Introduction to Behavioral Neuroscience A

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https://youtu.be/vyWaKRhrj-w

Lecture video at above link.

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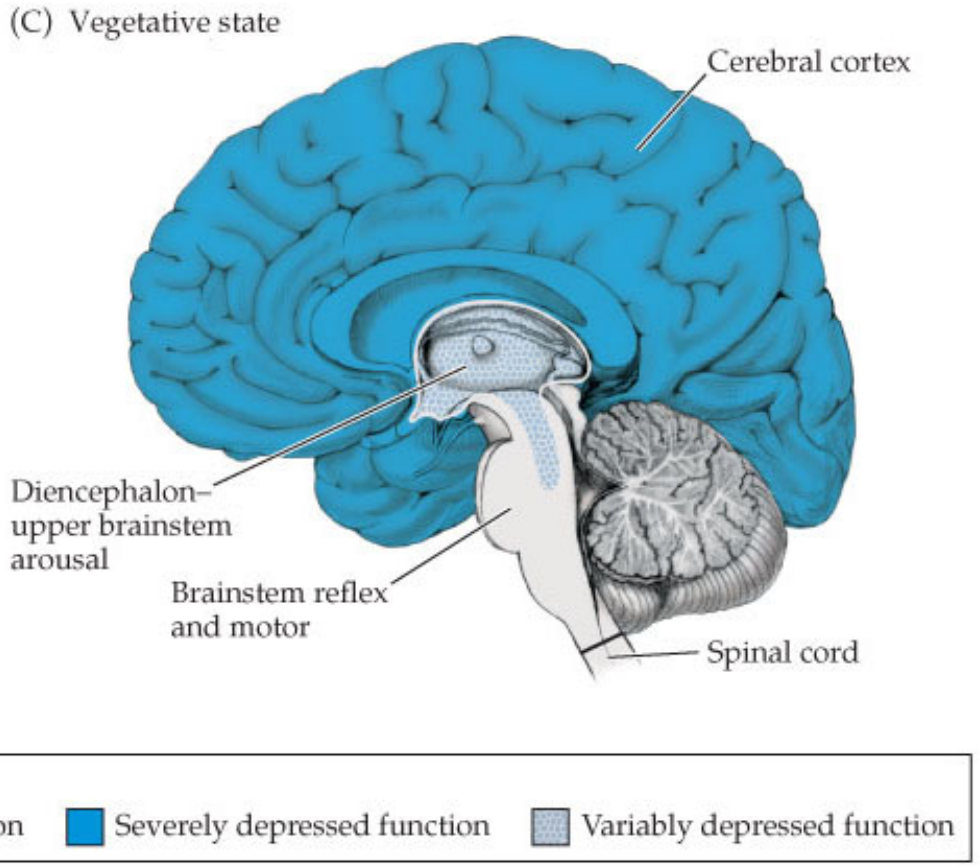
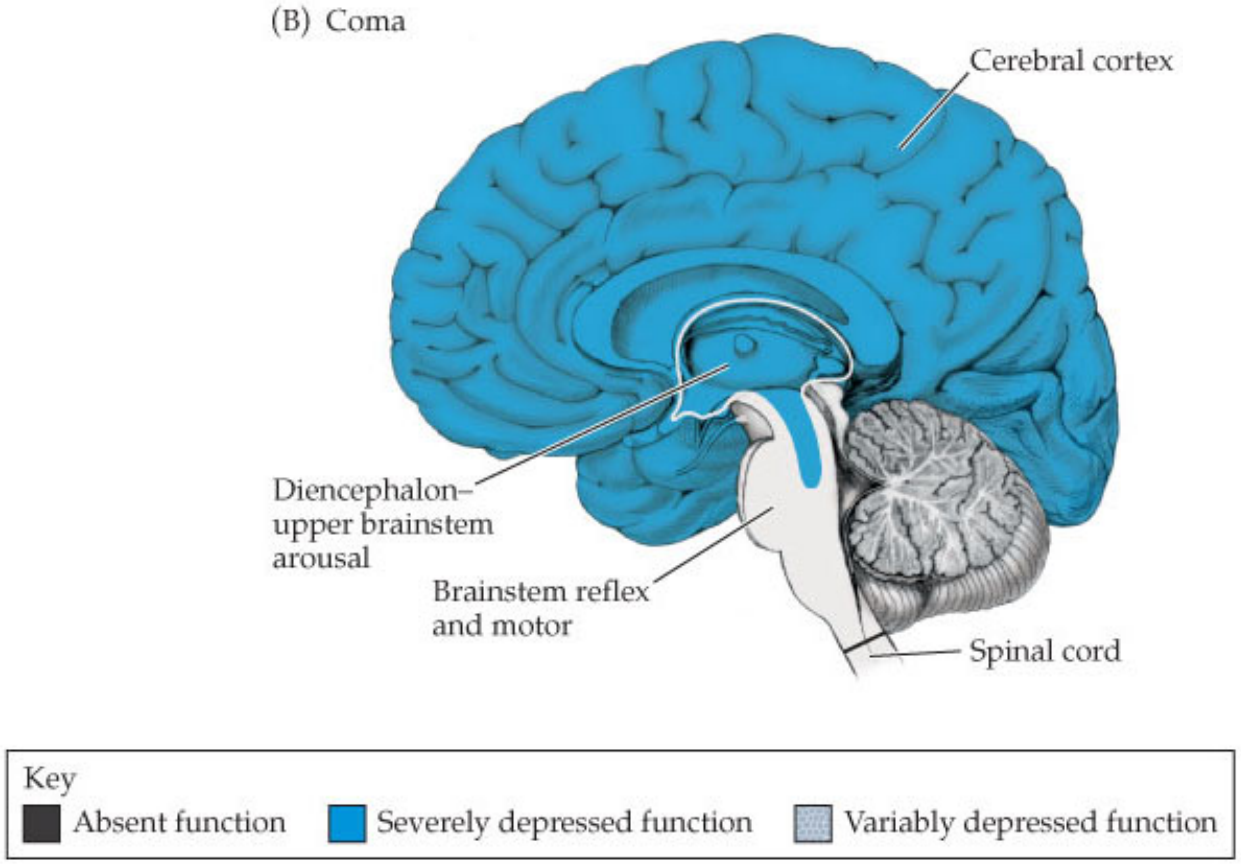
This course is ONLINE spring 2020 (due to COVID-19)
→ So, email me.

We don’t understand the brain



You’ve heard of people in “vegetative states”
→ Do you think we know what causes it?

We don’t understand the brain



What’s the difference between vegetative state and a coma?

We don’t understand the brain

TABLE 14.3 Coma and Related States

ANATOMY (SEE FIGURE 14.16)	CEREBRAL CORTEX	DIENCEPHALON–UPPER BRAINSTEM AROUSAL SYSTEMS	BRAINSTEM REFLEX AND MOTOR SYSTEMS	SPINAL CORD CIRCUITS
FUNCTIONS TESTED	PURPOSEFUL RESPONSES TO STIMULI?	BEHAVIORAL AROUSAL, SLEEP-WAKE CYCLES?	BRAINSTEM REFLEXES?	SPINAL CORD REFLEXES?
States of impaired consciousness				
Brain death	No	No	No	Yes
Coma	No	No	Yes	Yes
Vegetative state	No	Yes	Yes	Yes
Minimally conscious state	Yes, at times	Yes	Yes	Yes
Stupor, obtundation, lethargy, delirium	Yes, at times	Variable	Yes	Yes
Status epilepticus	Variable	Variable	Yes	Yes
Akinetic mutism, abulia, catatonia	Yes, at times	Yes	Yes	Yes
Sleep, normal and abnormal	Yes, at times	Yes	Yes	Yes
States resembling impaired consciousness				
Locked-in syndrome	No[a]	Yes	Yes	Yes
Dissociative disorders, somatoform disorders	Yes, at times	Yes	Yes	Yes

[a]Some locked-in patients may have preserved vertical eye movements, eye blinking, or other slight movements under volitional control.

Modified with permission from Blumenfeld H. 2009. The neurological examination of consciousness. In *The Neurology of Consciousness*, S Laureys and G Tononi (eds.), Chapter 2, pp. 15–30. Elsevier, Ltd.

Blumenfeld, Neuroanatomy through Clinical Cases

We don’t understand the brain

We can look at:
→ Different behaviors
→ Brain activity

We know there is different brain activity for one specific type of behavior:
(1) coma → no arousal or wake/sleep cycles
(2) vegetative state → yes arousal and wake/sleep

We don’t understand the brain

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→ Different behaviors
→ Brain activity

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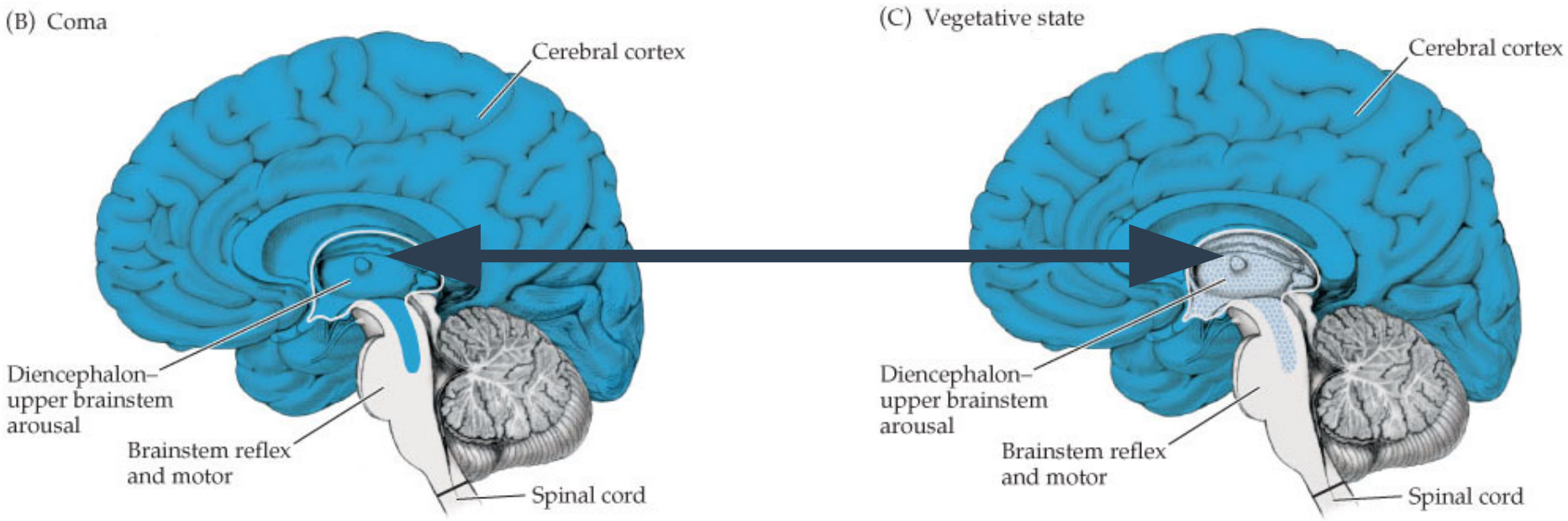
(1) coma → no arousal or wake/sleep cycles
(2) vegetative state → yes arousal and wake/sleep

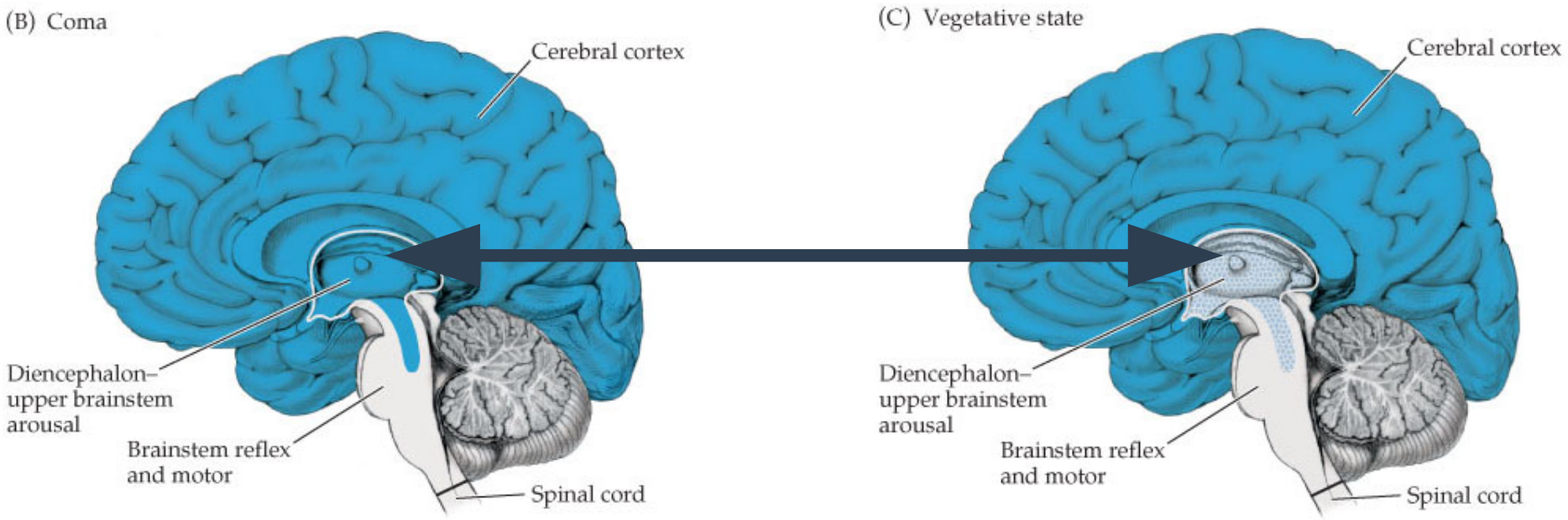
What do you conclude?
Do you understand something about the brain?

We don’t understand the brain



What do you conclude?
Do you understand something about the brain?
→Maybe the upper brain stem is important for controlling arousal and wake/sleep?

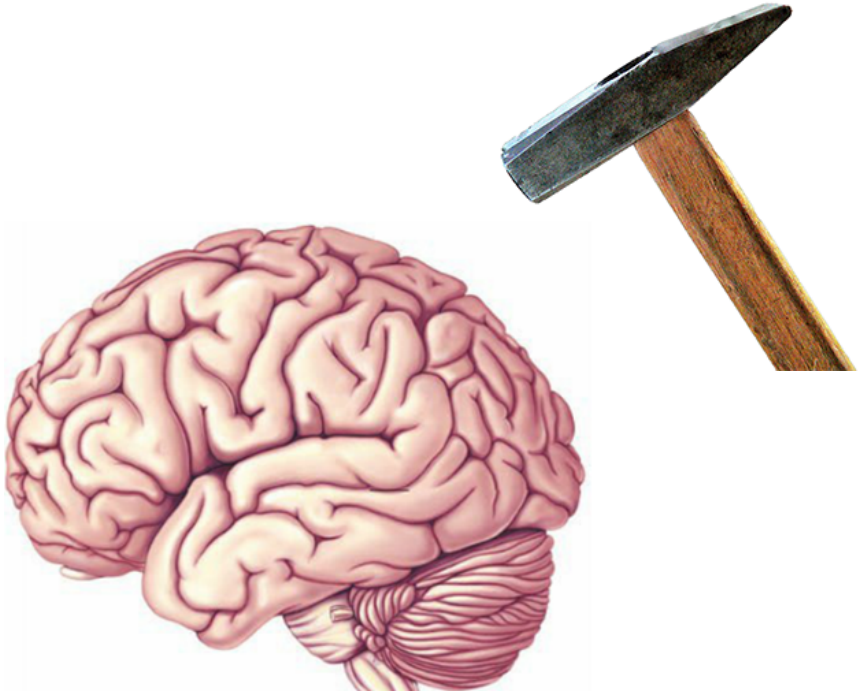
We don’t understand the brain



What do you conclude?
Do you understand something about the brain?
→Because the *activity* of that *part of the brain* is different and the behavior is different.

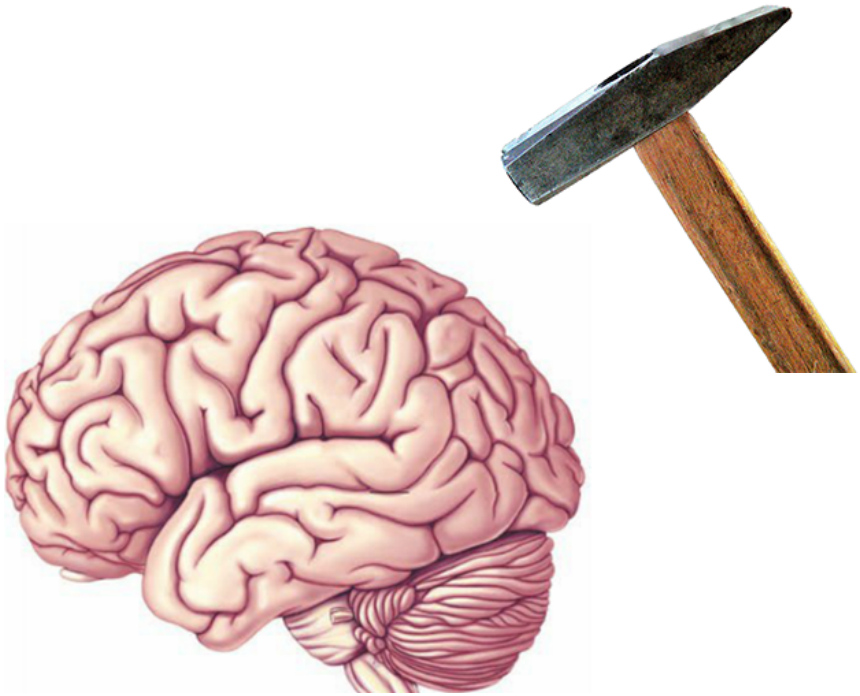
We don’t understand the brain

Can you think of one other disease/disorder?
→ Have you ever heard of specific brain areas associated with the disease/disorder?



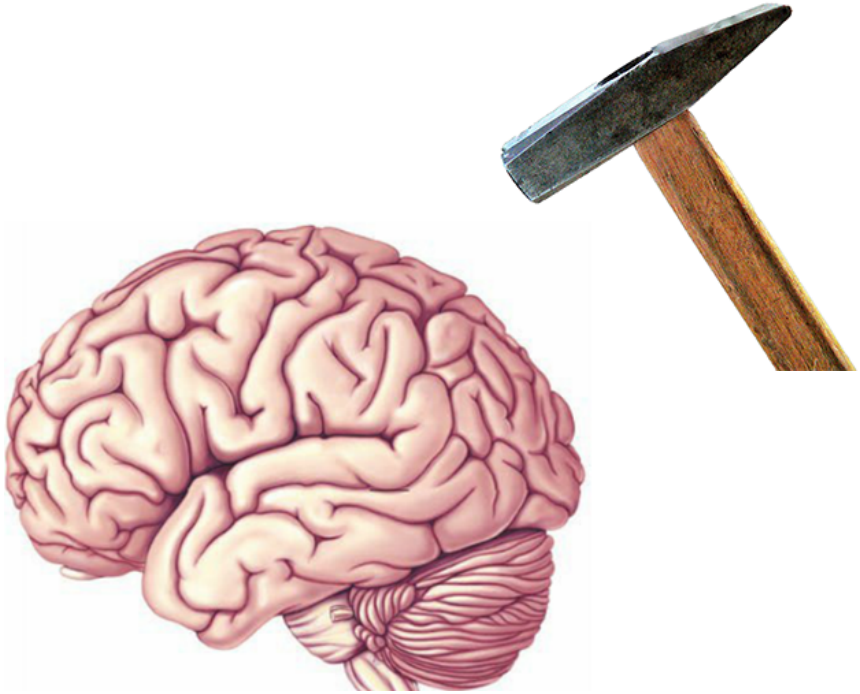
We don’t understand the brain

Schizophrenia? Alzheimer’s? Autism? Parkinson’s?



We don’t understand the brain

A lot of our understanding of neuroscience comes from comparing brains and behavior of different diseases with healthy subjects.



Behavioral Neuroscience

Have you ever heard of the Nobel Prize?

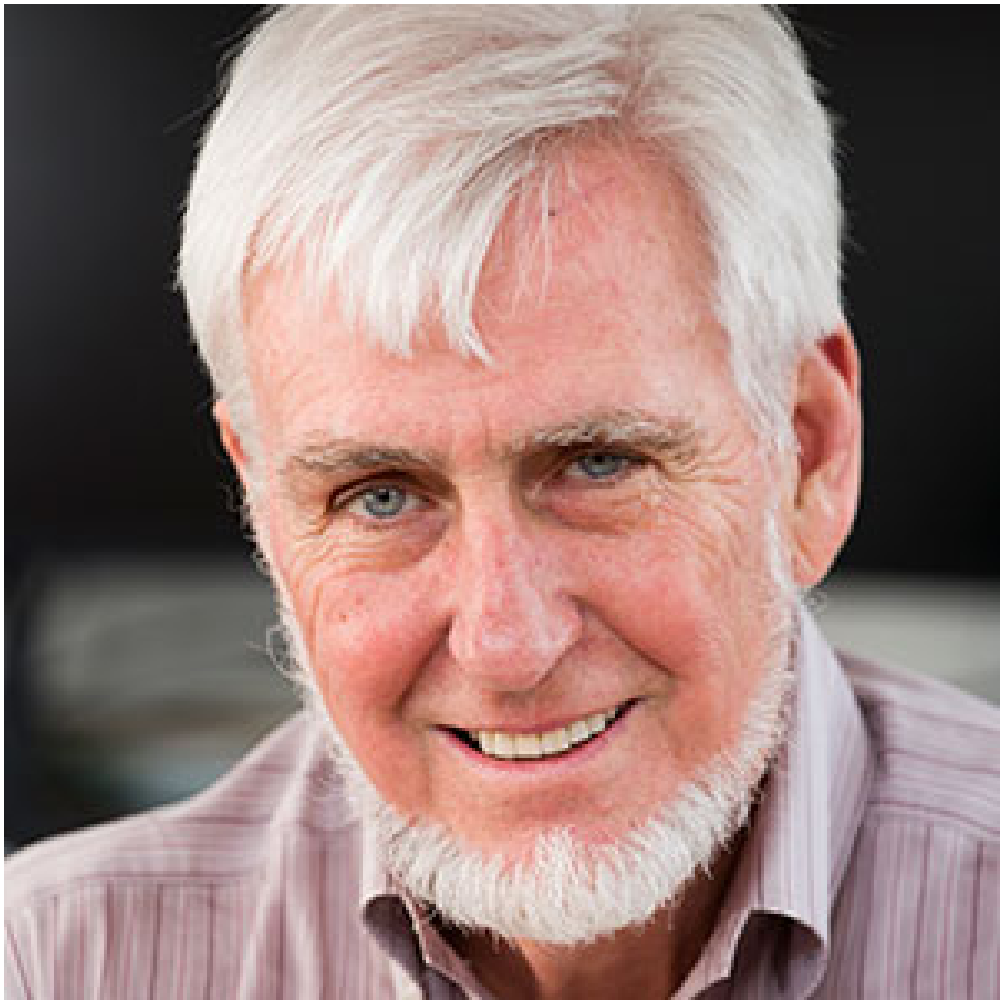
Behavioral Neuroscience

Have you ever heard of the Nobel Prize?

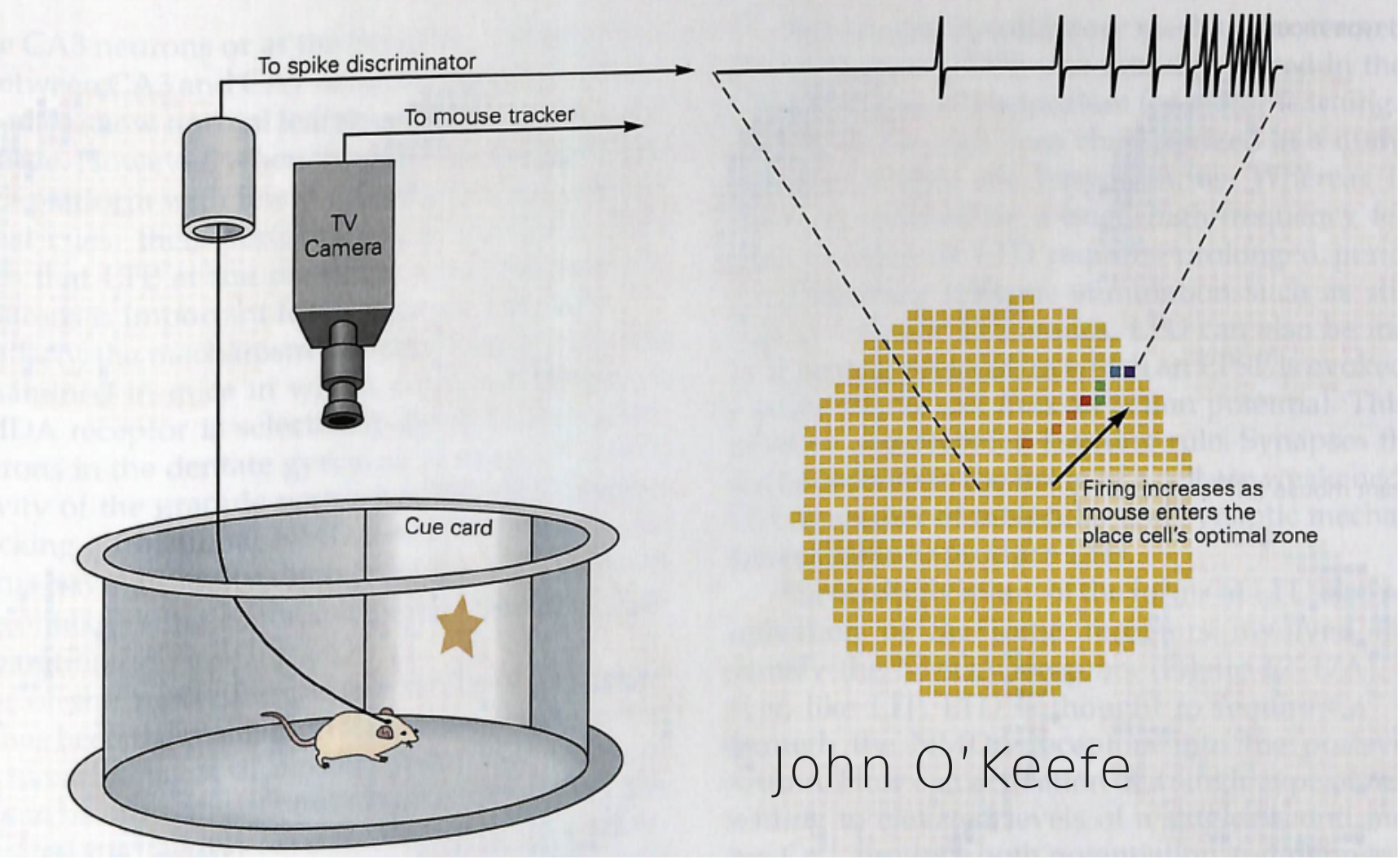
Do you know who won it in 2014?

Behavioral Neuroscience

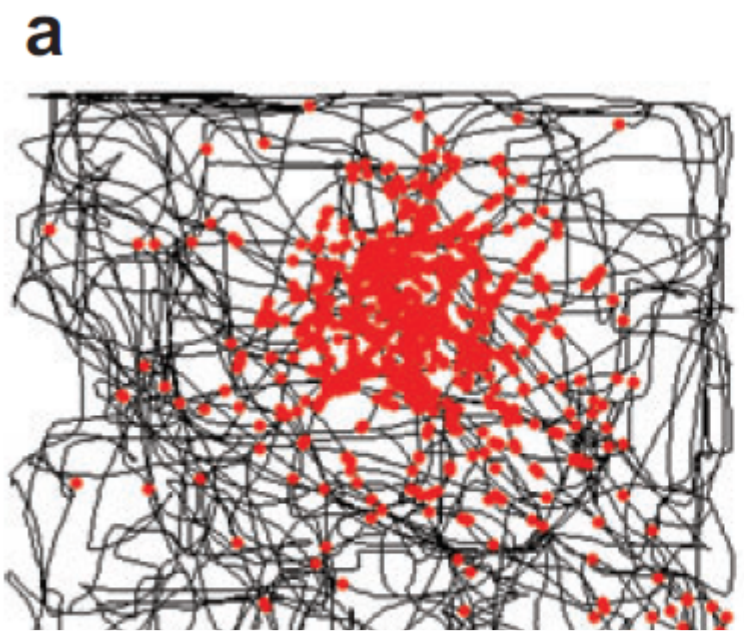
John O'Keefe



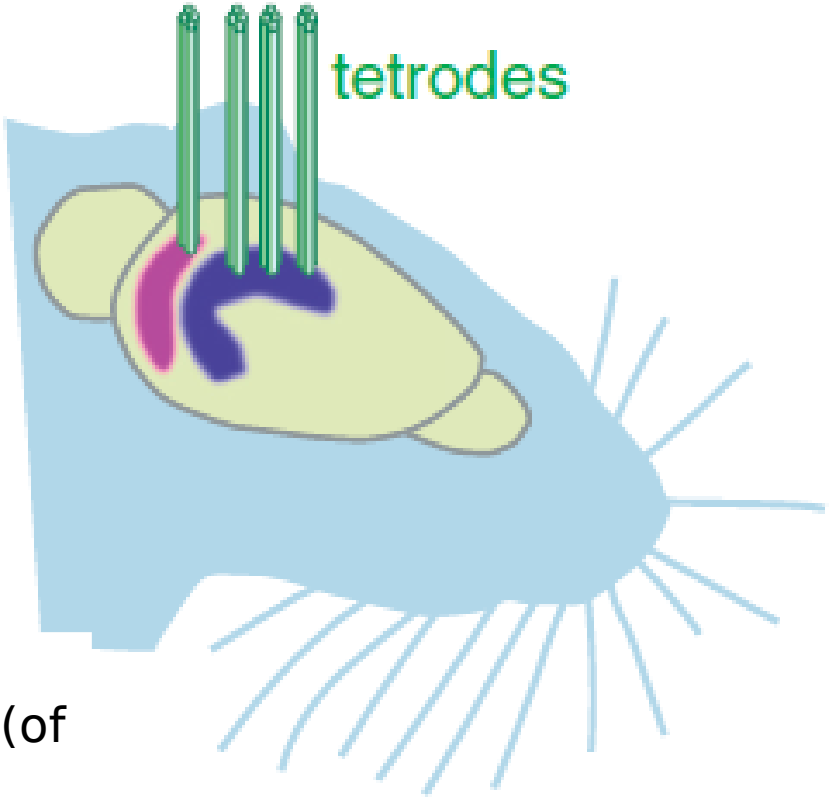
Place Cells


To spike discriminator
To mouse tracker
TV Camera
Cue card
Firing increases as mouse enters the place cell's optimal zone
John O'Keefe

Place Cells

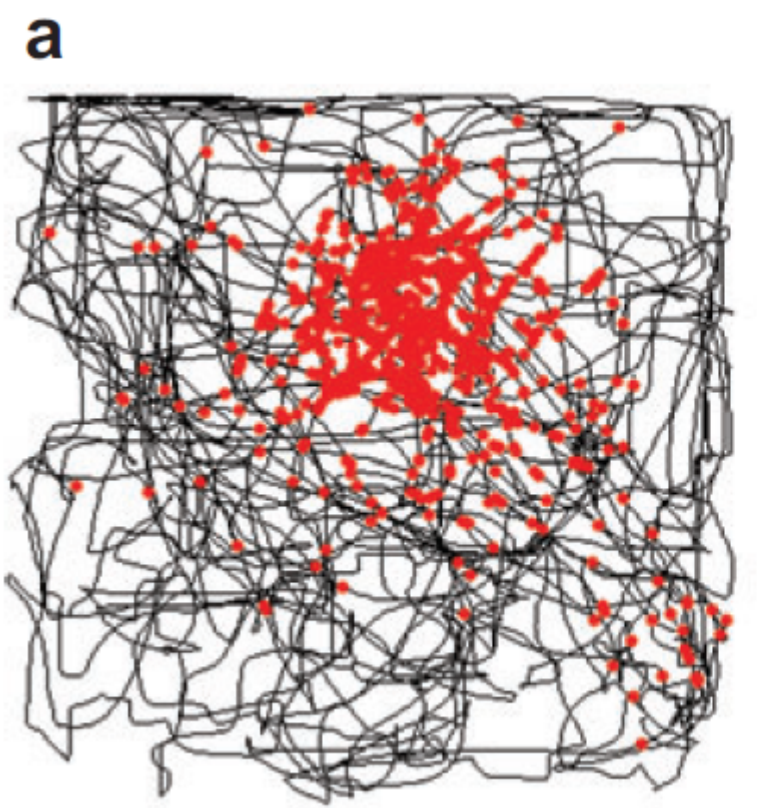


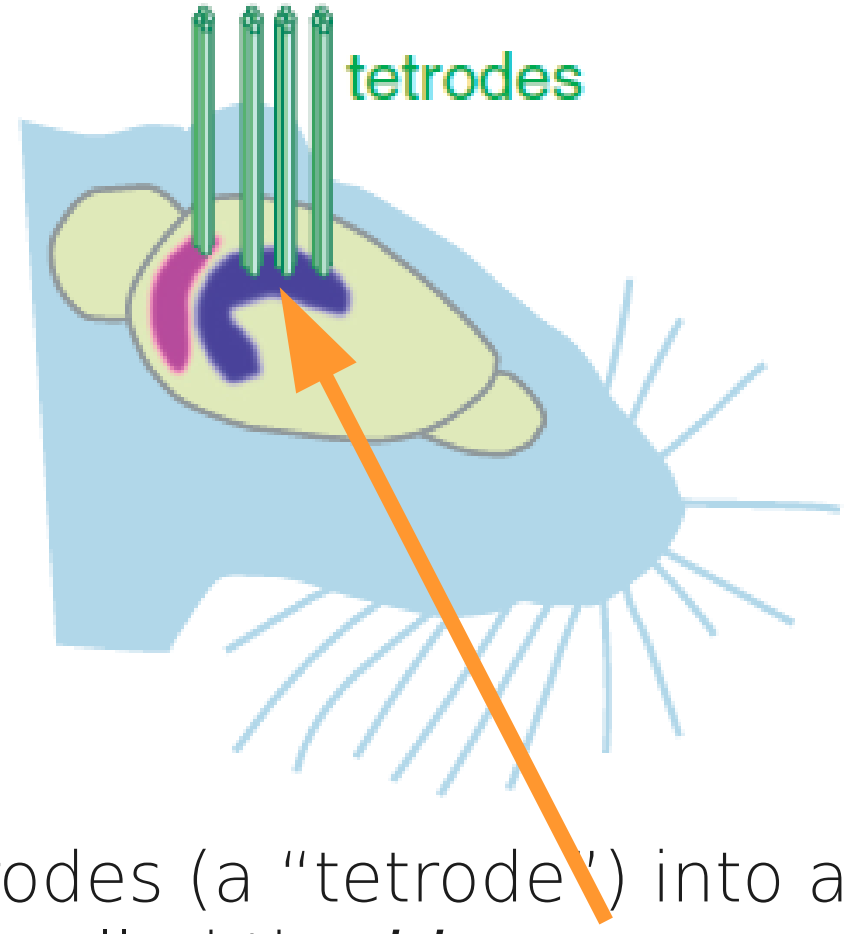
Mouse walking path
Red dots are where brain activity (of the one brain cell) increased



One method for measuring brain activity is to stick wires ("electrodes") into the brain to measure electrical activity

Place Cells





O'Keefe put 4 electrodes (a "tetrode") into a part of the rat brain called the ***hippocampus***

Moser et al., Annual Reviews in Neuroscience, 2008

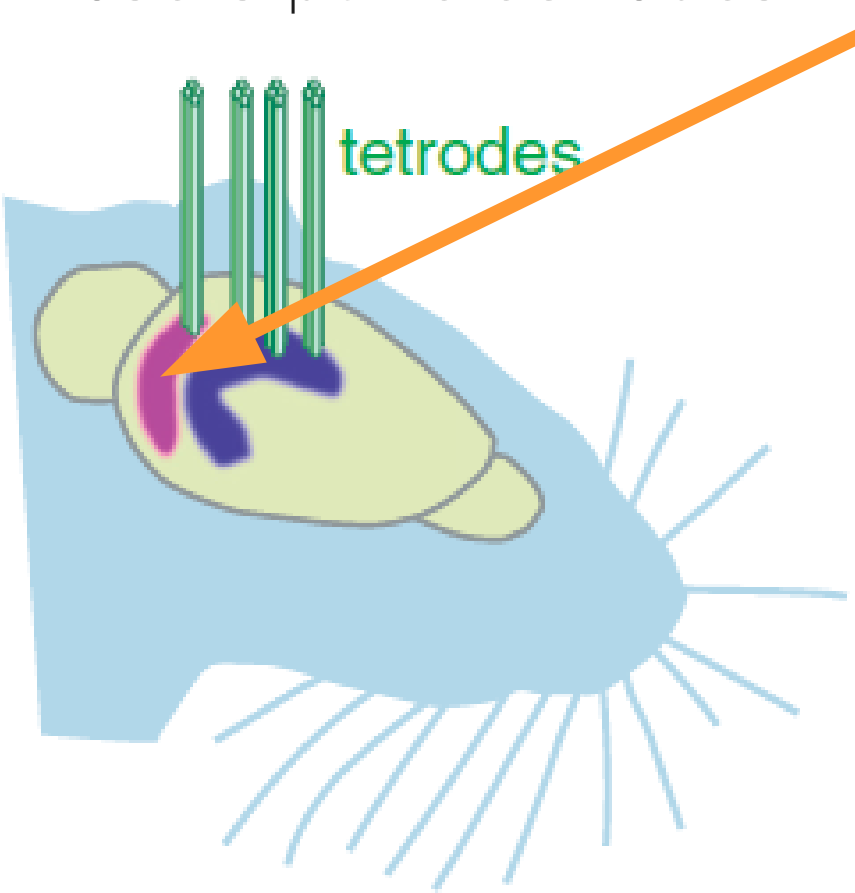
Behavioral Neuroscience

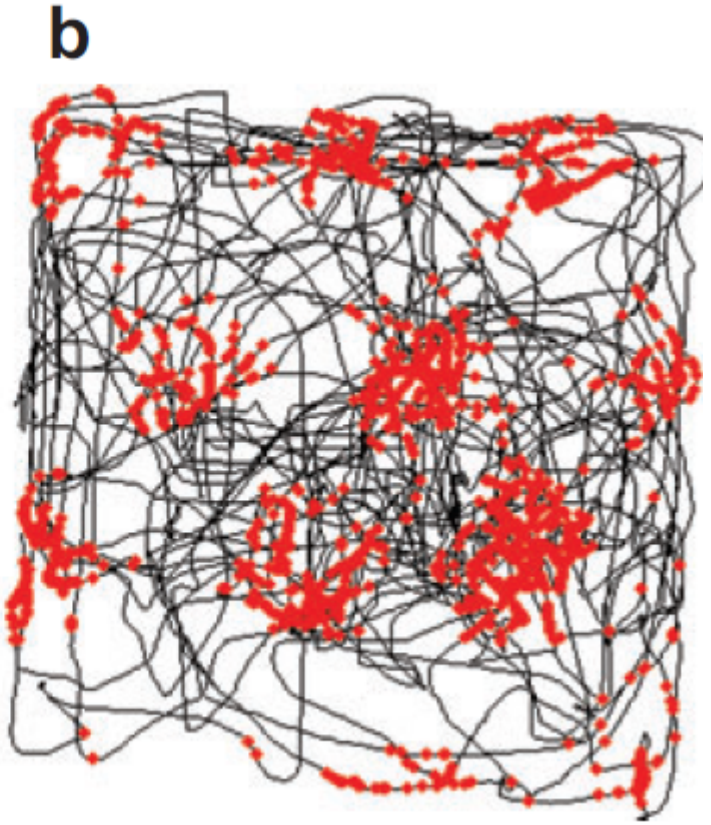
He actually shared the prize…

May-britt Edvard
Moser

Grid Cells

The Mosers put electrodes in *entorhinal cortex*

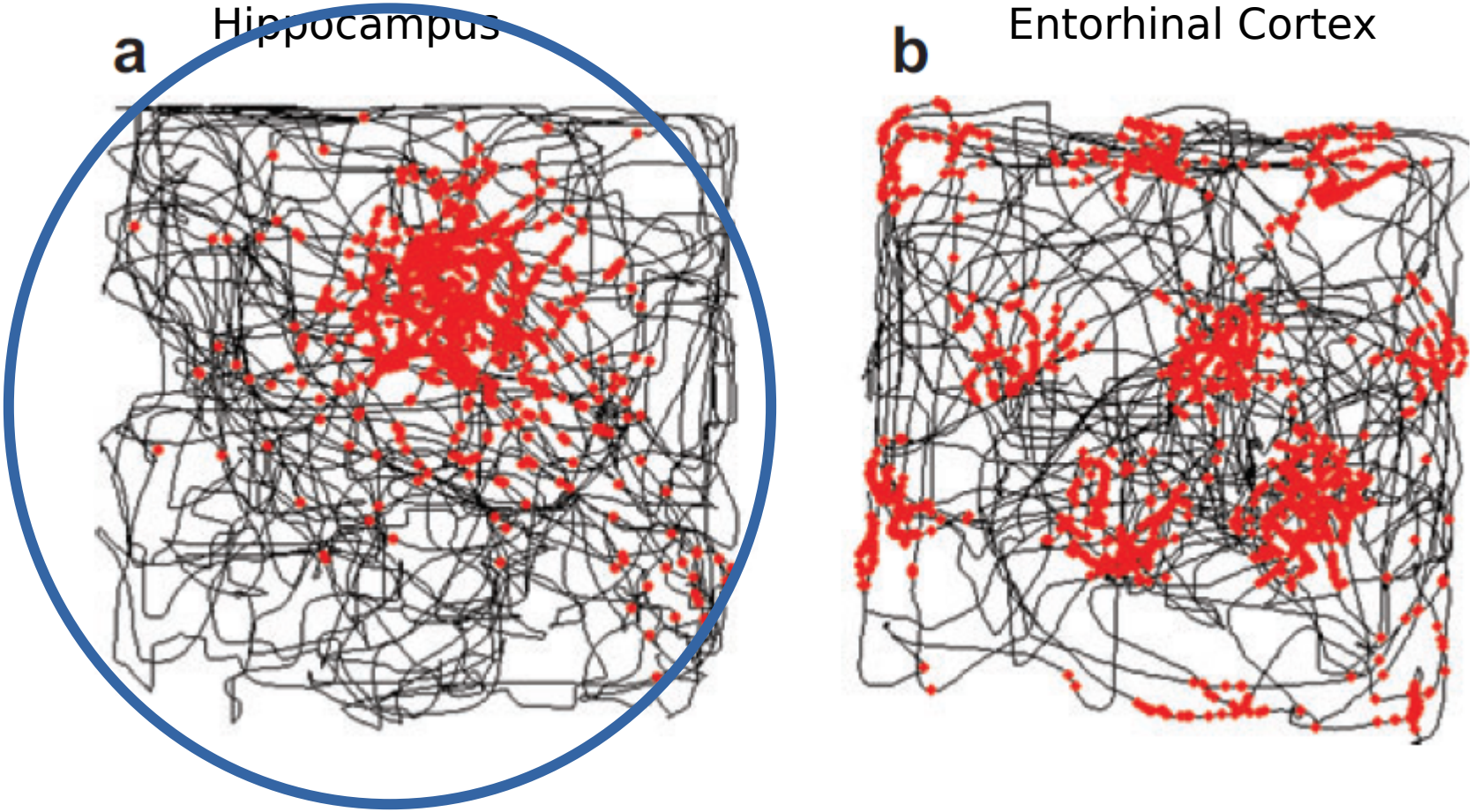




Mouse walking path
Red dots are where brain activity (of the one brain cell) increased

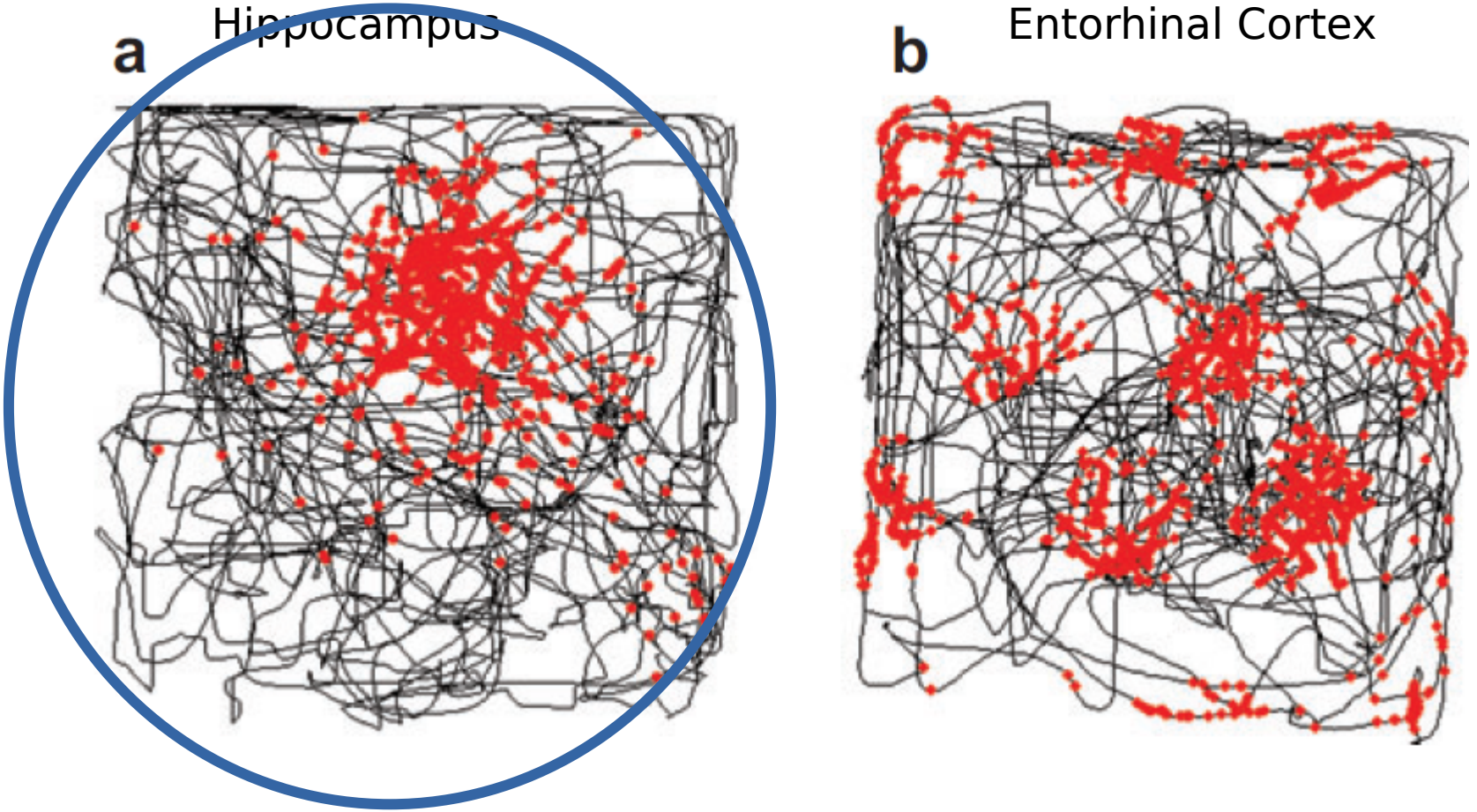
Grid Cells / Place Cells

What difference do you see?



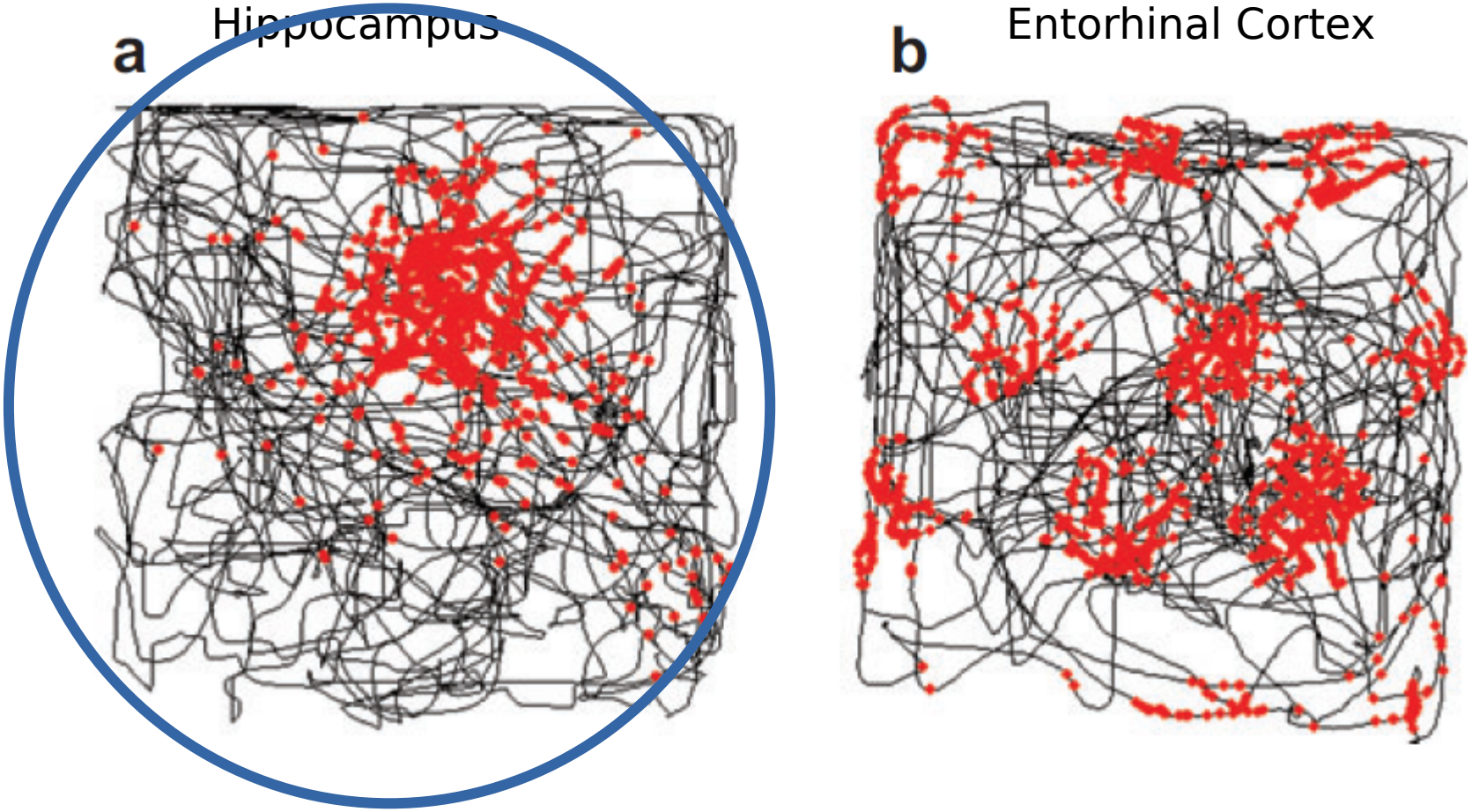
Place Cells / Grid cells

The Hippocampus cell responds when the rat is in *one specific location.*



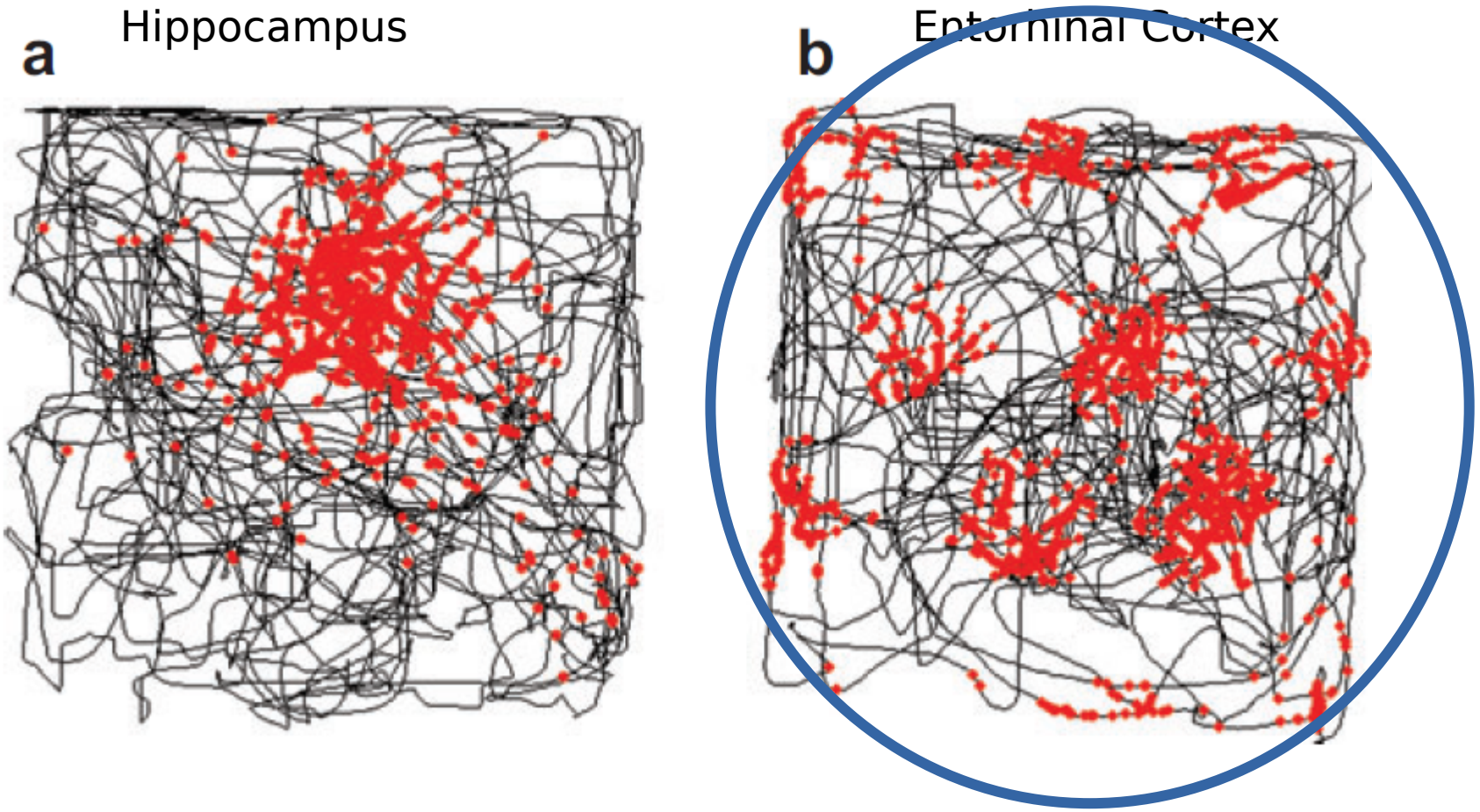
Place Cells / Grid cells

The Hippocampus cell responds when the rat is in *one specific location* → *They called it a* ***place cell***



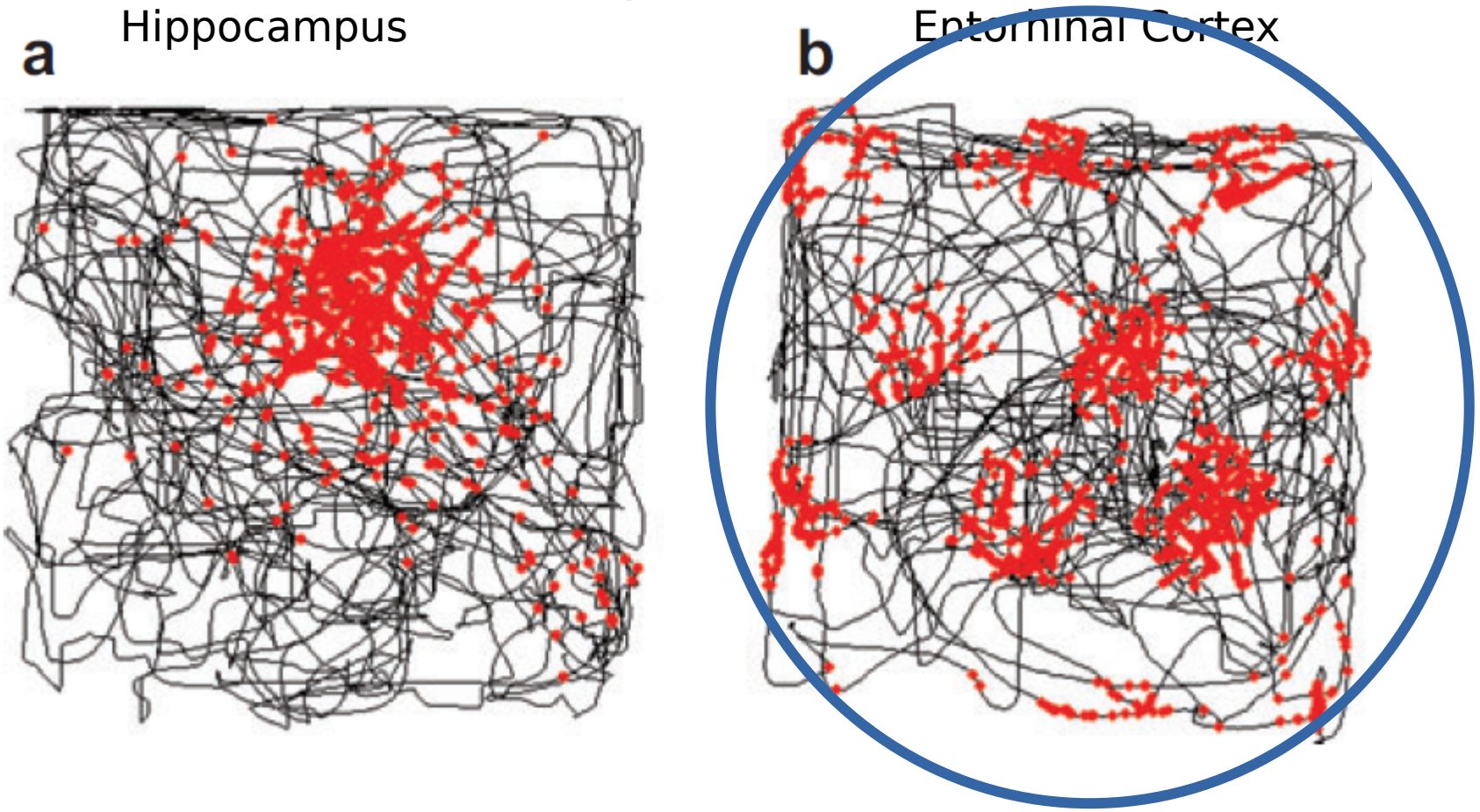
Place Cells / Grid cells

The entorhinal cortex cell responds to a “grid” of places.



Place Cells / Grid cells

The entorhinal cortex cell responds to a "grid" of places → *They called it a **grid cell***



Behavioral Neuroscience

In this case, they connected brain activity in different parts of the brain during the ***same behavior*** (walking around) to understand one function of those specific brain areas (entorhinal cortex and hippocampus).

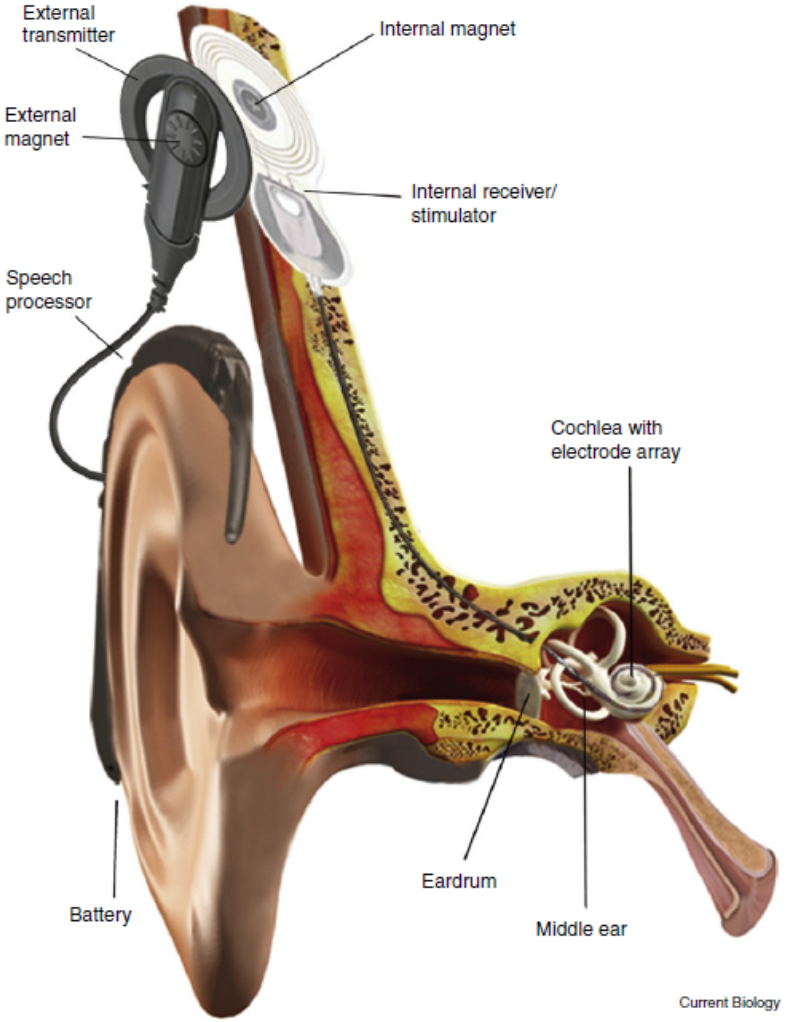
→ If you met a person who had difficulty recognizing where he is, can you make a hypothesis about what might be different in his brain?

What else is neuroscience good for?

You can also use electrodes to ***stimulate*** activity in certain parts of the brain!

Have you ever heard of a *cochlear implant*?

Electrodes (wires) are inserted into the ***cochlea*** – the part of the inner ear that converts sound into brain cell activity.



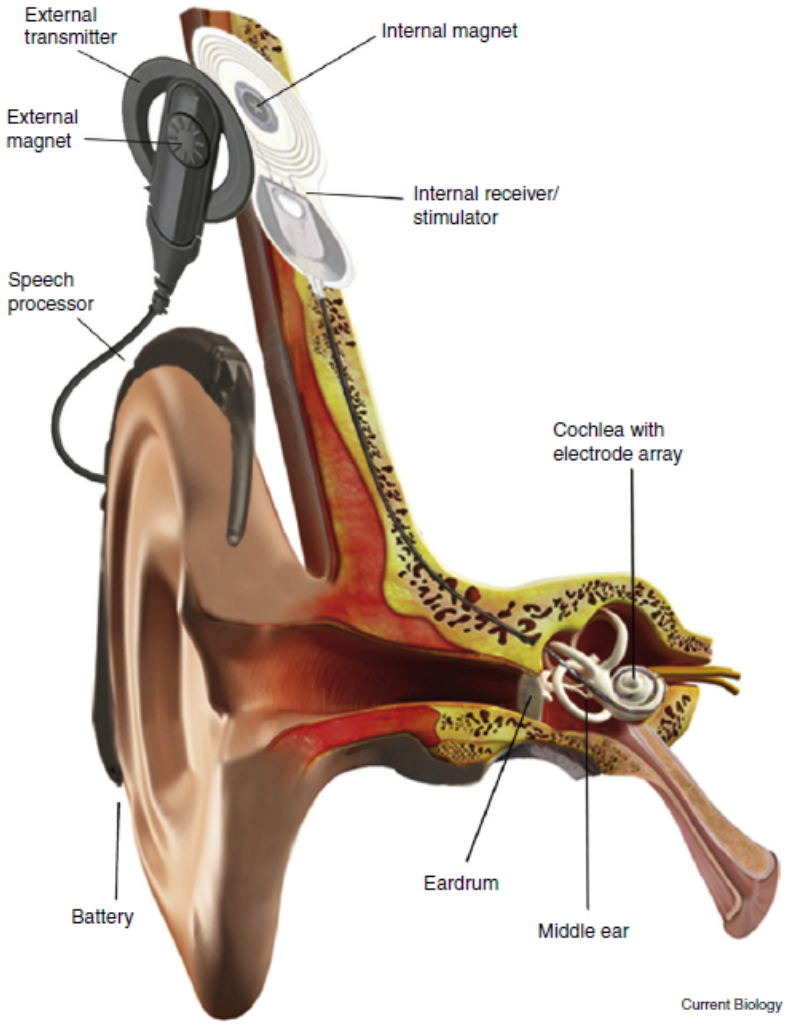
Cochlear Implant (Hearing Loss)

You can also use electrodes to ***stimulate*** activity in certain parts of the brain!

Have you ever heard of a *cochlear implant*?

A microphone turns sound into electrical signals sent via electrodes in the cochlea.

→ Deaf people can hear!

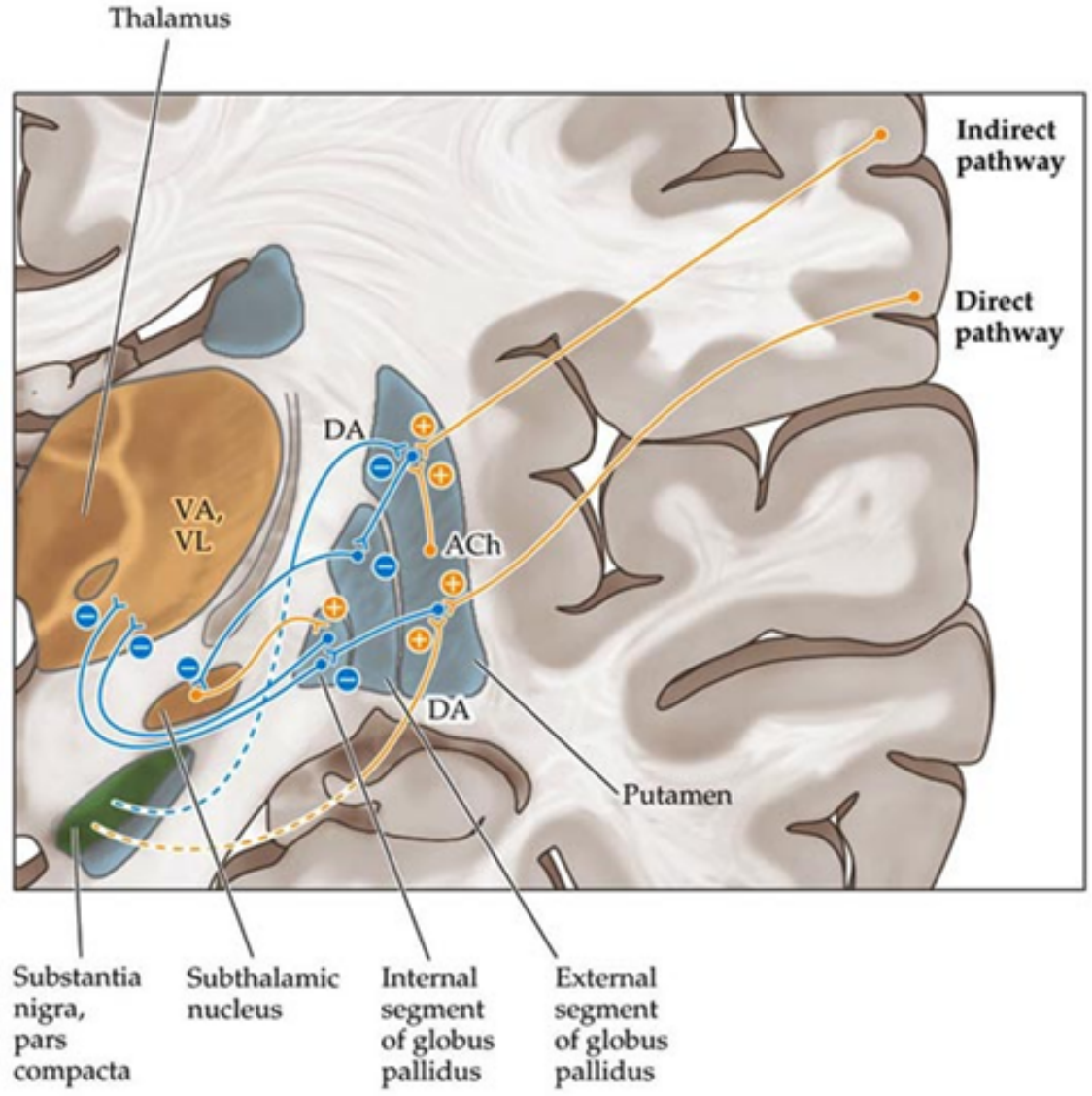


Deep Brain Stimulation (Parkinson's)

In Parkinson's patients, dopamine neurons in the basal ganglia die.

One treatment involves inserting an electrode (wire) into the basal ganglia to make the surviving dopamine neurons work harder.

→ This helps ease symptoms such as tremor!



DBS Videos

DBS example:

https://www.youtube.com/watch?v=wZZ4Vf3HinA

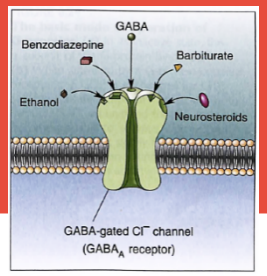
How it works:

https://www.youtube.com/watch?v=kaThzeghWnM

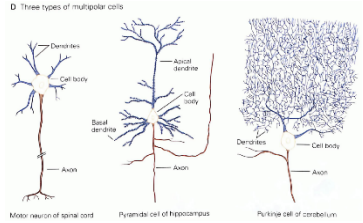
Levels of Analysis

How do membrane channel proteins mediate neural signalling?

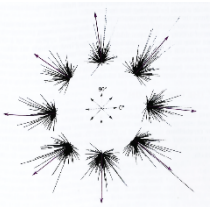
Molecular



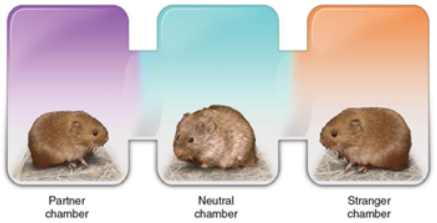
Cellular



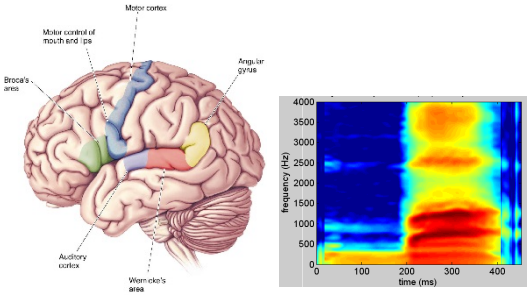
System



Behavior

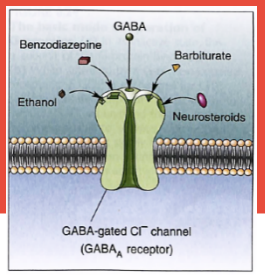


Cognition



Levels of Analysis

Molecular



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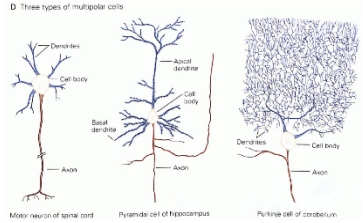
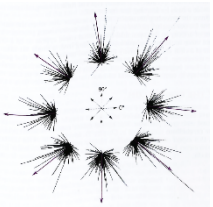
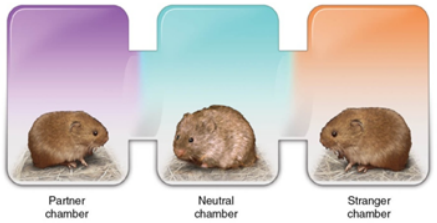


How does the shape and connectivity of brain cells define their function?

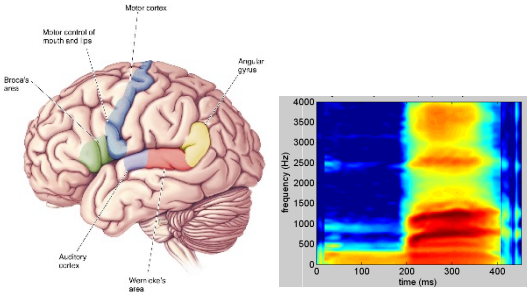
System



Behavior

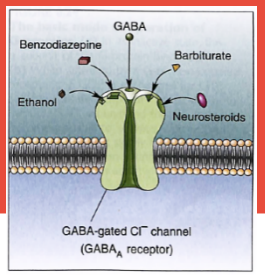


Cognition



Levels of Analysis

Molecular



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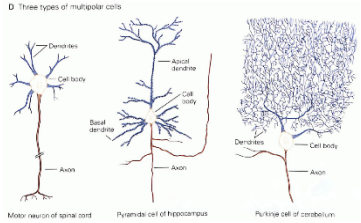
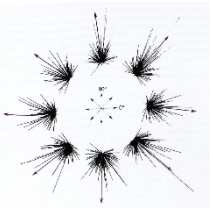
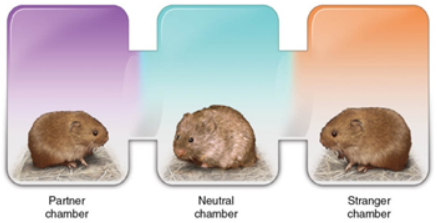


How does motor cortex encode movements?

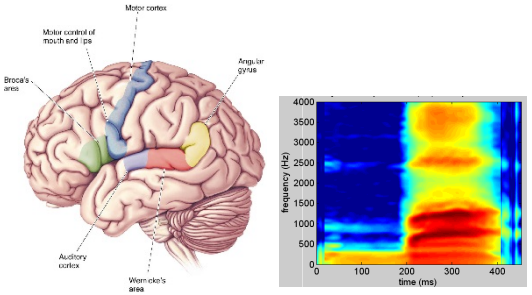
System



Behavior



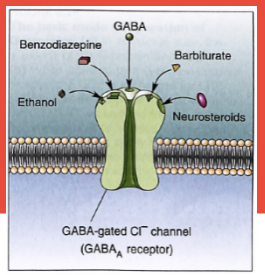
Cognition



Levels of Analysis

How is mating behavior regulated?

Molecular



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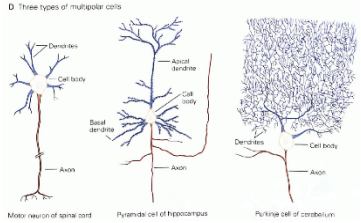
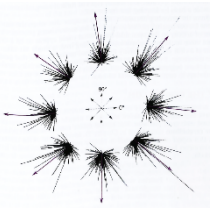
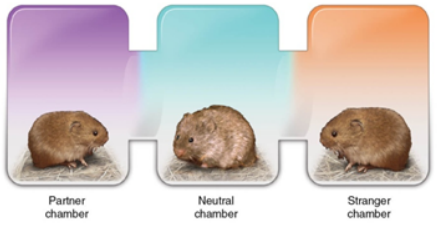


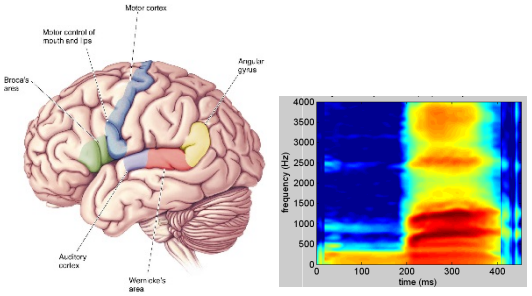
System



Behavior



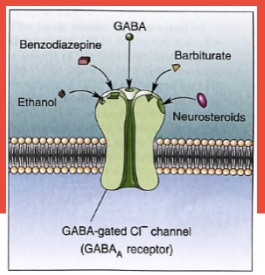
Cognition



Levels of Analysis

How is language encoded, processed, and produced by the brain?

Molecular



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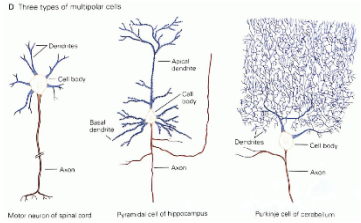

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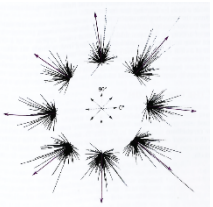

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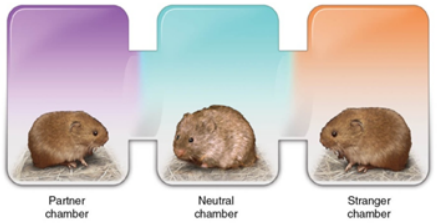
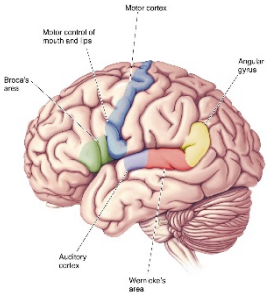
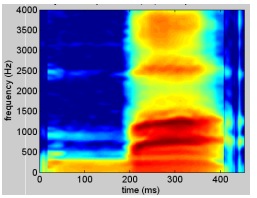


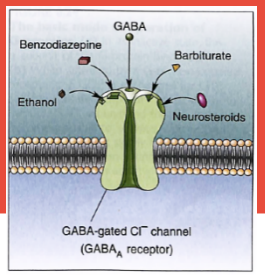
Cognition



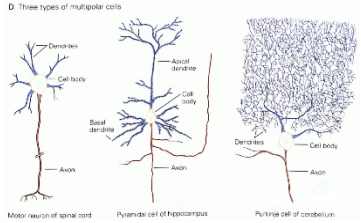


Levels of Analysis

Molecular



Cellular

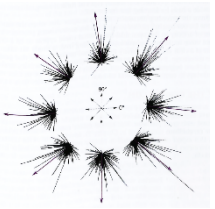


To really understand the brain and behavior, we need to use all the levels.

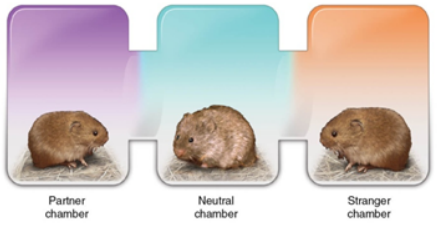
...for many behaviors

...in many types of animals.

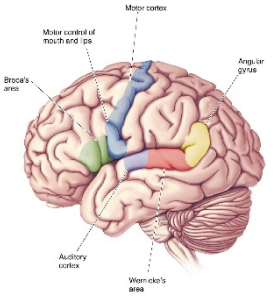
System

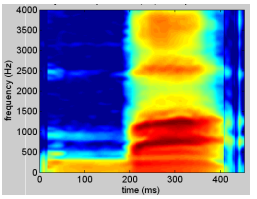


Behavior

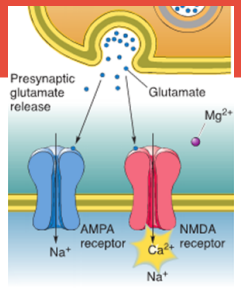


Cognition

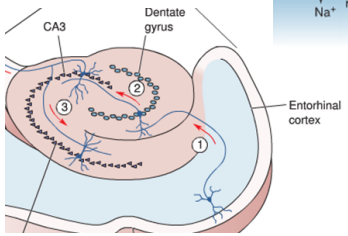




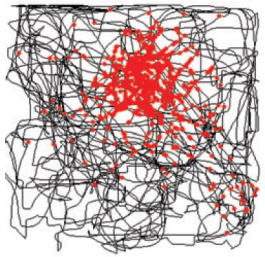
Levels of Analysis: Place cells



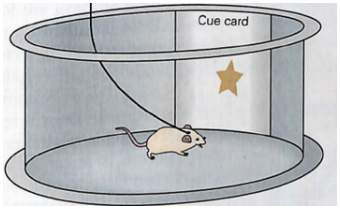
"What membrane channel proteins mediate plasticity in hippocampus?"



"How are neurons in the hippocampus interconnected?"



"How is space encoded in place cells?"



"How do rats navigate in environment?"

"Do mammals have an internal map?"

Computational Modeling

“If you can’t build it, you don’t understand it.”

“If you can build it, you do understand it.”

Computational Modeling

“If you can’t build it, you don’t understand it.”

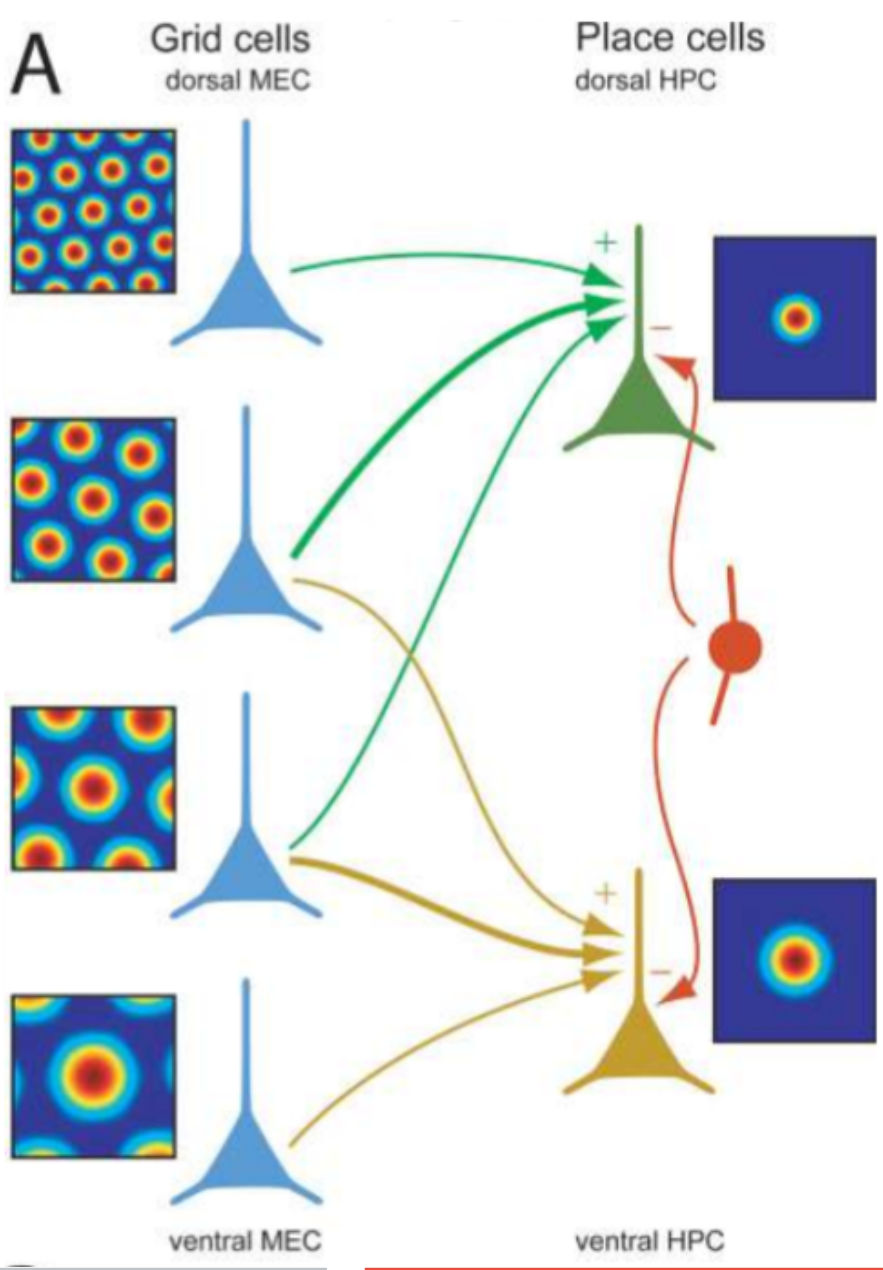
“If you can build it, you do understand it.”

→ Computational (or mathematical) modeling is using computers or mathematical functions to *model* the parts of the brain or behavior.

Computational Modeling
Grid Cells → Place Cells

How does the brain go from sensory input (light on the eyes) to representing where you are (place cells)?

→ One way to represent where you are is by adding together the activity of many different grid cells.
→ Each grid cell has different spatial frequencies and offsets (phases).



Schedule (Spring 2020)

Date	Content
8 May	Introduction
15 May	Coarse neuroanatomy
22 May	Cells in the nervous system
29 May	Neural information processing
5 June	Neurotransmitters, Hormones
12 June	Methods & EEG recording (Long)
19 June	Vision
26 July	Audition
3 July	Touch and pain
10 July	Sensory Integration
17 July	Attention
24 July	Body Movement / Movement Planning

Schedule (Spring 2020)

Date	Content
8 May	Introduction
15 May	Coarse neuroanatomy
22 May	C
29 May	N
5 June	N
12 June	N
19 June	V
26 July	A
3 July	T
10 July	S
17 July	A
24 July	E

- I will post slides on the date specified.

- I will also try to post a video lecture (it might be a day later).

- Video lecture will contain:
  a) examples from the slides
  b) answers to questions from students

Schedule (Spring 2020)

Date	Content
8 May	Introduction
15 May	Coarse neuroanatomy
22 May	C
29 May	N
5 June	N
12 June	N
19 June	V
26 July	A
3 July	-
10 July	S
17 July	A
24 July	E

QUIZZES

I will upload short quizzes (15 minutes) on PANDAS about content from the lectures/slides.

There will be about 10 quizzes for the whole semester.

You can do the quizzes any time and you can use any materials you like.

Schedule (Spring 2020)

Date	Content
8 May	Introduction
15 May	Coarse neuroanatomy
22 May	C
29 May	N
5 June	N
12 June	N
19 June	V
26 July	A
3 July	T
10 July	S
17 July	A
24 July	E

RESEARCH ESSAY

You must write a 2 page research essay about a neuroscience topic of your choice.

This essay will be due a the end of the semester.

Grading/Evaluation

80% – Quizzes (8 points / quiz)

20% - Research Essay

I will post “discussion questions” on PANDA (usually referring to material in the lectures).

There will be a forum to discuss this material, and I will offer extra points for participation.

Behavioral Neuroscience B (I teach it Fall Semester)

Unit	Content
1	Introduction to higher brain functions
2	Motivation
3	Learning
4	Memory
5	Spatial memory and navigation
6	Executive functions / planning
7	Emotions
8	Reproductive behavior
9	Communication
10	Human Language / Language disorders
11	Social interaction
12	Evolution and Development
13	Neurological and psychiatric disorders
14	Behavioral treatment strategies

Research Essay

Choose 1 Topic from a list of topics
(or – propose your own related to class material)

Write about 2 A4 pages. It does not have to be exactly 2 pages. It can be 1½ or 2½ if you need to add figures or explanations, or you think you have enough.

Reasonable sized text, reasonable spacing. You can include (reasonable) figures/images/charts. Cite your sources (I don't care what format)

Submit as PDF on PANDA under assignment section.

Research Essay

The purpose of this is to make you learn (more) about a neuroscience topic that is not covered in class.

→ For example, maybe you want to understand how a certain drug works.
→ Or, you want to understand a new disease.
→ Or, you want to understand a new type of therapy.
→ Or, you want to understand a particular behavior.

Submit by 31 July, 23:55 PM.

Research Essay

Examples from previous year...

Behavioral neuroscience A – 2017 Essay topics

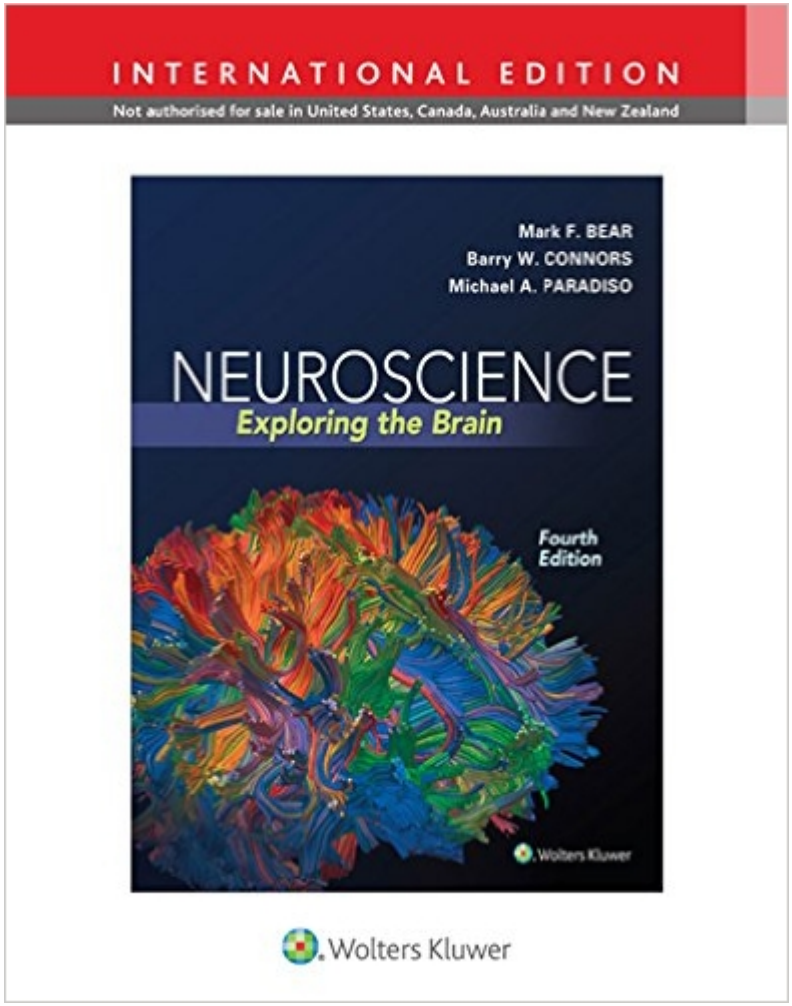
Date of the class	Topic 1	Topic 2
2017/04/28 Neurons and glia	What cells are affected by Huntington's disease? Why can its diagnosis affect the lives of a whole family?	What are treatment options for Alzheimer's disease?
2017/05/12 Neural signaling	What was the scientific achievement of Sir John Eccles (nobel prize 1963)?	Why is Apamin (found in honeybee poison) poisonous?
2017/05/19 Neurotransmitters	What was the scientific achievement of Sir Henry H. Dale (nobel prize 1936)?	What are treatment options for Schizophrenia?
2017/06/02 Methods	Describe positron emission tomography (PET). What are its merits and disadvantages?	Describe transcranial direct current stimulation (DCS). What are its merits?
2017/06/09 Vision	What factors can lead to myopia (short-sightedness)?	How good is current face recognition by computers? Is it comparable to humans?
2017/06/16 Audition	How can loud music damage your hearing?	Does human echolocation exist?
2017/06/23 Touch and pain	What is congenital insensitivity to pain?	Are there differences in the neural pathways of pain and itch?
2017/06/30 Multisensory integration	Why do you think is the car industry interested in multisensory integration?	How can other sensory modalities (smell, vision, hearing, touch) affect the taste of food?
2017/07/07 Attention	Why is resting state brain activity (measured with fMRI) interesting?	How do magicians distract their audience's attention when they perform tricks?
2017/07/14 Motion	What happens to the muscles when somebody dies?	Why is it so hard to create robots that move like humans (climbing stairs, etc.)?
2017/07/21 Movement planning	What is ataxia?	What are mirror neurons?

Literature

Bear, Connors, Paradiso
Neuroscience – Exploring the Brain

Main textbook that I used for the lecture slide materials.

You do not have to buy this book – but it is a good reference.

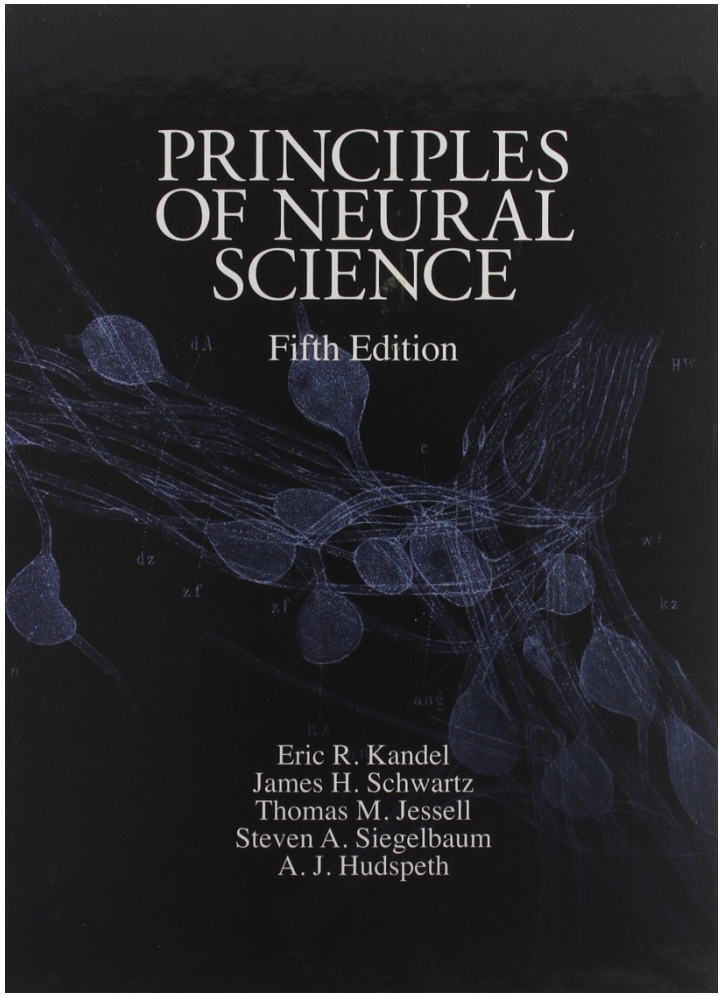


Literature

Kandel, Schwartz, Jessell, Siegelbaum, Hudspeth
Principles of Neural Science – 5th edition (2012)

Very detailed.

This is the book I used in graduate school.



Literature

Verstynen, Voytek
Do zombies dream of undead sheep?

In case you like zombies

→ c.f. David Chalmers's "philosophical zombie" (is it possible to have an identical physical body and brain which does ***not*** experience consciousness?)

*Title is a riff on Phillip K. Dick's novel "Do androids dream of electric sheep" – Basis for ***Bladerunner***