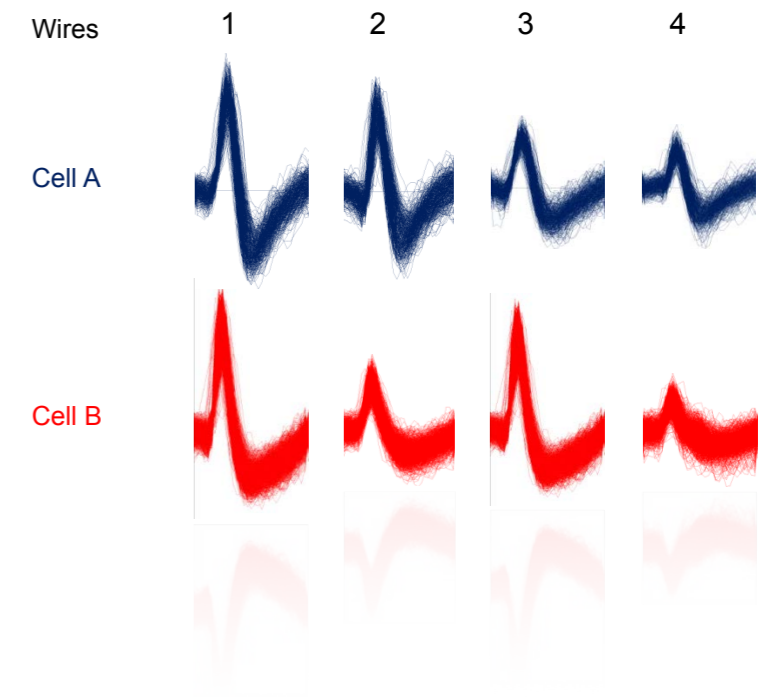
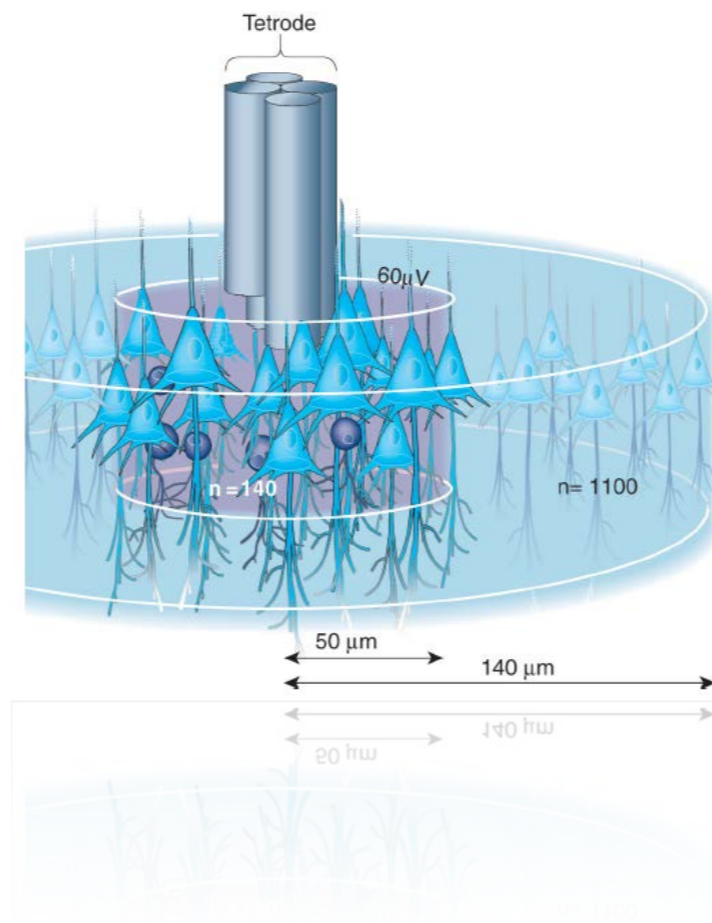
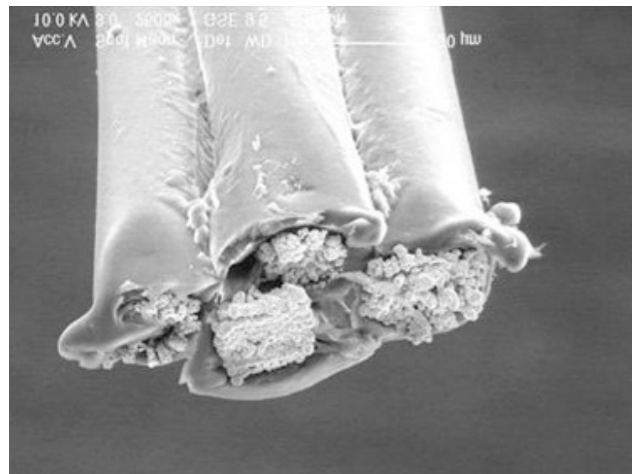


SINGLE-CELL RECORDINGS

Norbert Fortin, PhD



Bio Sci 38: Mind, Memory, and the Brain

OVERVIEW

- Why do we need single-cell recordings? Pros and Cons of the approach
- Using single-cell recordings to study memory and cognition
 - Basic approach (rodents, monkeys and humans)
 - Rodents (majority of literature)
 - Humans (few studies)
- Using single-cell recordings to understand other brain systems and functions.
- Potential for medical breakthroughs

WHY DO WE NEED SINGLE CELL RECORDING TECHNIQUES?

PROS AND CONS OF ELECTROPHYSIOLOGICAL METHODS

- Pros

- Direct measure of neural activity (e.g., spiking activity of individual neurons)
- High temporal resolution (ms level)
- Provides information about how a structure can support a specific type of memory

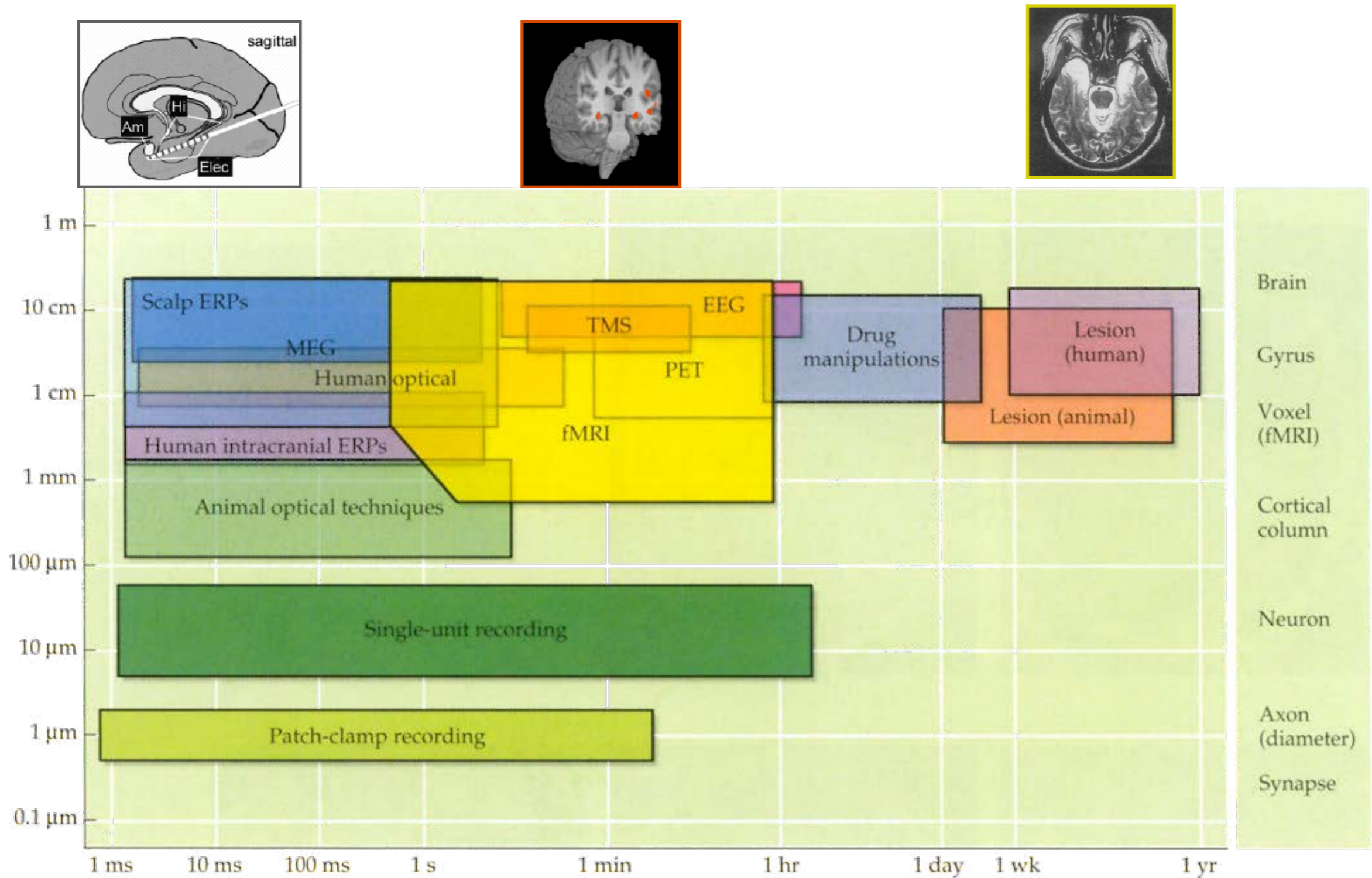
- Cons

- Poor “coverage” from each electrode
 - Though large arrays of electrodes are now being used
- Intrusive
- Very challenging, time-consuming

*** *No one method is ideal* ***

WHY DO WE NEED SINGLE CELL RECORDING TECHNIQUES?

REVIEW: SPATIAL AND TEMPORAL TRADE-OFFS



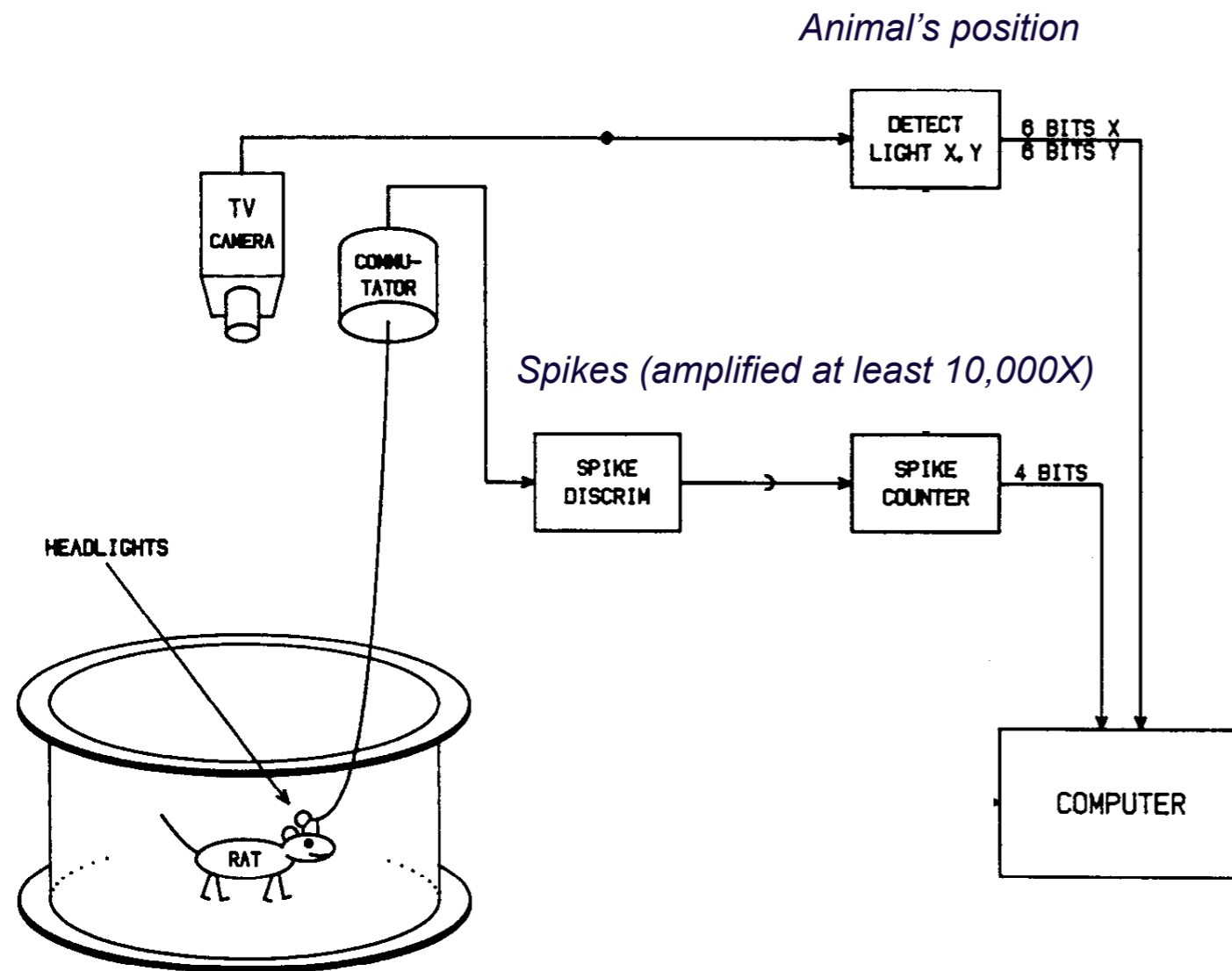
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USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION

BASIC APPROACH (IN RATS, BUT SIMILAR IN PRIMATES)

Basic setup



from Muller, Kubie and Ranck (1987)

Modern setup (i.e., my lab)

Modern high-density recording headstage

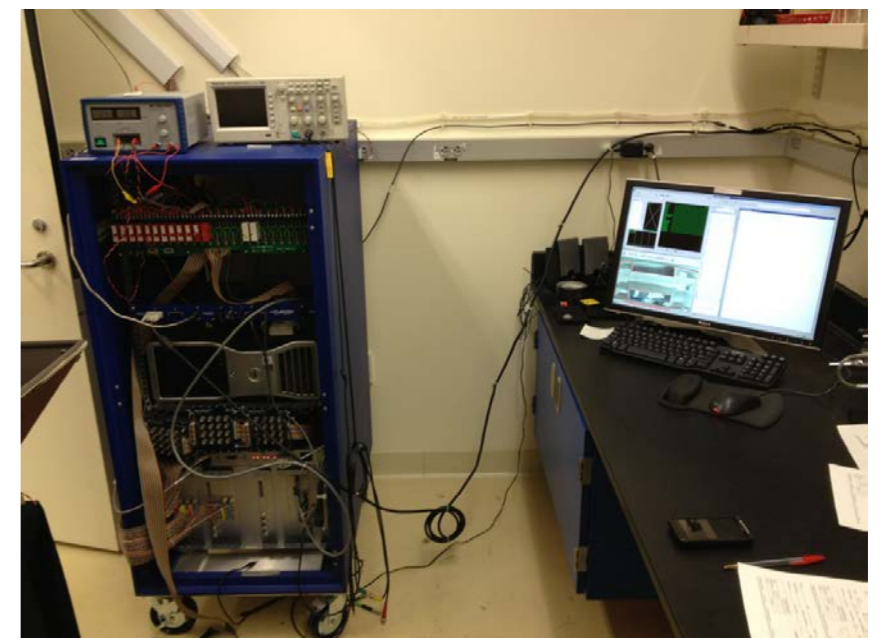


- Control >24 tetrodes (groups of 4 wires) independently
- Ultra-compact, ultra-light
- Stable for months

Connector and pre-amplifier



Data collection hardware

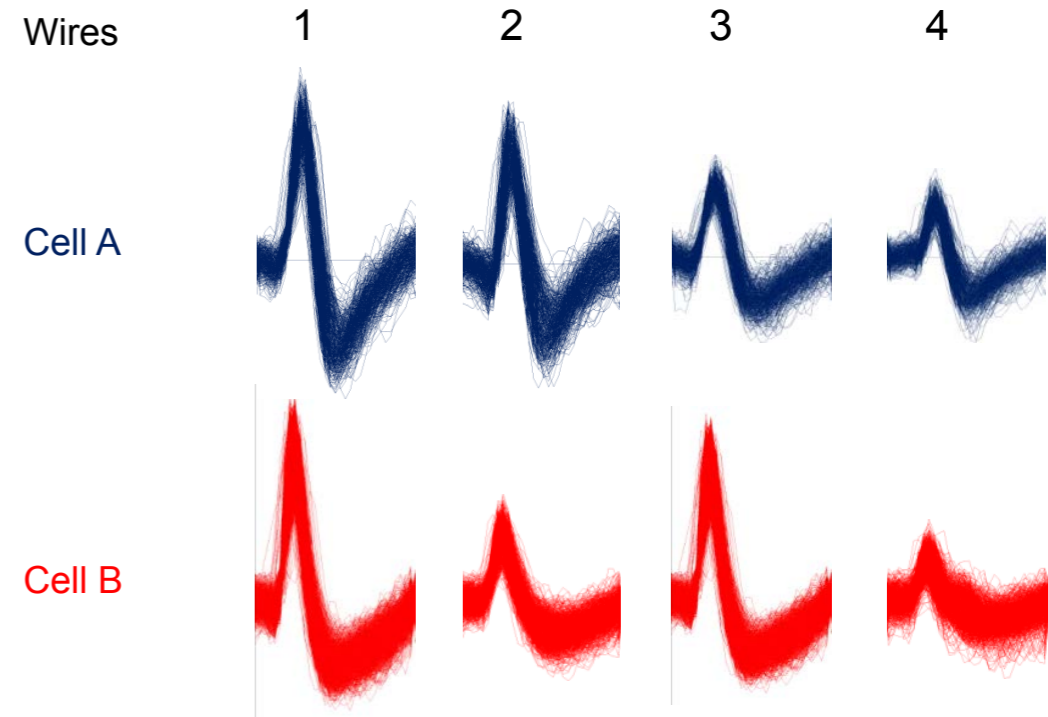
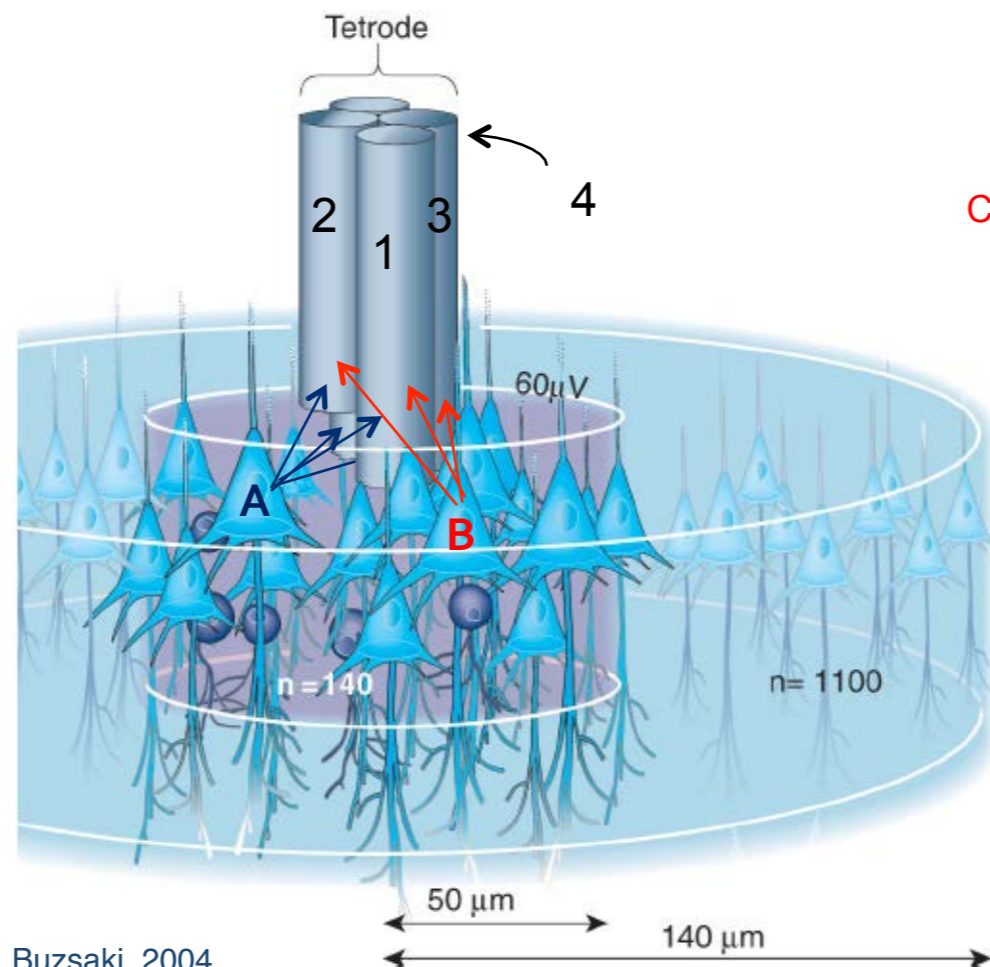
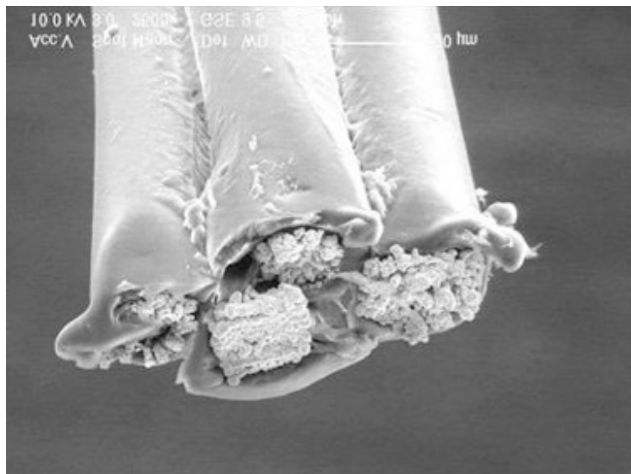


USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION

BASIC APPROACH (IN RATS, BUT SIMILAR IN PRIMATES)

Bundles of electrodes help discriminate different cells
e.g., a tetrode is a bundle of 4 electrodes (recording wires)

Pic of tetrode tip

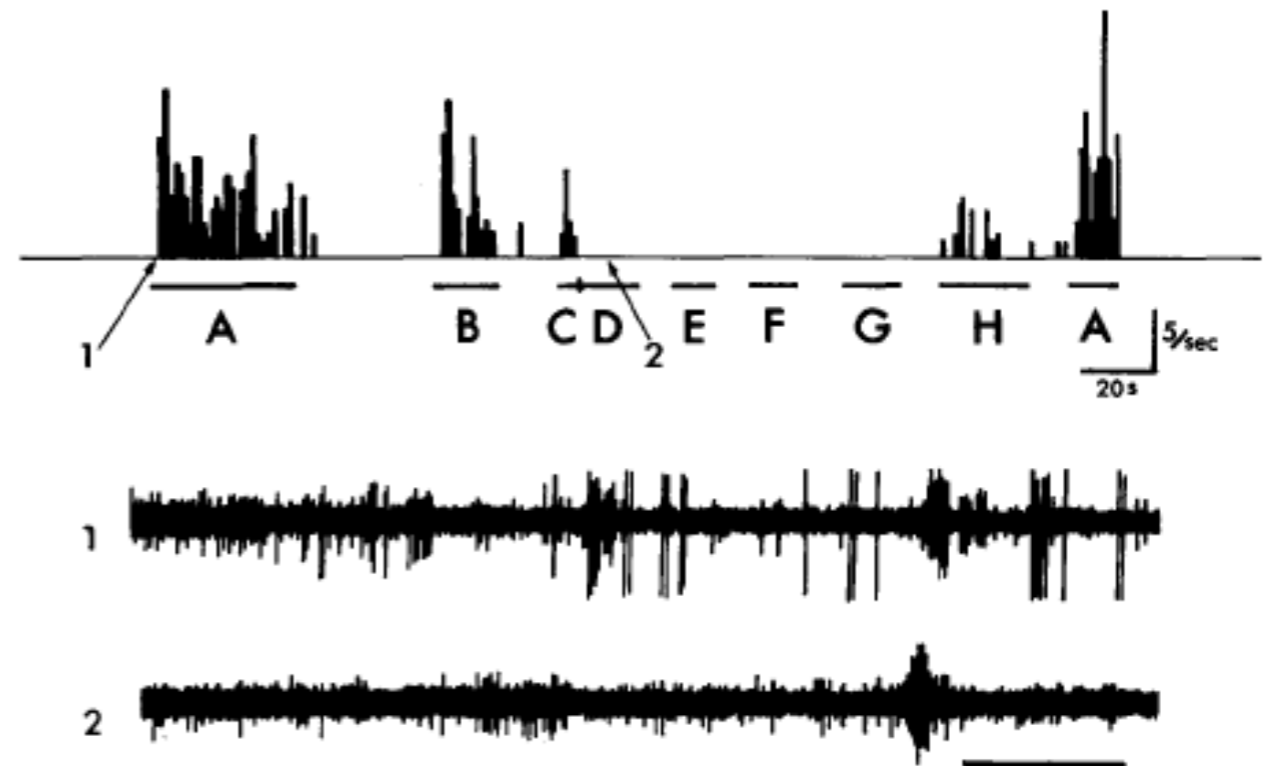
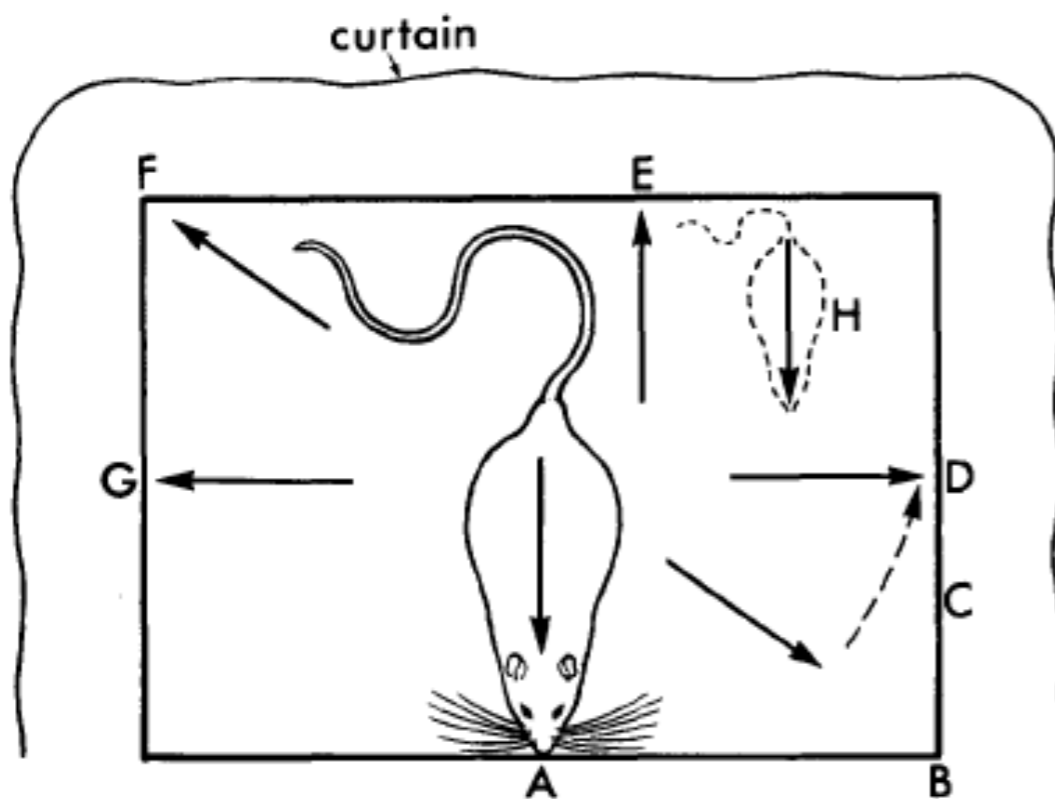


Technique developed by Dr. Bruce McNaughton, now at UCI!

USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN RATS

HIPPOCAMPAL NEURONS ENCODE SPECIFIC LOCATIONS IN THE ENVIRONMENT

- Original report: O'Keefe and Dostrovsky, 1971



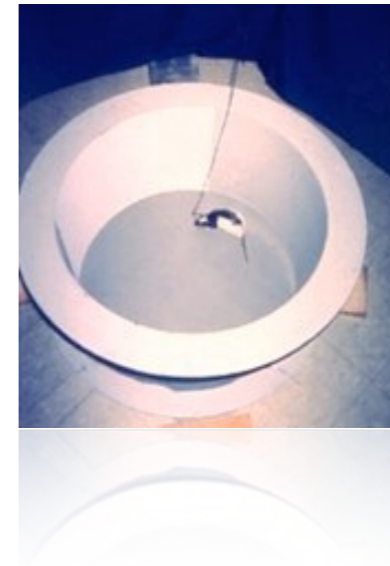
Cells showing place-specific activity are called “place cells”
(since O'Keefe, 1976)

USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN RATS

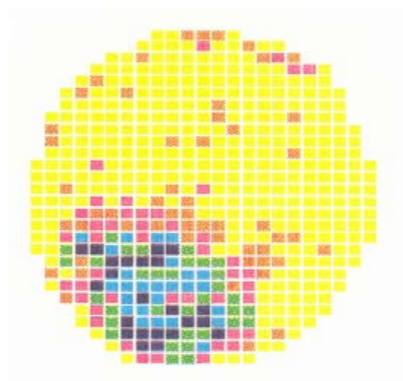
HIPPOCAMPAL NEURONS ENCODE SPECIFIC LOCATIONS IN THE ENVIRONMENT

- A little more precise: Muller, Kubie and Ranck, 1987

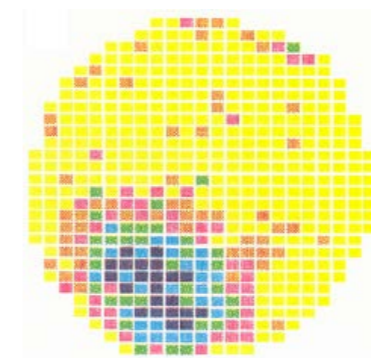
Top view of circular environment



Spikes per pixel



=



Firing rate map

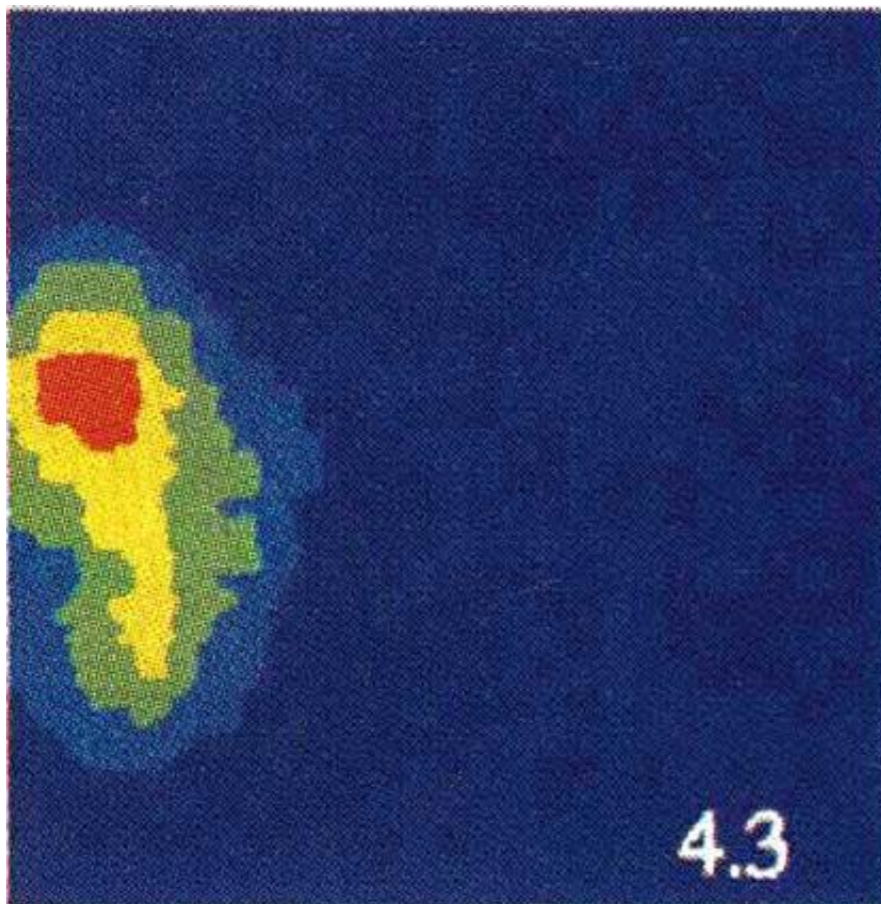
Time spent in each pixel



USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN RATS

HIPPOCAMPAL NEURONS ENCODE SPECIFIC LOCATIONS IN THE ENVIRONMENT

- More current: O'Keefe and Burgess, 1996



Firing rate:

Red > yellow > green > blue

Top view of square environment

USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN RATS

HIPPOCAMPAL NEURONS ENCODE SPECIFIC LOCATIONS IN THE ENVIRONMENT

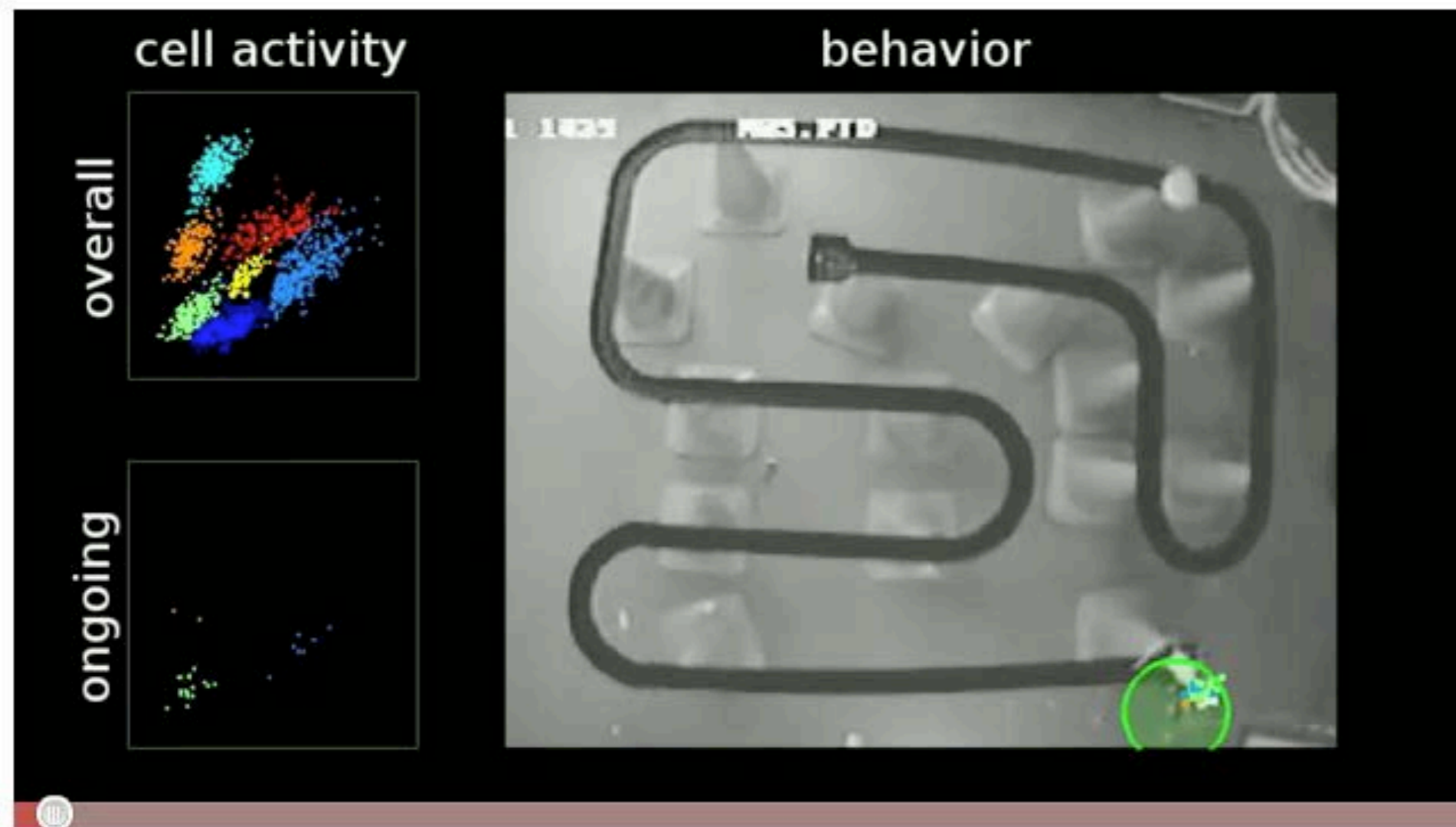
- Latest technology
 - ~ 24-32 tetrodes in the hippocampus
 - Recording from > 40 cells at once

Hippocampal place cells recorded in the Wilson lab at MIT

[mwlmovies](#)

1 video

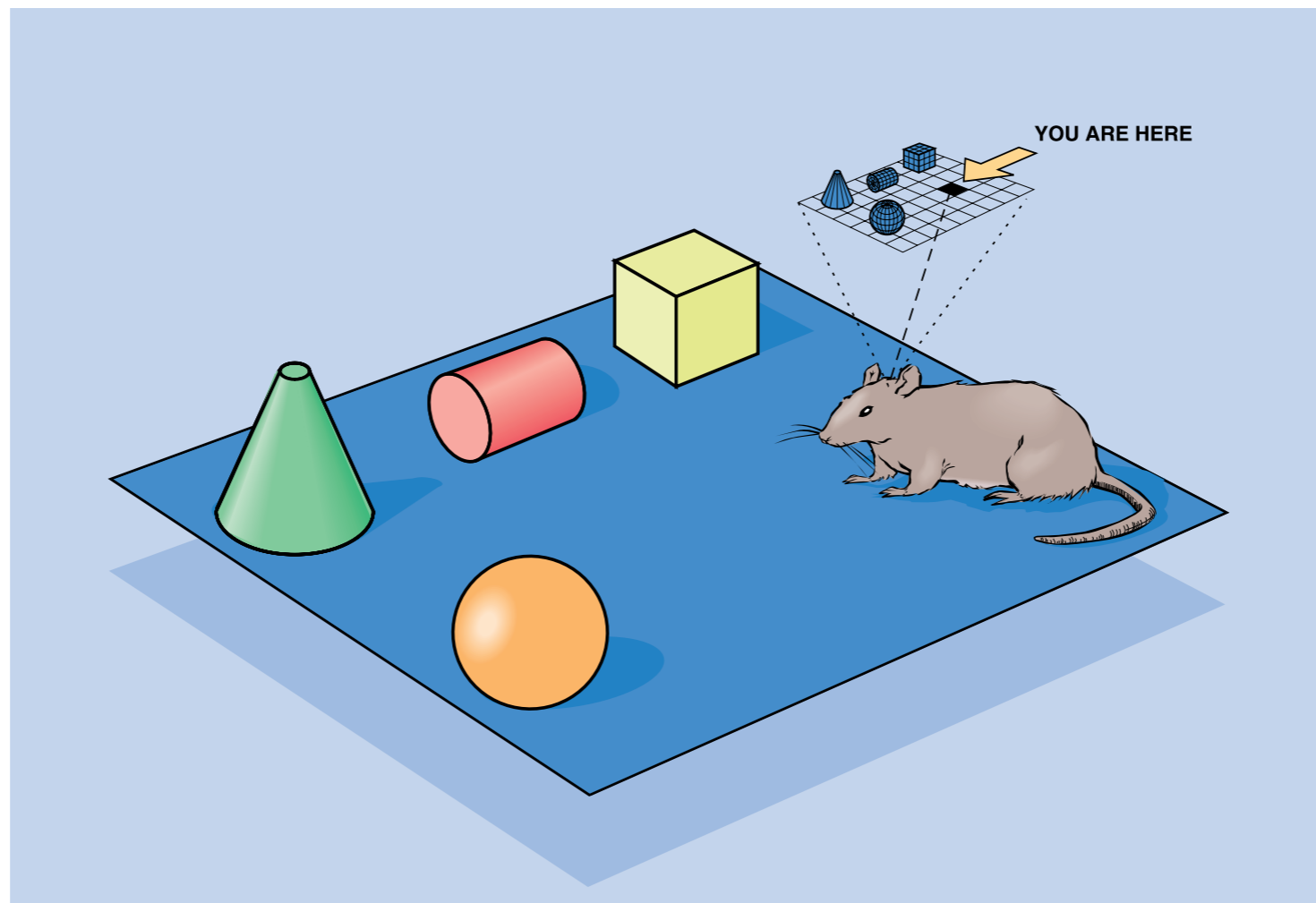
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USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN RATS

HIPPOCAMPAL NEURONS ENCODE SPECIFIC LOCATIONS IN THE ENVIRONMENT

- These findings provide support for the “Cognitive Map theory”
 - The idea that the hippocampus builds a faithful map of the environment



- We'll see later that this is not the full story

USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN RATS

RECORDING FROM OTHER AREAS

What does this cell do?



USING SINGLE CELL REC'S TO STUDY MEMORY & COGNITION IN HUMANS

INDIVIDUAL NEURONS ENCODE SPECIFIC EXPERIENCES

Supplementary Movie S1a
viewing session

accompanying
demonstration for Fig. 1

Firing of a single entorhinal cortex neuron while watching short video episodes

(Original audiovisual movie clips are replaced
by a textual description of the clip content)

Beeps represent single spikes

H. Gelbard-Sagiv, R. Mukamel, M. Harel, R. Malach, I. Fried, *Science* (2008)

OVERVIEW

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SINGLE CELL REC'S HELP US UNDERSTAND MANY BRAIN SYSTEMS AND FUNCTIONS

- e.g., what do neurons in the visual system do?
 - “ON” cell in LGN (e.g., Hubel and Wiesel, 1959, 1962)



OVERVIEW

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SINGLE CELL REC'S MAY LEAD TO MEDICAL BREAKTHROUGHS E.G. NEURAL PROSTHETICS

Mind Control Monkey Moves Robot in Japan

DukeUniversityNews

196 videos



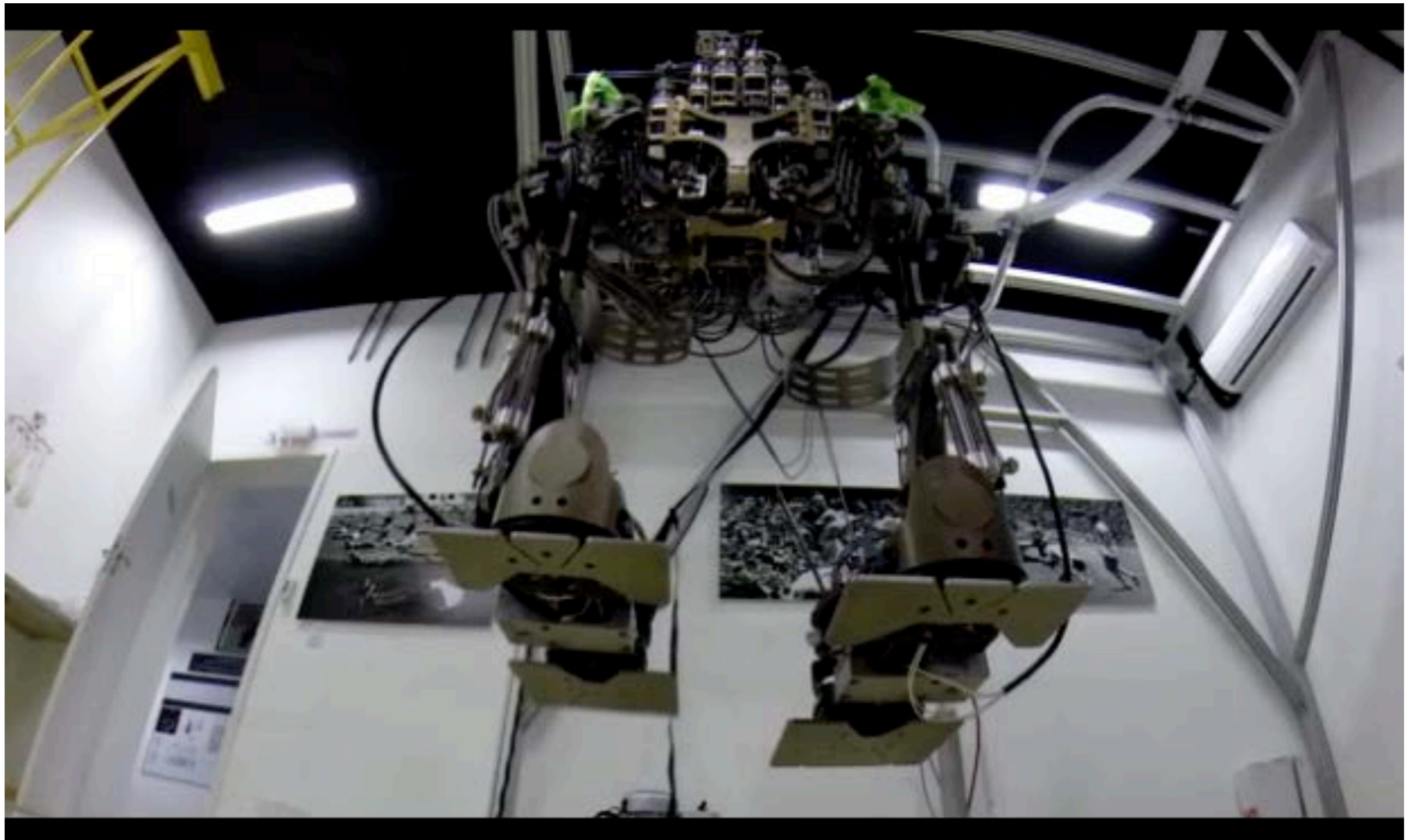
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**Monkey's Thoughts
Makes Robot Walk
from Across the Globe**

JANUARY 2008

SINGLE CELL REC'S MAY LEAD TO MEDICAL BREAKTHROUGHS E.G. NEURAL PROSTHETICS

Controlling an exoskeleton with your brain



Nicolelis lab, Duke University

<http://www.theguardian.com/science/video/2014/apr/01/robotic-exoskeleton-world-cup-debut-video>

SINGLE CELL REC'S MAY LEAD TO MEDICAL BREAKTHROUGHS E.G. NEURAL PROSTHETICS

For more details, check out Dr. Nicolelis' TED talk



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Brain-to-brain communication has arrived. How we did it

TEDGlobal 2014 · 18:57 · Filmed Oct 2014

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[https://www.ted.com/talks/
miguel_nicolelis_brain_to_brain_communication_has_arrived_how_we_did_it#t-923952](https://www.ted.com/talks/miguel_nicolelis_brain_to_brain_communication_has_arrived_how_we_did_it#t-923952)

SINGLE CELL REC'S MAY LEAD TO MEDICAL BREAKTHROUGHS E.G. "RESET" OF ABNORMAL BRAIN ACTIVITY PATTERNS

Spinal Cord Stimulator Sparks Hope for Parkinson's Disease

DukeMedicine

143 videos

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