Perception in tiny nervous systems

Dendritic non-linearities

Sparse, highly overcomplete representations

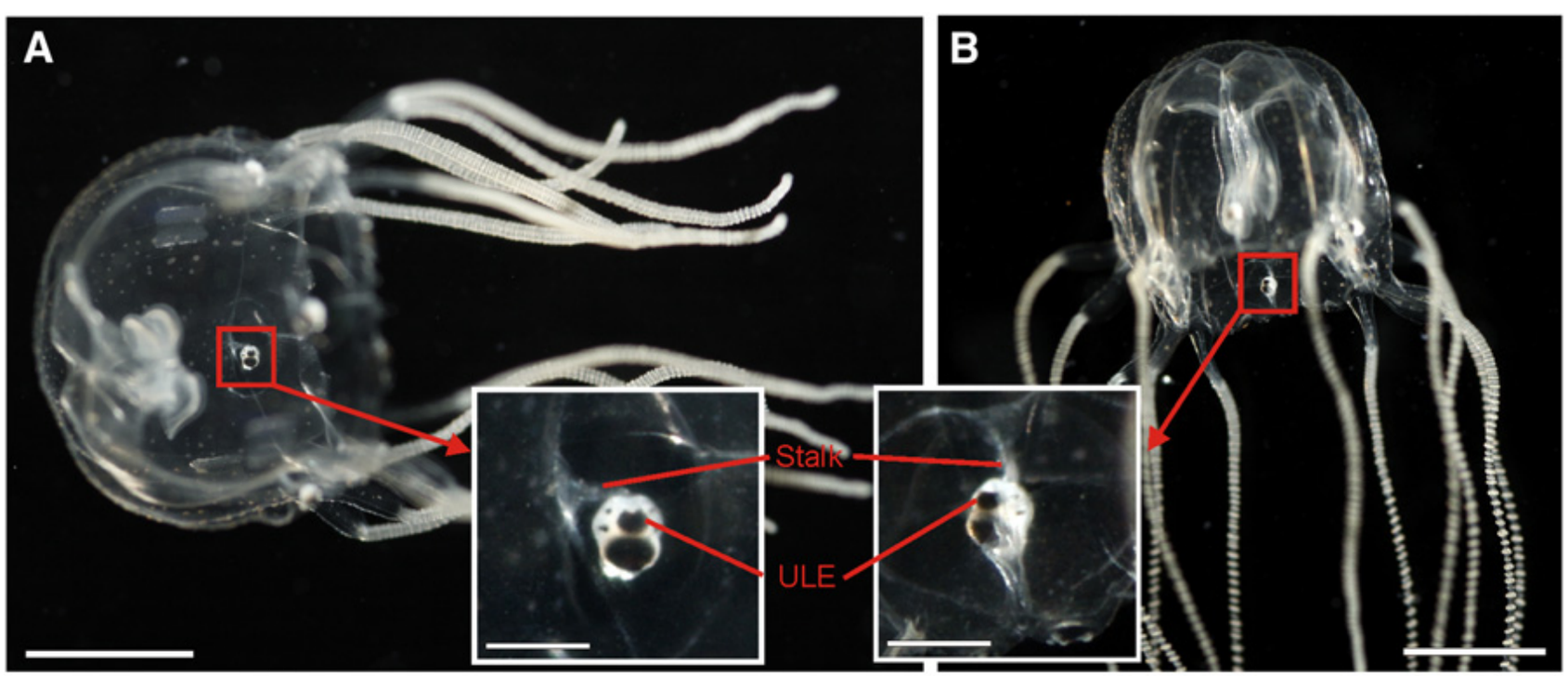
Recurrent computation in cortical circuits

Efficient storage in analog, nanoscale devices

Even ‘simple’ nervous systems can exhibit profound visual intelligence

jumping spider

sand wasp



box jellyfish

Jumping spider visual system

Current Biology *24*, 2580–2585, November 3, 2014 http://dx.doi.org/10.1016/j.cub.2014.09.029

Report

Visual Perception in the Brain of a Jumping Spider

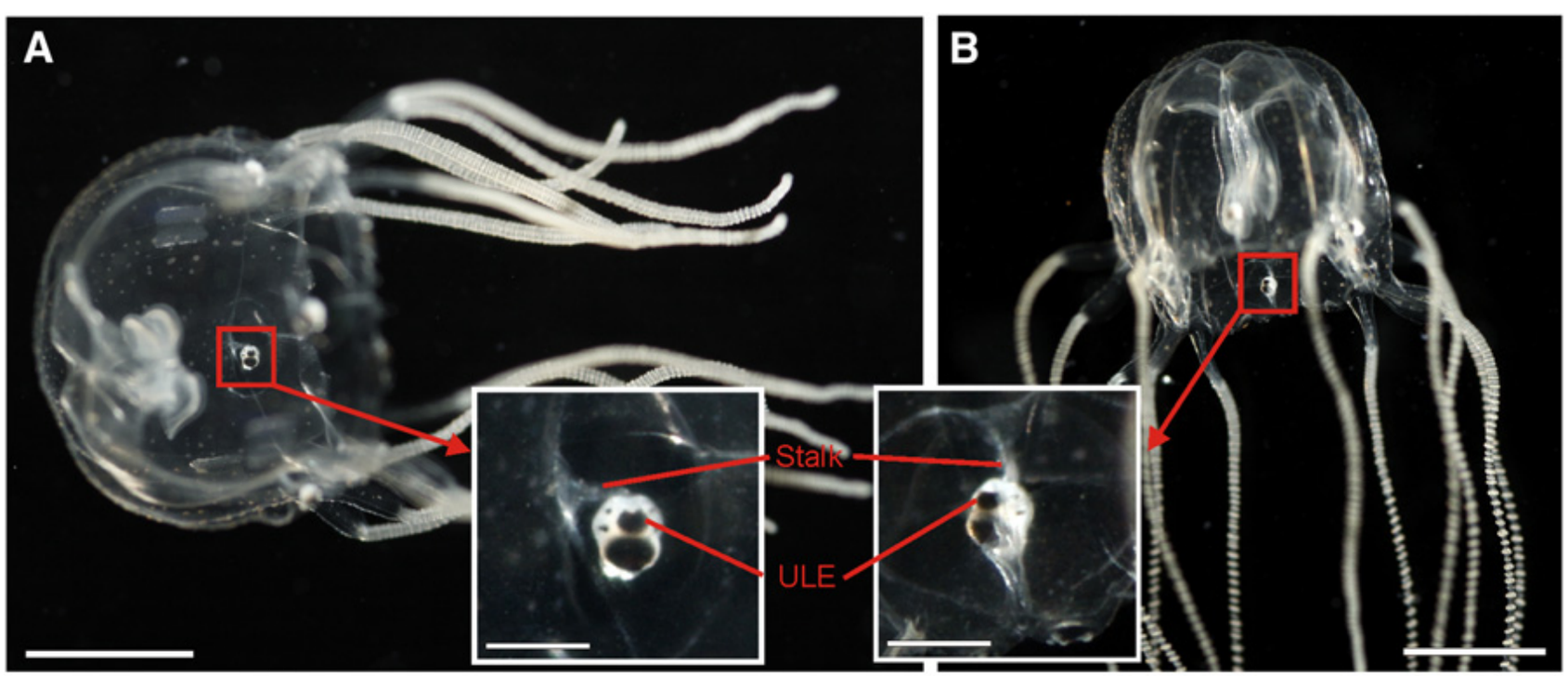
Gil Menda,[1] Paul S. Shamble,[1] Eyal I. Nitzany,[2,3,4] James R. Golden,[5] and Ronald R. Hoy[1,*]
[1]Department of Neurobiology and Behavior, Cornell University, Ithaca, NY 14853, USA
[2]Department of Biological Statistics and Computational Biology, Cornell University, Ithaca, NY 14853, USA
[3]Division of Systems Neurology and Neuroscience, Brain and Mind Research Institute, Weill Cornell Medical College,

17]. In making a small opening in the cuticle (approximately 100–200 μm in diameter) as opposed to the larger windows typical of arthropod neurophysiological preparations, we were able to prevent the catastrophic fluid loss that has limited recordings in spiders until now. The scale of this incision enabled the animal's clotting mechanisms to prevent continuous loss of hemolymph—ensuring the viability of the preparation without additional methodological or technical

Even ‘simple’ nervous systems can exhibit profound visual intelligence

jumping spider

sand wasp



box jellyfish

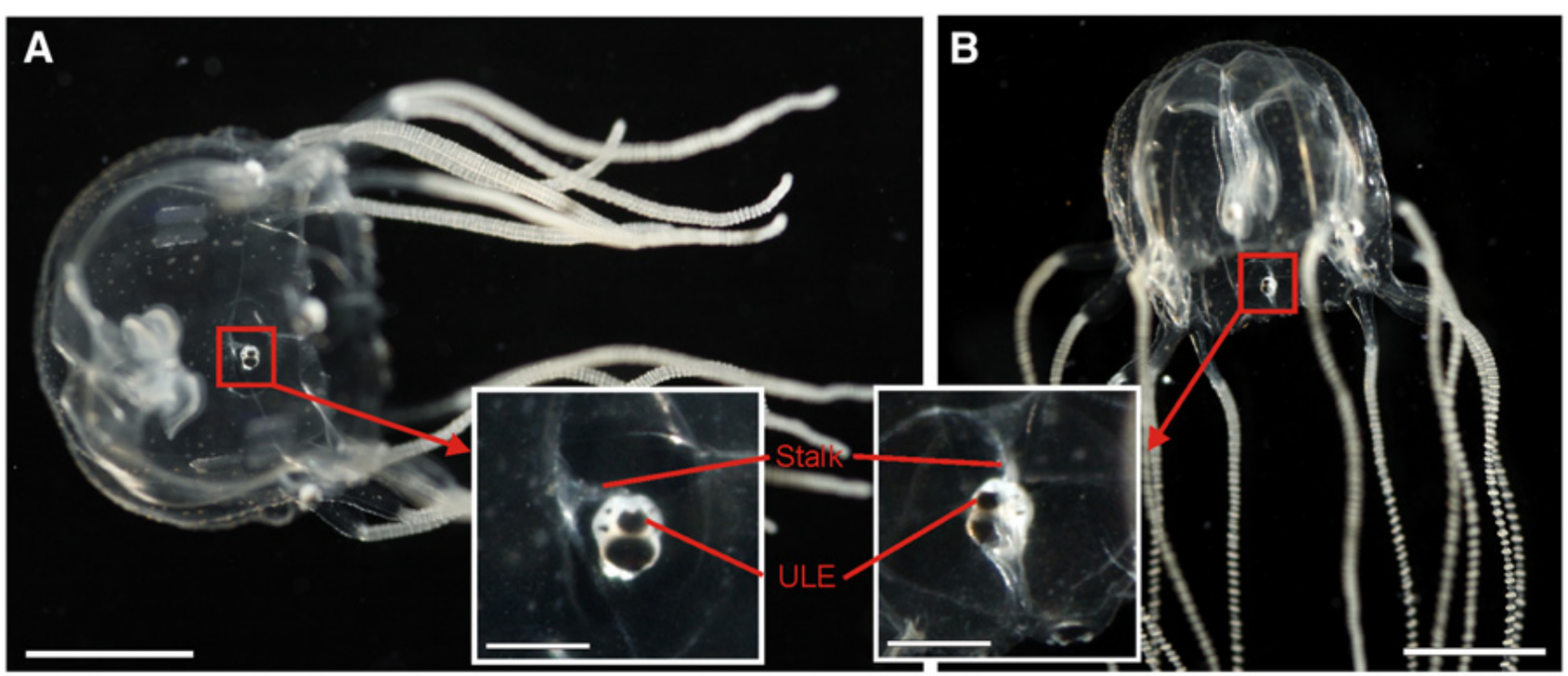
Facial recognition in wasps

(Sheehan & Tibbets, 2008)

Even ‘simple’ nervous systems can exhibit profound visual intelligence

jumping spider

sand wasp



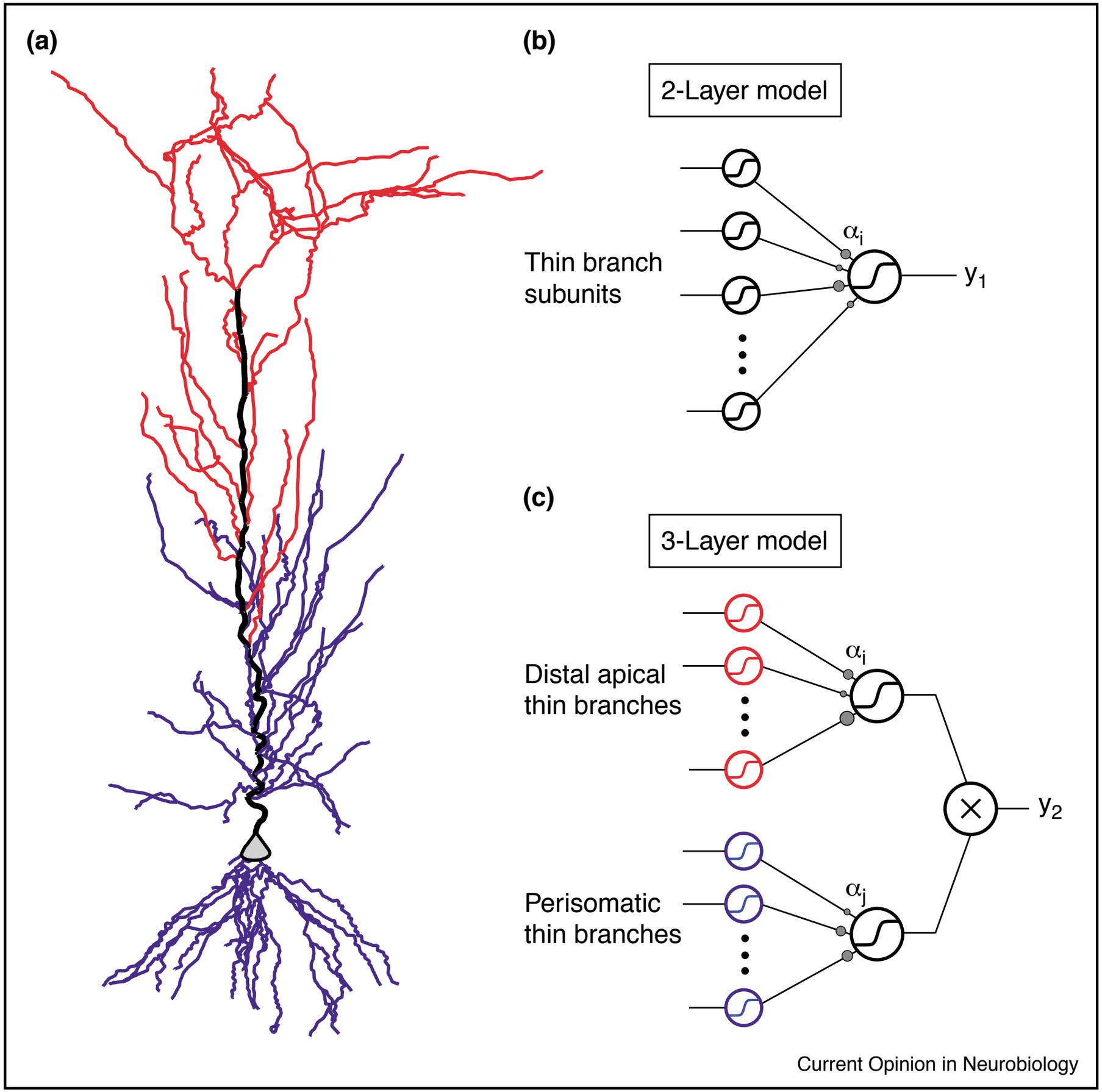
box jellyfish

…problem solving behavior, language, expert knowledge and application, and reason, are all pretty simple once the essence of being and reacting are available. That essence is the ability to move around in a dynamic environment, sensing the surroundings to a degree sufficient to achieve the necessary maintenance of life and reproduction. This part of intelligence is where evolution has concentrated its time--it is much harder.

— Rodney Brooks, "Intelligence without representation," *Artificial Intelligence* (1991)

Hausser & Mel (2003)

Pyramidal cells do not linearly sum their inputs



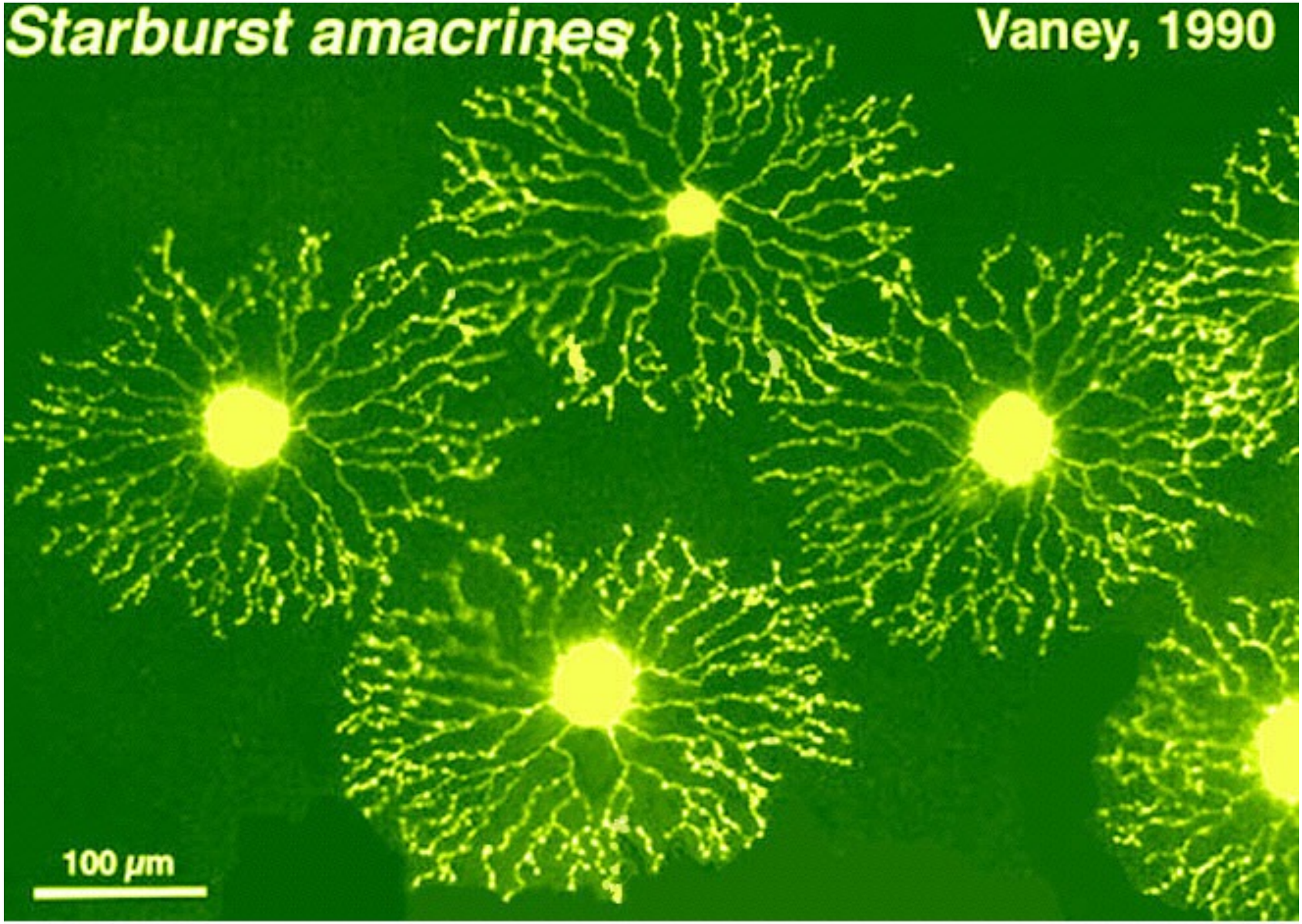
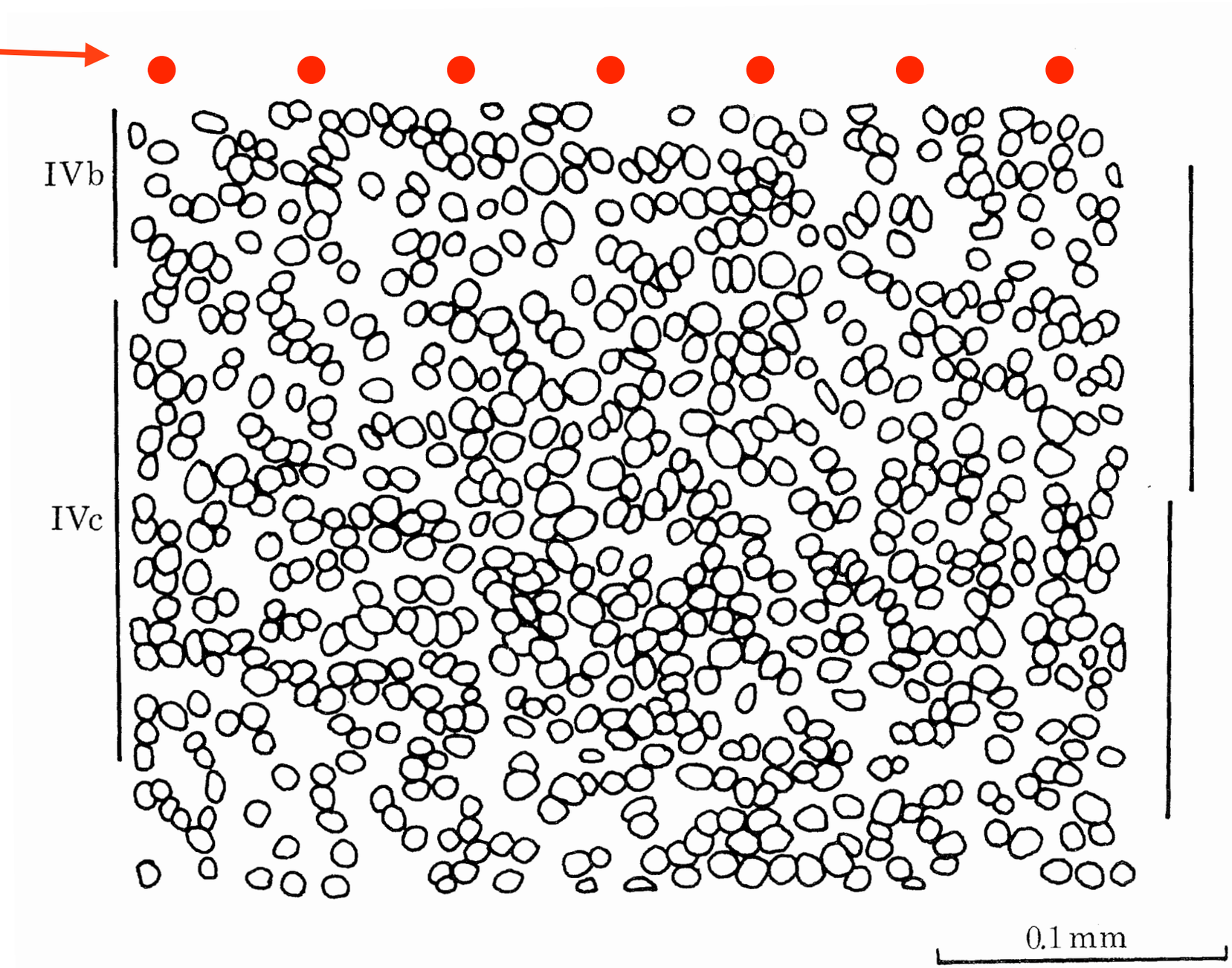


Fig.7. Starbust amacrine cells as stained with lucifer yellow in wholemount rabbit retina.

V1 is highly overcomplete

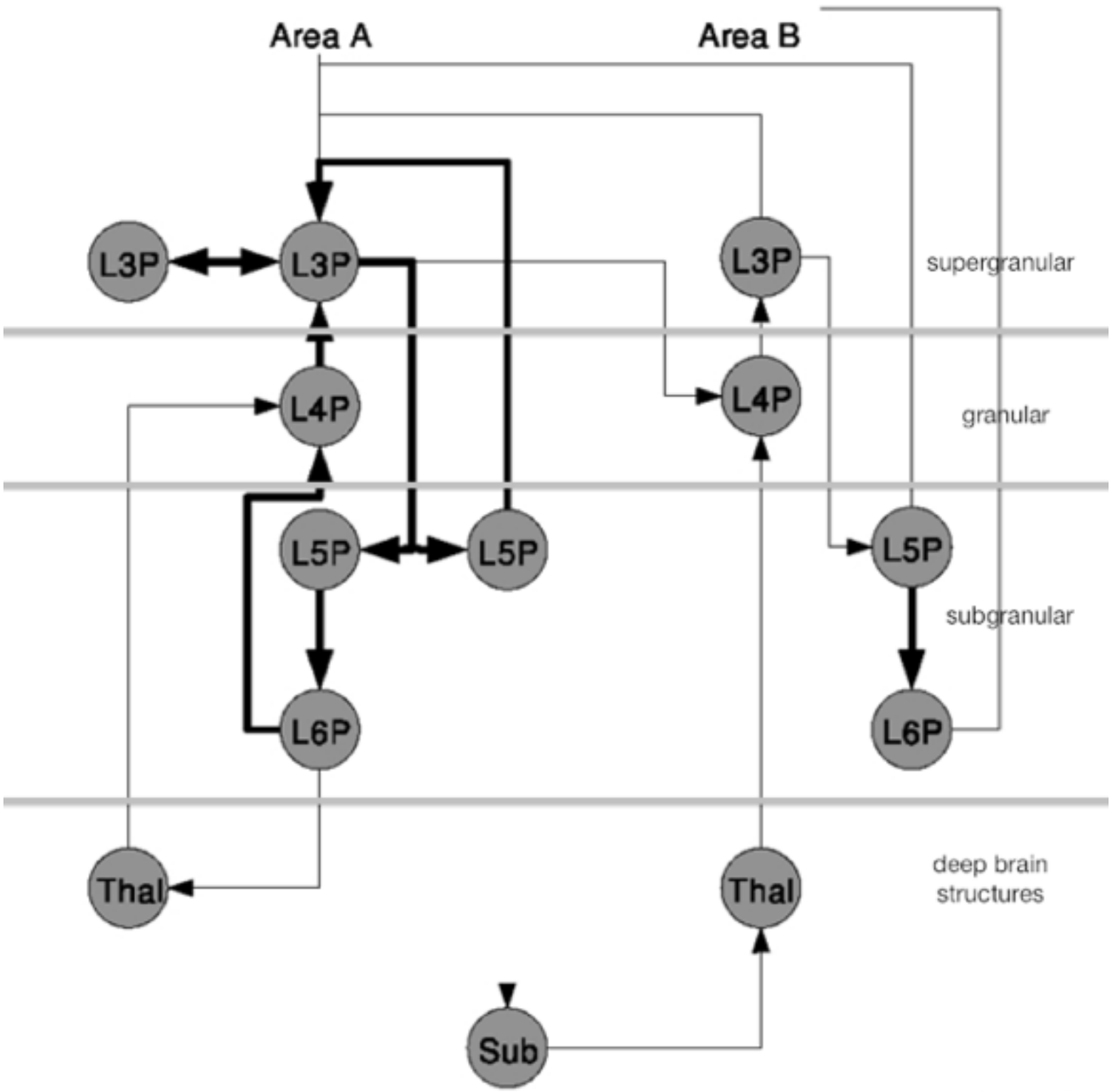
LGN afferents

layer 4 cortex



Barlow (1981)

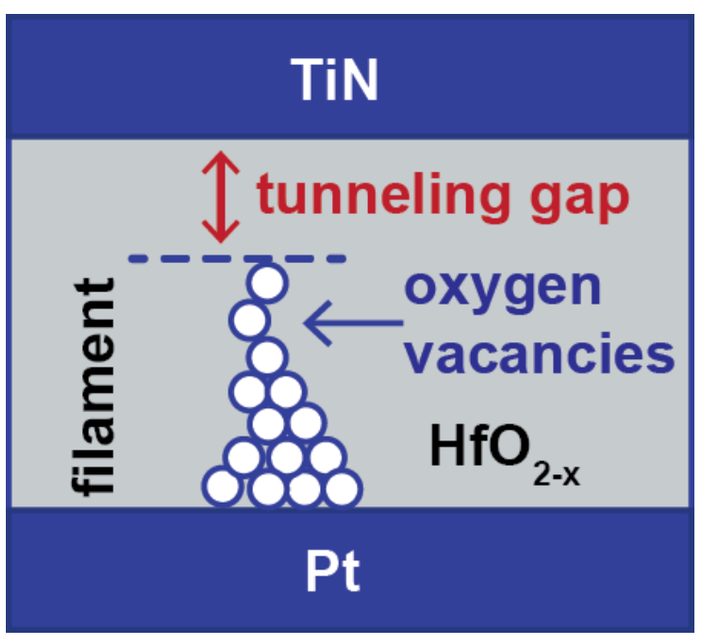
V1 contains a highly structured microcircuit with strong recurrent loops



Douglas and Martin (2004)

Efficient storage in analog, nanoscale devices

RRAM
(Resistive RAM)



PCM
(Phase change memory)