The 2014 Nobel Prize in Physiology or Medicine
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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
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)
Relevance for humans and medicine

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

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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° (sd = 7.1°).
- Scaling: number of activity nodes increased, but their density remained constant.
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°- 59°, sd = 1.8 cm
- Field size: 326 - 709 cm², sd = 42 cm²
- 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
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.