Lecture 3: electrophysiology

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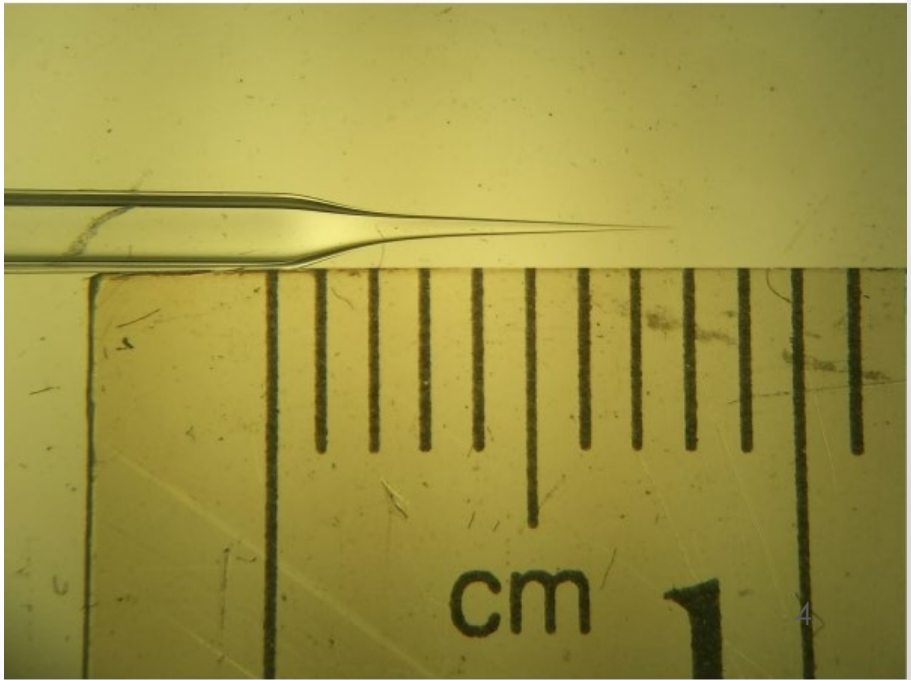
Types of recording preparations

- In vitro for ion channels
  - Xenopus oocytes
  - HEK293 cells
  - Purified proteins in lipids
- Neurons in vitro
  - Cultured neurons
  - Squid axon
- Neurons ex vivo
  - Slices: acute vs. slice culture
- Anesthetized animal
- Head-fixed awake animal
- Freely moving animal

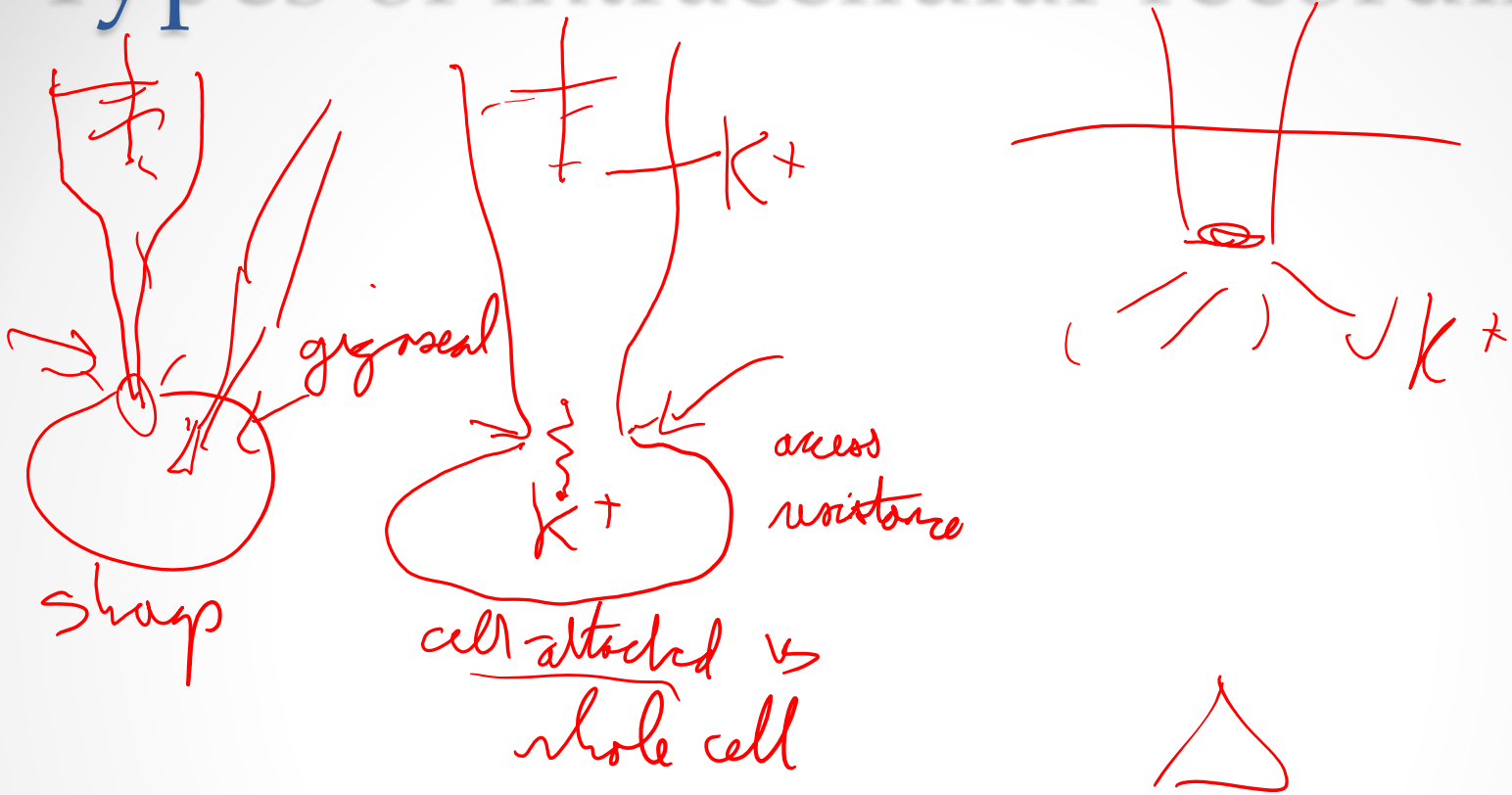
Types of electrodes and recordings

- Intracellular
  - Sharp electrode
  - Patch electrode: cell-attached vs. perforated vs. whole-cell
  - Sharpened tungsten (experimental, not widely used)
- Juxtacellular/loose patch
  - Excellent unit isolation
  - Cells can be filled iontophoretically
- Extracellular
  - Different metal wire types: tungsten, nichrome, stainless steel
  - Multisite: stereotrode, tetrode, silicon probe
- Field potentials
  - LFP: large wires
  - EEG: large surface electrodes

Intracellular electrodes: pulling glass pipettes



Types of intracellular recordings

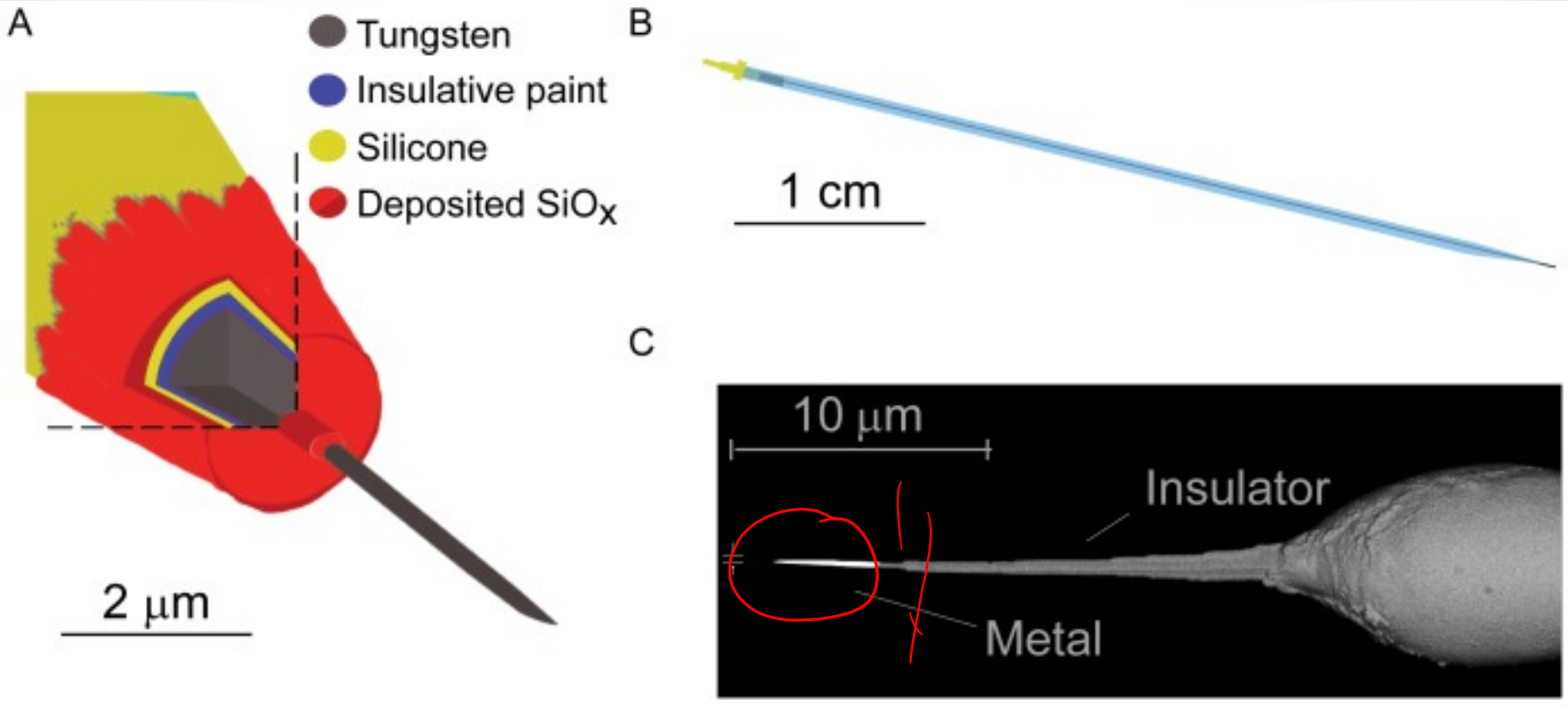


Types of intracellular recordings

Pros and cons

- Voltage clamp vs current clamp
- Composition of pipette solutions
- Mechanical stability
- Dialysing cytoplasm

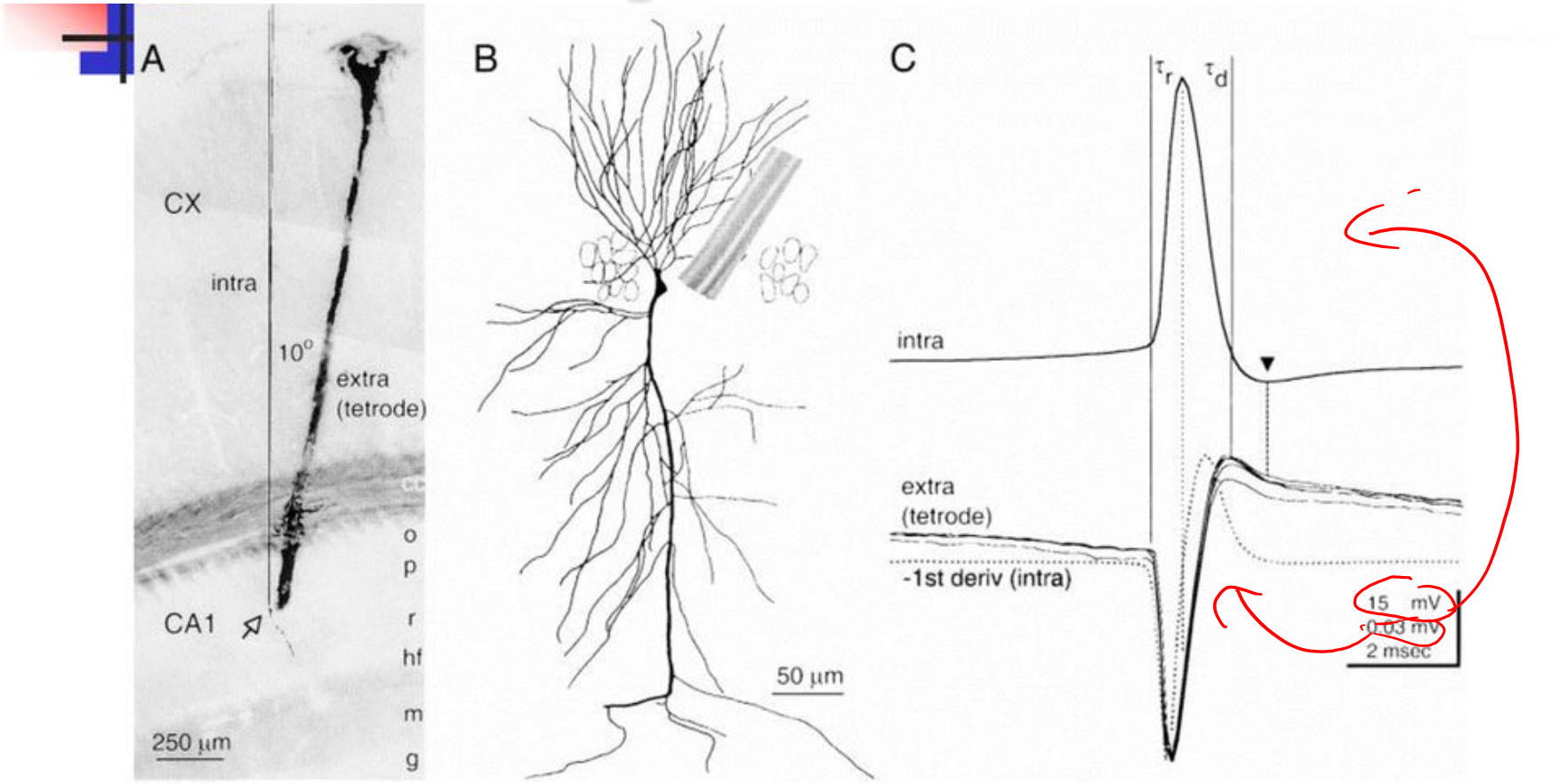
Intracellular tungsten



New technology, not widely used

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3419643/

Extracellular recording: the waveform is upside down



Extracellular waveform is *almost* minus derivative of intracellular

https://slideplayer.com/slide/15830058/

Microwire recordings

- tungsten – inert
- nichrome – gold-plate

Tip impedance

Tetrodes: recording several isolated units simultaneously

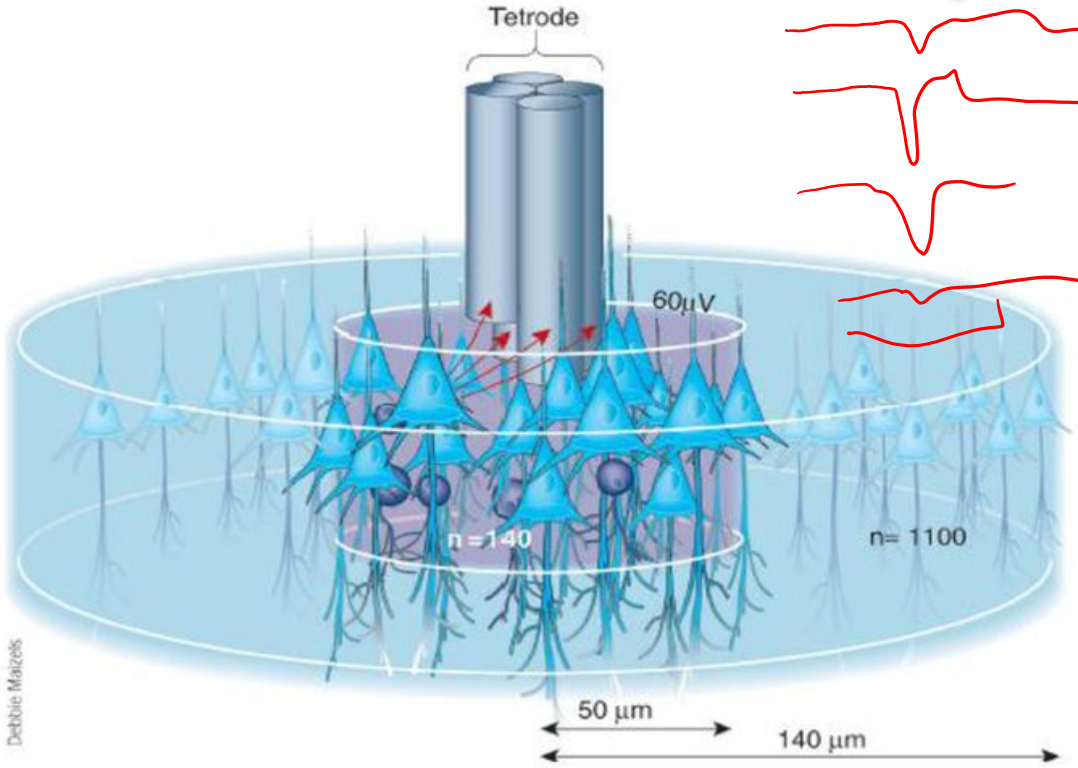
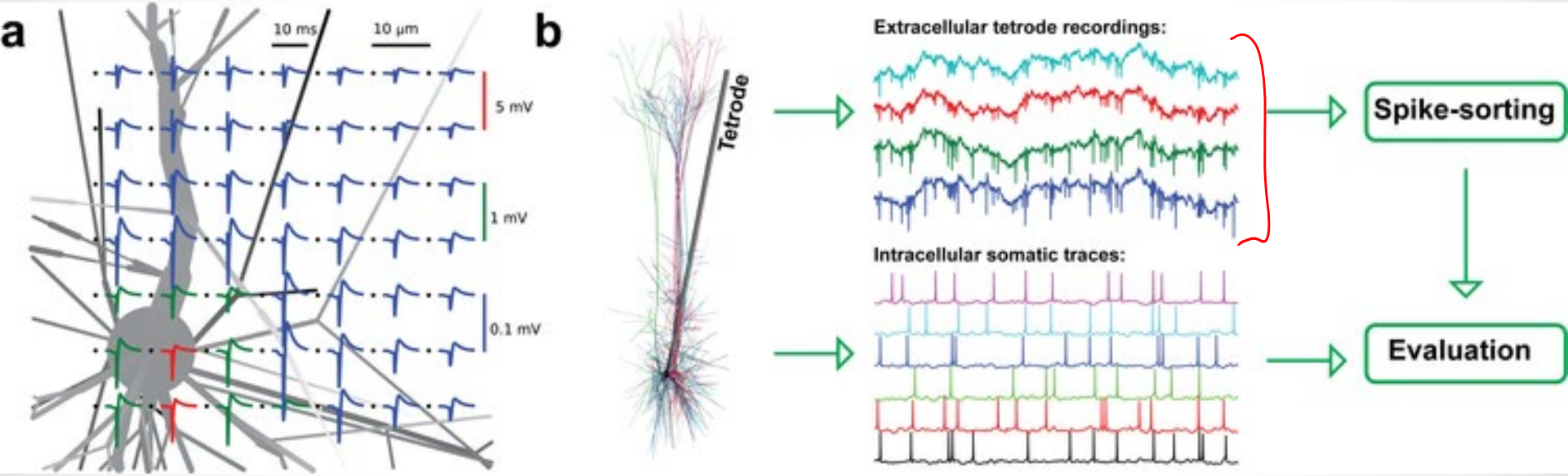


Figure 1 Unit isolation quality varies as a function of distance from the electrode. Multisite electrodes (a wire tetrode, for example) can estimate the position of the recorded neurons by triangulation. Distance of the visible electrode tips from a single pyramidal cell (triangles) is indicated by arrows. The spike amplitude of neurons (>60 μV) within the gray cylinder (50 μm radius), containing ~100 neurons, is large enough for separation by currently available clustering methods. Although the extracellularly recorded spike amplitude decreases rapidly with distance, neurons within a radius of 140 μm, containing ~1,000 neurons in the rat cortex[19,21], can be detected. Improved recording and clustering methods are therefore expected to record from larger number of neurons in the future. (Data are derived from simultaneous extracellular and intracellular recordings from the same pyramidal cells from ref. 19.)

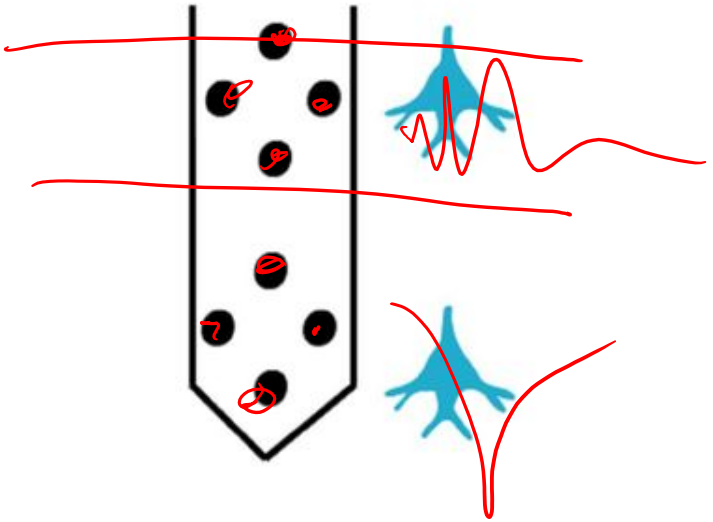
Buzsaki 2004

Multisite extracellular recording



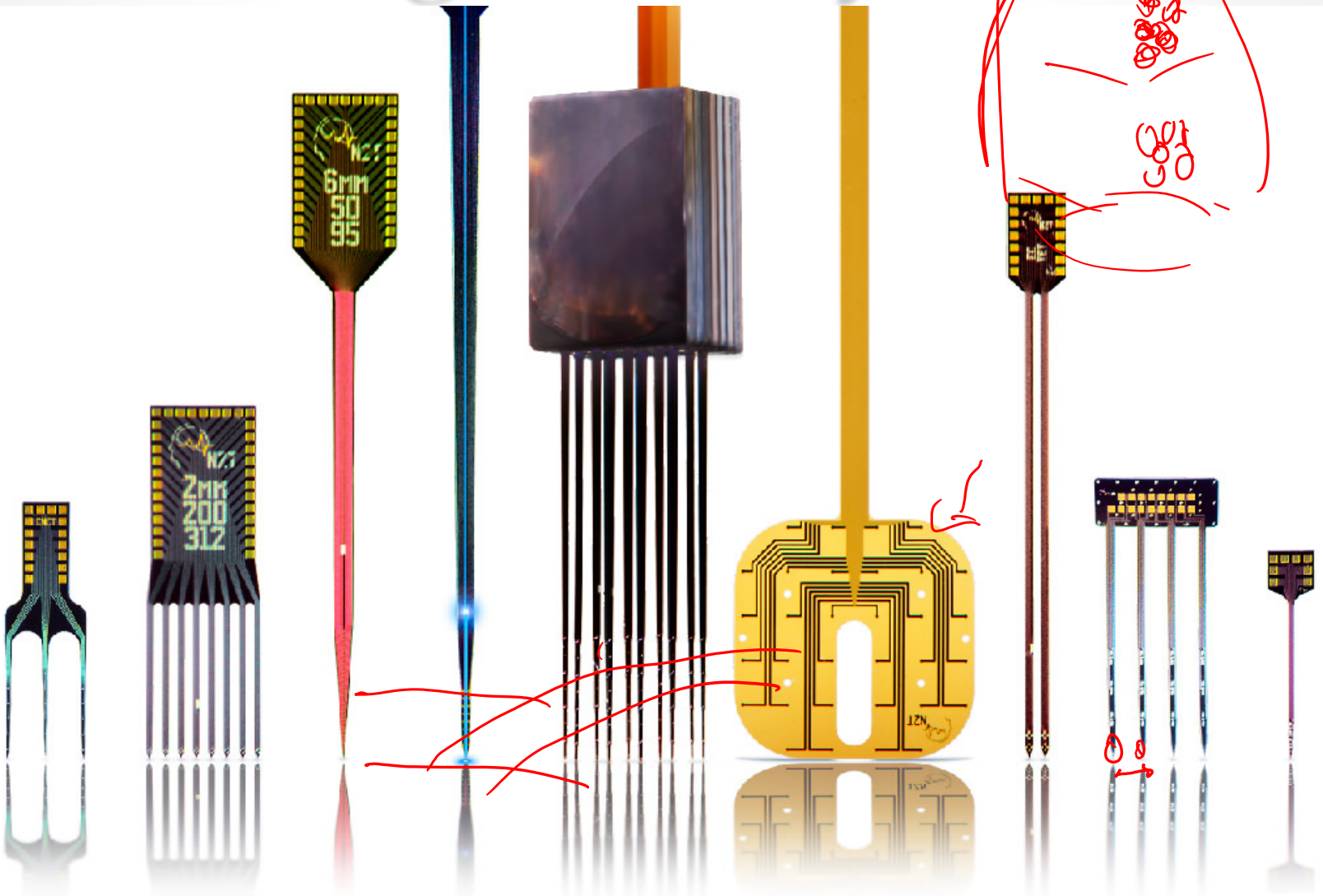
http://neuroinformatics2012.org/abstracts/modeling-realistic-extracellular-recordings-of-neuronal-populations-for-the-purpose-of-evaluating-automatic-spike-sorting-algorithms.html

Raw data from 8 shank probe

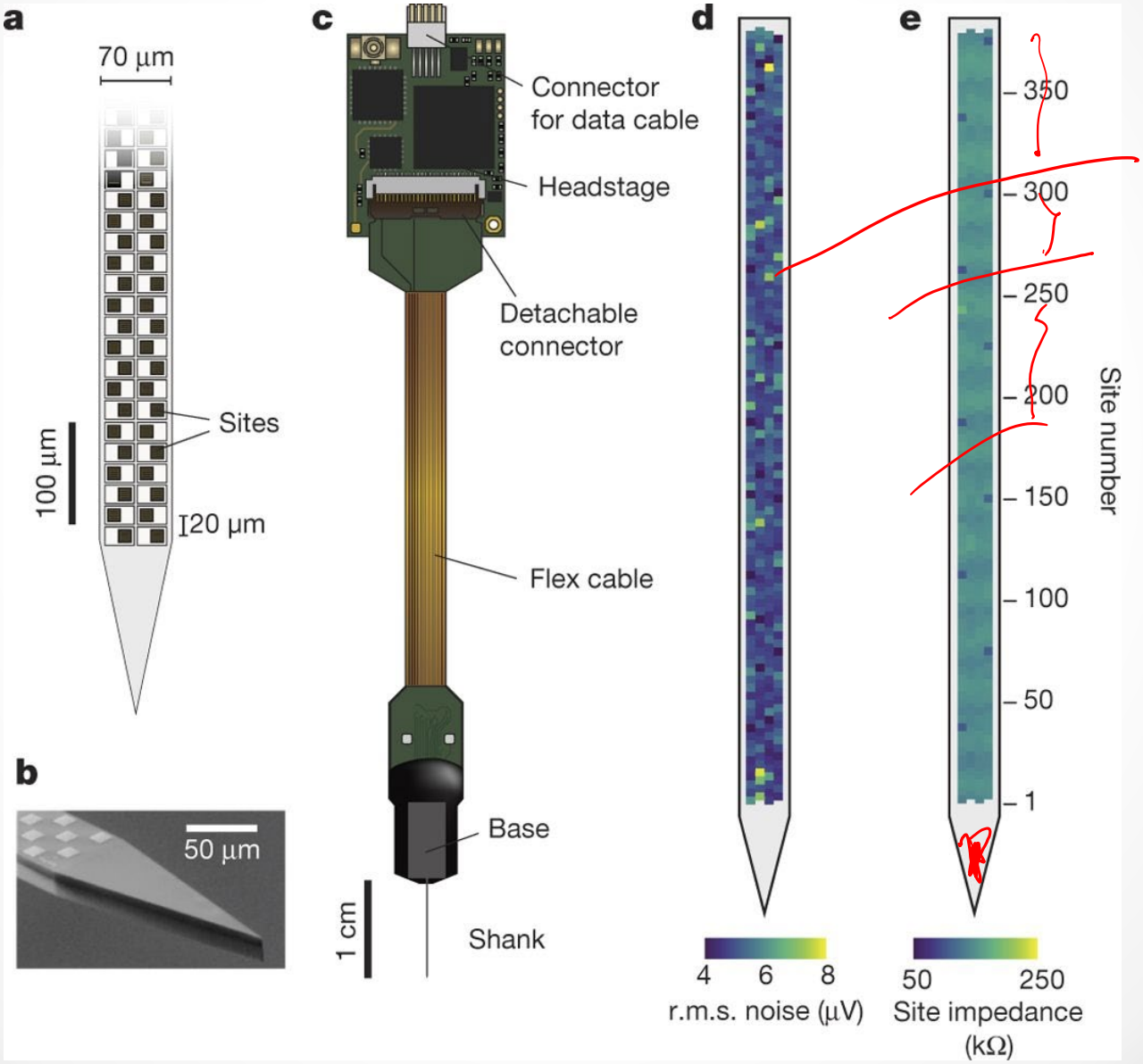


Bartho et al. J Neurophysiol. 2004

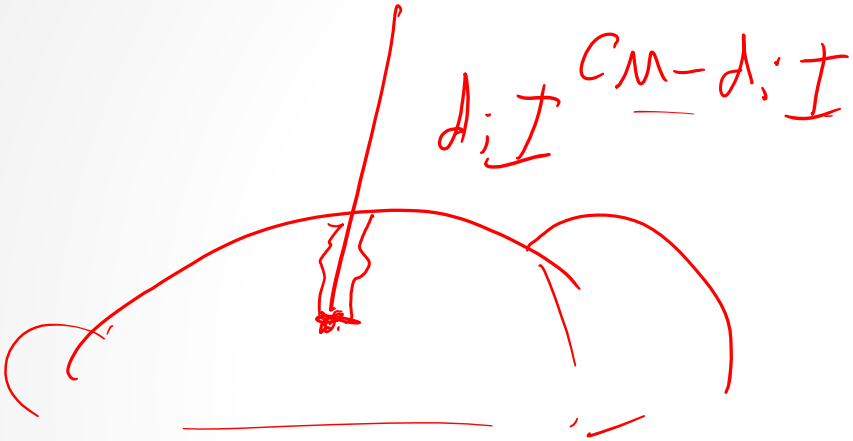
Silicon probes: precise geometry



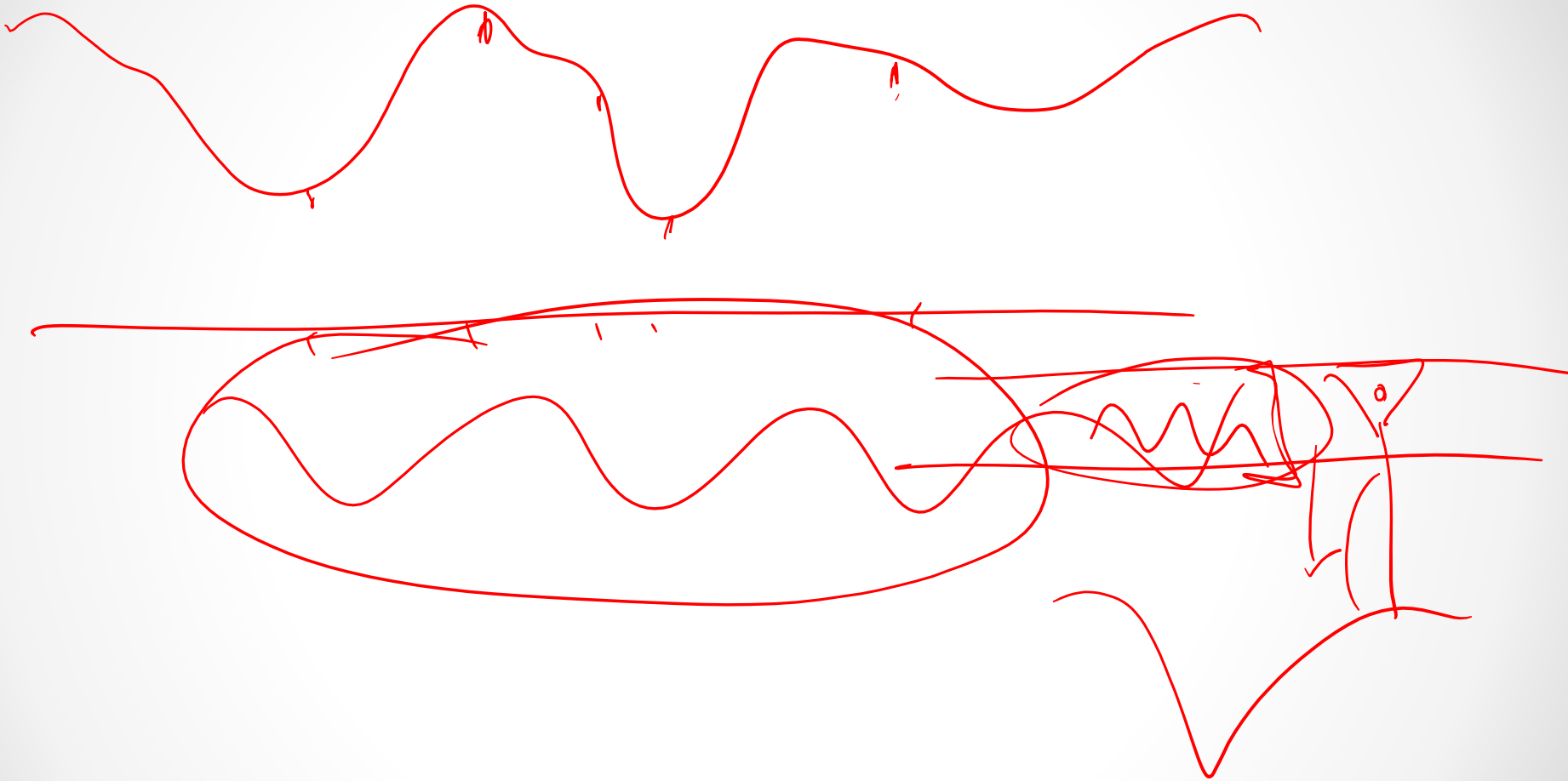
Neuropixels



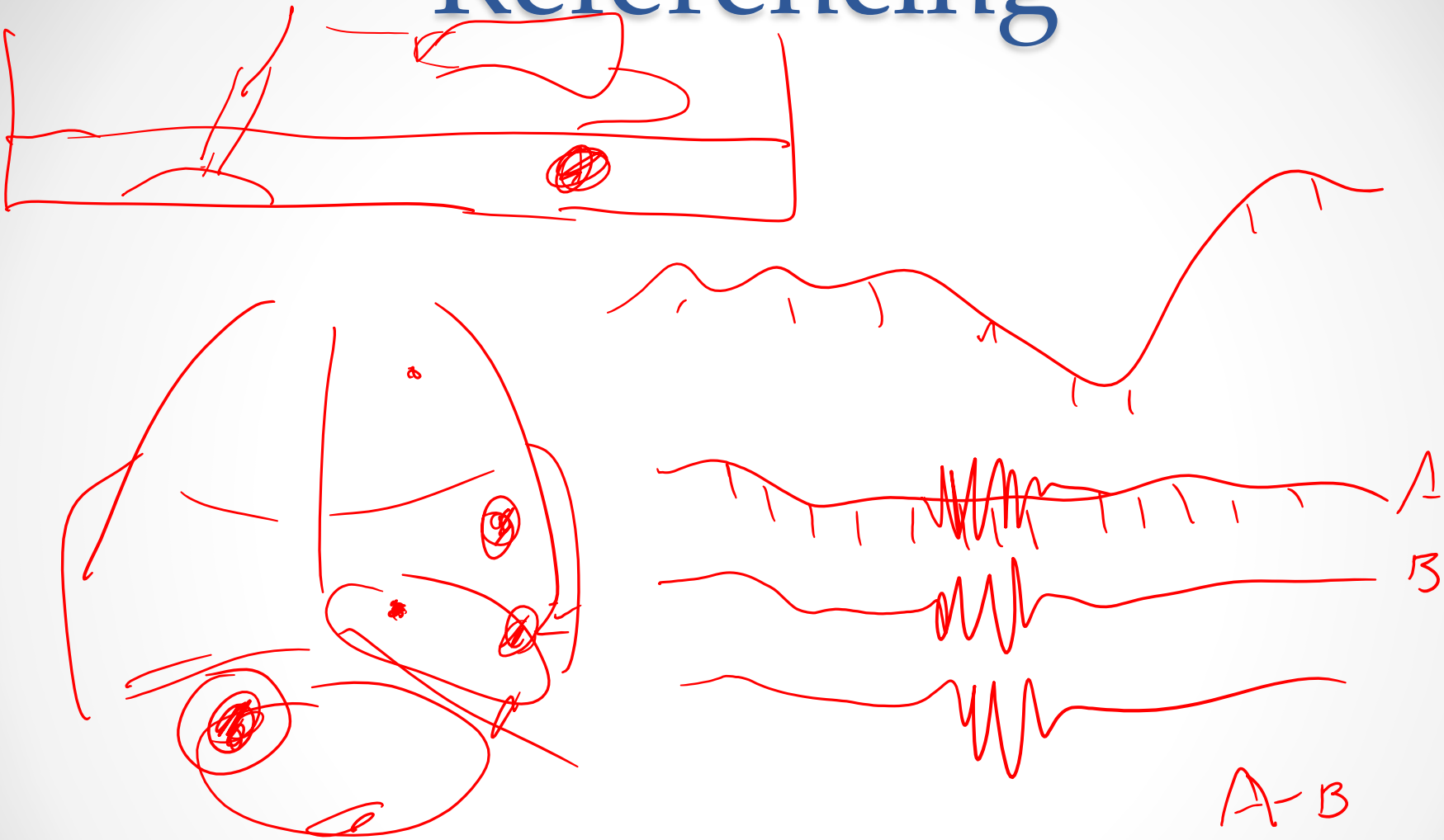
How to check where your electrodes went?



LFP, EEG recordings



Referencing



Data acquisition

Grounding