Influenced by light, biological rhythms say a lot about animal (and human) health

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Credit: AI-generated image (disclaimer)

Life patterns help humans and other animals stay in sync with nature and in good form.

For several days after each November full moon, a wondrous spectacle occurs on the Great Barrier Reef in Australia: corals release into the water billions of eggs and sperm that unite to form free-floating larvae. These eventually settle, seeding new coral colonies.

Corals are not the only creatures to synchronize breeding by the light of the moon. Such rhythms are typically governed by circalunar clocks, a form of protein-controlled biological clock attuned to the 29.5-day cycle between new moons.

Synchronizations

Most multicellular organisms have, or are thought to have, some kind of inbuilt biological clock and many important processes including feeding and reproducing rely on accurate timings. The ability to stay "in sync" is key to survival.

"Understanding how the time-related interconnection of individuals within and across species works is critical for ecologically stable systems," said Professor Kristin Tessmar-Raible, a neurobiologist at the University of Vienna in Austria.

Another, perhaps more familiar, form of biological clock—the circadian one—modulates the daily 24-hour sleep-wake cycle in response to environmental cues like light and temperature. The clock's name comes from the Latin words "circa," meaning "around," and "dies," meaning "day."

This complex system regulates everything from sleep and digestion to metabolism and mood. Researchers are shedding light on the environmental factors that may knock these biological rhythms out of sync.

But much about "chronobiology" remains unknown, including the mechanisms involved at a genetic and molecular level.

Moonlight signals

To delve deeper, Tessmar-Raible has been studying circalunar rhythms in ocean-dwelling animals as part of the Mari.Time project, which runs for five years through 2024.

One of her focuses is a marine bristle worm called Platynereis dumerilii, which inhabits coastal waters from temperate to tropical seas.

"The biggest takeaway so far is that we uncovered a photoreceptor—or light-sensing cell—that provides the organism with information about the type of light and duration of moonlight in the sky," said Tessmar-Raible.

The L-Cry protein identified by the researchers belongs to a group of light-sensing molecules called cryptochromes. The protein is important because it can help explain how organisms are able to synchronize to a specific moon phase.

The research suggests L-Cry acts as a gatekeeper that allows only the "right" light to affect the worms. It can also distinguish between light levels in different lunar phases and between sunlight and moonlight.

"This can explain how individual worms are able to synchronize their circalunar clock to the same moon phase," said Tessmar-Raible. "We uncovered that moonlight, besides its role in monthly timing, also schedules the exact hour of nocturnal swarming onset to the nights' darkest times, probably to optimize survival and reproduction."

The hope is that Mari.Time will offer fresh clues about how human influences like artificial light and climate change affect the stability of ecosystems and suggest ways to reduce the effects.

The project may even help research into human health given the growing evidence that the moon affects things like sleep and depression.

"Many hormones in the worm species we study have closely related human counterparts," said Tessmar-Raible.

She said researching the mechanisms of the lunar cycle in marine species may improve understanding of other monthly patterns. These include the menstrual cycle and mood patterns in certain mental disorders.

Night and day

Professor Johanna Meijer, who researches biological clocks at Leiden University in the Netherlands, has been studying circadian rhythms in animals for more than 30 years.

According to her, much remains to uncover about the circadian clock, including how it works in diurnal, or day-active, species like humans.

Much more is known about nocturnal animals because such species, like the mice normally used in laboratories, have been easier to examine at a molecular level, according to Meijer.

The DiurnalHealth project that she leads is exploring the differences between diurnal and nocturnal animals.

Circadian rhythms are regulated by a group of nerve cells in the hypothalamus known as the suprachiasmatic nucleus (SCN), which serves as the body's master clock.

Because it is sensitive to light, the SCN helps to regulate the sleep-wake cycle by synchronizing with the natural light-dark one of the environment.

When the SCN is disrupted, such as during long-distance travel or shift work, there is evidence that it can lead to a range of health troubles including sleep disorders, depression, diabetes and even cancer.

Meijer's pioneering work on the SCN in diurnal rodents such as the Sudanian grass rat and a species of day-active ground squirrel is providing new information on how circadian rhythms are generated and synchronized.

The research is also offering insights into how environmental cues such as light, temperature and physical activity are used to fine-tune the body's internal clock.

"The SCN can perceive light input and also behavioral input, and this behavioral input can strengthen the clock," Meijer said. "Isn't that amazing? So our own behavior is in fact part of a feedback loop."

This means that external cues could potentially be used to right disruptions to internal body rhythms. Light is the first candidate, but other factors such as exercise, temperature and eating times also play a role.

Light levels, colors

Breakthroughs in imaging technology harnessed by the team have made it possible to observe the SCN in unprecedented detail.

The findings suggest that the cells in diurnal rodents are less responsive to light than those in their nocturnal cousins.

"This indicates that for diurnal animals and humans to have enough light for their clock, they need more than a nocturnal animal," said Meijer.

In separate research, light levels appeared to influence the synthesis of serotonin in diurnal rats more strongly than in than nocturnal ones. As serotonin affects mood, emotions and appetite, such findings may have implications for human disorders like depression.

The team also found more direct evidence that the circadian clock is affected by different colors of light, not just the blue part of the visible spectrum often blamed for the harmful effects of artificial night lights and screens on electronic devices.

Blue light is known for disrupting circadian rhythms and leaving people feeling alert instead of tired. But, of the colors tested by the team, green and orange light also affected the circadian clock and only violet showed little impact.

"It's a bit of a warning that, if you don't want to disturb your clock, you cannot only stay away from blue light," said Meijer.

Earthwide implications

What is emerging from both projects is a much more detailed understanding of the precise mechanisms of internal biological clocks in living creatures and their importance for the way that human beings and other animals function.

The findings may lead to new, effective recommendations for improving lifestyle patterns and protecting natural environments.

Meijer stressed the importance of how these things affect not just people but also all ecosystems.

"After billions of years of evolution, the light-dark cycle is good for animals," she said. "Now, we're throwing light over the Earth as if it's harmless—and it isn't."

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