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Editorial: ChronoBiophotonics

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Editorial on the Research Topic
ChronoBiophotonics

Human beings have long recognized the intertwined threads of light, cycles, and life that form a shared reference for cultural traditions and celebrations. From the onset, the conceptualization of the scientific method incorporated cycles or oscillators to comprehend and analyze natural phenomena, such as the movement of celestial bodies, ebb-and-flow of ocean tides, periodic alteration of climate, and additionally propagation of light, sound, heat, and other phenomena. During the 20th century, the probability amplitudes of quantum physics and basis for nuclear, atomic, and molecular structures were understood in terms of energy-quantized oscillations. In the physical sciences, oscillators are elegantly characterized by complex numerical representation of amplitude – measure of oscillator strength – and phase – measure of oscillator relative temporal or spatial position.

The central role of light in pacing the multitude of the body's endogenous circadian clocks and numerous processes they drive was recognized during the 21st century. The master clock, the superchiasmatic nucleus (SCN) located in the hypothalamus, is responsive to neural input signals of environmental light, especially those of the blue light spectrum, sensed not only by cone and rod photoreceptors but specialized intrinsically photosensitive ganglion cells of the retina that express the photopigment melanopsin. The 2017 Nobel Prize in Physiology was awarded to Michael Young, Jeffrey Hall, and Michael Robash for their discovery of the two inter-locked, transcription-translation feedback loops that generate 24-hour cycles at the cellular level. This and related discoveries have established the biology of human beings is precisely organized in time as an extensive network of circadian clocks that are time-cued in period, i.e., 24.0 h, and coordinated in phase relationship, i.e., timing of peak and trough, by the SCN in response to environmental light as the primary Zeitgeber (time giver). Thus, the energy flows of every cell of tissues and organs are precisely regulated by resident oscillators predominantly paced by the light-cued SCN master pacemaker.

Contributions to the featured ChronoBiophotonics Research Topic examined the intimate connection between light and circadian oscillators in humans and representative laboratory models. Moore-Ede et al. addressed the potential impact of light, particularly artificial light produced by light-emitting diodes, on human health and wellbeing. The consensus of hundreds of scientific investigators and thousands of peer-viewed papers suggest the need of standards and warning labels that stipulate the potentially harmful effects on circadian timekeeping and health of blue spectrum artificial light at night (ALAN) exposure. Bumgarner et al. reported how ALAN can impact the progression and severity of diabetic neuropathy. Using a diabetic mouse model, they found such ALAN effect can be sex-dependent; it increases blood glucose level and alters body mass in male but not female murine subjects. Rea et al. used a computational model to investigate the duration of time required to re-entrain the circadian system to the culturally instituted 1 h spring-time advance and fall-time delay of external clocks that results in altered temporal pattern of light exposure. Model results suggest the impact of such changes may be dependent on one's chronotype (e.g., morning vs. evening phenotype) and time-of-day patterns and behaviors that affect exposure to light. Das and Milner reviewed the role that retinal Müller glial cells (MGCs) play on circadian dysregulation – disturbance of the phase relationships of sleep-wake and other circadian rhythms and processes – concluding MGC dysregulation is related to AD retinopathy.

ALAN exposure is the consequence of the invention of the electric light bulb by Edison in 1880. Artificial light use became widespread by construction of electrical power delivery networks shortly thereafter. Such artificial sources of light within the short span of only seven or so generations resulted not only in huge and rapid changes in lifestyle but alteration of the primary external time cue that paces the circadian system. The artificial environmental conditions of today are not the natural ones in which humans and other species evolved over many thousands of years and to which they are well adapted. ALAN has enabled the growth of night and shift work. Investigation of the detrimental effects of mistimed ALAN was initially stimulated by reports of elevated incidence of breast cancer in night-working women. Subsequent epidemiological investigations further revealed elevated risk of breast cancer in women residing in urban settings chronically exposed to ALAN. Many other direct and indirect negative impacts of ALAN have since been reported. ALAN enables adults and children to extend their waking span well into the night, resulting in abnormally shortened sleep spans. International medical societies, in-line with international sleep societies, recommend 7–9 h (7-8 for seniors) sleep/night for adults and more for children according to age to promote heart health and optimal physical and cognitive performance. Nonetheless, short sleep duration of less than 7 h/night is epidemic, leading to risk for increased blood pressure/hypertension and late eating/snacking that leads to weight gain, obesity, metabolic syndrome, and type-2 diabetes, which collectively increases vulnerability to atherosclerosis and cardiovascular disease and associated adverse events. The potential effect of ALAN on species other than humans is additionally concerning, including disruption of the normal patterns of navigation by migratory species and life cycle events of botanical species and their pollinators that are fundamental for plant reproduction, that are synchronized by the onset, offset, and duration of light per 24-hour span during the different seasons of the year. Additional research is necessary to fully comprehend the chronobiophotonics of natural and artificial light. This entails novel investigations to answer unanswered questions of, among others: (i) Are light Zeitgebers sensed not only by specialized receptors of the retina but additionally by penetration of light of different wavelengths through the skull that reaches brain tissue? (ii) Does reception of light of various wavelengths during the daytime of diurnally active persons by the skin serve as Zeitgebers, for example, through affecting peripheral blood vessels constituents and vitamin D synthesis through exposure to natural light, which in turn acts as a hormone affecting many biological processes in a time-related manner? and (iii) Is the rest-activity pattern of nocturnal species that is likely shifted toward the daytime by ALAN increase the risk for zoonoses – infectious diseases caused by bacteria, viruses, parasites, fungi, or prions passed between animals and humans – because of breakdown in time of evolved activity patterns that ordinarily serves as barrier of contact and infection transmission between diurnally active humans and nocturnally active animals? We editors believe that the field of ChronoBiophotonics will continue to experience extraordinary growth, and we hope this feature Research Topic of Frontiers in Photonics spurs further research of the effects of natural and artificial light on biological timekeeping and other attributes of our planet's diverse lifeforms.

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