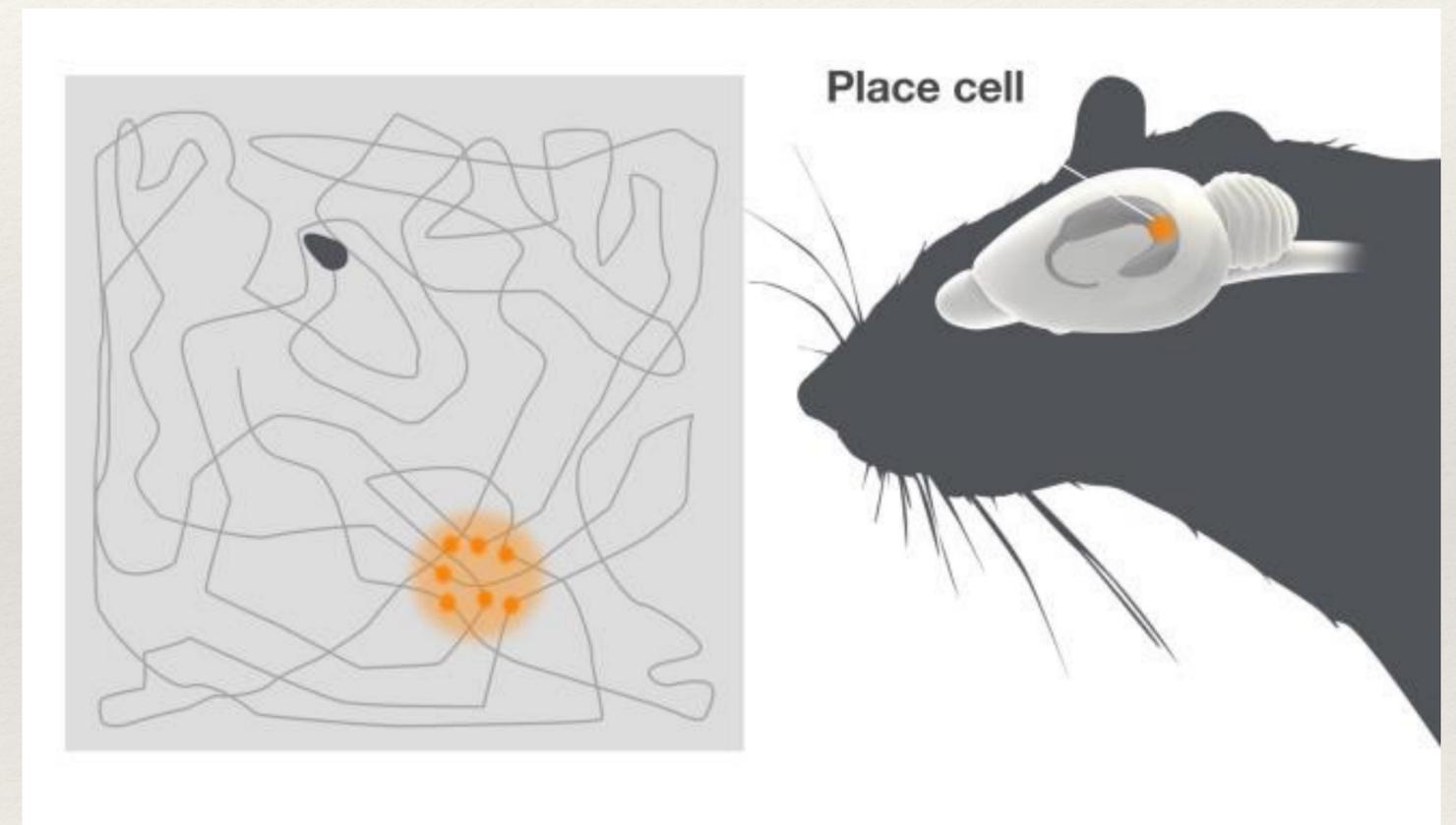


# **The 2014 Nobel Prize in Physiology or Medicine**

The 2014 Nobel Prize in Physiology or Medicine  
with one half to  
**John O'Keefe**  
and the other half jointly to  
**May-Britt Moser and Edvard I. Moser**  
for their discoveries of cells that constitute a positioning  
system in the brain

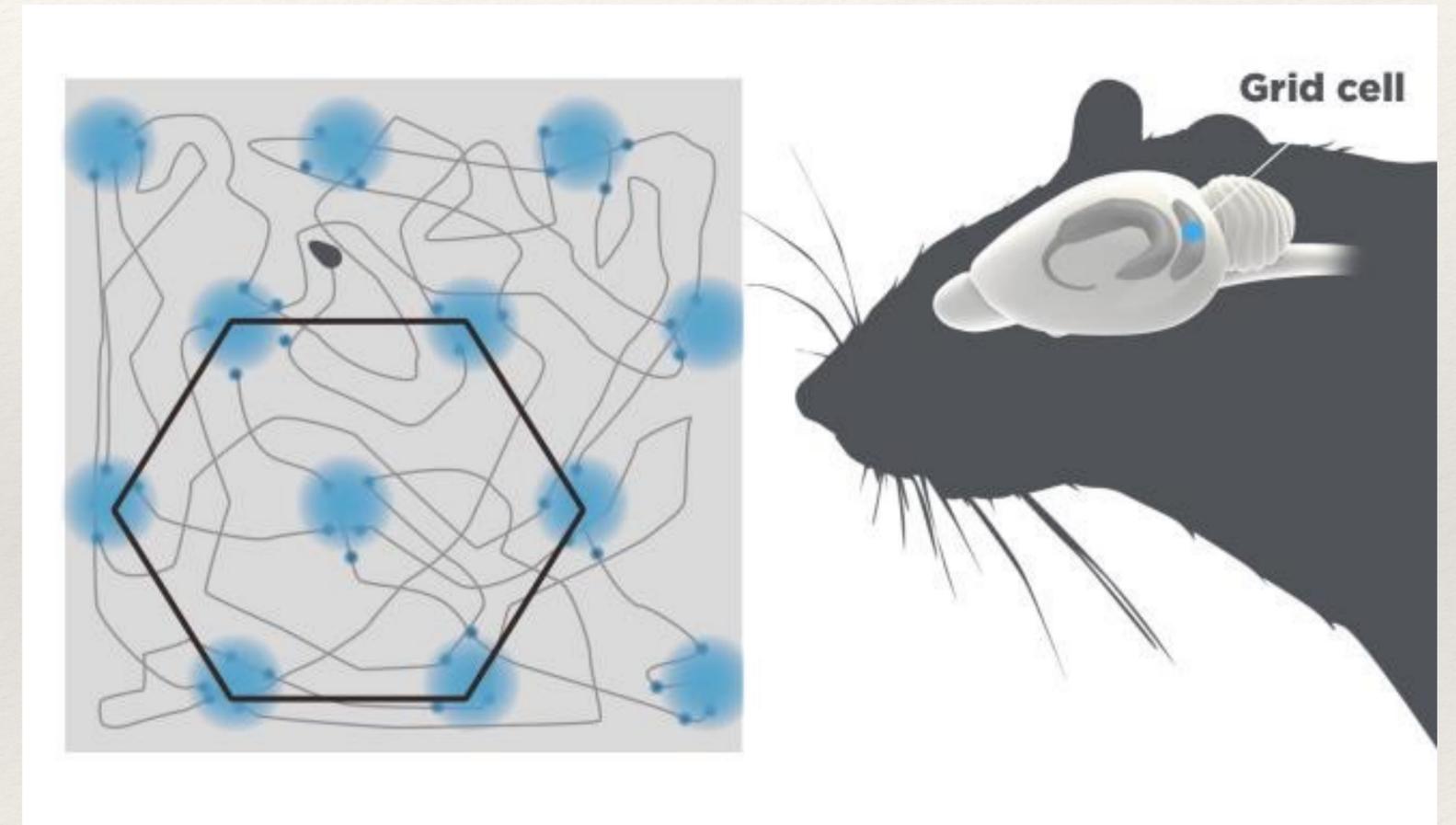
# Place cells

- 1971: John O'Keefe
- location: dorsal partition of hippocampus, called CA1
- activation: only in a particular place
- as result: internal neural map
- hippocampus can contain multiple maps
- place cells might have memory functions



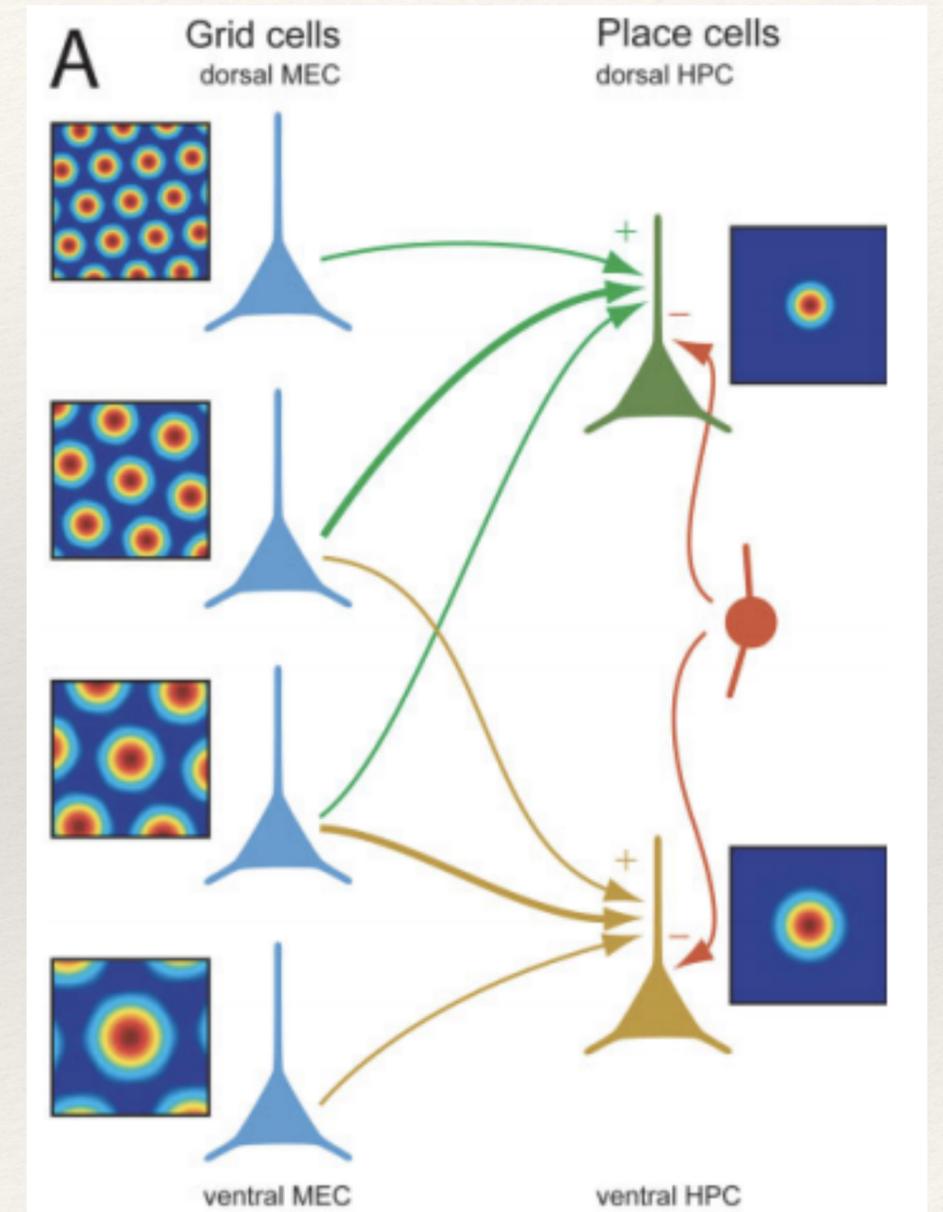
# Grid cells

- 2005: May-Britt Moser  
Edvard Moser
- location: medial entorhinal cortex
- activation: in multiple place
- as result: extended hexagonal grid



# Relationship between grid and place cells

- ❖ The first idea: place fields of hippocampal pyramidal cells are formed by linear summation of appropriately weighted inputs from entorhinal grid cells. (“From Grid Cells to Place Cells: A Mathematical Model”, 2006)
- ❖ Place cell spatial firing patterns are determined by environmental sensory inputs, including those representing the distance and direction to environmental boundaries, while grid cells provide a complementary self-motion related input that contributes to maintaining place cell firing. (“What do grid cells contribute to place cell firing?”, 2014)



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# Relevance for humans and medicine

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place and grid cells play key role in episodic memory  
the episodic memory is affected in several brain disorders

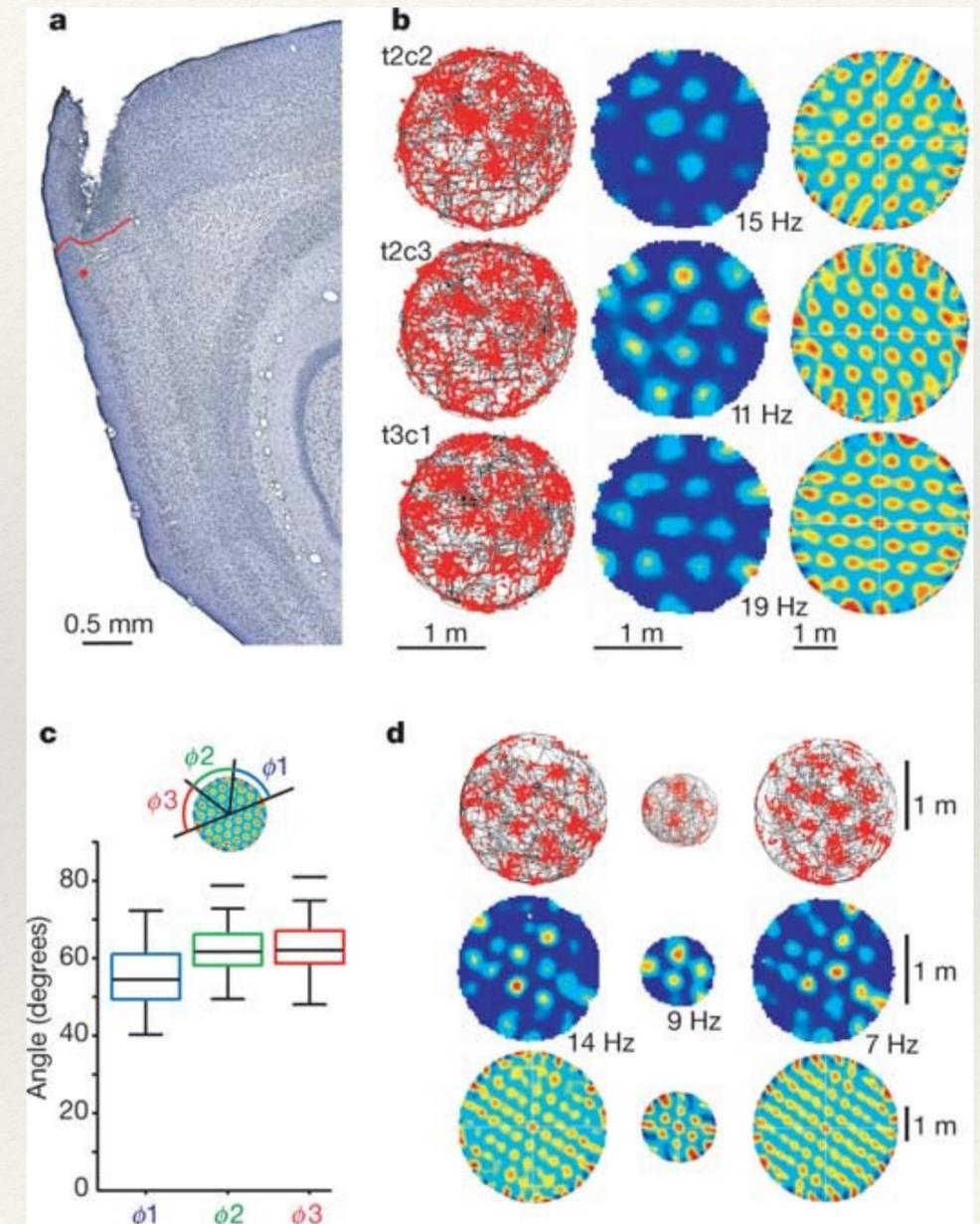
# Microstructure of a spatial map in the entorhinal cortex

Authors: Torkel Hafting, Marianne Fyhn, Sturla Molden, May-Britt Moser & Edvard I. Moser

presented by: Lisa Yankovskaya

# Grid cells have tessellating firing fields

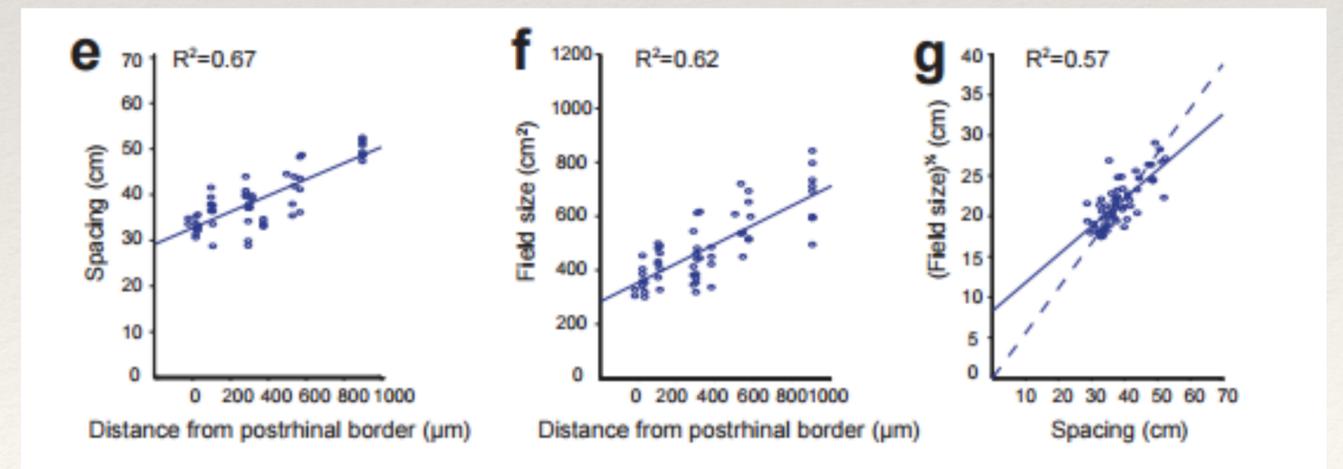
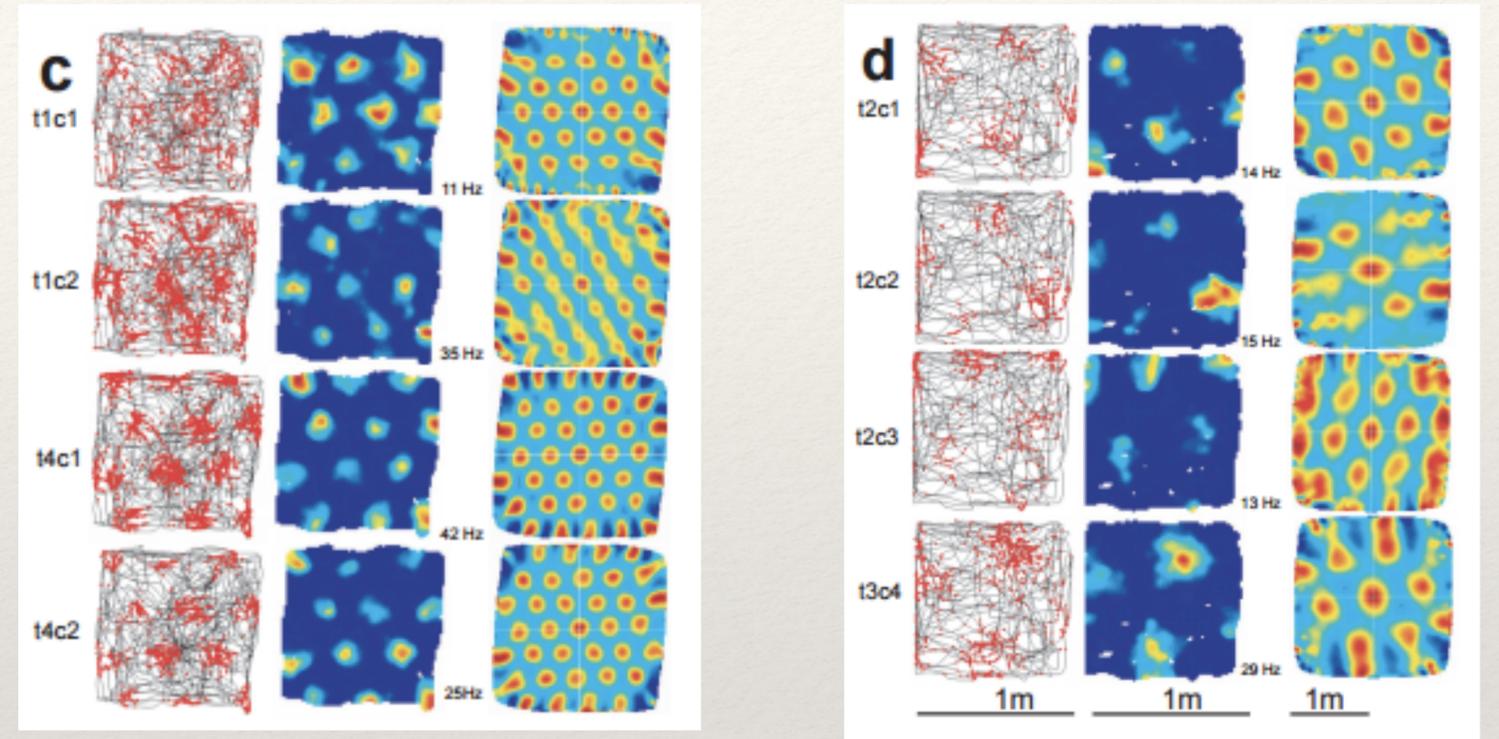
- ❖ Experiment: six rats, 45 neurons, circular enclosure with a diameter of 2 m.
- ❖ Distance from the central peak of the autocorrelogram to the nearest six peaks was nearly constant for one firing grid.
- ❖ Distances in different cells are various: from 39 to 73 cm,  $sd = 3.2$  cm.
- ❖ The angular separation of the vertices of the inner hexagon was in multiples of  $60^\circ$  ( $sd = 7.1^\circ$ ).
- ❖ Scaling: number of activity nodes increased, but their density remained constant.



Microstructure of a spatial map in the entorhinal cortex

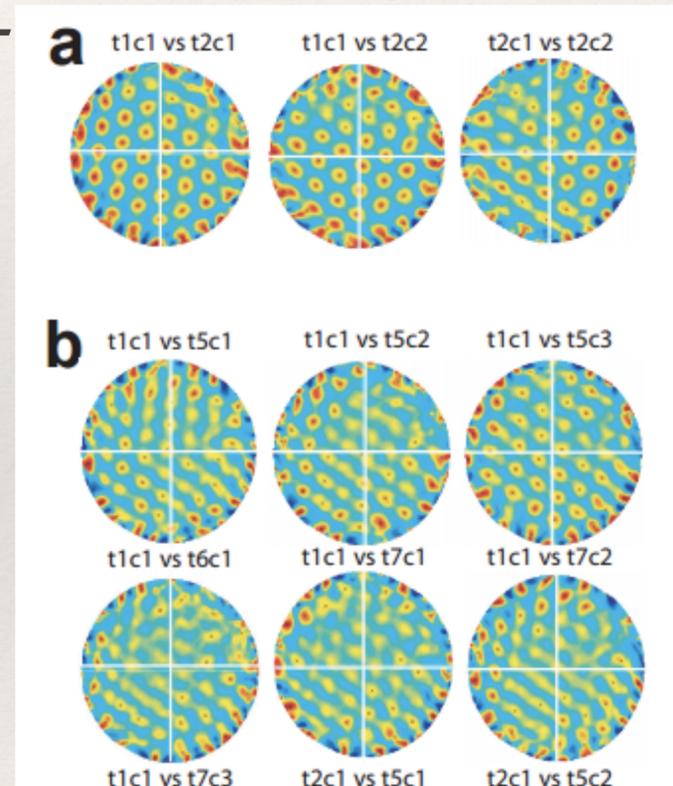
# Grid cells are topographically organized

- ❖ Grids shared a number of metric properties: spacing, orientation and field size.
- ❖ Spacing: varied by 30 cm,  $sd = 2.1$  cm
- ❖ Orientation:  $1^\circ - 59^\circ$ ,  $sd = 1.8$  cm
- ❖ Field size: 326 - 709  $cm^2$ ,  $sd = 42$   $cm^2$
- ❖ Spacing and field size increase with distance from the postrhinal border (dorsal and ventral)

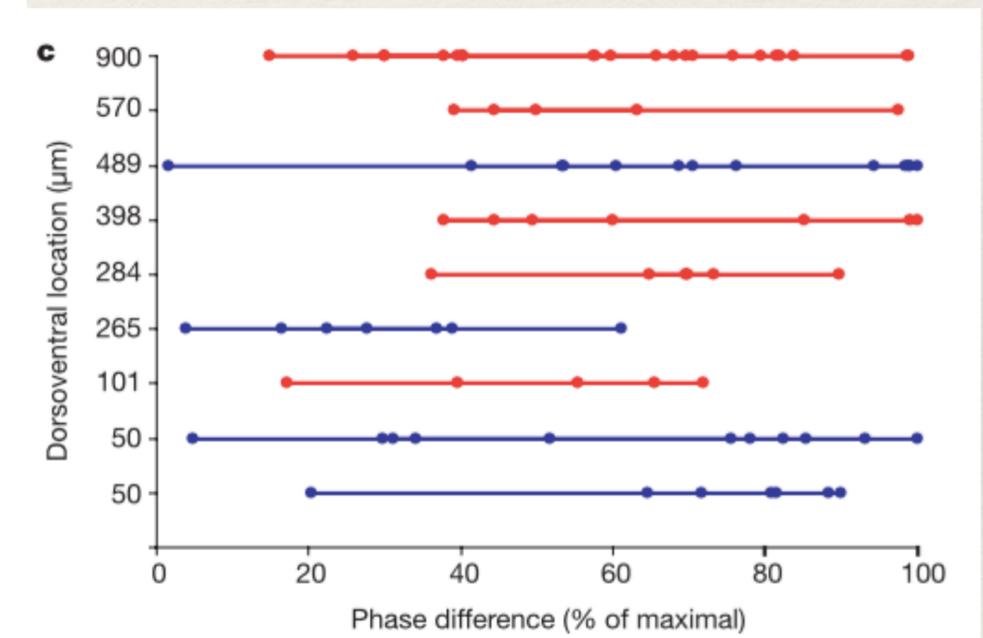


# Grid cells are topographically organized

- ❖ Cross-correlation of cells recorded at different locations (with different spacing and orientation) gave cross-correlograms with more dispersed peaks and lower peak amplitudes
- ❖ Among the co-localized cells, the average phase shift, expressed as the distance from the origin to the nearest peak in the cross-correlogram, was evenly distributed.



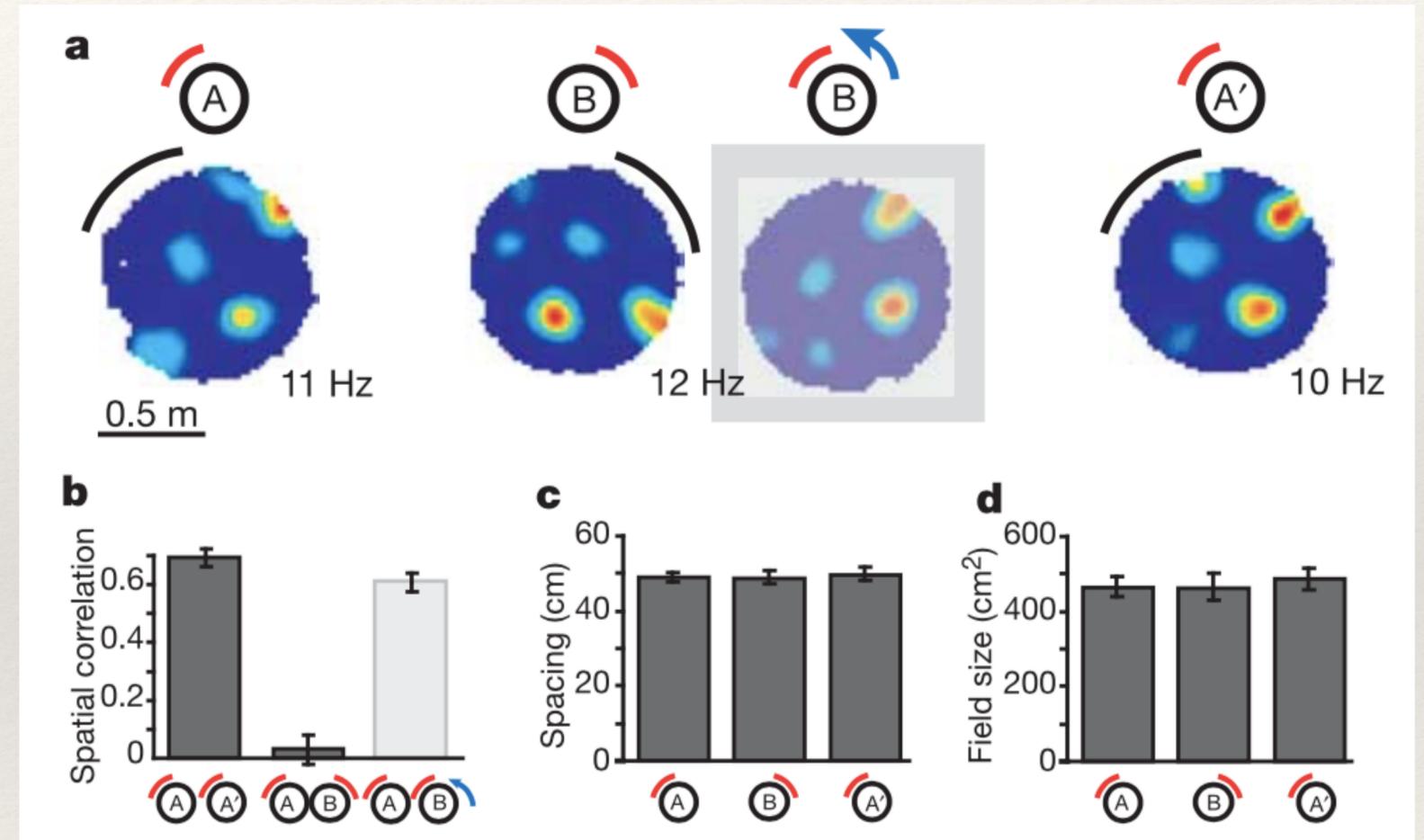
Supplementary materials: Microstructure of a spatial map in the entorhinal cortex



Microstructure of a spatial map in the entorhinal cortex

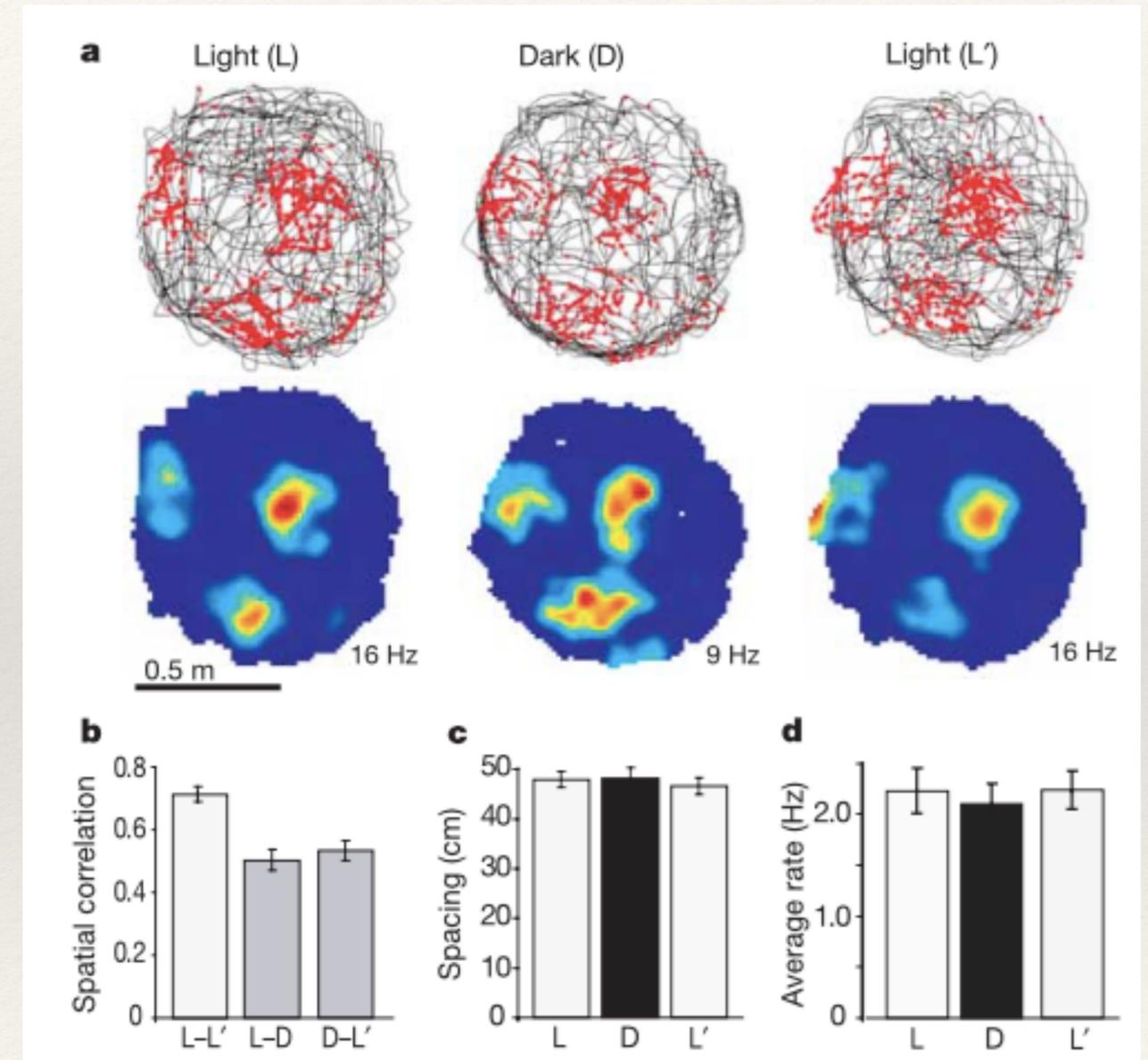
# How does the spatial map contribute to navigation?

- ❖ Experiment: three rates, 24 cells.
- ❖ Locations of discharge are determined by allothetic cues or idiothetic cues?
- ❖ Stability of the grid vertices across trials in the same enclosure suggests that allothetic cues exert a significant influence.



# Grid structure persists after cue removal

- ❖ Experiment: four rates, 33 cells.
- ❖ No significant changes in spacing of the grid, average firing rate or spatial information per spike
- ❖ Total darkness caused a weak dispersal or displacement of the vertices.



# Grid development in a novel environment

- ❖ Experiment: seven rates, 24 cells.
- ❖ May grids to a large extent be based on hardwired network mechanisms?
- ❖ There is a need a time to set phase and orientation in relation to context-specific landmarks.
- ❖ The orientation of the grid in the new room was different from the orientation in the familiar room.

