How monarch butterflies are wired for navigation

May 4 2005

In their extraordinary annual migration from North America to Mexico, monarch butterflies are known to use the angle of polarized sunlight as a celestial guide to help them keep to a straight and true path southward. But details of their navigational machinery have remained a mystery.

Now, researchers, led by Steven Reppert of University of Massachusetts Medical School, Ivo Sauman of the Czech Academy of Sciences and Adriana Briscoe of the University of California at Irvine, have explored the infinitesimal butterfly brain to uncover new insights into that machinery. Their findings show that the same ultraviolet light that has become an anathema to cancer-wary humans is critical for butterfly navigation. Also, the researchers were surprised to discover a key wiring connection between the light-detecting navigation sensors in the butterfly's eye and the creature's circadian clock--a critical link if the butterflies are to compensate for the time of day in using their "sun compass."

The researchers' techniques include molecular analysis of butterfly brain proteins, as well as flight tests in which the scientists manipulated the light reaching their insect subjects and measured the navigational response.

In their studies, the researchers discovered that ultraviolet photoreceptors dominated in the region of the butterfly visual system known to specialize in polarized light detection. To confirm that the butterflies, indeed, required ultraviolet polarized light to navigate, the

researchers tested the insects in a "flight simulator," in which they could control the light polarization and thus influence the butterflies' direction of flight. The researchers found that when they placed a UV-interference filter over the polarized light source, the butterflies lost their orientation response.

The researchers also pinpointed the location of the circadian clock in the butterfly brain. Such circadian clocks govern the approximately 24 hour activity and metabolic cycles of animals from the simplest insects to humans. Reppert and his colleagues found that key genes responsible for the clock's molecular "ticks" were expressed in a brain region called the dorsolateral protocerebrum. Using tracer molecules, they were surprised to discover tiny neural fibers containing a key clock protein that connected with the polarization photoreceptors in the butterfly eye.

"This pathway has not been described in any other insect, and it may be a hallmark feature of butterflies that use a time-compensated sun compass," wrote the researchers. They also speculated that another such clock-related pathway of fibers they detected between two regions of the butterfly brain may play a role in regulating the insects' hormonal system, to induce the longevity that enables the butterfly to extend its survival in its overwintering grounds in Mexico.

Source: Cell Press