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Gerkema, Menno P.

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Circadian Desynchronization/ Circadian Desynchrony

►Circadian Sleep Phase Syndromes

Circadian Food Anticipatory Activity (FAA)

►Food Entrainment

Circadian Output Genes

►Clock-Controlled Genes

Circadian Pacemaker – Temperature Compensation

Menno P. Gerkema
Department of Chronobiology, Faculty of Mathematics and Natural Sciences, University of Groningen, Groningen, The Netherlands

Definition

One of the defining characteristics of circadian pacemakers and indicates the independence of the speed of circadian clock processes of environmental temperature. Mechanisms involved, so far not elucidated in full detail, entail at least two processes that are similarly affected by temperature changes, but with an opposing and counterbalancing effect on the periodicity of the clock system. As a result of temperature compensation, the increase in reaction velocity for every 10° rise in temperature (►Q_{10}) of processes governed by ►circadian pacemakers reaches values of about 1.

Characteristics

The Phenomenon

The first study on temperature independence in circadian timing was published in 1932 [1], showing the precision in time memory of foraging bees in spite of changes in environmental temperature. The early notion that the velocity of circadian processes does not vary with environmental temperature (within certain ranges) has been based on experimental evidence from a wide variety of sources. Evidence for temperature compensation of circadian rhythms has been collected for luminescence rhythms in unicellular algae, daily leaf movements in plants, and locomotor activity in cockroaches and lizards (as compiled in [2]). Comparisons of ►period length, expressed as Q_{10}, the quotient of reaction rates per 10°C, revealed Q_{10}s in the range of 0.9–1.2 [3]. This is in sharp contrast to the usually temperature-dependent kinetics of biochemical processes resulting in Q_{10} values of roughly 2–3 [4]. These findings, together with the insight that a functional clock subject to temperature dependence would be prone to inaccuracy in the natural environment, caused Pittendrigh to list temperature compensation as item XI on his famous list of 16 empirical generalizations about circadian rhythms [3]. Since then, a vast literature on circadian Q_{10} values has accumulated, confirming early observations. Recently, temperature compensation has been demonstrated in ►clock gene expression rhythms in mammalian fibroblast cultures [5]. Also the phosphorylation rhythms of the Cyanobacterial protein KaiC *in vitro*, in the presence of two other proteins but in absence of transcription and translation, shows temperature compensation, in the range of 25–35°C [6].

Mechanism

A simple model for temperature compensation has been based on two chemical reactions, both of which are temperature-dependent. The rate of the first reaction may control period length, whereas the product of the second reaction would inhibit the first reaction. With such a model, Q_{10} values slightly smaller than 1 also can be explained [7]. Temperature compensation also is an important aspect of neuromodulation (e.g., motor networks), and here again the intrinsic temperature dependences of the processes that contribute to the system output can simply balance each other because reaction rates have been "chosen properly" [8].

Alternatively, the structure of the network itself can stabilize its output, as also has been suggested for networks in clock systems, emphasizing pathway phenomena rather than results of single enzyme properties [9]. The hunt for molecular key players in the process of temperature compensation has nevertheless started, as illustrated in a study on the role of specific core clock proteins in Arabidopsis [10].

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Circadian Pacemaker Neuron

Definition

Circadian rhythms of animal behavior and physiology are coordinated by a master clock in the central nervous system of each individual. This master clock comprises a collection of multiple circadian pacemaker neurons.

Each pacemaker neuron has the capacity for autonomous circadian oscillation of cellular parameters such as gene transcription and action potential firing rate. Pacemaker neurons communicate circadian phase information to one another – for the purpose of synchronizing or otherwise coordinating their autonomous rhythms – and to downstream neural targets – for the purpose of driving overt behavioral and physiological rhythms. This communication of phase information occurs via both classical synaptic neurotransmission and the release of peptide neuromodulators.

►Cellular Clock
►Circadian Rhythm
►Human Circadian Timing System
►Morning/Evening Oscillators

Circadian Rhythm

Definition

A circadian rhythm is a biological oscillation that has a frequency of about once per 24 h when conditions are constant (e.g., when removed from regular, 24 h daily cycles of the environment, such as light and dark or warm and cold). The word “circadian” is derived from circa dies, Latin for “about a day.” Circadian rhythms are synchronized to exactly 24 h under natural conditions by zeitgebers, with light acting as the major synchronizing agent.

►Chronobiology
►Entrainment
►Human Circadian Timing System

Circadian Rhythm Sleep Disorders

►Circadian Sleep Phase Syndromes

Circadian Rhythms of Autonomic Functions

Ruud M. Buijs
Instituto de Investigaciones Biomedicas, Department Fisiologia, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico

Synonyms

Circadian rhythms are all biological rhythms that express themselves with a rhythm of ~24 h.

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