Laboratory of Comparative Neurobiology

Graduate School of Science

Professor	Sakiko SHIGA	shiga.sakiko.sci @osaka-u.ac.jp
Associate Professor	Yoshitaka HAMANAKA	hamanaka@bio.sci.osaka-u.ac.jp
Assistant Professor	Hisashi TOBITA	tobita.hisashi.sci @osaka-u.ac.jp
Assistant Professor	Aisa SAKAGUCHI	sakaguchi.aisa.celas@osaka-u.ac.jp
Specially Appointed Assistant Professor	Xi Jili	xijier.pb4 @osaka-u.ac.jp

URL: https://www.bio.sci.osaka-u.ac.jp/bio_web/lab_page/shiga/

Our research aims to elucidate the behavior and physiology of animals, which have been refined through natural selection, from the perspective of neurobiology. In particular, we are interested in how the brain and nervous system process information with a time axis. We are trying to understand how invertebrates such as insects and mollusks use circadian clocks to know the seasons based on environmental photoperiodic information (combination of light and dark period), and how circadian clocks produce rhythms that are multiples of 24 hours. By comparing the behavior and physiology of various animals and understanding their similarities and diversities, we believe that we can also explore the evolutionary paths of individual animals.

Photoperiodism and diapause in insects

Animals adapt their behavior and physiology to the seasons, such as birdsong and migration in birds and hibernation in mammals. Insects also develop and reproduce during the appropriate season for their survival, and go into diapause during the harsh season, temporarily arresting development and reproduction. In order to adapt to the seasons, animals need to accurately predict and prepare for the coming seasons. The brain uses a circadian clock to measure the length of the day, which provides a clue to the season, and then counts the number of days to determine the season. Subsequently a developmental program is determined for each season, and growth, reproduction, and diapause are regulated through endocrine mechanisms.

We use field collected insects

We study the neural mechanisms of photoperiodism and diapause regulation by rearing field-collected blow flies and bean bugs in the laboratory. Adults of Protophormia terraenovae and Riptortus pedestris develop ovaries on long days but enter diapause with ovary development suppressed by short days.

Brain neurons involved in photoperiodic and diapause regulation

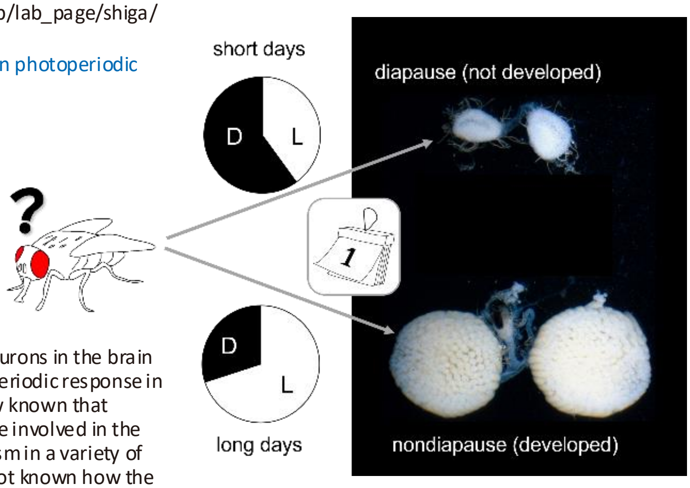

Figure 1: Photoperiodic response in the blowfly

The circadian clock neurons in the brain are required for photoperiodic response in P. terraenovae. It is now known that circadian clock genes are involved in the photoperiodic mechanism in a variety of insects. However, it is not known how the circadian clock reads day length and switches between diapause and non-diapause programs after a certain period of days. We have shown that circadian clock neurons have contacts with pars laterals neurons (neurons required for diapause) and pars intercerebralis neurons (neurons required for reproduction), and that the electrical activity of the pars intercerebralis neurons exhibits photoperiodic response, depending on circadian clock gene expression. We study how information processing occurs in these neural networks.

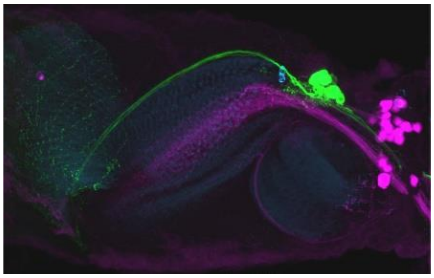

Figure 2: Circadian clock cells (blue) mapped in the optic lobe in the bean bug *Riptortus pedestris*. Pigment-dispersing factor immunoreactive neurons (green), and anterior lobula neurons (mazenta) are shown involved in the photoperiodic response in this bug.

Two-day Behavioral Rhythm (Circa'bi'dian Rhythm)

The black chafer Holotrichia parallela has a unique behavioral rhythm in which it emerges from the ground once every two days at dusk to forage and mate, and then rests in the ground for the remaining day and a half. This is called a circabidian rhythm, since the rhythm continues even under constant temperature and constant darkness. The circabidian rhythm disappears when the brain regions at which the circadian clock resides in many insects are removed. Based on this, we believe that the brain has a mechanism that uses the 24-hour circadian clock to produce a 48-hour behavioral rhythm, and we are studying the neural mechanisms underlying this unique rhythm.

Diversity of animal behavior and physiology is astonishing. There are interesting research subjects that no one has done yet. Let's take on this challenge together.

Department of Biological Sciences
Graduate School of Science, Osaka University
1-1, Machikaneyama-cho, Toyonaka, Osaka
560-0043, Japan
TEL: +81-6-6850-5423

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