The Function of Evening and Morning Oscillators in the Circadian Clock

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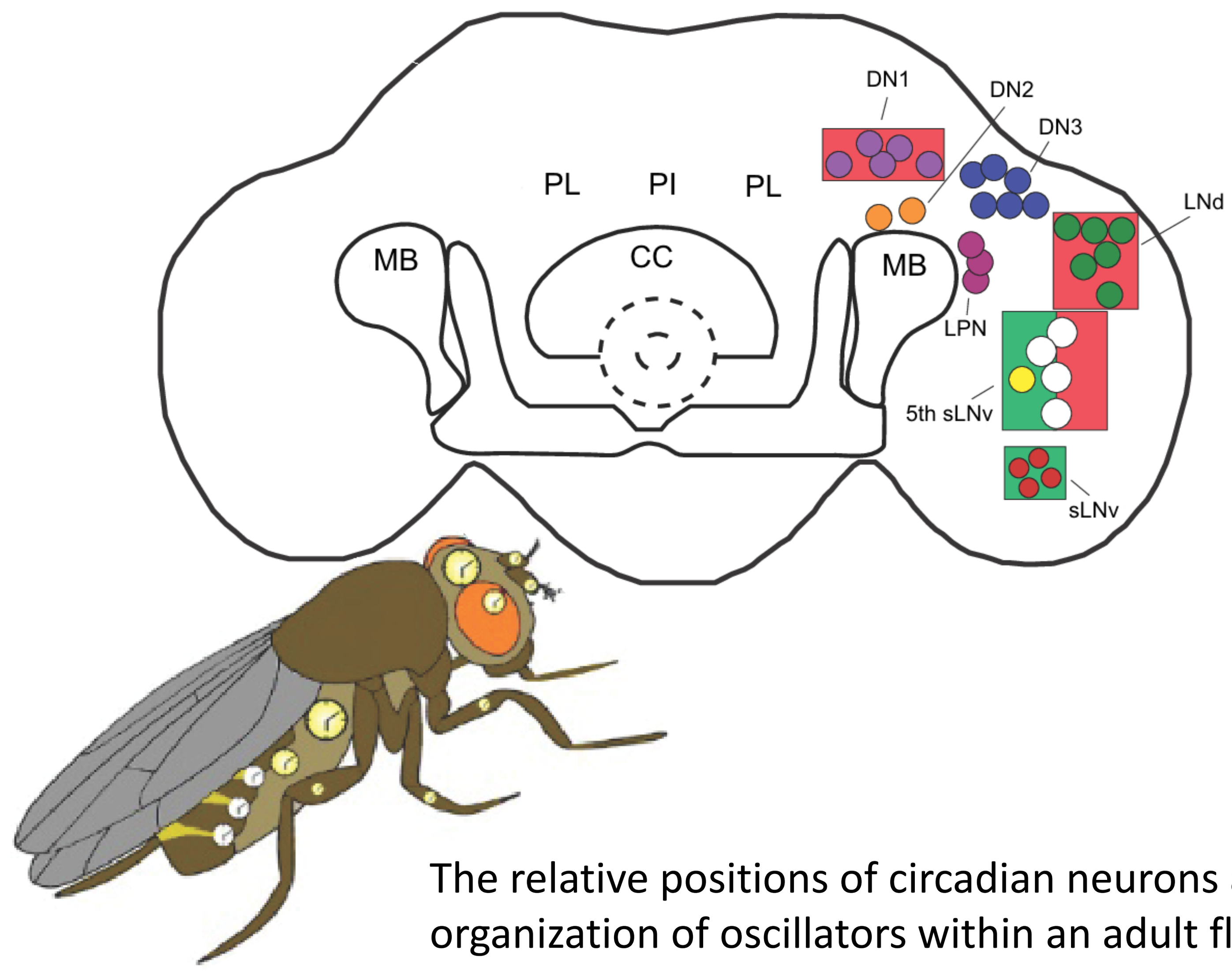
What is the Circadian Clock?

Light released from the sun fluctuates rhythmically every 24 hours, which causes organisms to experience day-night physiological changes. The circadian clock helps organisms adapt to changes in environmental settings by synchronizing their physiology and behavior with their surroundings. The circadian clock consists of three parts: an input, an oscillator, and an output. The input pathways transmit information about the environment to the oscillator, which then controls output functions (an organism's physiology and behavior).[9]



The relative positions of circadian neurons and the organization of oscillators within an adult fly's brain

What are E and M Oscillators?

In a standard 12 hour light and 12 hour dark (LD) cycle, Drosophila exhibits two peaks of activity. The morning (M) peak is driven by Pigment Dispersing Factor (PDF) and Positive Small Ventrolateral Neurons (s-LNvs). These cells are referred to as M oscillators. The evening (E) peak is driven by six Dorsolateral Neurons (LNds), two PDF-negative s-LNvs (fifth s-LNvs), and Dorsal Neurons (DN1s). These cells are known as E oscillators.[1]

PER and TIM

- Cryptochrome (CRY) is the most important photoreceptor within Drosophila. It acts to reset the clock by promoting light-induced degradation of the proteins Timeless (TIM) and Period (PER).[4]
- The two proteins act to repress their own gene transcription by interfering with the activity of transcription factors Clock (CLK) and Cycle (CYC).[5] In the transcription feedback loop of the clock, the dCLOCK-dCYCLE heterodimer is the positive reinforcement (transactivator), and the dPER-dTIM complex acts as the negative reinforcement (repressor).[4]
- The phase of the feedback loop can be reset by light, and it is suggested that dCRY-mediated degradation of dTIM is a key step of this occurrence. [4]

Morning Oscillators

- Typically defined as lateral neurons, both small (s-LNvs) and large (l-LNvs).[6]
- Contain Pigment-Dispersing Factor expressers, labeled as PDF-positive. [6]
- Modulate only a subset of PDF-negative (E) cells. [2]
- Function as pacemaker neurons by controlling behavioral rhythms in constant darkness.[1]
- CRY is required in M cells for phase delay[3]
- Activity is increased and offers adaption when exposed to light increased photoperiods. [7]

Evening Oscillators

- They do not contain Pigment-Dispersing Factor (PDF) and are thus PDF-negative[3]
- Consists of some lateral neurons and six dorsalateral neurons (LNds) per hemisphere.[3]
- Are controlled by two PDF negative s-LNvs (fifth s-LNvs) and some Dorsal Neurons (DN1s).[1]
- Lateral PDF-negative neurons consist of three unique subsets: (1) two pairs of sNPF+/PDFR+ neurons strongly coupled to PDF neurons; (2) two pairs of ITP+/PDFR+ neurons that are less coupled to PDF neurons; (3) three pairs of PDFR– neurons that are not directly coupled to PDF neurons.[3]
- Hypothesized to have independent control of activity rhythms in DD.[3]

Components	M Oscillators	E Oscillators
JET is required[1]	✚	✚
JET can autonomously trigger TIM degradation[1]	✚	✖
TIM degradation is affected by pulses of light[3]	✖	✚
Work to reset circadian locomotor activity[1]	✚	✚
Essential for behavioral phase shifts[1]	✚	✚
Molecular cycling responds to an 8 hour phase shift of Light-Dark (LD)[3]	✖	✚

The Future

We hope to gather information that further supports the E and M oscillators' effect on the circadian clock and the importance of TIM's degradation in causing phase shifts and delays to occur.

References

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