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TIME AND LIFE: A BIOLOGICAL AND EPISTEMOLOGICAL ANALYSIS OF TIME'S IRRELEVANCE IN BIOCHEMICAL REGULATION

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ABSTRACT

This study presents a critical analysis of the concept of time as a regulatory quantity in living systems, exploring the hypothesis that time, although widely used as a descriptive reference in physics and social organization, does not exert a causal role on biochemical and physiological processes. Through an interdisciplinary approach involving physics, biology, and philosophy of science, the mutual dependence among SI units, particularly between the second and the meter, is examined, exposing the arbitrariness and anthropic construction of these references. Mechanisms of enzymatic and physiological regulation are discussed, highlighting their reliance on concentration gradients and electrochemical potentials, not on temporal measurements. Ultimately, the epistemological implications for understanding life are discussed, proposing that biology functions under its own internal logic, disconnected from chronological time. It is hypothesized that life emerged from what was physically present in the universe, and not from 'time', since the mechanisms that sustain life do not require time to exist.

Keywords: time; biology; metabolism; epistemology; living systems.

INTRODUCTION

Modern science organizes the understanding of the universe through fundamental quantities, among them time, space, and mass. These quantities are formalized in the International System of Units (SI), which sets standards for the measurement of natural phenomena and provides a common language across scientific disciplines. However, as research on living systems deepens, it becomes increasingly evident that the physical-mathematical models based on temporality do not fully apply to biology. Although time is widely used to describe changes and events, living organisms do not appear to use it as a regulatory variable in their internal processes. Metabolic regulation, physiological mechanisms, and biological rhythms are governed by local factors such as concentration gradients, electrochemical potentials, and molecular interactions, not by chronological measurements. This study proposes a biological and epistemological analysis of the hypothesis that time, although useful as a theoretical and cultural construction, is not a governing quantity in biological systems. Through an interdisciplinary approach combining principles from physics, biochemistry, physiology, and philosophy of science, this study seeks to demonstrate that living organisms operate autonomously from external chronology, revealing the non-temporal nature of life.

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METHODOLOGY

This article was developed based on qualitative bibliographic research, using classical and contemporary works from physics, biochemistry, physiology, and philosophy of science. Sources were selected based on theoretical relevance and methodological consistency, prioritizing renowned publications and reference authors such as Albert Einstein, Henri Bergson, Jacques Monod, Albert Lehninger, Fritjof Capra, and W. Freeman. The integration of concepts across these fields enabled an interdisciplinary analysis of the presence. or absence, of time as a regulatory variable in living systems. The methodological approach involved analytical reading of selected texts, focusing on the comparison between the physical definition of time and its real applicability in the regulation of biological processes. No empirical experiments were used, as this is a theoretical and epistemological investigation. This article included partial use of artificial intelligence tools for support in text revision and idea organization, under the supervision and authorship of the researchers.

FUNDAMENTAL PHYSICAL QUANTITIES AND THE MUTUAL DEPENDENCE BETWEEN TIME, DISTANCE AND MASS IN THE INTERNATIONAL SYSTEM

The observable universe, from subatomic particles to galaxies, is described through events regulated by fundamental physical quantities such as length, mass, and time. These quantities allow accurate description of natural phenomena and are standardized in the International System of Units (SI): the meter (m), kilogram (kg), and second (s). Modern definitions of these units reveal not only an attempt at absolute precision but also their interdependence, showing that none of them are completely autonomous. Since 1983, the meter has been defined as the distance light travels in a vacuum in 1/299,792,458 seconds, meaning the unit of length directly depends on the unit of time. Conversely, the second is defined (since 1967) as the duration of 9,192,631,770 periods of radiation corresponding to the transition between two hyperfine levels of the cesium-133 atom, a definition based on quantum phenomena that are spatial and material. Because the concept of a “period” involves a physical cycle or movement, such as the Earth’s rotation, time itself relies on the notion of space. The kilogram, while currently based on the Planck constant, is also related to measurements of frequency and energy, both of which derive from time and length. This reveals a conceptual circularity: time defines the meter, but the meter also defines time. Contrary to Newton’s classical idea of an absolute, autonomous time, modern physics, through Einstein’s relativity, recognizes time as relational, dependent on gravity and velocity and always linked to the observer. Thus, time emerges not as an intrinsic entity of the universe but as a theoretical construct inseparable from material reference points. This undermines the notion of time as a universal, standalone magnitude, especially when applied to biological systems, which, as will be shown, function independently of any chronological parameter.

BIOCHEMICAL REGULATION IN LIVING SYSTEMS: MOLECULAR DYBANICS INDEPENDENT OF TIME

In living organisms, metabolic activity is regulated by biochemical mechanisms that operate with remarkable complexity, precision, and autonomy, without the need for an external temporal variable. Fundamental life-sustaining reactions, such as cellular respiration, photosynthesis, and protein synthesis, are driven by local states of reagent and product concentrations, cofactors, and physicochemical conditions like pH and temperature. Enzyme regulation, a cornerstone of cellular biochemistry, operates through mechanisms such as allosteric control, competitive and non-competitive inhibition, feedback modulation, and reversible phosphorylation. None of these involve time as a modulating agent. For example, phosphofructokinase-1 (PFK-1), essential in glycolysis, is activated or inhibited based on intracellular concentrations of AMP and ATP, which signal the cell’s energy status. Likewise, acetyl-CoA carboxylase regulates lipogenesis in response to metabolic signals, without reference to temporal markers. Michaelis-Menten kinetics, commonly used to describe enzyme behavior, includes time only as a parameter for reaction rate measurement, not for controlling the reactions. This distinction is critical: time quantifies events using clocks, devices where hands move across space, but does not dictate when or how events begin or end. Even biological rhythms like the circadian cycle, while seemingly governed by an internal “clock”, are actually the product of self-organizing molecular feedback loops involving genes such as PER, TIM, BMAL1, and CLOCK. Studies with organisms kept in constant darkness have shown that these cycles persist independently of external time, confirming that endogenous rhythms are self-regulated, not imposed by a universal timeline. Homeostasis is maintained through local dynamic adjustments mediated by concentration gradients, molecular interactions, and electrochemical potentials, not by seconds, minutes, or hours. This reinforces the idea that time is not a functional variable at the molecular level in living systems, but a construct applied externally for measurement and description.

PHYSIOLOGICAL EVIDENCES OF THE INDEPENDENCE OF LIVING SYSTEMS FROM TIME

Animal physiology offers incontestable examples of the autonomy of biological processes from the variable time, reinforcing the notion that living organisms do not rely on time as a regulatory factor. A classic example is the spinal reflex arc, especially the stretch reflex. In this mechanism, the sudden stretching of a skeletal muscle stimulates sensory receptors in muscle spindles, which send electrical impulses via afferent neurons to the spinal cord. The reflex response, muscle contraction, occurs through efferent pathways without cortical or conscious mediation. This circuit responds to a physical stimulus in real time, and the reaction occurs instantly according to the involved action potentials and synapses, with no ‘waiting’

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or chronological planning. Another notable case is glycemic regulation by insulin. The release of insulin from pancreatic beta cells is a direct response to elevated blood glucose levels, detected by membrane sensors and activated through intracellular mechanisms involving potassium and calcium ion channels, vesicle mobilization, and exocytosis. Time plays no modulatory role here; the body responds purely to present metabolic conditions. Renal physiology further demonstrates this principle: osmoregulation is controlled by hypothalamic osmoreceptors that detect plasma osmolarity changes, triggering responses that alter renal tubule permeability to promote water reabsorption. None of this depends on time measurements, it is driven by internal physicochemical sensors. The same applies to thermoregulation, heart rate modulation, and inflammatory responses: these are adaptive reactions, fast or slow depending on conditions, but triggered by imbalance and corrected by negative feedback, the fundamental organizing principle in biology. These examples clearly demonstrate that living organisms do not function based on internal chronometers governed by absolute time, but rather on continuous responsiveness to internal and external states, revealing the non-temporal character of biological regulation.

TIME AS A CONCEPTUAL ABSTRACTION: A HUMAN CONSTRUCTION RATHER THAN A REGULATORY QUANTITY

Given the biochemical and physiological evidence discussed, it becomes plausible to assert that time, as conceived by the physical sciences, plays no direct role in the functional organization of living systems. This leads to a broader hypothesis: that time is not a universal physical magnitude but a human construction used to describe and organize perceived events. Even the definition of a second, based on atomic transitions in cesium. is a convention for standardization, not an inherent property of nature. In this sense, time does not “exist” as a substance or agent, but as an epistemological tool. Henri Bergson, in “Duration and Simultaneity” (1922), differentiated between measured time (quantitative, spatialized) and lived duration (qualitative, continuous), arguing that time is a product of consciousness, not of physical reality. This was echoed by philosophers like Heidegger, who in “Being and Time” (1927) posited that time emerges from human existence as a horizon of understanding and action. Biological data support this perspective: metabolic cycles, physiological rhythms, and regulatory mechanisms operate based on internal states, not external succession. Even biological clocks. like circadian systems—result from molecular interactions rather than absolute time. Thus, time is a representation of change, not its cause. Organisms do not “follow” time; they respond to stimuli (e.g., molecular concentration, mass), interact with their environment (space, distance), and self-regulate through mechanisms that do not require the variable “time” to function. Life, in this regard, is timeless in its organization, even though it undergoes transformation. Time is the language we use to narrate change, not the force that drives it.

AS BIOLOGICAL EPISTEMOLOGICAL, SCIENTIFIC, AND CULTURAL IMPLICATIONS OF THE ABSENCE OF TIME AS BIOLOGICAL VARIABLE

The hypothesis that time does not play a regulatory role in living systems, and may not even exist as a physical magnitude, has deep implications for biology, physics, philosophy, and even daily life. In physics, this view challenges the Newtonian paradigm of continuous, absolute time. Though relativity and quantum physics have modified this notion, time still appears as a necessary formal parameter in mathematical models of reality. However, contemporary researchers such as Carlo Rovelli and Julian Barbour have questioned this assumption. In ‘The End of Time’ (1999), Barbour argues that reality consists of static configurations of the universe, “now”, and that the sense of time passing is an illusion derived from memory and consciousness. In the philosophy of science, such ideas challenge the linguistic structure of scientific discourse, which depends on temporality to organize causes and effects. If time is not fundamental, causality itself must be redefined in terms of structural dependencies rather than temporal sequences. In biology, this means explaining life through models based on equilibrium states, metabolic transitions, and local biochemical flows, rather than chronological timelines. In daily life, reconceptualizing time affects how we relate to our bodies, health, and aging. Modern society revolves around the clock, deadlines, schedules, appointments, yet our bodies follow physiological needs that do not conform to social time. Sleep, hunger, stress, reproduction, and healing operate by internal rhythms modulated by stimuli, not timekeeping. The dissonance between lived and measured time can cause suffering, as seen in sleep disorders or anxiety from deadlines. Recognizing that time does not determine vital processes allows for a biology more attuned to subjective experience and the complexity of living systems. The hypothesis that life emerged and persists without being modulated by what we call “time” suggests its nonexistence as we perceive it. Life ends from “material wear” rather than an inherent aging process. Are we facing a new Copernican revolution in physics?

Common Misconceptions Leading Us Astray: Another Example

Just as our ancestors misinterpreted the Sun and Moon’s motions in the sky, many everyday perceptions still mislead our understanding of time. A clear example is in Medicine, specifically in treating patients with pulmonary disorders using mechanical ventilators. These machines assist those who cannot breathe on their own and must be regulated to provide proper oxygen levels and eliminate CO_2. It is routine for physicians to set these devices based on time, configuring how many breaths the machine gives per minute, this is called time-cycled ventilation. Adjusting this temporal parameter helps normalize blood gas levels and restore physiology. Clearly, this illustrates the utility of time-based control in sustaining life. However, as the article demonstrates, this is an artificial life adjustment. It metaphorically illustrates how our

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perception exaggerates time's importance in biology. It reinforces the psychological belief that time is a physical property of the universe—undeniable due to its role in regulating machines that keep our loved ones alive.

CONCLUSION

From an integrated analysis of physical, biological, and philosophical sciences, we conclude that time, though widely used as a descriptive tool, does not serve a functional role in living systems. Biochemical reactions, physiological reflexes, and internal rhythms are regulated by mechanisms responsive to local and structural changes, not to an absolute temporal flow. The hypothesis that time is a human construction, not a universal magnitude, is strengthened by the autonomy of life processes from chronological conventions. This conclusion invites a revision of biological epistemology and opens new perspectives for understanding life and reality. Liberating biology from temporal paradigms allows for a reinterpretation of life according to its own internal logic, rather than imposing an external framework. Acknowledging this independence supports more sensitive approaches in both science and culture to engage with vital phenomena, respecting their internal logic instead of forcing them into imposed temporal structures. Biochemically, life does not require temporal modulation. Yet for humans, as in the ventilator example, clock time acquires another meaning. Paraphrasing Humberto Maturana, science and philosophy walk on the edge of an epistemological razor.

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