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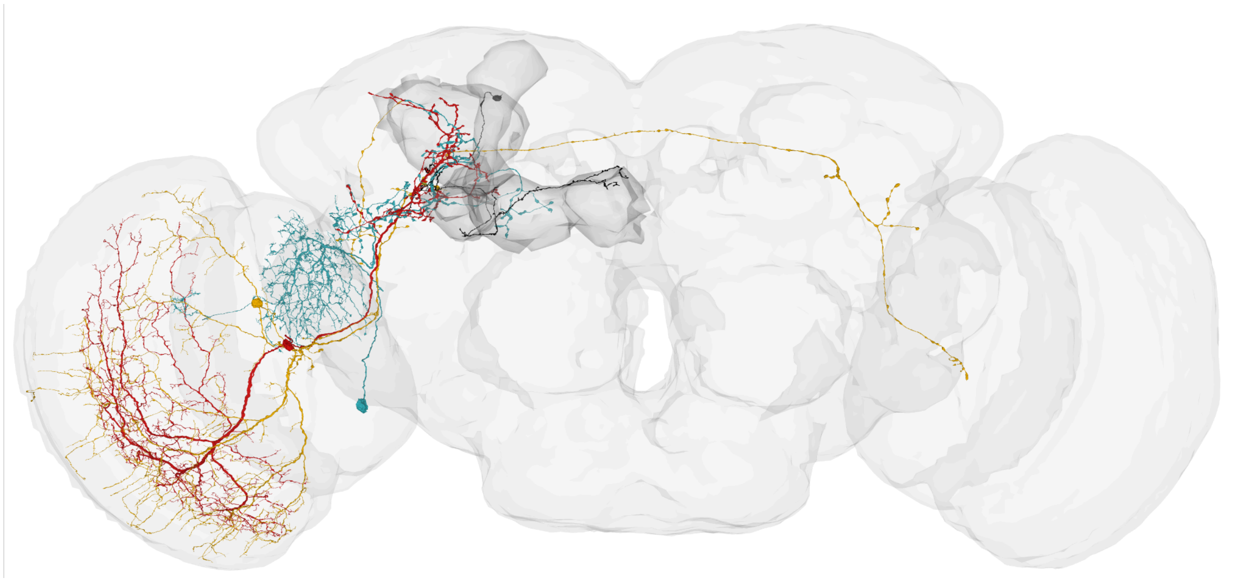
A Memory Center Linked to Smell In Insects Also Opens a Window Into Their Sight

By tracing connections inside the fruit fly brain, Zuckerman Institute researchers hope to learn more about multisensory learning



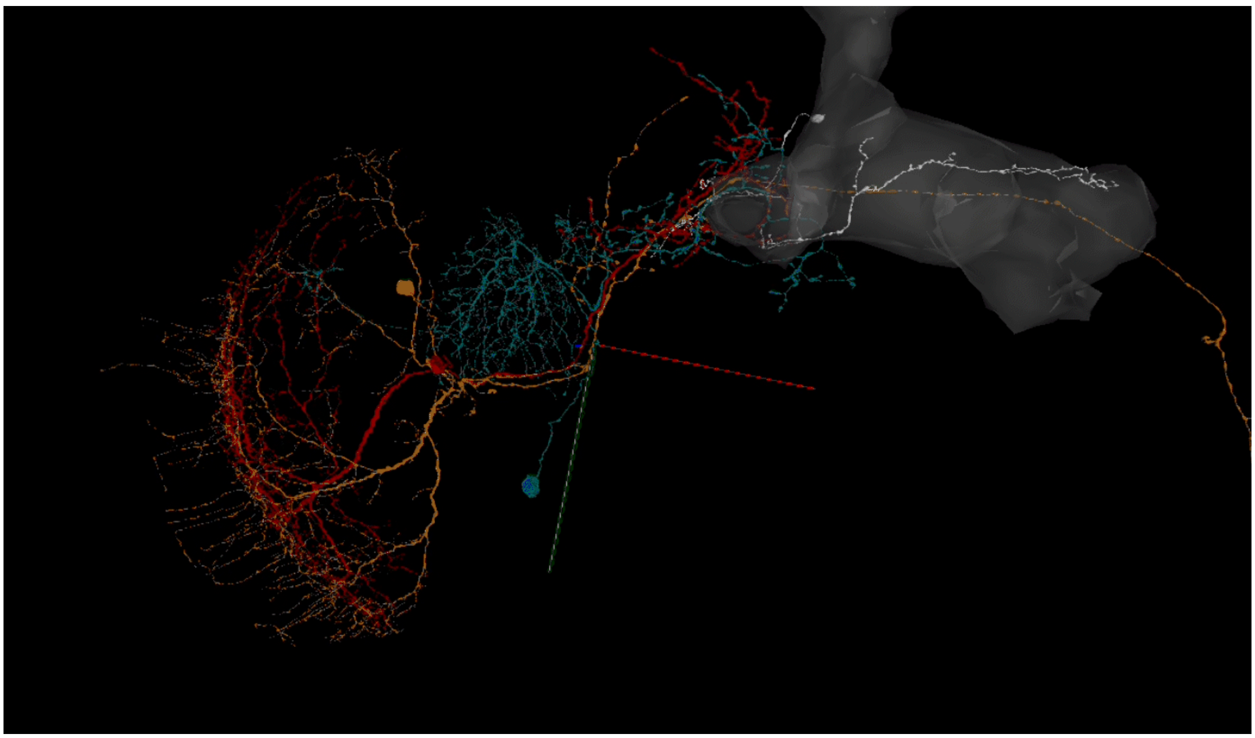
Three different types of visual projection neurons (red, yellow, and green) from the optic lobe all connect to the same visual Kenyon cell (black) inside the mushroom body, shaded in gray. (Credit: created with FlyWire under CC BY-NC 4.0 license by Ishani Ganguly and Emily Heckman / Behnia lab / Columbia's Zuckerman Institute)

NEW YORK, NY — To create memories from smells, such as ones that signal tasty food, insects depend on a brain region known as the mushroom body. Intriguingly, in fruit flies, about one out of 10 cells in that brain area receives information stemming from the fly's eyes, instead of the equivalent of its nose. What the mushroom body "sees" and how its visual neurons are involved in learning and memory remains uncertain.

Uncovering the role of sight in the function of the mushroom body could shed light on how the brain learns using more than one sense at a time, said Ishani Ganguly, a doctoral student in the labs of Ashok Litwin-Kumar, PhD, and Rudy Behnia, PhD, at Columbia's Zuckerman Institute.

"To survive and thrive, flies — and humans, too — want to use as much information from their surroundings as possible to help them make predictions about the future," Ganguly said.

To learn more about the part of the mushroom body devoted to sight, Ganguly and her colleagues, using a recently available diagram of neural connections in the whole fly brain, produced the first map yet of all the brain-cell circuits between the optic lobe in the fruit fly and the mushroom body (as shown in the images above). They reported their findings in *Nature Communications*.



Video showing reconstructions of visual projection neurons (red, yellow, and green), all connected to the same visual Kenyon cell (white), in 3D. (Credit: created with FlyWire under CC BY-NC 4.0 license by Ishani Ganguly / Behnia lab / Columbia's Zuckerman Institute).

Scientists still don't know for sure what the majority of the optic lobe's neurons do in these circuits. It's like having a map of electrical wires in a building but not knowing the function of most of the devices connected to those wires.

Still, by analyzing the shape and structure of the mushroom-body-connected optic lobe neurons, the researchers can make predictions of what these brain cells might do. This is akin to how an electrical wiring map might let you guess that a building hosts lots of low-power home appliances instead of a few pieces of high-power industrial equipment.

"These new findings can serve as a roadmap for guiding researchers seeking to uncover how visual information might be used in multisensory learning," said Dr. Behnia, a principal investigator at the Zuckerman Institute and an assistant professor of neuroscience at Columbia's Vagelos College of Physicians and Surgeons.

The implications of this go beyond insect vision and olfaction. Learning more about how the mushroom body works could reveal details about the human brain. "The mushroom body has a similar structure to our cerebellum, and also to our hippocampus, the brain's memory center," Dr. Behnia said.

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The paper, "Diversity of visual inputs to Kenyon cells of the *Drosophila* mushroom body," was published online in *Nature Communications* on July 7, 2024.

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The authors report no conflicts of interest.