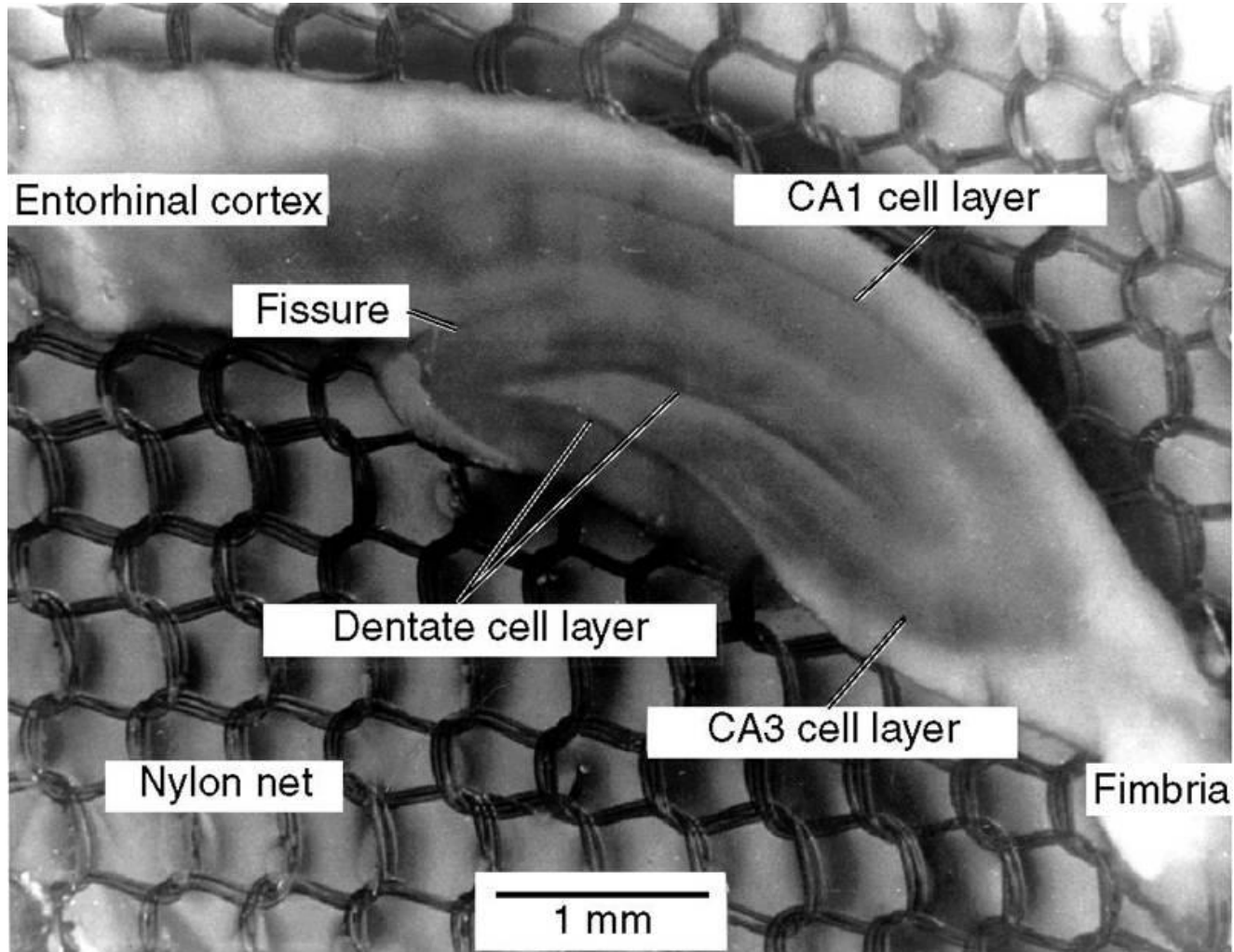
General Tools

- For cellular electrophysiology the tissue usually has to be prepared for *ex-vivo* investigation.
- In most cases we need to keep this tissue alive by immersing it in a special liquid.
- Optical magnification and signal amplification are generally needed.

Tissue Preparation I

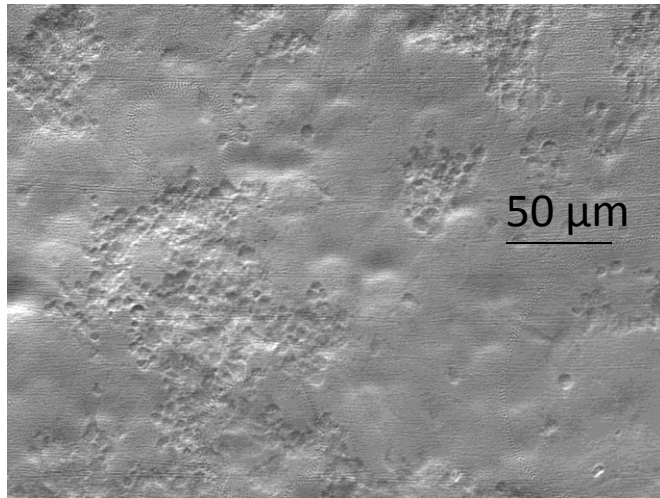


Tissue Preparation II

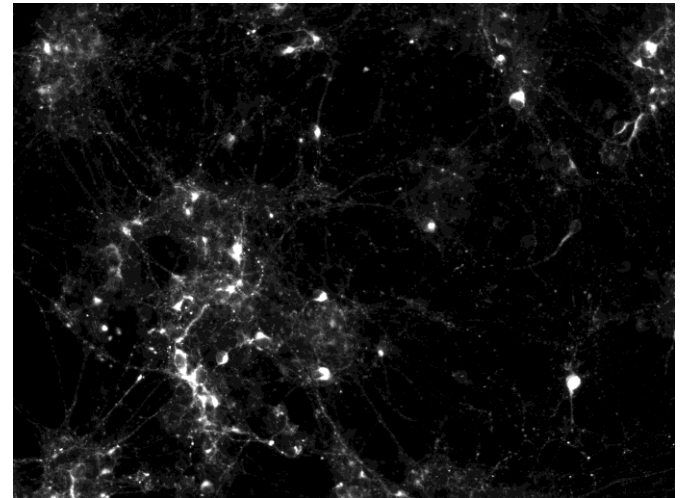


Tissue Preparation III

Phase contrast

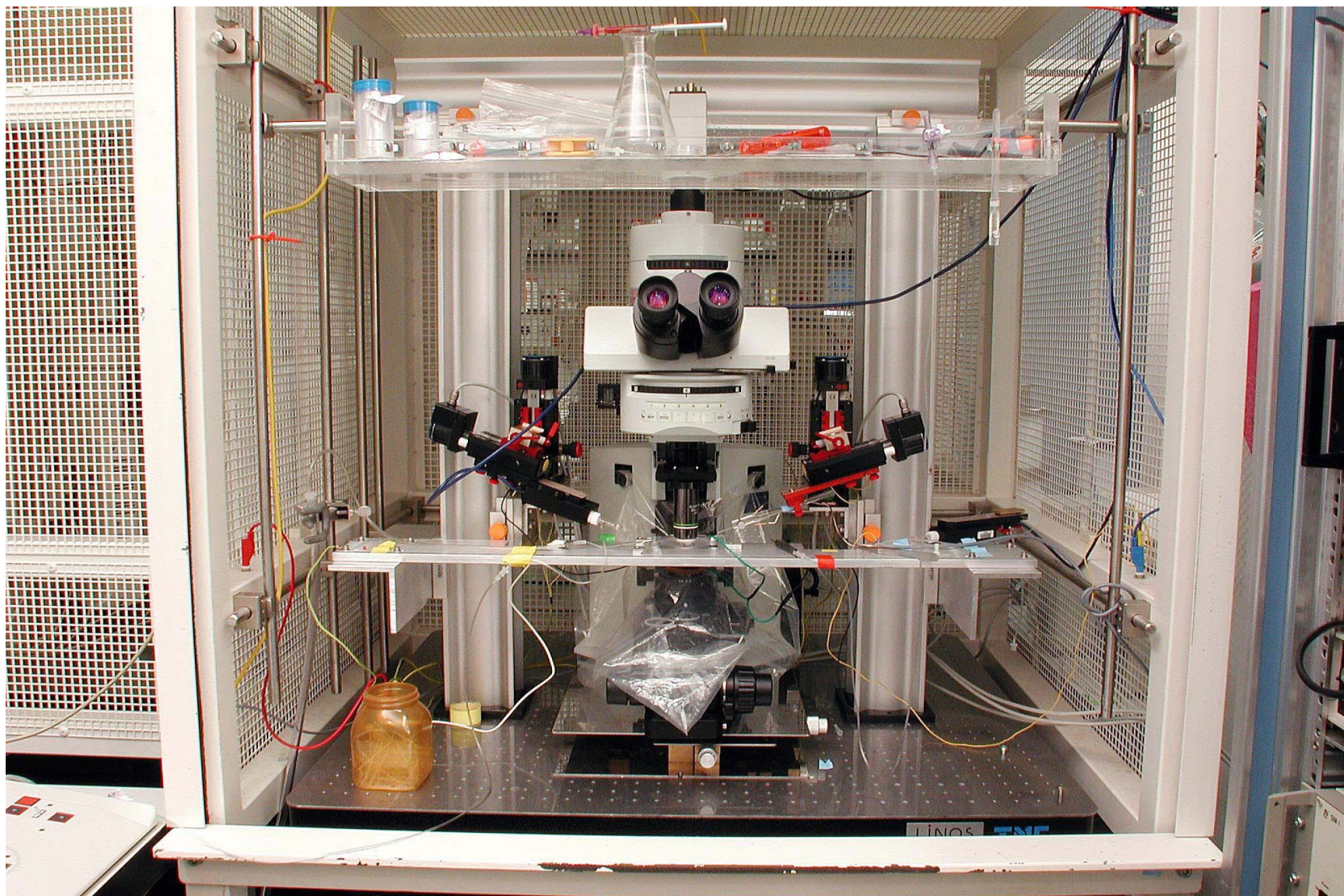


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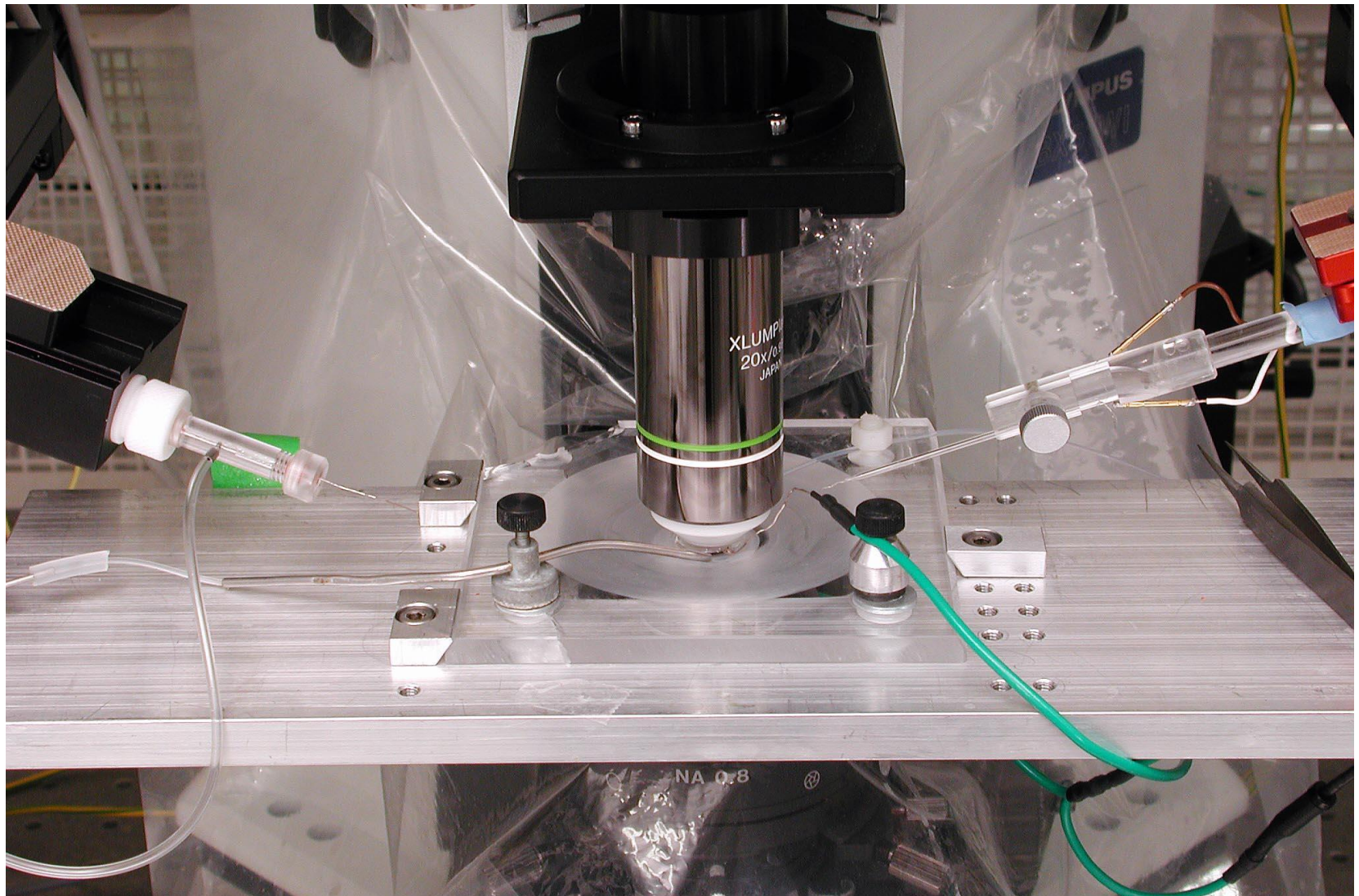


Mouse embryonic stem cell-derived neuronal culture

The Rig..



..and A Close Up



The Instruments

Stimulus Generator

Oscilloscope

Computer

Amplifier

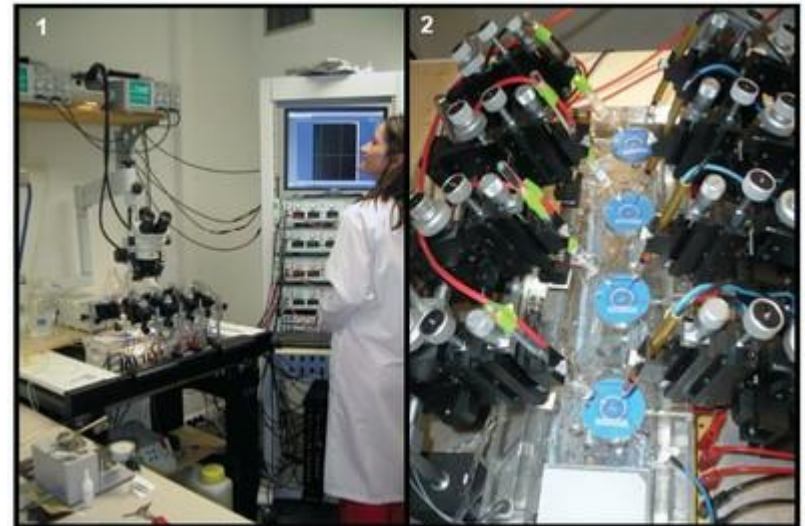
DAC



Field Recording Chamber



Not so demanding in terms of optical resolution and mechanical sophistication.



University of Leuven

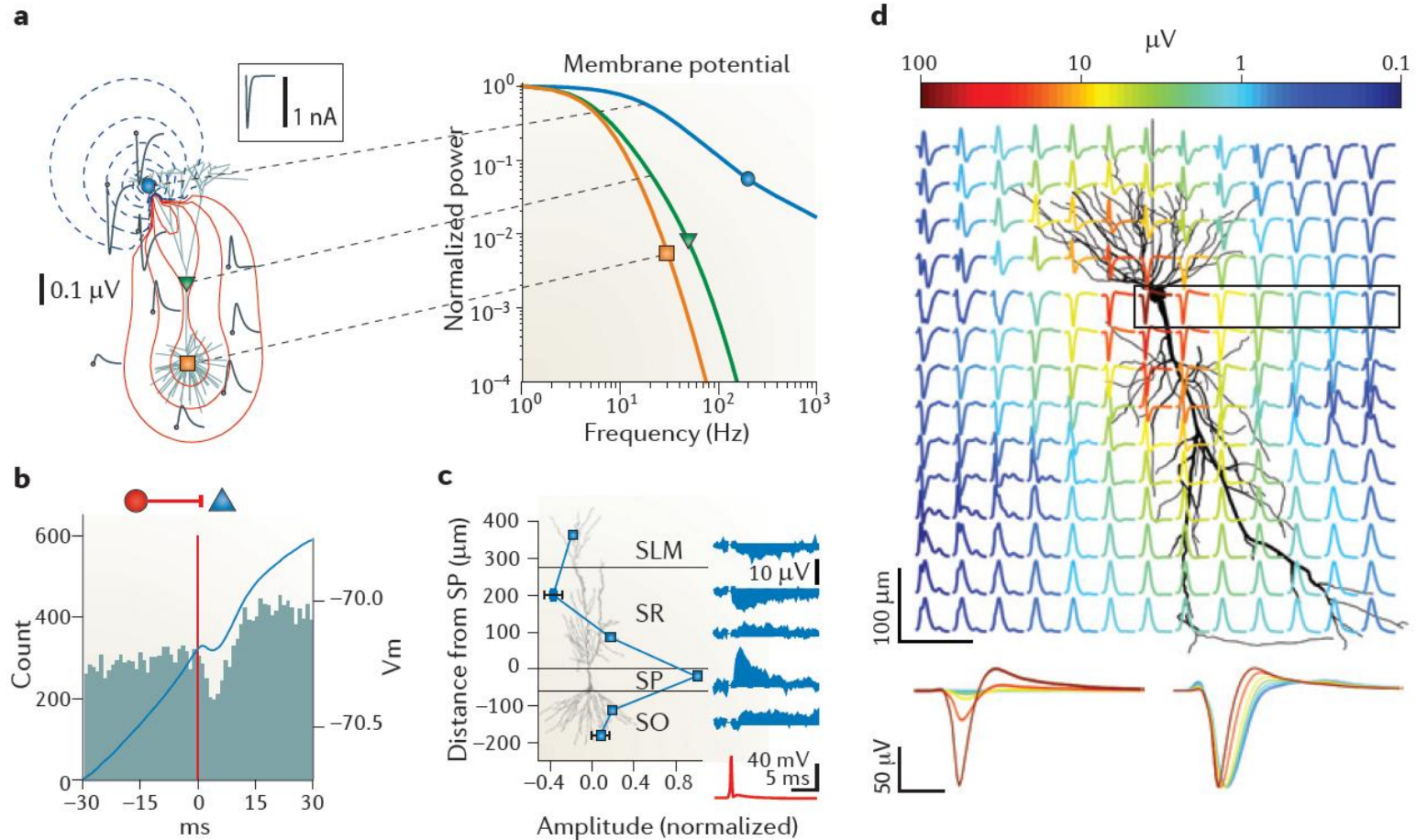
Extracellular Recording

- The resistance of the extracellular and intracellular space is not zero, but it is much smaller than the transmembrane resistance.
- The flow of charges during neuronal electrical signals is therefore accompanied by small extracellular voltage transients.
- These usually need to be summed up and even then are on the order of microvolts.

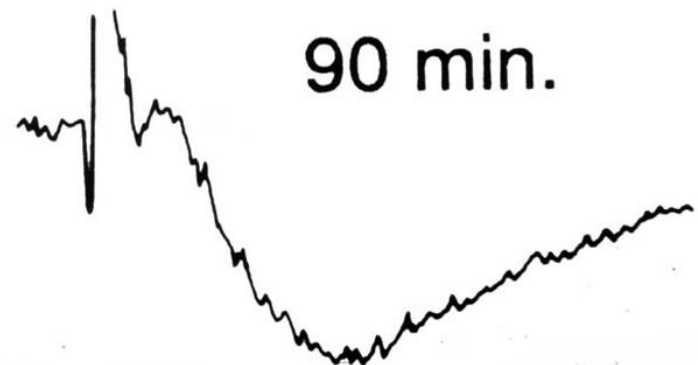
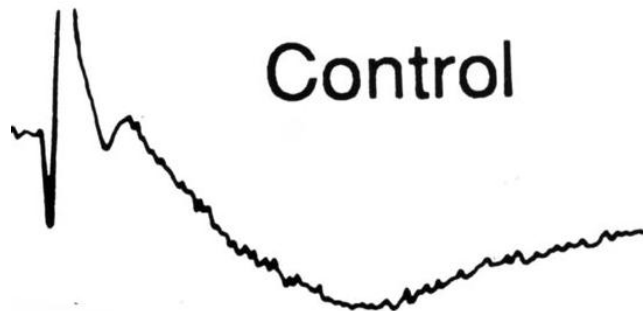
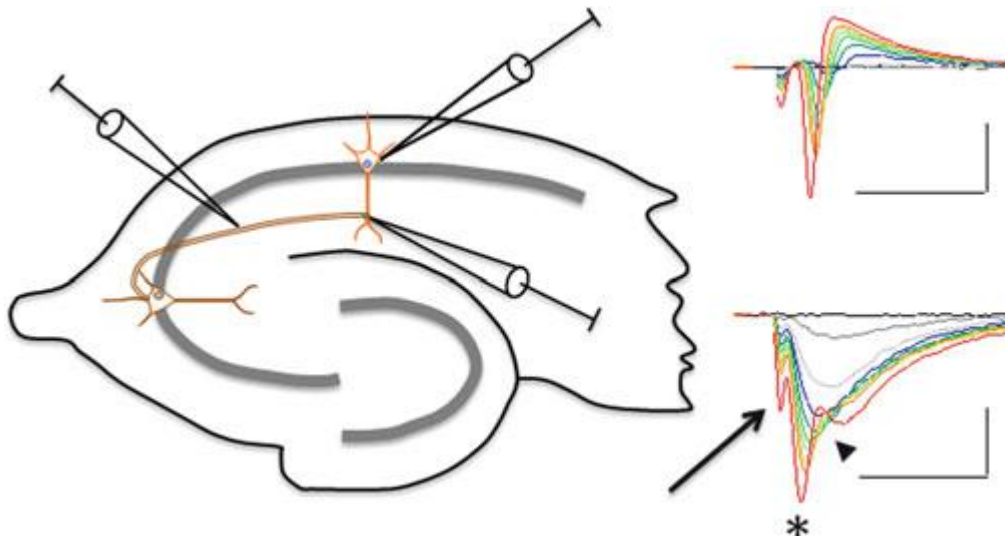
Field Potentials

The origin of extracellular fields and currents — EEG, ECoG, LFP and spikes

György Buzsáki^{1,2,3}, Costas A. Anastassiou⁴ and Christof Koch^{4,5}



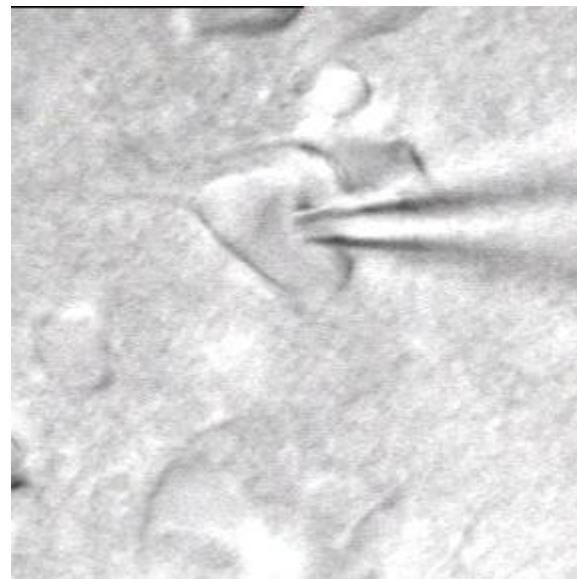
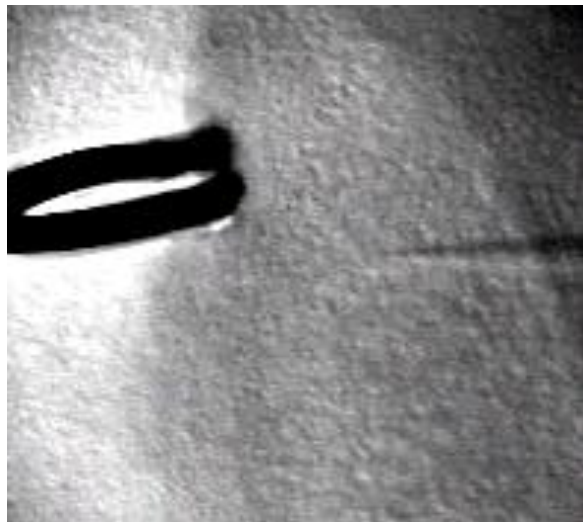
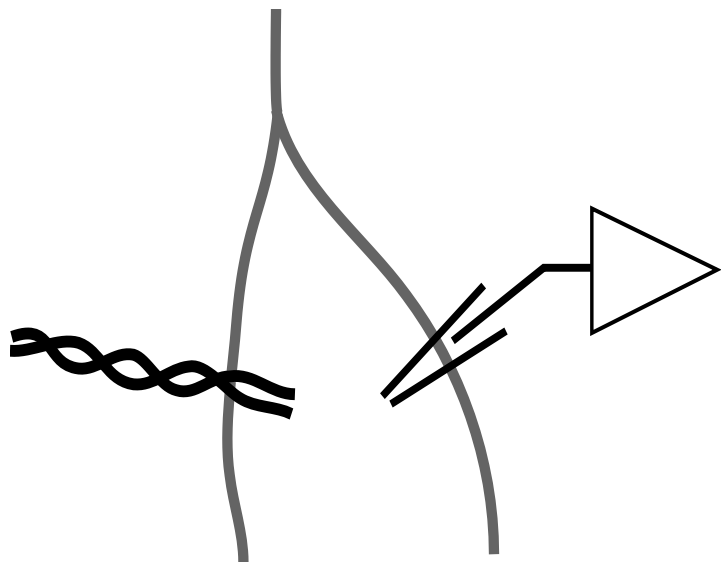
Hippocampal Fields



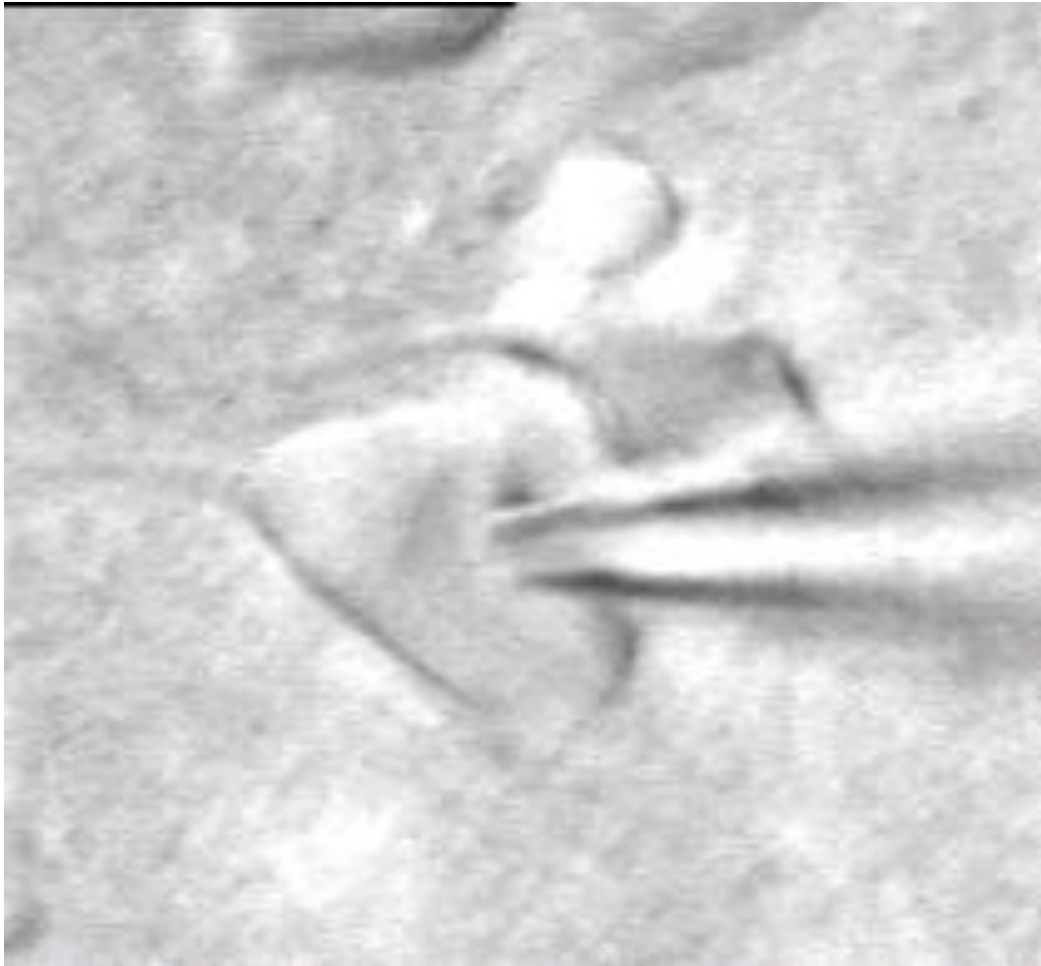
Patch Clamp

- The resistance of cell membranes is very high.
- Any method to measure currents across cell membranes therefore needs to be able to achieve equally high resistances.
- Patch clamp recordings solved this problem.
- It is one of the few techniques with which the function of a single protein can be observed in detail.

General Setup

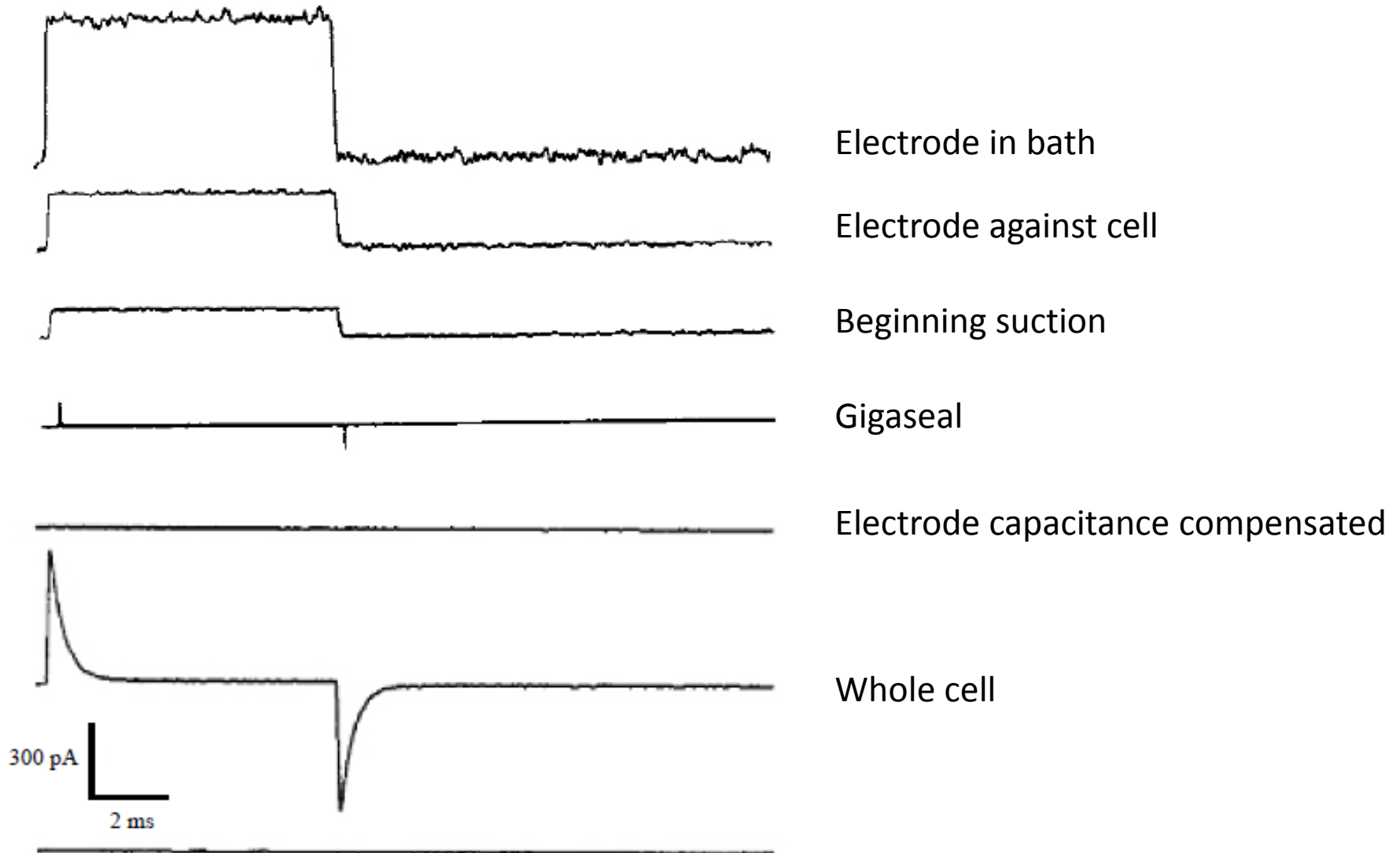


Higher Resolution

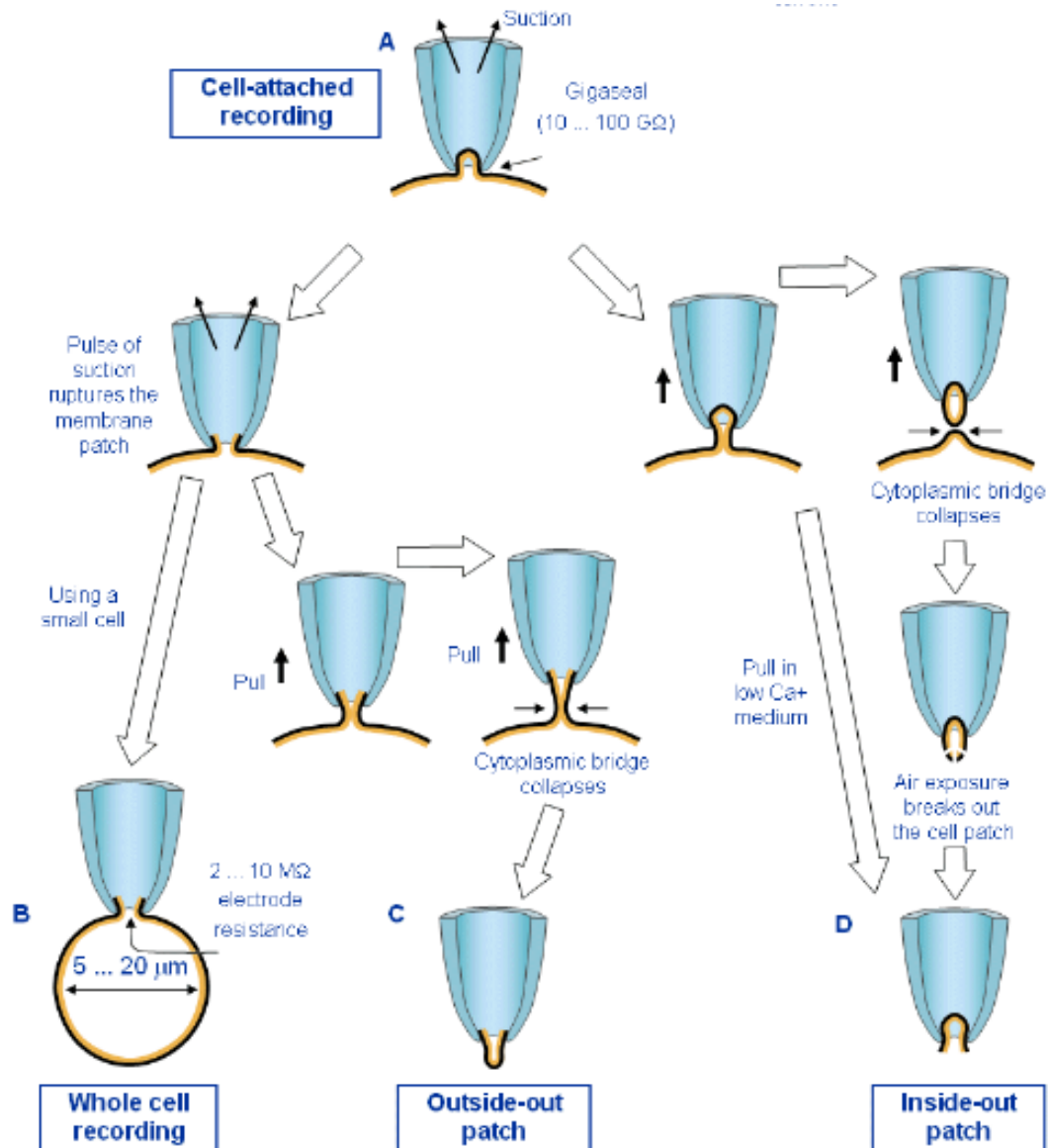


Note that:
The neuron has a nice ,plump' shape.
The pipette is firmly set against the cell (forming a half-moon).

Seal Formation - Transients



Recording Types



Patch Clamp Recording

- Extra- and intracellular solutions have to be carefully composed and prepared.
- Glass surfaces have to be extremely clean.
- Rig has to be mechanically stable.
- Cells have to be chosen, approached and patched with care.