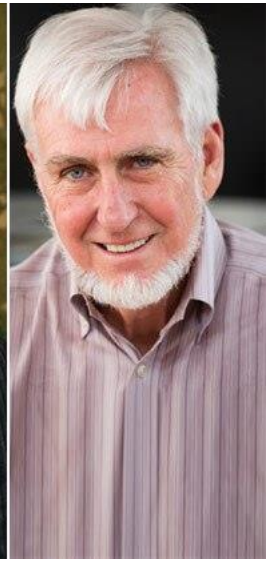
Positioning system in the brain

Valuthy Karunakaran
Sara Maisonhaute

May-Britt Moser



Edvard I. Moser

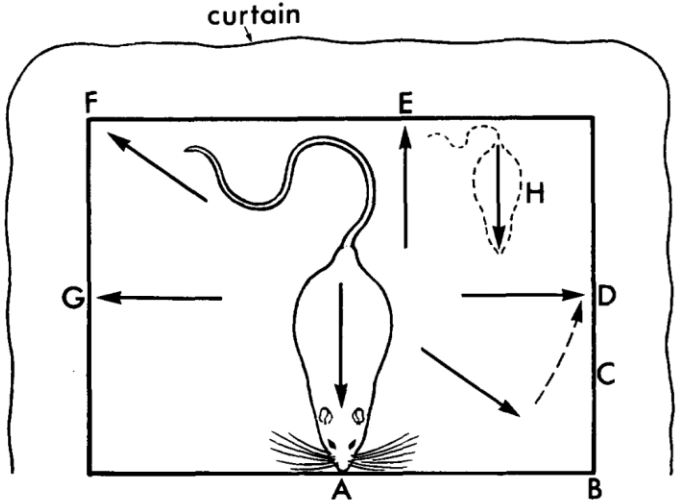
John O'Keefe

2014 Nobel Prize in Physiology or Medicine

- Importance of place cells in the positioning system. (John O'Keefe)
- Functioning mechanics of grid cells. (May-Britt Moser and Edvard I. Moser)

O'Keefe in 1971 and 1975

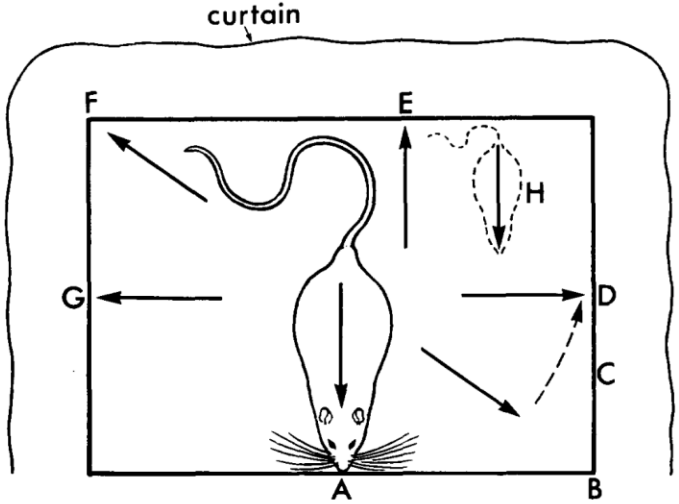
- Freely **moving rat** in a room



Publications:
The hippocampus as a spatial map (1971),
Place Units in the Hippocampus of the Freely Moving Rat (1975)
By John O'Keefe

O'Keefe in 1971 and 1975

- Freely **moving rat** in a room
- Electrodes placed in **hippocampus**



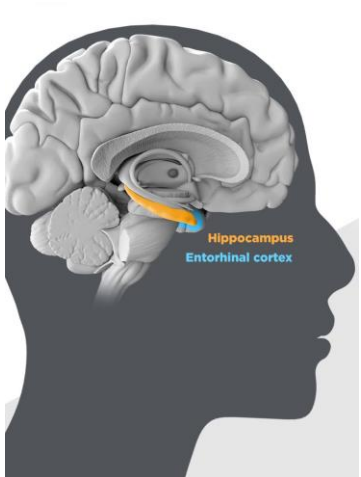


Image from the Nobel price press publication

Publications:
The hippocampus as a spatial map (1971),
Place Units in the Hippocampus of the Freely Moving Rat (1975)
By John O'Keefe

O'Keefe in 1971 and 1975

- Freely **moving rat** in a room
- Electrodes placed in **hippocampus**
- **Experiment**:
  - Measurement of firing rates
  - Changes in features of the room
  - Showing existence of a cognitive map

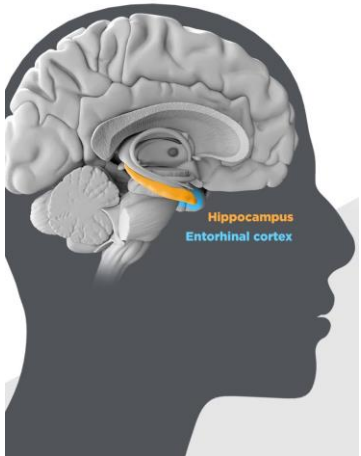
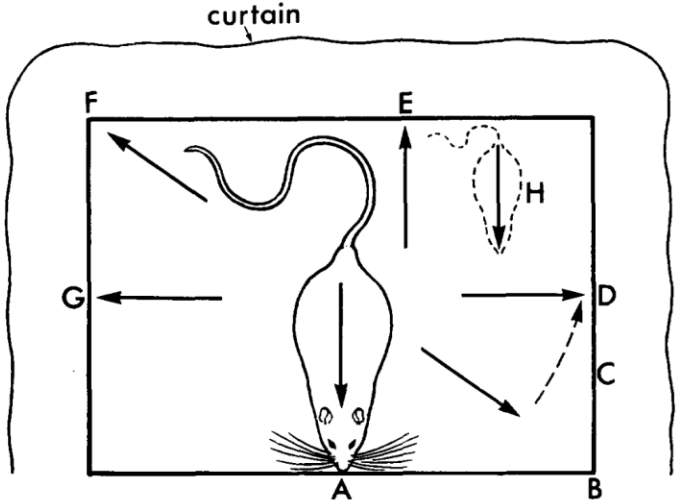
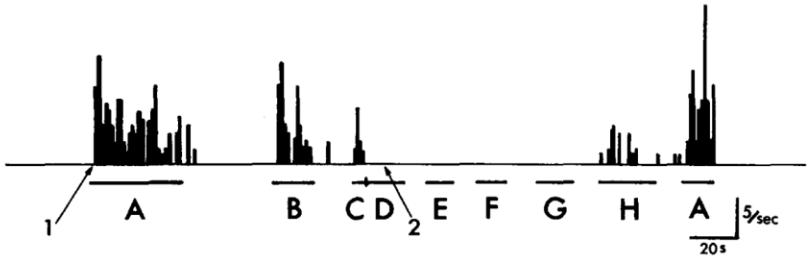


Image from the Nobel price press publication





Publications:
The hippocampus as a spatial map (1971),
Place Units in the Hippocampus of the Freely Moving Rat (1975)
By John O'Keefe

Place cells fire based on position and orientation

From from Artem Kirsanov's YT video

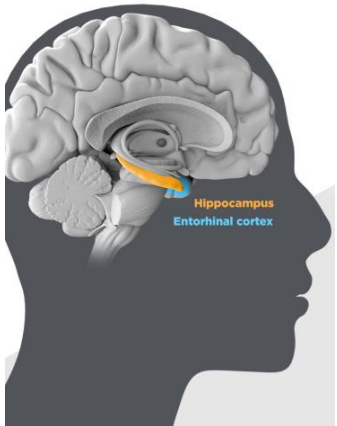
May-Britt and Edvard Moser in 2004 and later

- Damaged hippocampus still allows navigation, how ?

Publications:
Spatial Representation in the Entorhinal Cortex (2004) - Marianne Fyhn et al.,
Microstructure of a spatial map in the entorhinal cortex (2005) - Torkel Hafting et al.,
Conjunctive Representation of Position, Direction, and Velocity in Entorhinal Cortex (2006) - Francesca Sargolini et al.

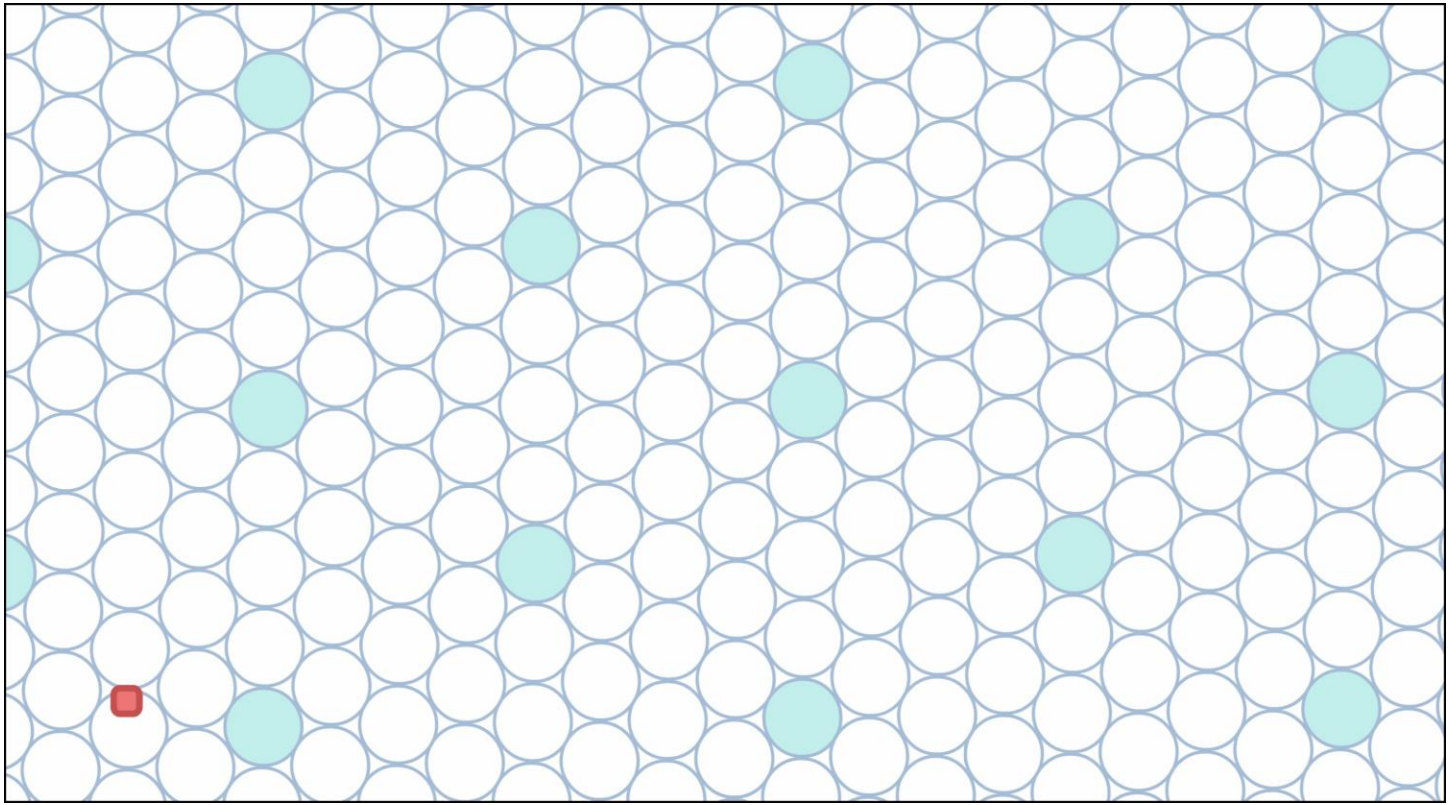
May-Britt and Edvard Moser in 2004 and later

- Damaged hippocampus still allows navigation, how ?
- Measuring activity in **Entorhinal cortex**
- **Experiment**:
  - Identify spatially attuned cells and their topology
  - Understand spatial representation independently of place cells



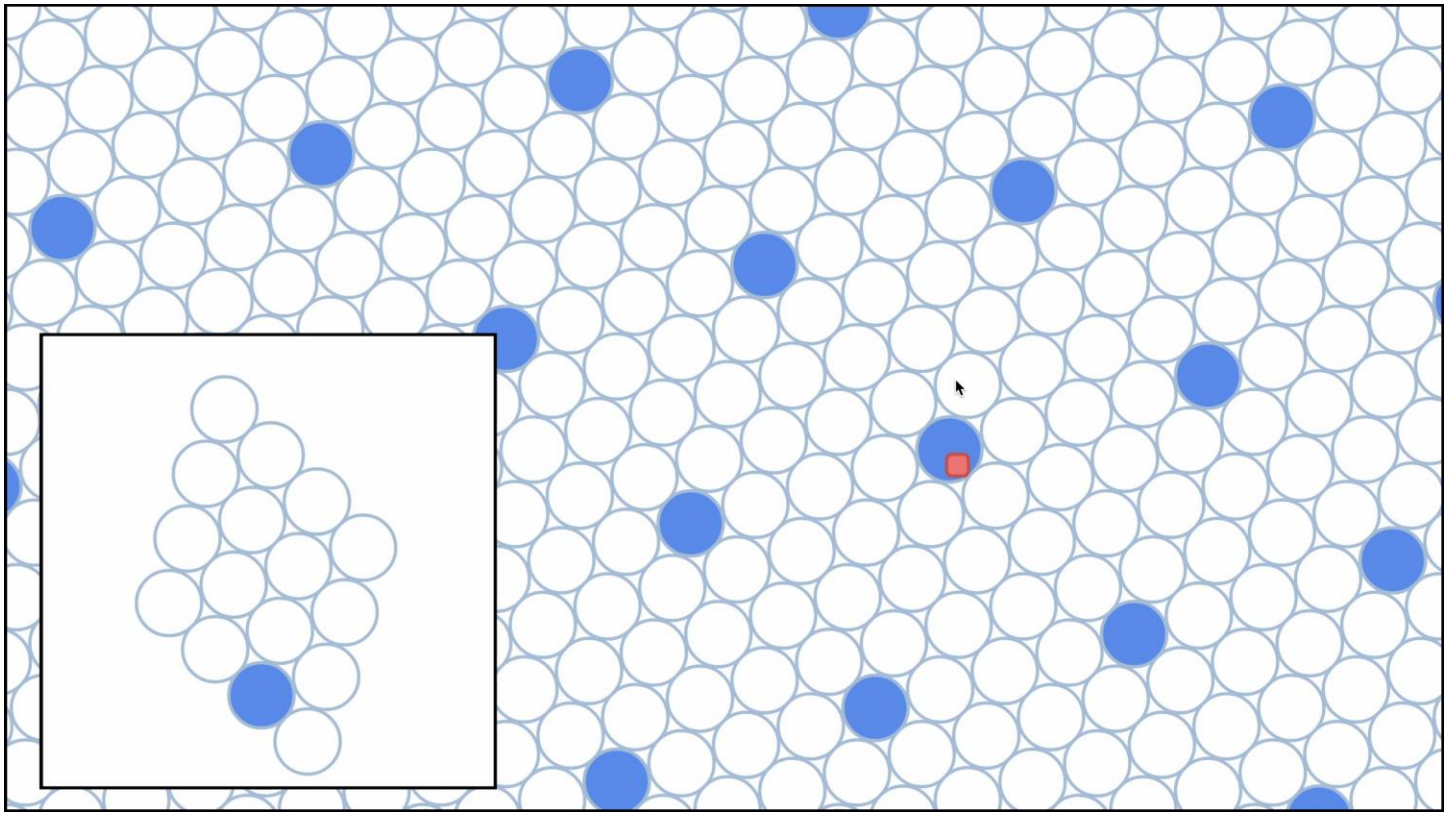
Publications:
Spatial Representation in the Entorhinal Cortex (2004) - Marianne Fyhn et al.,
Microstructure of a spatial map in the entorhinal cortex (2005) - Torkel Hafting et al.,
Conjunctive Representation of Position, Direction, and Velocity in Entorhinal Cortex (2006) - Francesca Sargolini et al.

Using one grid cell



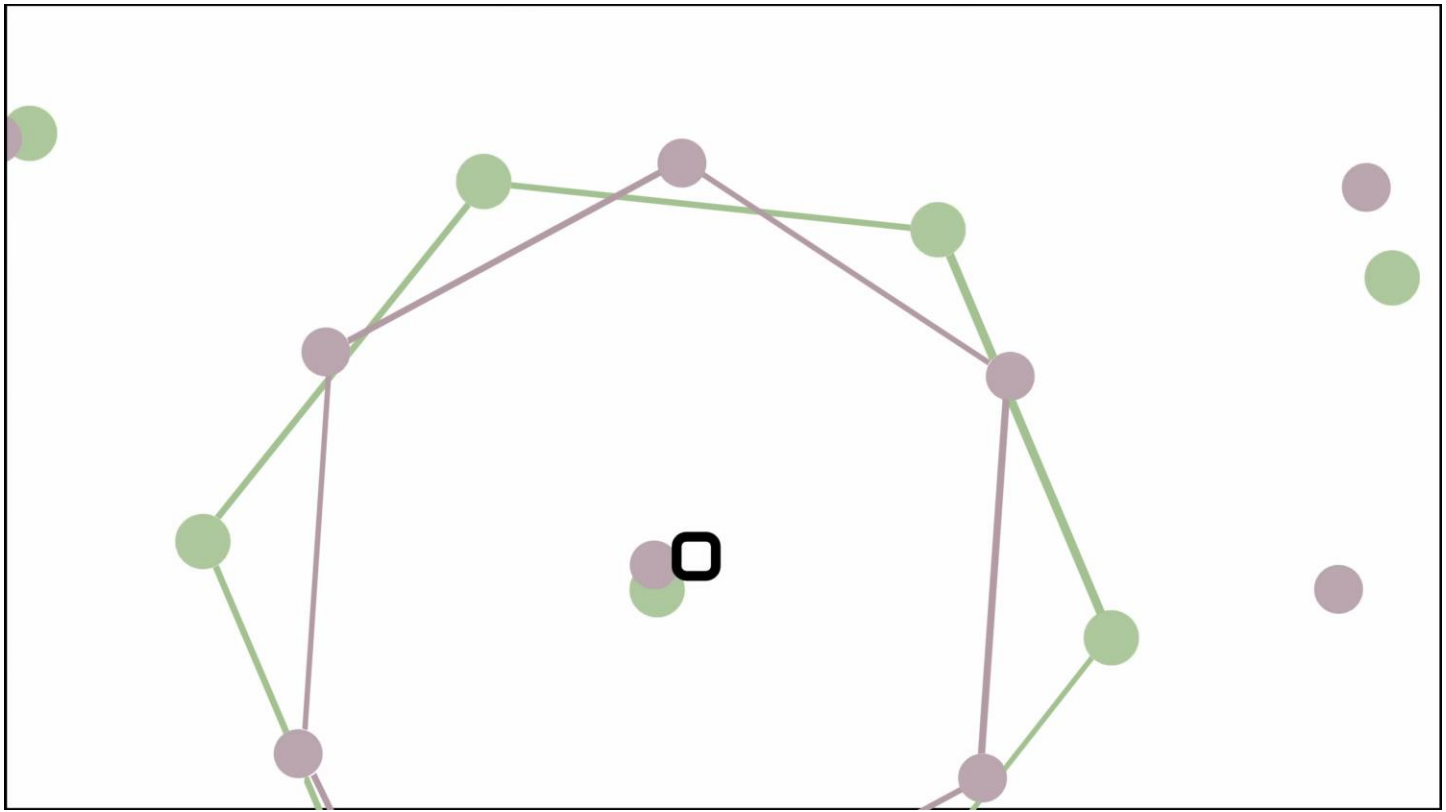
https://www.numenta.com/blog/2018/05/25/how-grid-cells-map-space/

Using a single grid cell module



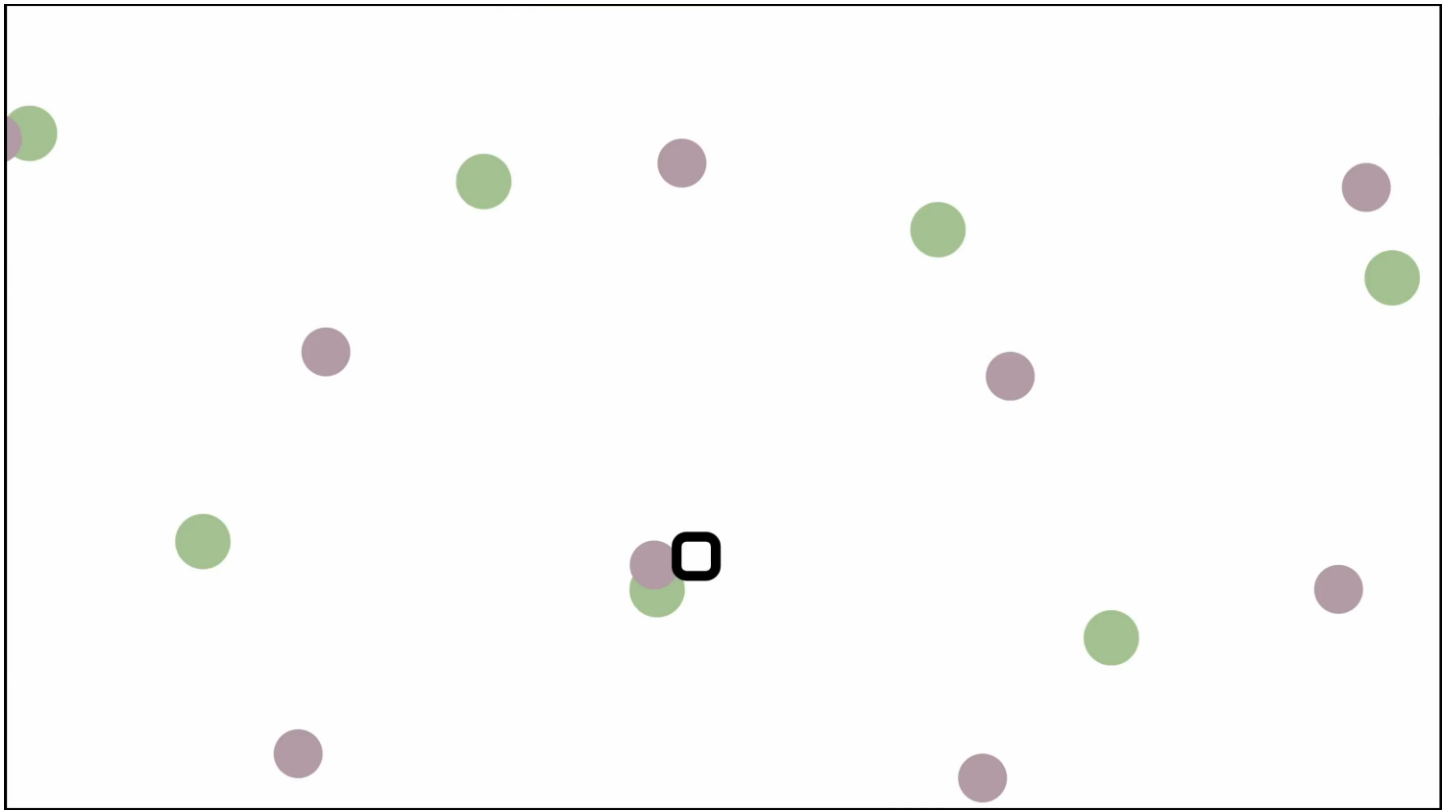
https://www.numenta.com/blog/2018/05/25/how-grid-cells-map-space/

Using 2 grid cell modules



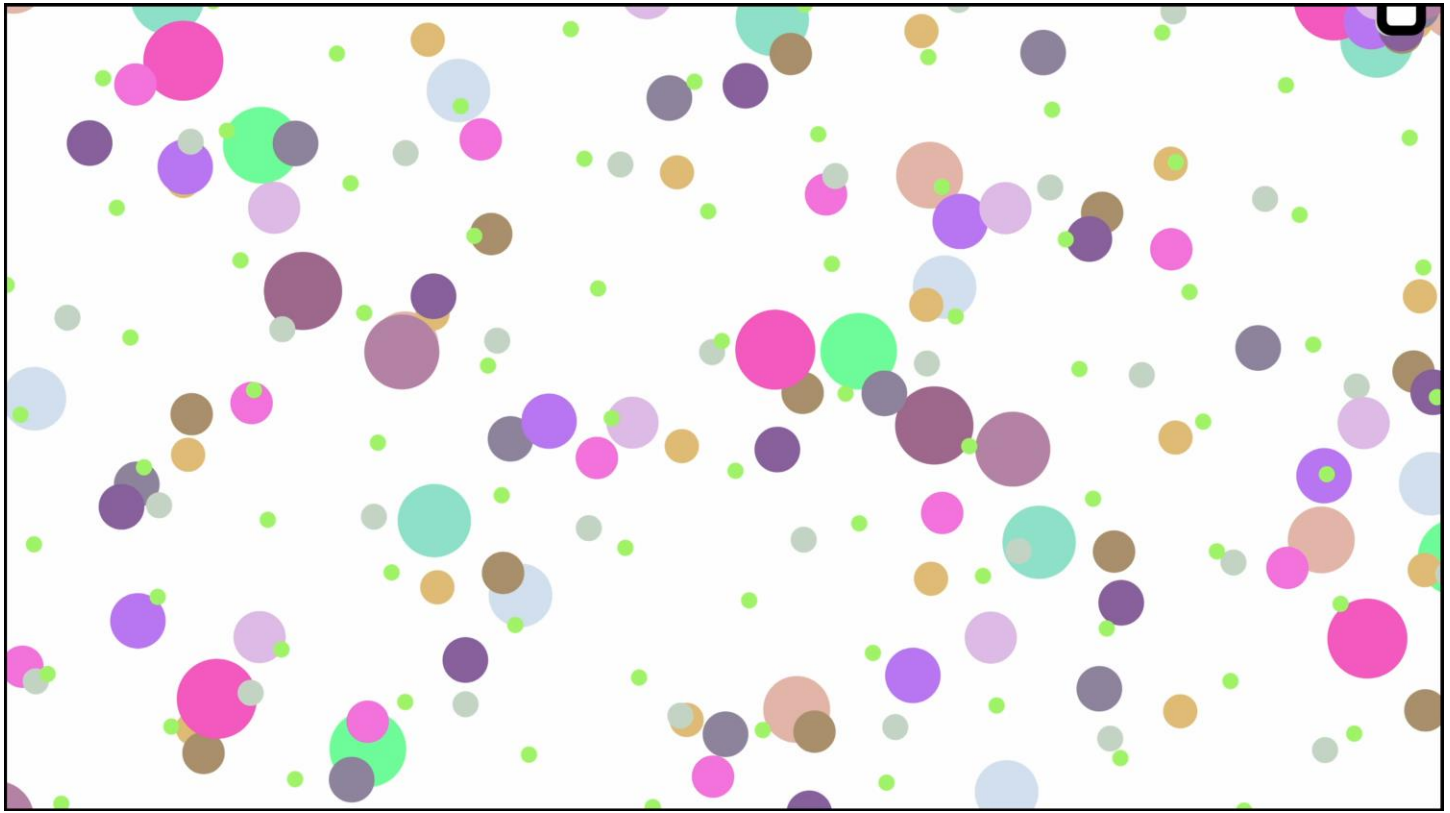
https://www.numenta.com/blog/2018/05/25/how-grid-cells-map-space/

Using 2 grid cell modules



https://www.numenta.com/blog/2018/05/25/how-grid-cells-map-space/

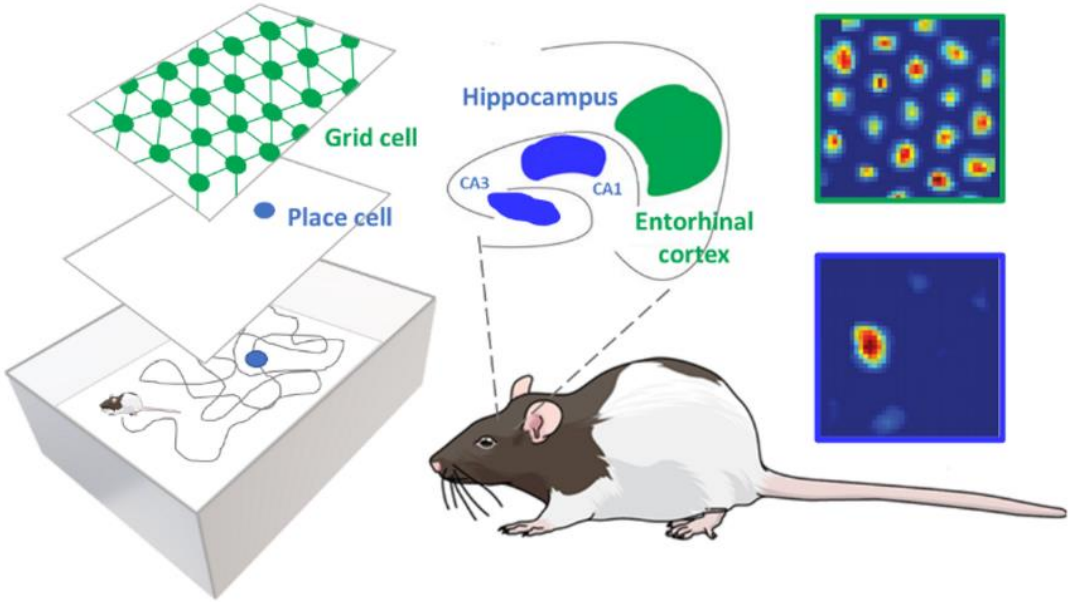
Using 16 grid cell modules



https://www.numenta.com/blog/2018/05/25/how-grid-cells-map-space/

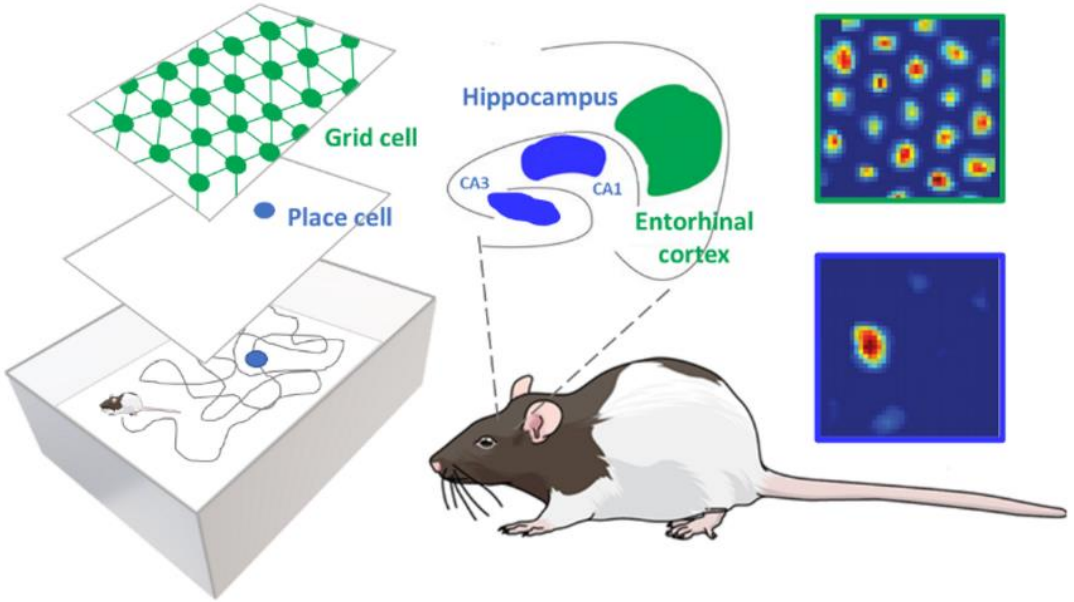
MEC and hippocampus

- Location information is already transformed in **MEC**



MEC and hippocampus

- Location information is already transformed in **MEC**
- **Hippocampus** more for memory and stabilization of the representation rather than location itself



Conclusion and take-home

- The **hippocampus** and the **entorhinal cortex** are key in our navigational abilities.
- **Place cells** are in the hippocampus, they remember and recognize specific and important places.
- **Grid cells** are in the EC and serve as inputs to place cells, they provide location information by integrating relative movements. This is why the hippocampus is not essential for navigation.
- All of this, among others works together to create a **cognitive map** in the brain

www.reddit.com/r/RATS/comments/15ljfzx/cutest_rat_in_the_sub