Single circadian clock regulates flies' response to light and temperature

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Animals have biological clocks with a cycle of about 24 hours — these circadian rhythms allow them to align their physiology and behavior to the earth's rotation. Now new research from Rockefeller University shows that the same molecular clock responsible for helping flies sync themselves with patterns of light and dark might be what helps them sync to patterns of temperature, too.

Researchers in the lab of Michael Young, the Richard and Jeanne Fisher Professor and head of the Laboratory of Genetics, took adult Drosophila and placed them in a dark environment where the only variable was temperature, which alternated between warm and cool in 12-hour intervals. After a few days of temperature variability, the scientists then held the temperature steady in the warm phase, at about 77 degrees Fahrenheit, to see whether their molecular clocks continued to cycle in the absence of temperature fluctuations.

When they looked at gene activity in the flies' heads, where their light-sensing capabilities are located, the researchers found a great deal of overlap between those genes that oscillate in response to cycles of light and dark, and those that oscillate according to cycles of temperature. Upon closer examination, they saw that although temperature-regulated genes also appear to be activated by light, as indicated by measurements of the transcripts the genes produce, the opposite was not true: Not all light-regulated genes fluctuate with temperature. "So, it seems that the temperature transcripts are a subset of the light transcripts," says Catharine Boothroyd, a postdoc in the lab and the paper's first author.

This, she says, means that the temperature-responsive genes are not controlled by a separate circadian clock.

Even more interesting, the researchers found that the transcriptional patterns of light and temperature genes are offset by about six hours, with light peaking earlier than temperature — a pattern that mirrors the ups and downs of the natural environment, in which temperature is lowest around dawn and highest near sunset.

And what happens if the single clock gets conflicting light and temperature signals? Over the ranges that Boothroyd and Young tested, temperature turned out to be the weaker of the two stimuli. “If you give the fly appropriate phases of light and temperature, it maintains its activity as it would in light alone,” Boothroyd says. “But if you give it light and temperature in the opposite phases — light during cooler temperatures and darkness during warmer ones — the fly somehow has to choose which one to follow, and it chooses light.”

“The big message,” she says, “is that there is one molecular clock, which integrates information from both light and temperature. And it presumably relays that information to the rest of the organism.”

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