

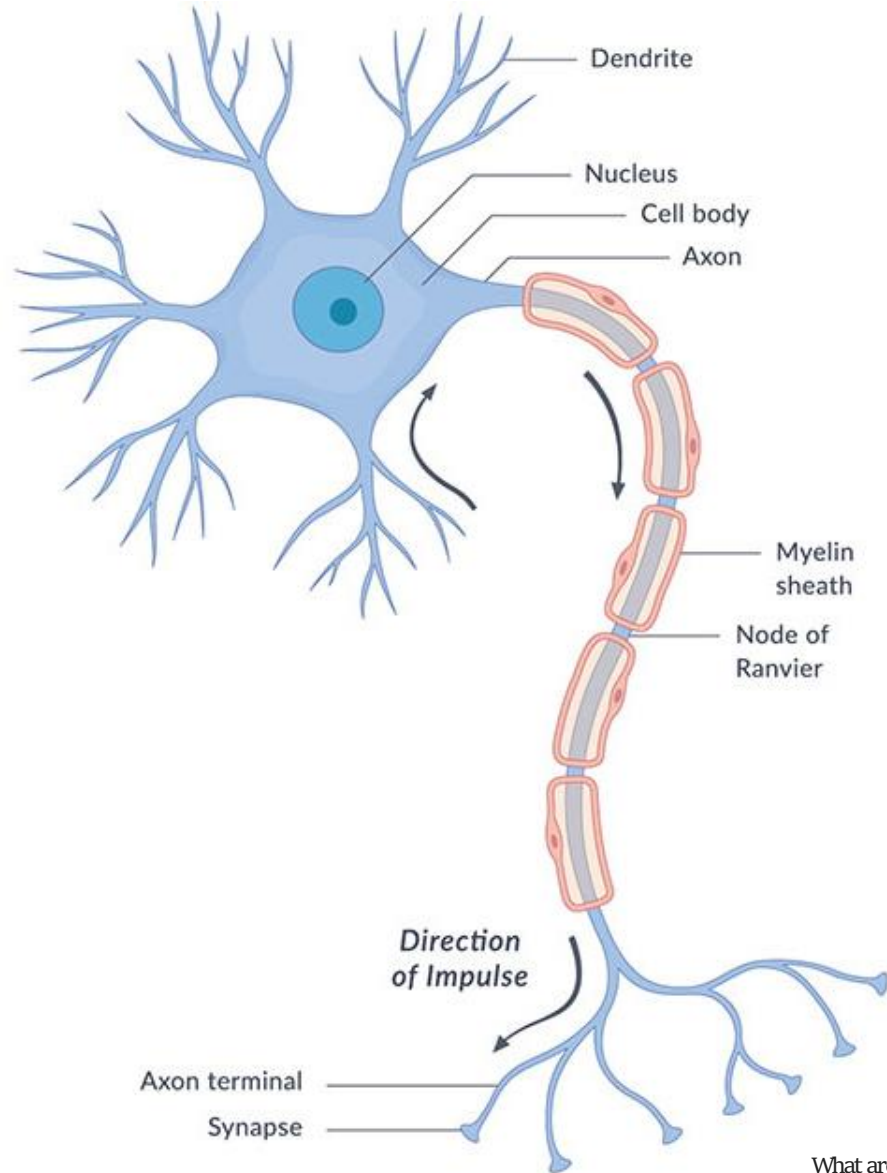
INTRODUCTION TO NEURAL OSCILLATION ANALYSIS



Cantin Ortiz, Letizia Signorelli
OBiWoW 2025 — 12/12/2025

IN THE BRAIN, INFORMATION IS PROCESSED BY NEURONS THROUGH ELECTRICAL SIGNALS

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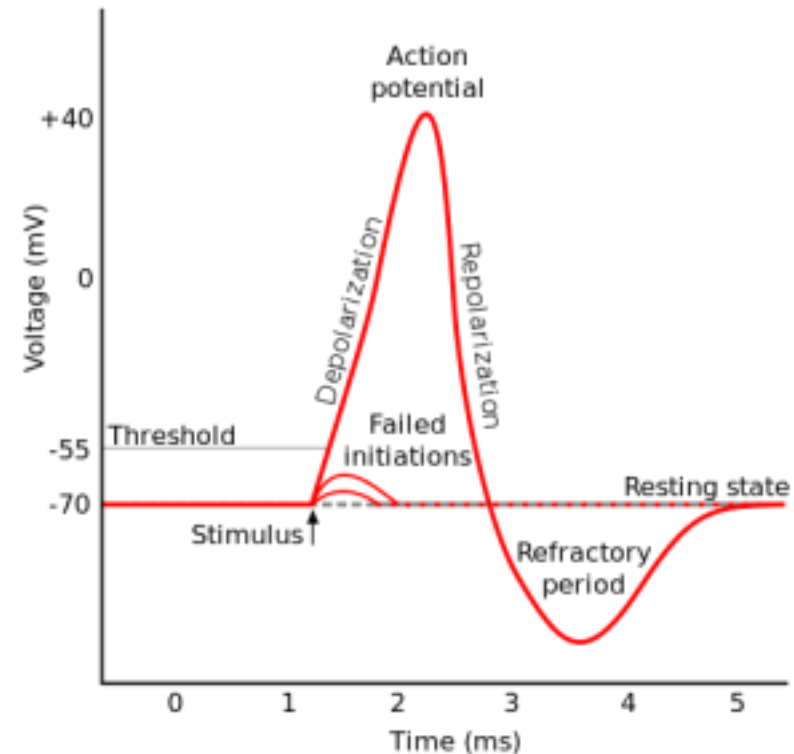


Neurons: dedicated cell type to process information

10^{11} in the human brain, $10^7 - 10^8$ in rodents

Highly interconnected (1000s synapses per neuron)

Mostly communicate via action potentials: non-linear responses



NICHHD, NIH
What are the parts of the nervous system?

NEURAL OSCILLATIONS EMERGE FROM SYNCHRONOUS MEMBRANE POTENTIAL FLUCTUATIONS

3

Current superimpose forming '**electric field**'

Neural oscillation: rhythmic, repetitive electrical activity generated by synchronous membrane potential fluctuations of a population of neurons

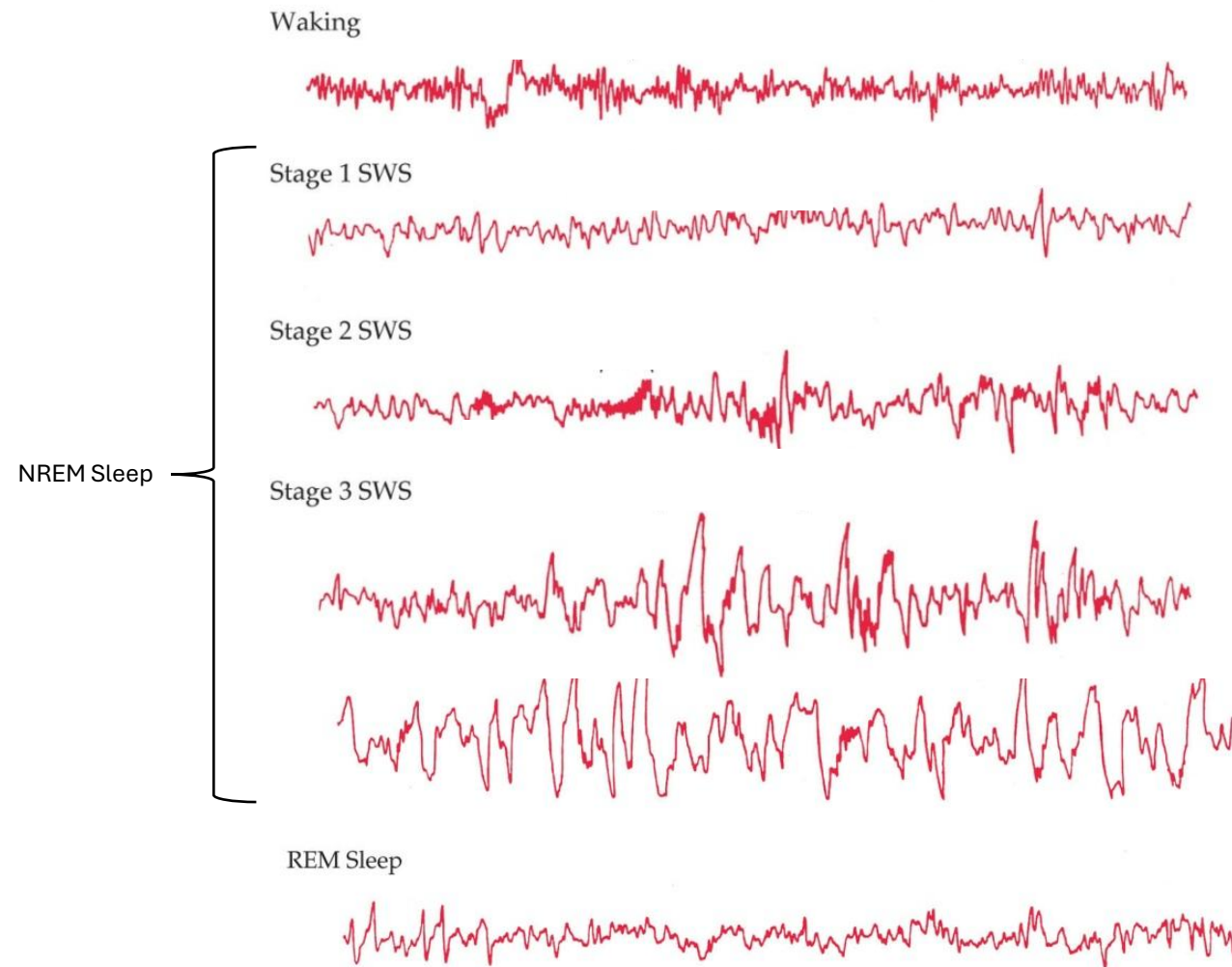
Mostly reflect synaptic activity: **inputs**

Characterised by their **amplitude** (“strength”) and **frequency**



EXAMPLE: IDENTIFYING DIFFERENT SLEEP STATES BASED ON NEURAL OSCILLATIONS

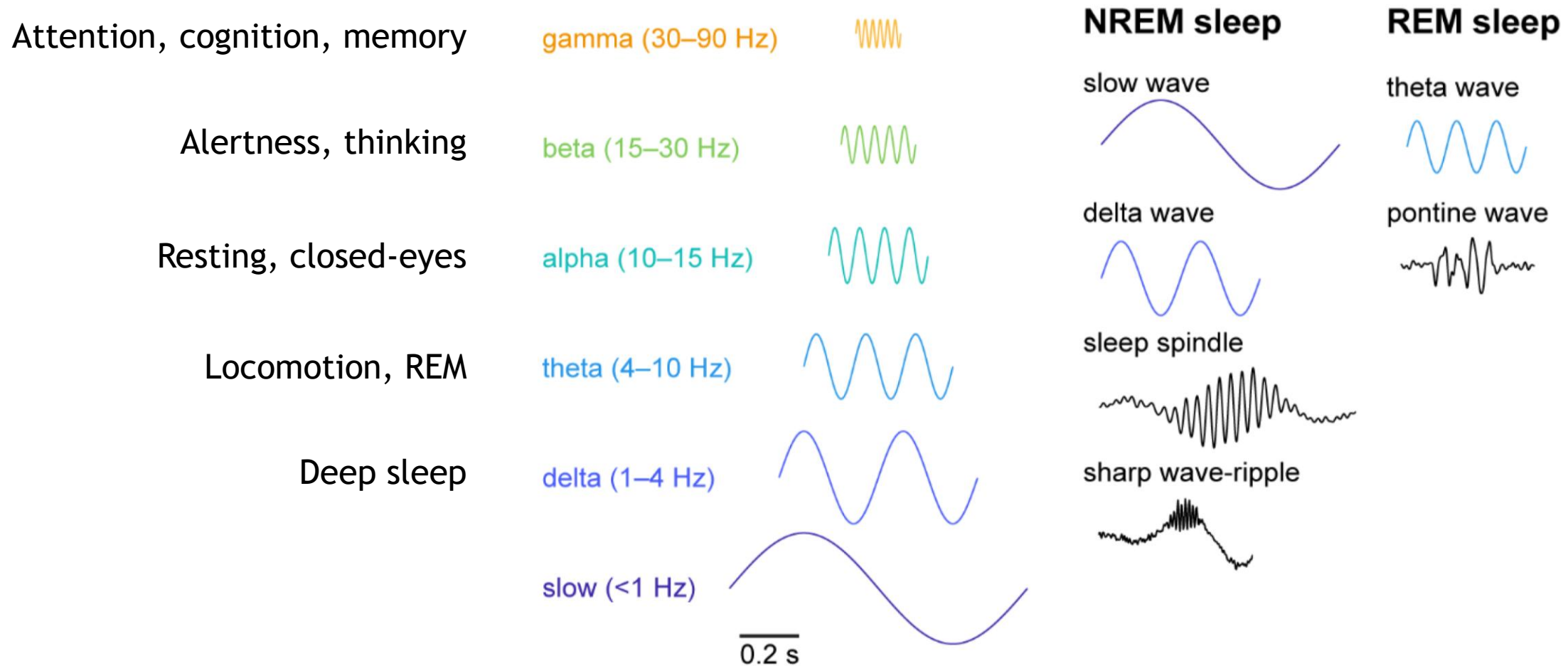
4



DIFFERENT TYPES OF OSCILLATIONS

We can analyse neural oscillations by their **frequency bands** and link them to **brain states**

Some oscillations are composite (envelop, unit activity) and require finer methods of detection



DIFFERENCES BETWEEN OSCILLATIONS (LFP) AND ACTION POTENTIALS

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1. Local Field Potential (LFP)

Oscillations 0.1 - 200 Hz - acquisition > 1500 Hz

Mostly reflect synaptic inputs

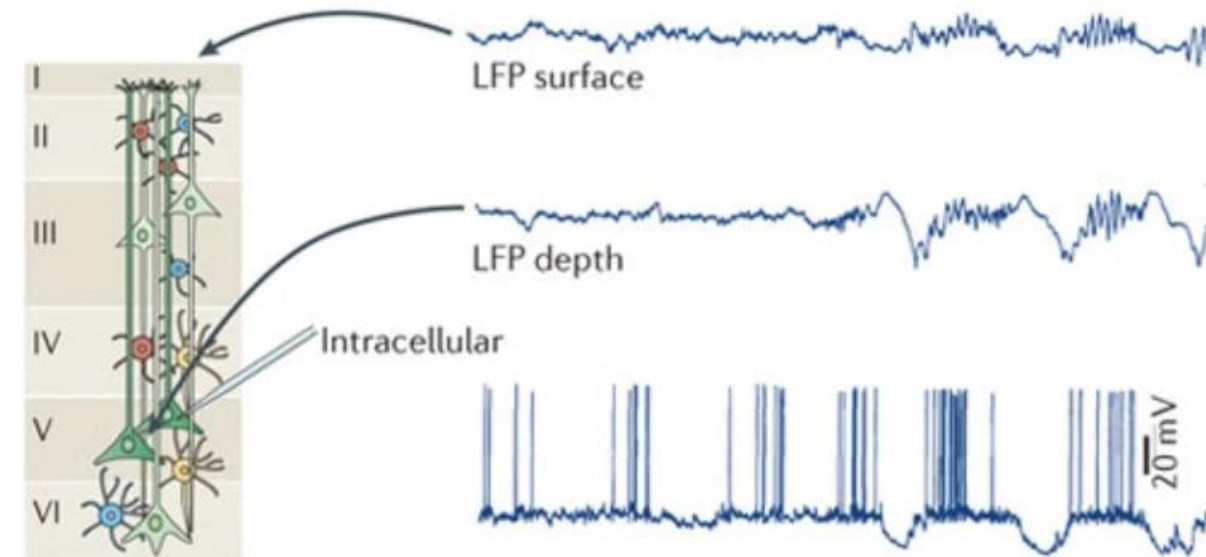
Summation of activity within a small region (ca \varnothing 300 μ)

2. Action potential

1-2 ms (500-1000 Hz) - acquisition > 20 000 Hz

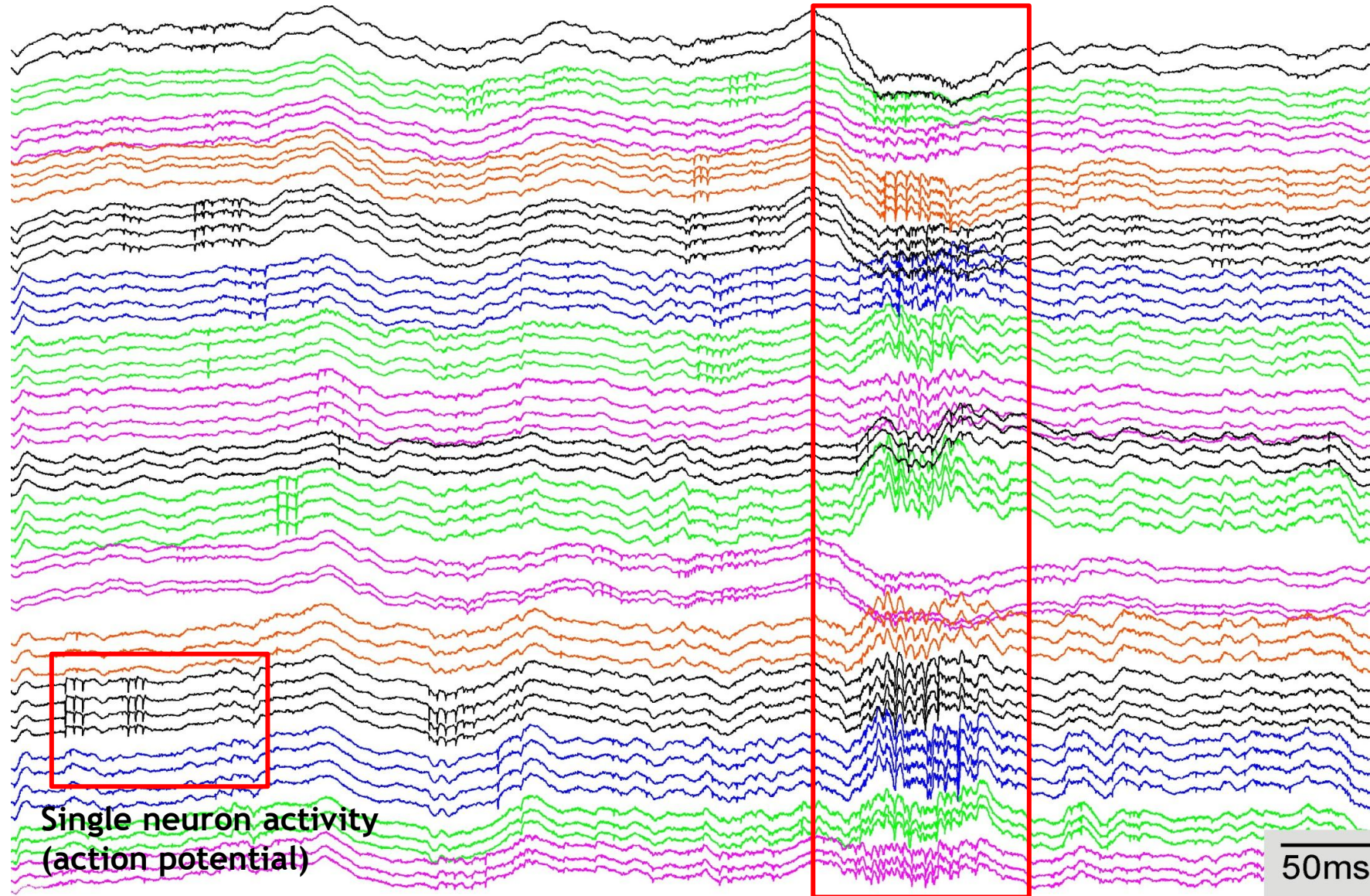
Neuronal output

Local activity (ca \varnothing 100 μ) - multi or single units



Buzsáki, György, Costas A. Anastassiou, and Christof Koch.
"The origin of extracellular fields and currents—EEG, ECoG, LFP and spikes."
Nature reviews neuroscience 13.6 (2012): 407-420.

EXAMPLE RECORDING WITH BOTH ACTION POTENTIAL AND OSCILLATIONS ⁷



Single neuron activity
(action potential)

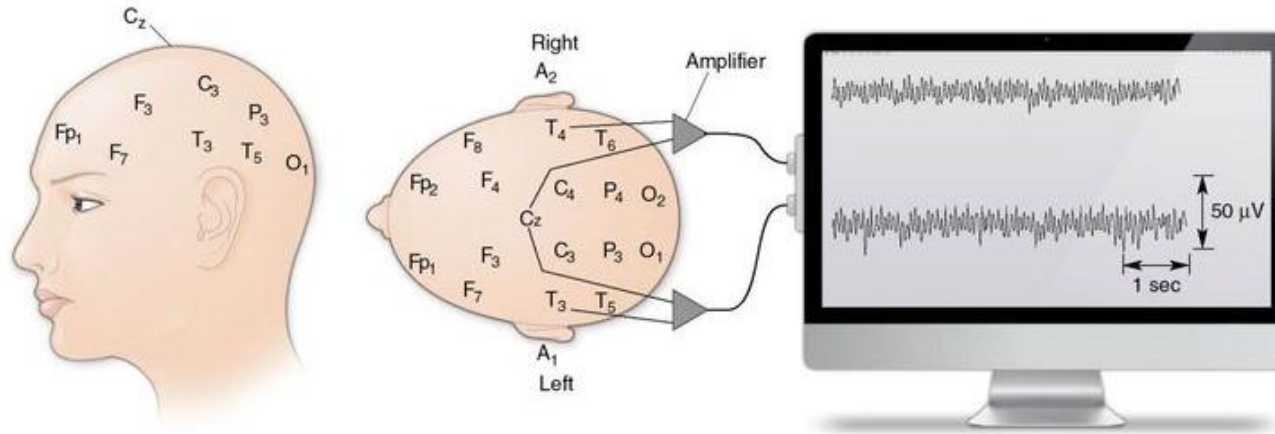
Global general neural events
("EEG like")

50ms

16 tetrodes (adult HPC)
From Charlotte Boccara

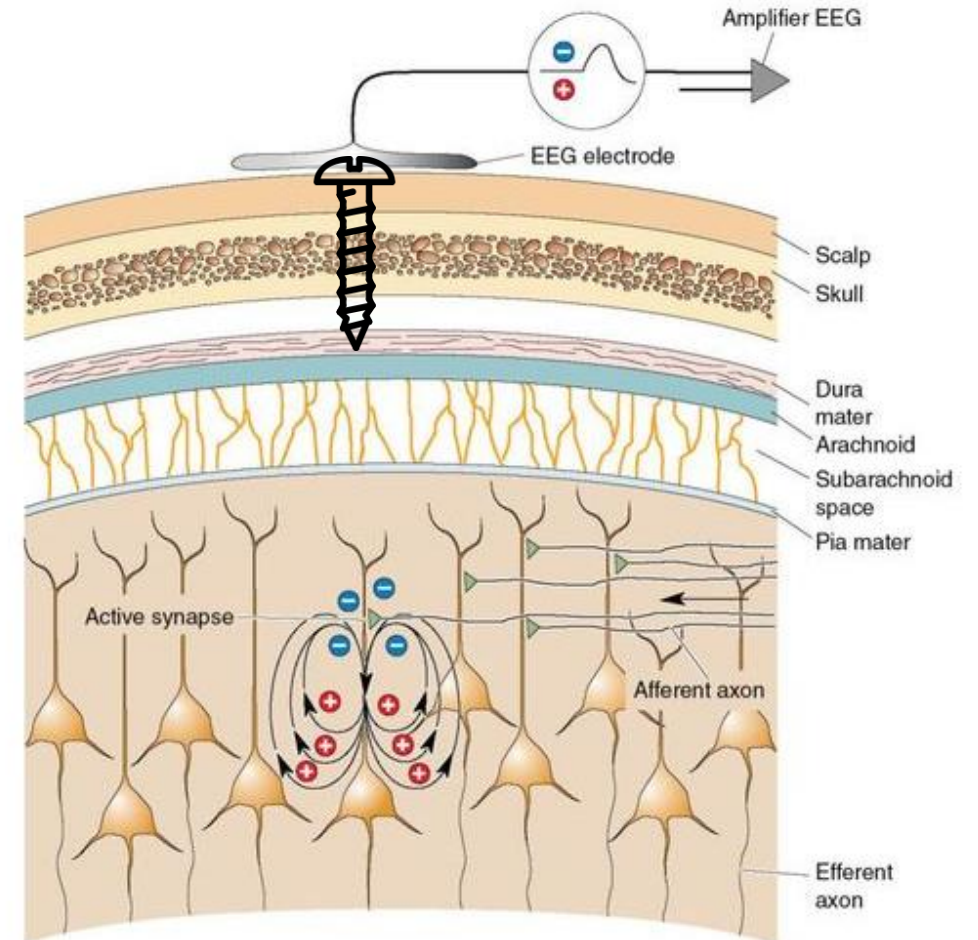
HOW TO RECORD OSCILLATIONS?

EEG: Electroencephalography

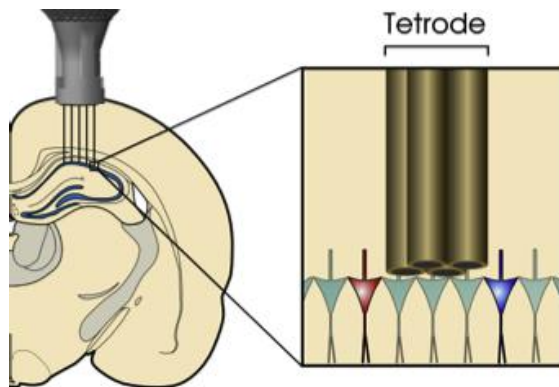


Bear et al, Neuroscience Exploring the brain 4th edition, Britton 2016

ECoG: Electrocorticography



Local Field Potential (LFP) with intracerebellar electrodes



WORKSHOP PLAN

1. 9H00 - 9H50: INTRODUCTION AND BASIC SIGNAL PROCESSING

Analog vs digital signal

Filtering

Downsampling

BREAK 1: 9H50 — 10H00

2. 10H00 — 10H50: TIME-FREQUENCY ANALYSIS

Fast Fourier Transform

Spectrograms

Important parameters

BREAK 2: 10H50 — 11H00

3. 11H00 — 12H00: SLEEP SCORING AND CONCLUSION

EMG and EEG

Wake vs Sleep

Non-REM vs REM

