Light cycles and living organisms

1. The solar cycle and seasonal rhythms

Figure 1. The solar cycle and seasonal rhythms. Schema adapted from Gothika (original image), Belg4mit (corrections), Simon Villeneuve (corrections) & Whidou (correction of various SVG bugs); [Source: CC BY-SA 3.0, via Wikimedia Commons].

The Earth's rotation period on its own axis in 24h is at the origin of the day/night cycle. Since life appeared on Earth nearly 3.8 billion years ago, 1,400 billion day/night cycles have followed one another. The Earth's rotation period around the Sun's axis, i.e. the duration of an Earth year, is 365.25 days and the inclination of the Earth's axis with respect to this rotation plane is 23.5°. Both are at the origin of the cycle of seasons. Thus, the terrestrial area that receives the sun's rays of light at a perpendicular angle is a function of the Earth's position relative to the Sun. However, the closer the photons that compose the rays of light arrive to a perpendicular angle, the greater the energy delivered and the hotter it gets. This is why we distinguish between summer and winter, as well as between seasons, spring and autumn. And throughout the year, the duration of the day during a 24-hour day varies. The inclination of the Earth's axis with respect to the Earth's plane of rotation around the sun is also at the origin of this variation. Thus, as latitude increases or decreases, so does the duration of the day. For each terrestrial hemisphere, the longest day is reached at the summer solstice and the shortest day at the winter solstice. Consequently, the annual change in the length of the day is associated with the annual change in seasons, regardless of the geographical area considered, except at the equator, and regardless of the date (Figure 1).

2. The lunar cycle and living organisms

Illuminated by the sun, the Moon reflects its light. At night, the Moon is therefore visible from the Earth and its light illuminates the atmosphere. The lunar cycle lasts 29 days for a complete rotation of the Moon around the Earth and 24.8 hours for a complete rotation of the Moon on its own axis. Sun, Earth and Moon are constantly changing positions. As a result, the portion of the Moon illuminated and visible from the Earth also changes. The illumination of our atmosphere varies greatly: from 0.0001 lux at the new moon to 1 lux at the full moon. It is 0.1 lux for a half moon and 0.01 lux for a quarter moon.

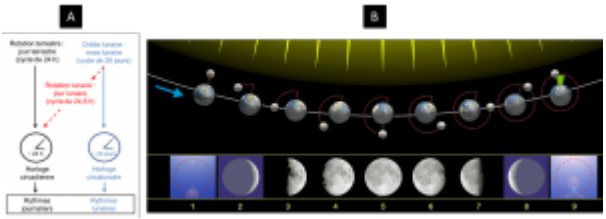

Figure 2. The Moon and the circalunar clock. The lunar month corresponds to the complete rotation of the Moon around the Earth's axis while it rotates around the sun (B): 1 & 9, new moon (night 0 & 29th night); 2, first crescent (4th night); 3, first quarter (7th night); 4, increasing Gibberous moon, 11th night); 5, full moon (15th night); 6, decreasing Gibberous moon (18th night); 7, last quarter (22nd night); 8, last crescent (26th night). This rotation lasts 29 days and synchronizes the circalunar clock, which regulates behaviour and certain physiological functions, including reproductive function, in living organisms. The lunar day corresponds to the complete rotation of the Moon on its own axis. This rotation lasts 24.8 hours and could be used, in conjunction with the 24-hour day/night cycle, to synchronize the circadian clock. A, Figure modified by Tallec according to Kronfeld-Schor et al (see ref. [1]); B, © Orion 8 (CC BY-SA 3.0) via Wikicommons.

These changes in light intensity during the lunar cycle affect the behaviour and biological rhythms of living organisms. In particular, the lunar cycle, by modifying the illumination of the environment, increases the risk of perceived predation and changes musculoskeletal and eating habits. Thus, most small nocturnal mammals reduce their overall activity on full moon nights. On the contrary, the increase in illumination tends to favour predators during their search for food. Biological rhythms are also modified. In some species, the lunar cycle synchronizes breeding periods between individuals. This is the case for amphibians and corals. These behaviours and rhythms would be trained and synchronized by a 29-day circalunar clock. However, studies are lacking and the mechanisms and photoreceptors involved have not yet been identified (Figure 2).

References and notes

[1] Kronfeld-Schor N, Dominoni D, De Iglesia H, Levy O, Herzog ED, Dayan T & Helfrich-Forster C (2013) Chronobiology *by moonlight*. Proceedings of the Royal Society: Biological Sciences 280, 1-11.

Further reading

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Koukkari WL & Sothern RB (2006) *Introducing biological rhythms.* New York, Springer Verlag.