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## Special Neurons Help Flies Sense the Wind

Fruit flies take in the rich *mélange* of smells, tastes, and sounds in their world by using finely tuned sensory neurons that stipple their antennae. Now, Howard Hughes Medical Institute (HHMI) scientists have discovered sensory neurons within the antennae that help flies respond to wind. This ability to detect wind – and differentiate it from the mechanical signals that signify sound -- could help flies navigate during flight.

HHMI investigator David Anderson became curious about how flies sense wind during a mini-sabbatical from his California Institute of Technology lab in 2003, when he was learning how to use a tube-like device to deliver alcohol vapors to excite *Drosophila melanogaster* flies. He noticed that the stream of air coming from the tube was enough to stop the flies from walking. The flies resumed walking when he stopped the stream of air.

The behavior was remarkably consistent, but no one in the lab had noticed it before because alcohol excites flies and this had masked their response to the wind. Puzzled by the observation, Anderson searched for relevant articles in the scientific literature to see if anyone else had described this phenomenon. His search turned up only a few papers published decades ago that described this type of behavior in wild *Drosophila* flies in Hawaii.

The story might have ended there, but Anderson's curiosity was piqued. "The question is – how does that really work?" he says. Now, six years into his studies, wind-sensing has become a major project in Anderson's lab. He and his colleagues are interested in understanding this behavior, which is called wind-induced suppression of locomotion or WISL, because they hope it will help reveal how the nervous system works. In particular, they think they can use their flies to learn how the creatures take a sensory stimulus from the environment—in this case, wind—and convert it into a specific behavioral response – stopping motion.

In a new study published March 11, 2009, in the journal *Nature*, Anderson and colleagues have come one step closer to determining how WISL works. Using new genetic tools, they determined that wind-sensing neurons reside in the Johnston's organ—a hearing organ in the fly's antenna. What's more, the Johnston's organ contains specific cells designated to detect wind and different cells to detect sound.

“Behavioral responses to wind are thought to have a critical role in controlling the dispersal and population genetics of wild *Drosophila* species, as well as their navigation in flight,” Anderson says. “But the underlying neurobiological basis of these behaviors is unknown.”

The study is the first to demonstrate that Johnston’s organ is directly involved in wind sensing. During earlier experiments, Anderson began to suspect that the organ was involved because when his graduate student Suzuko Yorozu glued the flies’ antennae to their heads or removed segments of the antennae, they stopped responding to wind.

Those observations suggested to Anderson and Yorozu that the flies were either detecting wind using the sensory hairs on their antennae, or using a specific structure in the antennae that senses movement. Yorozu next used genetic techniques to interfere with the function of cells in Johnston’s organ, which is the only known structure in the fly’s antennae. Those genetically

manipulated flies could not respond to wind, suggesting that the organ itself is important for wind detection.

Since Johnston’s organ senses both sound and wind, the researchers next asked whether it could tell the two signals apart. With the help of scientists from the University of Tokyo, Yorozu developed flies with genetic alterations that allowed her to visualize the activation of specific groups of neurons using fluorescent proteins. To watch these neurons in a living fly, she cut away a tiny piece of the cuticle that encases the brain.

Looking through this “window” underneath a microscope, Yorozu was able to see which neurons lit up when she exposed a female fly to a stream of air or played the fly a love song – a chirpy mating sound. A bright glow from the neurons indicated that they were receiving a strong activation signal.

Not only did distinct groups of neurons light up for sound and wind, but separate groups of neurons lit up when the air stream came from different directions -- either straight-on or at the side of the fly’s head.

The finding suggests that the brain determines what kind of signal has been experienced (sound vs. wind) according to what kind of neuron is activated, rather than by deciphering different patterns of firing elicited in a common set of neurons by each of the different signals.

In the last decade, scientists have steadily accumulated examples that have challenged this notion. In a previous study, Anderson’s group presented another example in flies. Anderson’s group identified a distinct set of neurons that detect carbon dioxide within a group of neurons that respond to smell. These carbon-dioxide-sensing neurons did not respond to other odorants.

Anderson and his research team are now working out ways to find the next neurons in the chain of cells that sense information, integrate that information, and trigger a behavioral response. One way is to genetically inactivate random neurons and screen for the presence or absence of WISL.

“Once we know something about the circuit, then we can start to look at the genes and ask where in the circuit are those genes acting and what do they do in the circuit,” Anderson says.