The Architecture of Rhythms in Life

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The complexity of the array of rhythms in the human body makes it difficult for even the most advanced modeling systems to fully describe the most well-studied rhythms, such as the heart rate, respiratory breathing, and circadian rhythm. At the same time, no rhythm can be fully described in isolation.

A helpful model for describing complex systems was pioneered by the Nobel prize awarded Herbert Simon, formulating the theory of *The Architecture of Complexity* in 1962. The theory states that "*complex networks must take the form of hierarchy with unifying properties independent of their specific content*." Applying the theory to the complex rhythms of life, we can identify master rhythms by unifying different rhythms by entrainment, keeping other rhythms in a frame, or phase-lock a rhythm to a constant value or ratio.

Unifying Master Rhythms. Humans need a multi-clock system to regulate the fast-changing environment and simultaneously have a long-term perspective to sustain life. Some of the most studied master rhythms are the cell cycle and the circadian rhythm. From the beginning of evolution, a cell is a unit for life, as is the cell cycle for the perturbation of life, making the rhythms of the cell fundamental for our life. On a whole-body level, all parts need to know the interaction and timing of all events. Even a cell needs to have a perception of time to time the metabolism and cell division. Just imagine the timing of cell division and differentiation in the developing embryo; all events happen with an incomprehensible timing of many rhythms at work.

The knowledge of circadian rhythm is central to getting a sense of the symphony of rhythms played in our bodies. The massive impact of the circadian rhythm is shown as 50% of our genes change their expression during a circadian cycle. The circadian cycle is regulated by oscillating neurons in the hypothalamus, a master unifying center for the function of our life. A group of oscillating neurons keeps this cycle entrained independent of the light/dark cycle to a range for humans of 21 to 29 hours. With a group of light-sensitive oscillating neurons, the 24-hour cycles are created. In addition to the sun giving a 24-hour cycle of light and dark, the moon provides a semi-diurnal 12-hour rhythm, making a high and low tide twice a day. The influence on water and solid matter is massive, creating high-low tides in oceans up to 40 feet and compressing and decompressing mountains. The circadian cycle is synchronized with or entrained with the 12-hour lunar cycle phases, which also affects our sleep pattern.

Autonomous rhythms. Autonomous rhythms are subdivisions in the life architecture that allow part of the system to free-run, receive entrainment, and make compensations from the environment. Examples of autonomous rhythms are the regulation of heart rate and respiratory breathing, both important for survival, with autonomous systems for the generation of rhythms that can be closely regulated according to the current needs. In the heart, there are autorhythmic cells (pacemaker) that, without extrinsic influence from neural or hormonal effects, keeps a beating around 100/min. Respiratory breathing has oscillating neurons in the brainstem that are not using a homogenous group of oscillating cells like the hearth pacemaker. Still, a system of at least two oscillating groups of neurons to keep breathing on a minute-to-minute balance.