Rhythm Generation

Subjects: Physiology

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Rhythms are essential to living beings. They allow fluxes to coordinate with one another. Rhythms, thereby, constitute an information system for body functions. Biosphere rhythmicity largely relates to geophysical oscillations. To ignore the latter also affects human health and performance.

Keywords: biological rhythms ; geophysical oscillations ; metabolic fluxes ; human health and performance

1. Introduction

Life implicates and depends on rhythms. Energy flowing through living beings generates linear and/or cyclic deviations from thermodynamic equilibrium [1] "Nondecaying, repetitive phenomena", or cycles, determine the chemical organization of living matter [2]. Cycles also occur in simple organic chemical processes like the Belousov-Zhabotinskii reaction [3]. Oscillatory reactions often involve positive free enthalpy (Durup, 1979 cited by [4]). An oscillating signal requiring less energy implicates a gain in precision of control [5]. Biological control based on periodical events, thus, becomes energetically more advantageous and more efficient than that relying on steady-state reactions [5]. Phased with the environment at more or less constant period length, endogenous oscillators influence the genome [6] and by means of the latter, also affect functions like cell growth, protein synthesis, stress responses, and intermediary metabolism [7]. Timekeeping of energy metabolism and related body functions is mostly under the control of transcriptionally based, cell autonomous mechanisms in step with post-translational processes. Interlocked by transcriptional feedback loops, gene products like CLOCK and BMAL1 drive biological clocks positively, while others like CRY1-2, PER1-3 and REV-ERBα do it negatively [6][8][7][9]. Individual phase differences in PER3 expression, thus, correlate with timing of sleep during a constant routine [10].

2. Mechanisms

The mechanisms by which the multiple feedback loops are integrated remain largely to be specified. Uncertain are also the post-translational mechanisms possibly involved in clock regulation [11][12][13][14]. Clock components (such as BMAL1 and CLOCK) may, moreover, additionally affect gene expression and metabolic processes, apparently not related to their proper timing function [15][16]. The mechanism by which clock protein stability connects with circadian period length is not yet exactly known [17]. Clinical consequences of period shortening in circadian cycles are evidenced in sleeping sickness caused by *Trypanosoma brucei* [18]. Noticeably, however, cycling also occurs in the absence of a genome, as shown by intracellular K^+ levels in human red cells [19]. However rhythms are caused, they allow the necessary time keeping in living beings, or as having stated by Joseph Bass (2017): *As energy metabolism being in constant flux, there would be time in biochemical processes, as there is in a central train station* [20].

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