

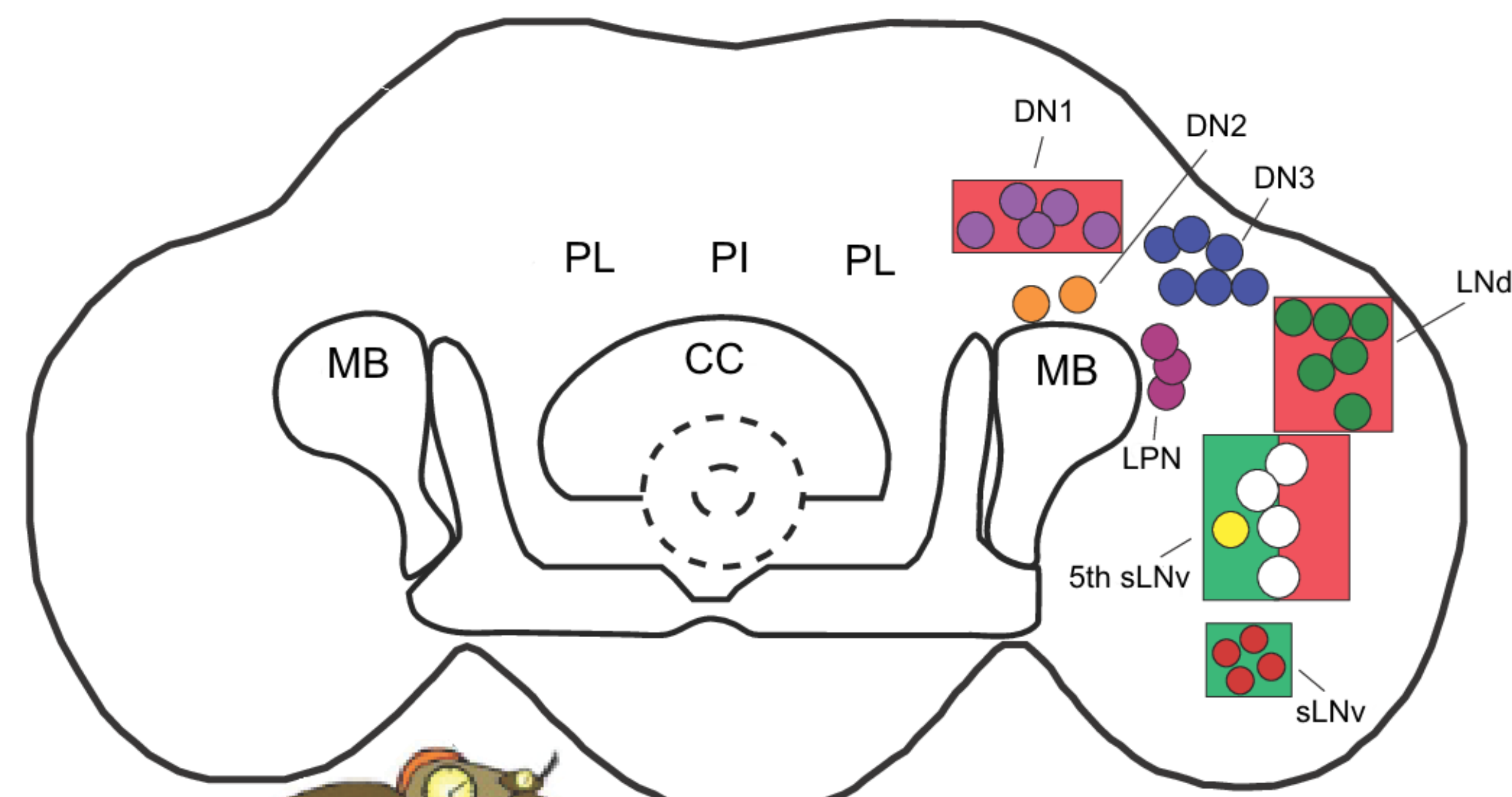
The Function of Evening and Morning Oscillators in the Circadian Clock

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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 delay³
- Activity is increased and offers adaptation when exposed to light increased photoperiods.⁷

Evening Oscillators

- They do not contain Pigment-Dispersing Factor (PDF) and are thus PDF-negative³
- Consists of some lateral neurons and six dorsolateral 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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