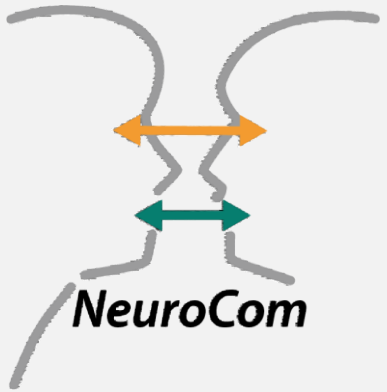
Neuroanatomy of Memory

Part 1

Derek Ott

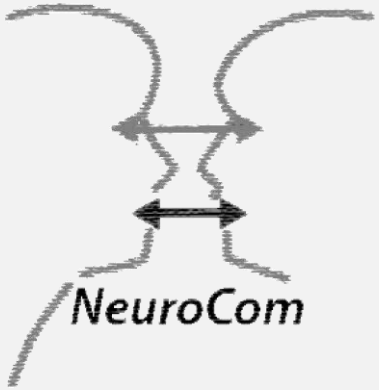
Max Planck School of Cognition
Unfallkrankenhaus Berlin

Oct 9, 2020



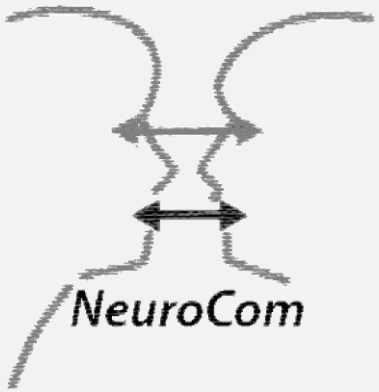
but first..:

- Who am I? [note to self: nobody's *that* interested…]
- contact: ottd@cbs.mpg.de
- literature:
  - mainly based on **Purves et al. (eds.): Neuroscience**, 6th ed. (2018)
  - corresponding pages are referenced in bottom line
  - as well as other relevant sources
  - my exam questions will be based exclusively on my slides
    (no statement or judgement about how my colleagues do it…)
- brain scan, SOCR website, MRICRON
- appoint co-moderator
- logon to kahoot! PIN: **3911590**

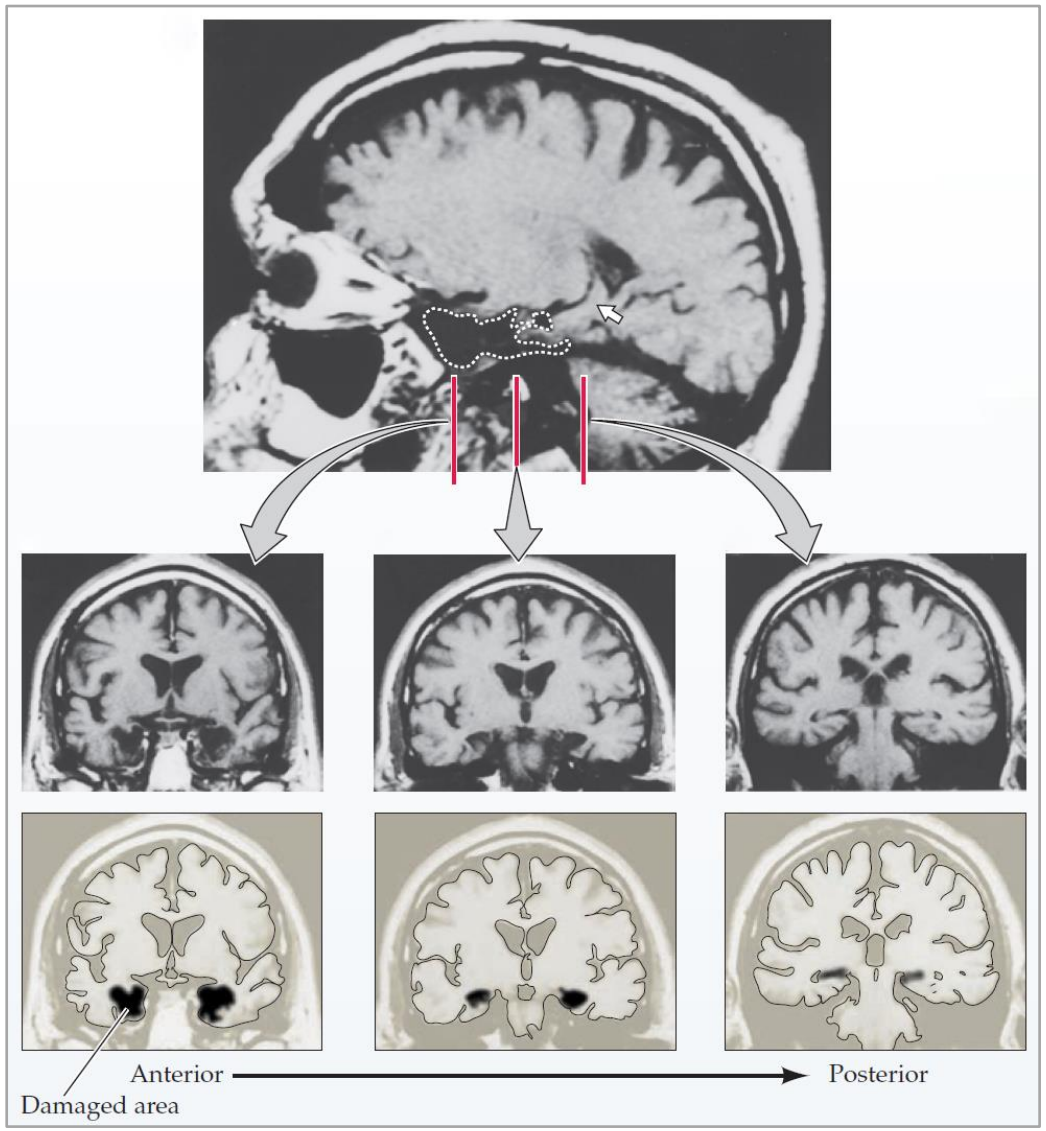


H.M.

- intractable epilepsy with recurring debilitating seizures
- at age 27, removal of both hippocampi (anterior two thirds), amygdalae, and parahippocampal gyri
- unable to retain new semantic or spatial information, but good memory of events prior to operation
- stuck in time: “March, 1953”
- studied by B. Milner for over 50 years; only felt “vague familiarity” when asked about her
- improvement in new skills (e.g. mirror drawing) with practice, but no recollection of training sessions
- memory is not a uniform capacity!
- YouTube: “What happens if you remove the hippocampus?” (TedEd)

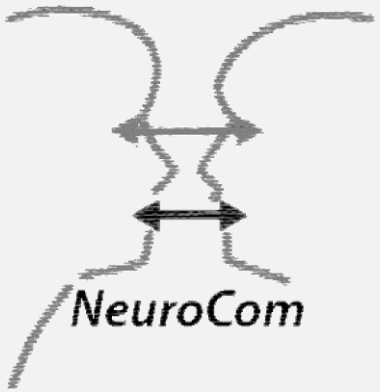


H.M.’s brain

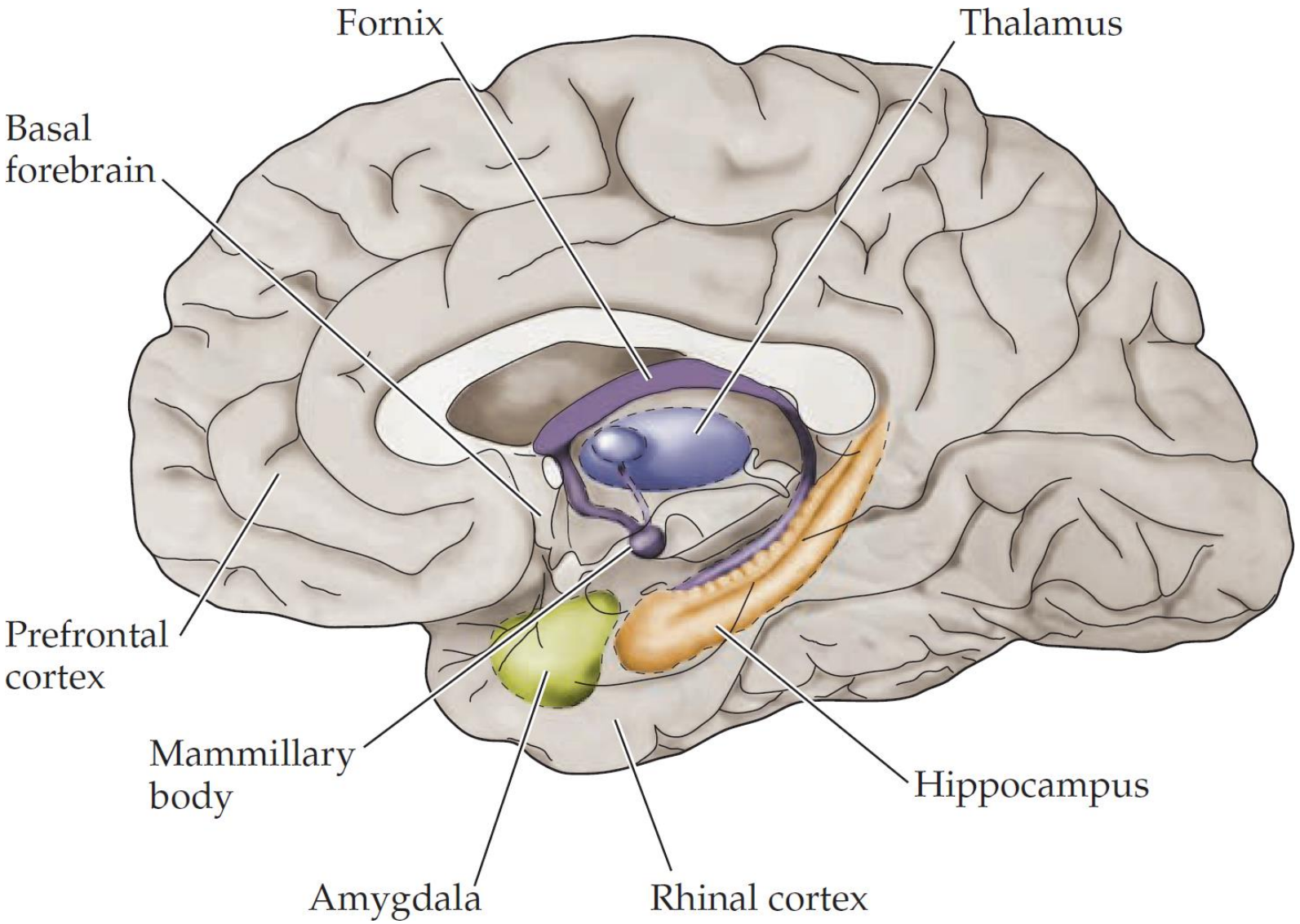


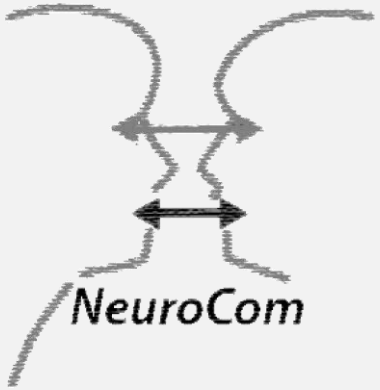
Declarative memory

- available to consciousness, expressible by language
- semantic memory (factual) vs. episodic memory (biographic)
- relies heavily on midline temporal structures, esp. hippocampus, mammillary bodies, and thalamus (“Papez circuit”)
- damage to causes anterograde amnesia (failure to encode of new information from damage onward)
- consolidated declarative memory is not dependent on hippocampus (no retrograde amnesia)
- long-term storage of “engrams” (neural correlates of memory) throughout the cortex
- PET/fMRI: recall seem to rely on cortical areas involved in perception (e.g. visual cortex in visual memories, etc.)



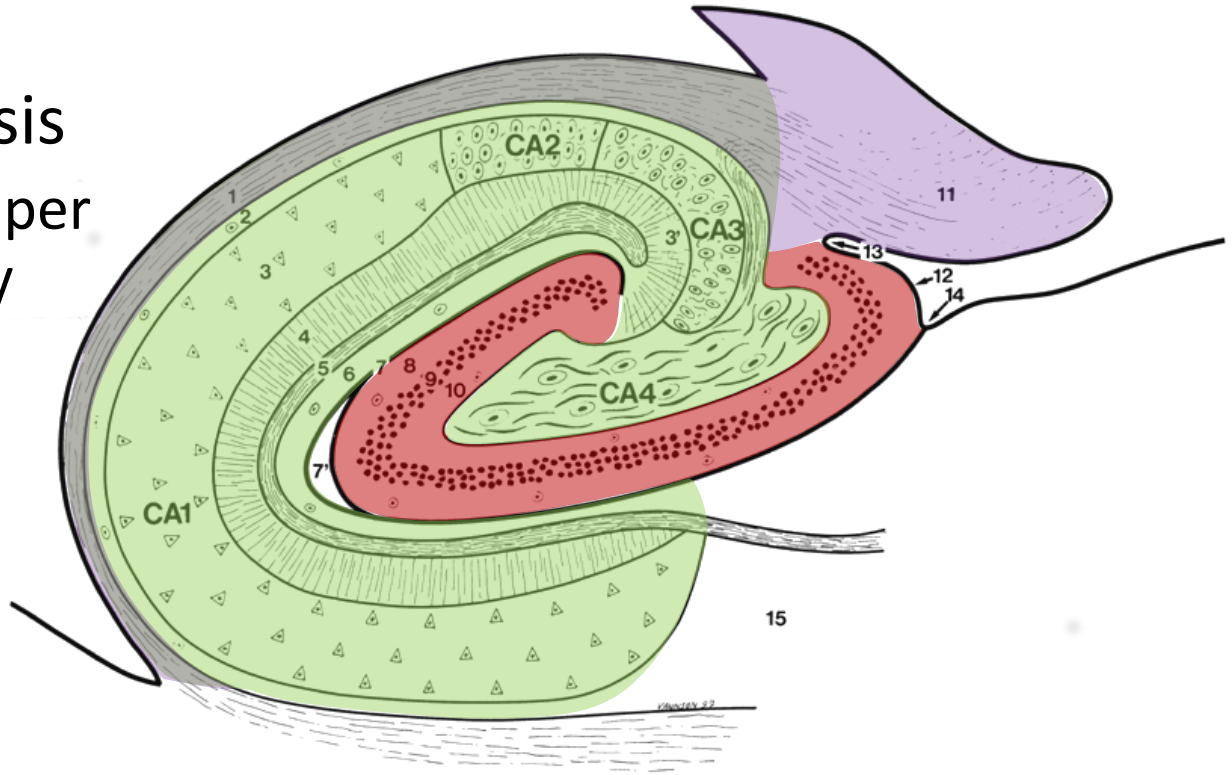
Structures involved in declarative memory



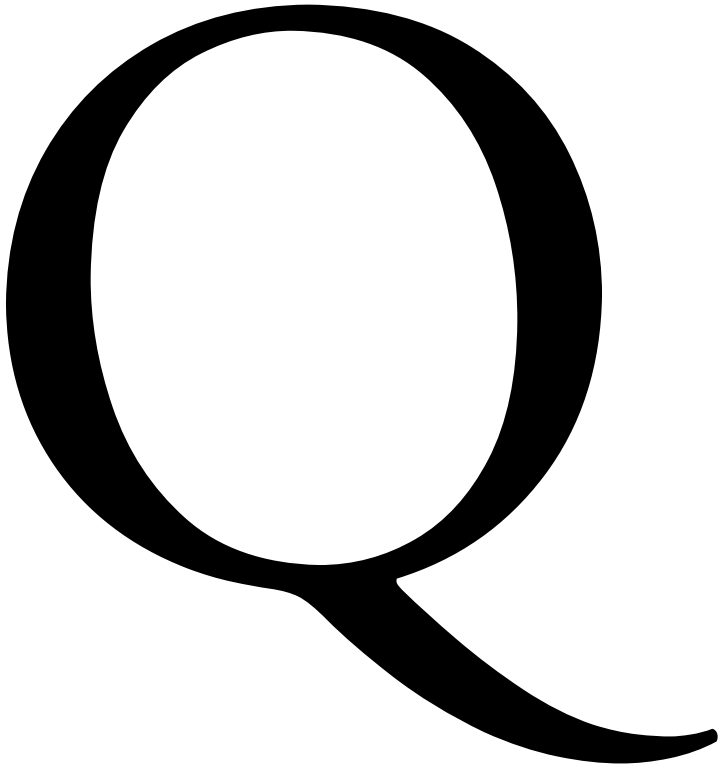


The architecture of the hippocampus

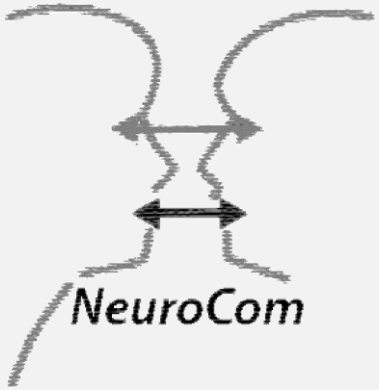
- cornu ammonis (CA, green) and dentate gyrus (red) as two intertwined “C”-shaped structures
- covered by fibers (alveus) that bundle into a flap (fimbria) (purple)
- DG: adult neurogenesis
  - approx. 700 neurons per hippocampus per day
  - equals turnover of 1.7 % mass per year
  - crucial for learning
  - susceptible to stress hormones and toxins



Questions?

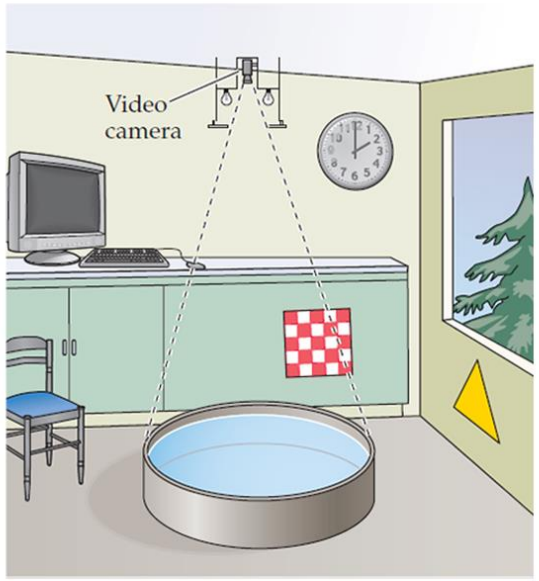


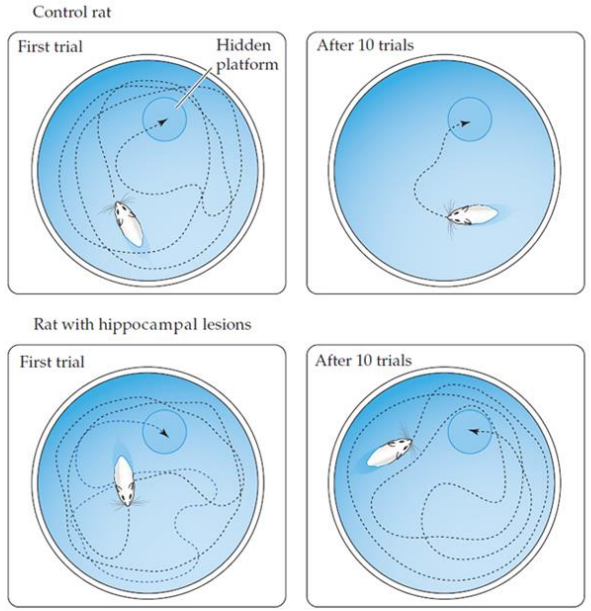
Where we ask one, we ask all.

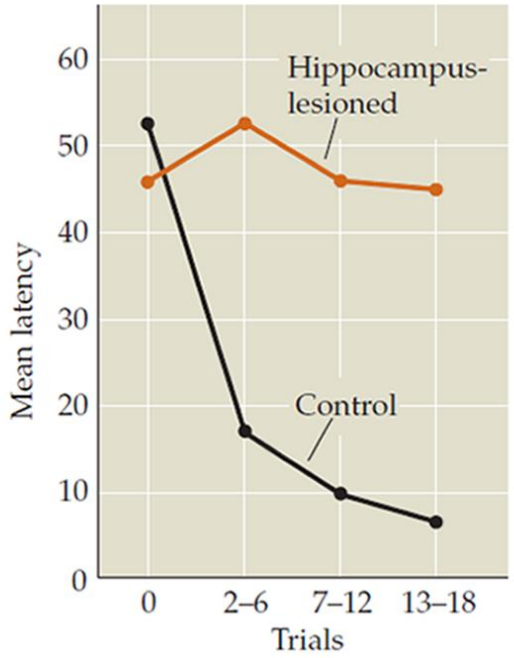


Spatial orientation

- seems to rely on the same structures as declarative memory
- Maguire: cab drivers have larger hippocampi than average
- rats with damaged hippocampi will not learn to find a submerged platform in a pool based on visual cues

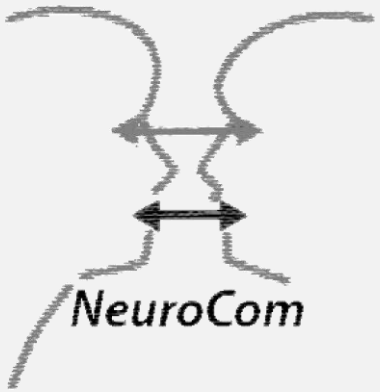






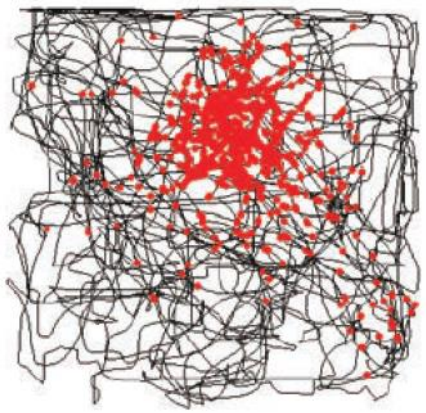
Cognitive maps, place and grid cells

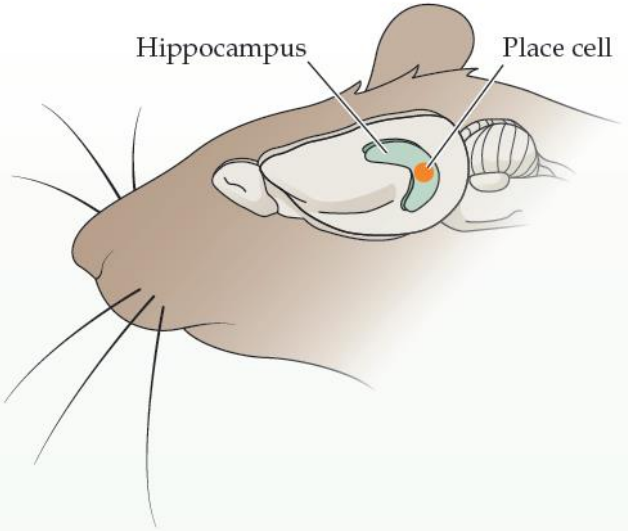
- initially two separate schools regarding hippocampal function: memory vs. spatial orientation
- E. Tolman (1940s): ‘cognitive maps’: memories are hypothesized to be organized in a contextual map, comparable to spatial orientation (“relational memory theory”)
- J. O’Keefe (1960s) finds hippocampal neurons that fire when being in a specific location (“place cells”), sensitive also to environmental features
- M.-B- and E. Moser: neurons in entorhinal cortex fired when rat was at multiple loci, establishing a hexagonal grid (“grid cells”), believed to establish a larger frame of reference
- 2014: Nobel prize for John O’Keefe, May-Britt and Edvard Moser



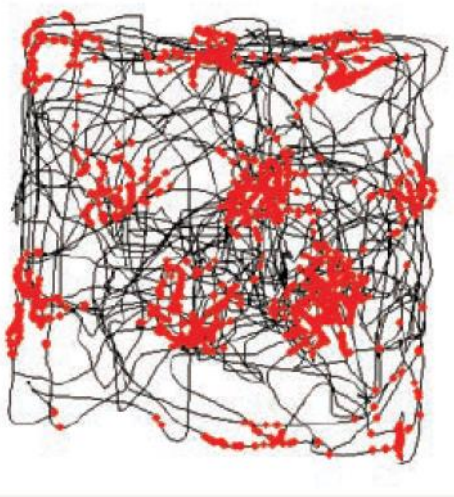
Response maps for place and grid Cells

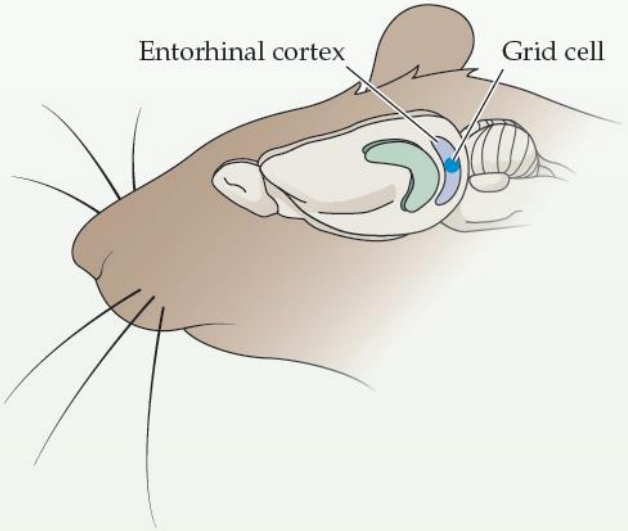
Place cells

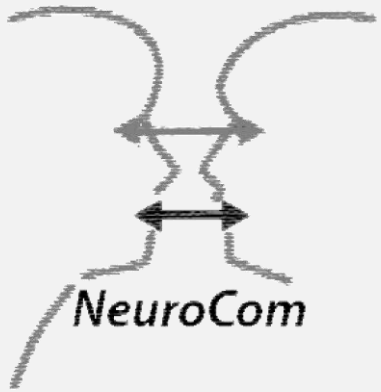




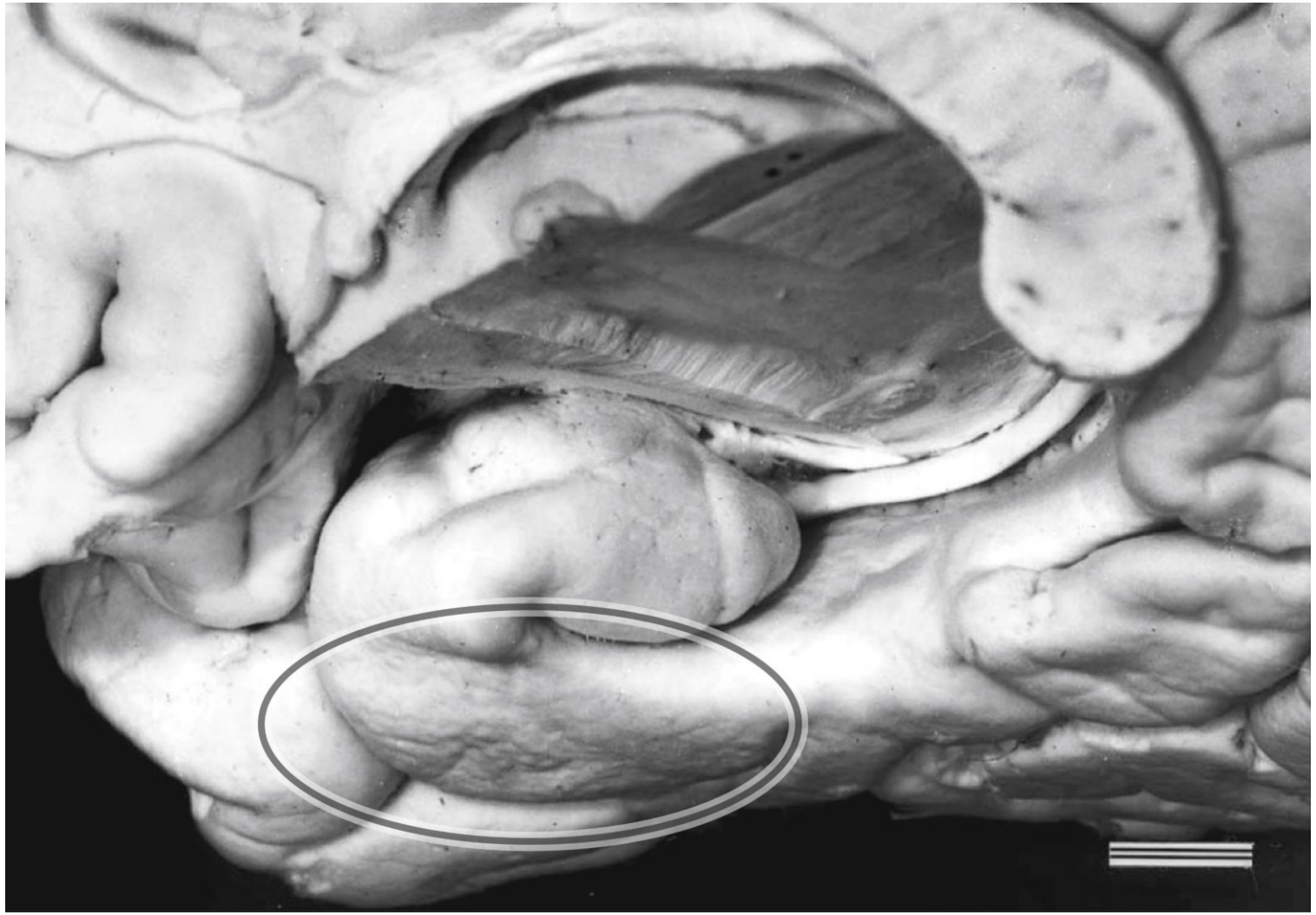
Grid cells







Human entorhinal cortex



Summary part 1

- cases as H.M. exemplify that memory is not a monolithic trait but rather a set of discernable adaptive capacities
- different brain areas support different types of learning
- declarative memory (semantic vs. episodic) is highly dependent on hippocampus for encoding and relies on continuous neurogenesis in the dentate gyrus
- hippocampal damage mostly results in anterograde amnesia
- consolidated memory has been conveyed to “engrams” distributed throughout the cortex (more resilient to damage)
- place cells (hippocampus) and grid cells (entorhinal cortex) establish “cognitive maps” for spatial and mnestic navigation