

Sleep, Negentropy and Consciousness

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Abstract

Circadian rhythms of alternating metabolic patterns homologous to those seen in the human sleep wake cycle are ubiquitous in virtually all life forms. Negative entropy metabolic activity, negentropy, the importation of high energy compounds and the elimination of low energy residua, used to maintain a low internal entropy environment is similarly ubiquitous. The metabolic cycle, as internalized across the life forms, functions to sequester portions of the negative entropy process which would interfere with each other if attempted simultaneously. Information is the essence of low entropy. Evolution is associated with the progressive increase in the direct importation of information and the utilization of that information to maintain low internal entropy. While 'Information is Physical', its management and storage, requires energy, alternative stored information do not differ in enthalpy but only in meaning. The only way to process and store information negentropy is to be aware of the information, understand the information, have the free will to choose and the ability to control the matter of the brain to affect that choice. The capacities which define the essence of Consciousness, are the same as those essential for Information Negentropy. In humans, the process that manages negentropy through wakefulness and sleep is continuous in its identity, also through some coma, dementia and some psychosis. The deeper understanding of Consciousness must transcend not only its various modes of function but more so its necessity to understand meaning in order to perform negentropy.

Key Words: Consciousness, Negentropy, Sleep, Information, Encephalization

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Introduction

Sleep is a normal, daily, essential and massive variation in the manifestations of Consciousness. This circadian rhythm in Consciousness is evident both by human introspection and the observation of others, and represent a major phenomenon that must

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be integrated into any understanding of Consciousness. Sleep, or phenomena that resemble human sleep, are ubiquitous in the animal kingdom (Jaggard et al., 2021; Omond and Lesku, 2024). Obviously, any changes in consciousness that may or may not occur in non-human species cannot be ascertained. The behavior in non-human animals that is confidently referred to as sleep is a circadian variation in mobility, metabolism and alertness. Nyctinasty, a sleep-like behavior, is seen in many plants. The analogy of Nyctinasty to sleep is built again on the similarity of diurnal variation in position and metabolism, although obviously without the behaviors that would imply consciousness (Draguhn et al, 2021). There are even diurnal variations in metabolism of single cell organisms that are at least vaguely analogous to sleep (Zones et al., 2015). Sleep-like variation in metabolism is essentially co-extensive with Life and as such suggests it is essential and fundamental.

The purpose here is to utilize the ubiquity and mechanisms of sleep to expose its role in the maintenance of life and the phenomenon of human consciousness. It was easy to assume that the circadian variation in metabolism was created in response to and continues to be driven by the astronomical reality of variation in light and temperature. However, it is well demonstrated that in humans the circadian rhythmicity is endogenous, independent of any external driver (Mills et al., 1974).

Endogenous not Light Driven

In single cell organisms and some plants, Nyctinasty continued without changes in light (Velez-Ramirez, 2011). Plants show circadian rhythm independent of light. (Venkat and Muneer, 2022). Indeed, all circadian rhythms in essentially all living systems, although presumed to have some origin in the astronomically driven daily cycle of solar light, appear to be internalized and made endogenous since the origins of life (Loudon, 2012; Gumz, 2013). If the apparent unity of endogenous circadian rhythmic variation across the entire spectrum of living species is valid, then three major conclusions follow.

Cellular Metabolic Fundamental Not Behavioral

1. The essential functions performed in sleep are internal, cellular metabolic, in their focus. There isn't, nor can there be, any truly analogous 'sleep related' change in the behavior of plants. If, from an evolutionary perspective, the circadian rhythm arose in plants in response to variation in sunlight, then the change in behavior of animals appears grafted on. The changes in behavior of animals in sleep are temporally associated with those metabolic activities, and may play other useful roles, but are not fundamental. The necessity and persistence of the cyclical metabolic activity is fundamental and

necessary now (Rutter et al., 2002). It's being normally synchronized with the external factors, is merely an evolutionary convenience. 2. The metabolic activity performed during these special periods (in humans sleep), must be disruptive to the standard and predominant metabolic activity during the rest of the cycle. It is that disruption which requires the special period to be temporally sequestered from the regular period. The cycle in modern animals is driven by the alternation of metabolic modes, not solar light. 3. The stability of the cycle means the disruption is necessary and positive, but not destructive.

Sleep and Energy Negative Entropy

Circadian Metabolic Changes

The circadian rhythm is intimately involved in energy metabolism. Most obviously in photosynthesis, with the acquisition of light energy and its transformation into bond energy is confined to daylight. However, the very same enzymatic mechanisms which are central to photosynthesis during the day (the Calvin Cycle), are problematic and counterproductive at night when the plant is catabolizing high energy compounds for its current use. Regulating these reactions "is considered to be an 'integrator' of information from metabolism and the environment" (Foyer and Noctor, 2009). Human sleep shows a "rapid and reversible control of human metabolism" (Nowak et al., 2021). The centrality of the metabolic aspect of the rhythm over the external lighting and the physical activity is documented in humans subject to social or experimental shifts in rhythm (Paller et al., 2020) and can be confirmed in animal experiments (Eckel-Mahan and Sassone-Corsi, 2013).

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Negative Entropy

Schrödinger virtually defines life, at least from the perspective of physics, as a volume of matter capable of importing energy, using it to lower the entropy internally, and to export the high entropy residua (Schrödinger, 1967). Life is a negative entropy, 'negentropy', machine (Ornes, 2013). The total negentropy process is: 1. Acquisition: Extracting the energy imported from outside by photosynthesis or by the rupture bond in imported molecules, catabolism of food; 2. Use: Utilizing that energy to form lower entropy structures internally, either in the structure of the living tissue or the formation of internal high energy chemicals for storage; and 3. Discard: Extruding the high entropy molecules not needed. All are governed by the standard laws of physics of the contents inside the living entity. There is no violation of the Second Law of Thermodynamics but living thing itself maintains an entropy lower than its environment despite continuing activity in,

and chemical interaction with, that environment. And in some circumstances, it progressively lowers its entropy.

Retention of Negentropy

The retention of lower entropy is done in part by the production of high enthalpy bond structures such as fats. This is accomplished in the hyper-organized, low entropy environment of the cell by coupling the synthetic low probability reaction to the degradation of a high energy bond derived energy source originally outside the cell. The external energy source provides the energy to drive a choice of the more orderly, negentropy result rather than the otherwise more probable path which increases disorder (Bennett, 2003). That synthetic process, in that produces a product of lower entropy is intrinsically the processing of information.

The low entropy of living tissue is primarily in the order of its structure not in the storage of high energy bonds. (Davies PC et al., 2013). There is more information, more low entropy content in the cell as it grows and maintains its proteins than was present in the DNA by which it was created. The anabolic and catabolic activities are both competing for the high energy negentropy resources acquired from outside and would interfere in each other's efficiency if attempted to be done at the same time.

The circadian rhythm of animals is internalized for metabolic reasons. One phase, usually daytime, the metabolism can be catabolic, burning high energy bonds to be active, resulting in wear and tear to tissue structure, and acquiring food, and in the other phase, typically in the sleep phase, it can be anabolic, storing high energy bonds and making repairs. The rhythm is driven by the alternation of the dominant metabolic activity.

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Sleep and Information Negative Entropy

Evolution of Information Negentropy

In energy negentropy, high energy bonds are utilized by the information implicit and explicit in the structure of the living tissue to maintain the low entropy internal environment. The acquisition of information itself is a negentropy interaction. The essence of Negentropy is the distinction between disorder and order. Information to make that distinction is the essence of negative entropy. All aspects of the acquisition and processing of information require energy (Landauer, 1991).

The homology of the circadian rhythm for the management of energy negative entropy across the entire range of life diversity resulting from evolution is remarkable. Although there is significant variation in size and aggregate energy requirements across the evolutionary variety,

the consumption and storage per unit mass, and the implied metabolic mechanisms is generally less than an order of magnitude (Marakareava, 2008). In contrast, the evolution from single cell organisms through multicellular animals culminating in human beings represents massive progressive change in relationship to information from the environment. Therefore, the energy consumption by the brain for information negentropy must rise.

Even immobile single cell organisms acquire information about temperature, pH, etc. Mobile single cell or very primitive animals may acquire the concentration of nutrients, chemical signature of prey, etc. (He et al., 2023). Higher animals have vast organized arrays of detectors of light and sound. The acquisition of information, most notably via the special senses in mammals is on the order 10^{11} greater, totally incomparable to lower animals. Indeed, the evolutionary progression toward greater and greater management of information, and a more manifest negative entropy, maybe regarded as the essence of time (Hazon and Wong, 2026). The human brain accounts for about 20% of the body's total daily energy and oxygen consumption, despite making up only roughly 2% of an adult's body weight (Raichle and Gusnard, 2002). That concentrated sustained energy consumption, primarily by the hydrolysis of ATP with the resulting accumulation of Adenosine, know to induce somnolence.

Information Negentropy and Circadian Rhythm

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That makes it even more remarkable that the management of information negative entropy was integrated into the circadian rhythm developed for energy negentropy. Information is no less physical than the energy imported. "Information is physical" (Landauer, 1991). However, the difference between the alternatives in information negentropy is not the enthalpy of the bond but the entropy, the meaning encoded in a sequence.

Sleep in humans is the fact that the internal processes developed for energy negentropy, at the very least in their temporal structure, were utilized for informational negentropy. The focus here is: 1. The disruption of cellular metabolism into two temporal phases derives from the demands of any negative entropy process. In information negentropy that energy is expended directly into low entropy structures based on their information content, not high enthalpy bonds.; 2. That while details of management of energy negentropy came to be distributed throughout the human body, the management of information negentropy became concentrated in the encephalized portion of the body. The encephalization was necessary because informational negentropy is quantitatively and qualitatively different. Because the human brain is the most extreme information negentropy entity, sleep in humans is the most direct opportunity to understand information negentropy processing.

There is no way to measure the body's or the brain's entropy. But we know the information content of the body, in the brain, rises massively through the senses. We know that therefore: 1. Acquisition: All of the data from every sense, all the accumulated information in education and culture, and that generated internally by 'thinking', of every moment of waking life must be represented, encoded, physically (Grzywacz, 2025); 2. Initial Use: Our perception and immediate term memory retain the information only momentarily. A minimal fraction of that is for at least some time a part of a labile short-term storage (Koch et al., 2006); 3. Long Term Use: Some data is rendered into long term memory. 4. Discard: The rest is erased. The management of the temporary storage, partial preservation, and partial fixate into long term is all not perceived.

Processing Informational Negentropy

In human beings we know that massive acquisition of information, perception, motor intent, thought, etc. are forms of negative entropy. Vision alone is greater than 10^9 b/sec (Zheng and Meister, 2024). All, most obviously sensory, perceptions are discarded except for a tiny faction rendered into labile short-term memory (Kim and Park, 2025). That perception et al. and initial transformation occurs during wakefulness. Evidence supports that 'consolidation', rendering of a portion labile short-term memory into long term more stable form and the loss, erasure, of the rest occurs during sleep (Lutz, 2025).

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This circadian management of this cellular metabolism of negentropy of information in human and other highly encephalized animals parallels the cause and pattern of management of the negentropy of energy in lower animals, plants and single celled organisms. The circadian rhythm was no doubt set at approximately 24 hours to match the astronomical reality. That rhythmicity was in many species then internalized. But the necessity and driver of the cyclicity is the acquisition of negentropy resulting in the accumulation of labile chemical structures and expended energy residua to the maximum tolerable. Drowsiness is triggered by lack of sleep not the clock (Sulaman, 2023). This makes clear that wakefulness accumulates a metabolic burden which must be cleared because wakefulness does not function properly unless that burden is cleared. The system then switches to a 'sleep-like mode' to consolidate the most useful results of the negentropy and eliminate the rest of the labile elements in order to restore the capacity to acquire more negentropy input (Diekelmann, 2010).

Encephalization, Culture and Pleomorphic Consciousness

Encephalization is at a minimum to progressive anatomical sequestration of the negentropy flow of information from the

negentropy flow of energy. This makes sense since the storage and utilization of information is intrinsically based on and enhanced by integration with other information (Resmini, 2011). The storage and utilization of energy has no analogous necessity to relate to other energy storage or use. Similarly, the retained content of information must be in a form of a specific relationship to other portions of information which is the orderliness that is the essence of information, of low entropy. The retained content of energy can be dispersed throughout the animal as the high enthalpy bonds are substantively identical.

Regardless of the details of the process, the mechanism, and in spite of even maximum energy efficiency of encoding (Marx 2012), the storage of information is by definition a highly information intensive process. As far as is known, information is stored both the micro-structures such as synaptic strength (Kennedy, 2013) and macro-structures, differential utilization of different parts of the brain (Geschwind, 1965). However, the commonality of the micro-mechanism and the extremely gross regional differences, encompass essentially nothing of the specificity. It is the hyper specificity of each and every iota of information which makes the totality of the process effective information negentropy requiring metabolically significant energy.

Various functional components of energy negentropy are manifest in their distribution to organs of the body, acquisition of oxygen to lungs, major metabolic energy extraction to the liver, etc. The removal of the unretained energy content in humans is accomplished by the kidneys, gut and lungs in a bulk manner. Beyond gross anatomy of encephalization for the total function, and the EEG temporal staging of sleep, there is currently no clear anatomical disaggregation of the information negentropy process. Some areas, most notably the hippocampus, appear to play some definable role in the flow of the process (Thorup, 2024), but none have any of the informational specificity that is the essence of this discussion. This is not a research failure but rather the necessary consequence of the centrality of specificity.

The effort to understand brain function by associating defined functions to defined pieces of brain. As the impossibility of that approach became evident, focus switched to a functional analysis, psychology, without significant reference to the physical basis. In the last 75 years, modeling has shifted to the concept of a network spread throughout the brain, capable of both massive specificity and interaction but retaining coordination (McCulloch, 2016). The global management of that network, including all aspects of the specificity of information negentropy, is exactly correlated and intimately related to the circadian cycle of Consciousness, awake and asleep.

The management of negentropy information flow in the brain is temporarily disaggregated into three defined stages, wakefulness,

Rapid Eye Movement (REM) sleep, and Slow Wave Sleep (SWS) with transitions between them (Lutz, 2025; Kim and Park, 2025). These have been associated with data acquisition, data storage and data, erasure, respectively. The removal of unretained information is accomplished by resetting the appropriate short-term memory structures. The essence of information is its meaning, and it is obviously impossible to manage that meaning without understanding the meaning.

The only way to process and store information negentropy is for the mechanism be aware of the information, understand the information, have the free will to choose; and for that mechanism to have the ability to control the matter of the brain including which atoms are in which place with which bond energies and as part of which larger structure, to affect that choice. The formation of information negentropy bonds and understanding ideas are two aspects of the same thing. 'Information is Physical' therefore 'Consciousness is a part of Thermodynamics'. That is the fundamental point of this discussion; one of the most ineffable features of Consciousness, understanding, overlaps the most hard-core physical analysis of the Brain, the Thermodynamics of its Chemistry.

This exposes, the ambiguities, variations, and even frank contradictions in the use of the word, conscious and related words such as consciousness. Thus, we may say that a human being becomes UNconscious in sleep or coma without any loss of continuity or other negative effect on their personal individual 'Consciousness', their sense of their individual identity and existence. While they are UNconscious in REM sleep, their Consciousness experiences their dreams. In slow wave sleep the person experiences nothing and is totally paralyzed, but again afterward, their Consciousness is continuous and has no negative consequences. It is perhaps better to say that 'Consciousness' is pleomorphic, has multiple modes of function. These modes include not just wakefulness, but active unconsciousness (REM) and normal total unconsciousness (SWS). Indeed, it has been long and widely understood that Consciousness includes components which are active at all times and always unconscious (Freud, 1915).

Negentropy and Consciousness

Energy and information negentropy are bound together in their circadian rhythm and the necessity to process information to make low entropy choices where the high entropy choice is thermodynamically preferred. They diverge to a degree virtually dichotomous; In evolution, energy negentropy remains remarkably similar throughout versus information negentropy has a massive quantitative explosion; Anatomically, energy negentropy processing is dispersed though the body versus information negentropy is organized

by encephalization. The parallelism and divergence raise the question, should both aspects of negentropy, be understood to belong to a unified functional mechanism?

The detailed mechanisms of both energy and information negative entropy are not known. That is specifically, how the choices are made to drive the specific metabolic changes toward lower entropy. Given that as Schrödinger emphasized, that negative entropy is the defining and essential uniqueness of life, negative entropy itself, both energy and information, must be understood as the deeper truth, not either separately. The central difference between the two varieties of negentropy at the fundamental cell metabolism level is that while alternative choices in energy negentropy have physical differences in bond energy and therefore could in theory be driven without 'understanding' the choices, no such differences exist between the physical representation of increased entropy and decreased entropy choices in information negentropy. The encoding of 'Paris the capital of France' and 'Paris the capital of Brazil' do not have different bond energies.

That processing and storage of information in human beings is done primarily during REM sleep, when the person is 'unconscious'. Arguably, this most iconic and defining property of the human Mind, beyond awakeness and perception, is performed in the 'unconscious' state but with the perception of dreams. Yet these fundamental mechanisms are manifest in cellular metabolism, including single cells, human zygote and single cell organisms. It is the structure of the human brain that aggregates those cellular properties and manifests it as human subjectivity, self-awareness and externally as behavior.

Ur-Consciousness

It is clear that in the human being, both awake, asleep, reversibly comatose, demented, psychotic, and other such states, there is a singular continuous 'Consciousness'. In all the various sub-modes of that Consciousness both energy and information negentropy functionality, or a matrix of interlocking similarly continuous functionalities continue. Consciousness includes but extends far beyond the state of being awake, "being conscious." It clearly includes sleep, unconscious feelings, etc. It is clearly intimately associated with the brain, and certainly not any of the organs that can be transplanted and or lost, without loss of that continuity. It cannot be defined in terms of anything else (Schrödinger, 1984). Perhaps 'Ur-Consciousness' might more clearly focus on the generality of the multi-modal, multi-phyla essence.

Conclusions and outlook

The meta philosophical question is still, if all the activities of Ur-Consciousness are understood to be fundamentally related, how does that affect the 'hard problem' in the mind body discussion (Chalmers, 1995)? There is no reason in physics for a boundary in evolution between abiogenesis and living tissue (Remler, 2026). The generalization and extension of Ur-Consciousness from the most apparently unconscious inanimate matter through abiogenesis to the most primitive life and then via evolution into the Consciousness we experience is some variety of Panpsychism (Goff, 2022). Since Ur-Consciousness is fundamental (Schrödinger. 1984), philosophically you have to place the essence somewhere and the only reasonable place is everywhere (Strawson, 2022).

The problem is that the generality of panpsychism leaves the two most essential questions unanswered. 'The combination problem': How is the diffuse essence get unified into a human consciousness? One resolution is to see Ur-Consciousness as an as yet undefined feature of quantum mechanics (Remler, 2026), essentially a Russelian Monism (Alter and Pereboom, 2023). The substantive question: Where does the content of a human consciousness come from to utilize the mere essence? The most straightforward answer is that it is part of the Information Negentropy acquired in life (Givental, 2026).

The mechanisms and process of Artificial Intelligence, AI, (IBM, 2026) are instructive in parsing the subtleties of the function of Consciousness in the Brain to produce Information Negentropy by storing Information. The originators of AI from Turing and von Neuman at the beginning through to today built larger and larger (encephalization) data banks to run every more complicated algorithms (evolution). They then applied a dataset, trained (acquired Information Negentropy), to the algorithm to produce a set of weights in the data bank (cerebral synapses). Earlier forms of AI training are analogous to Pavlov's dogs, building an array of correlations. Even in these methods, a data scientist (consciousness) is needed in the selection of data from which to build the correlation. The training process is how meaning is inserted by the nature of the correlations in the data used.

Each step in the evolution of the modern Homo Sapiens has been associated with massive, orders of magnitude, increase in each individual's negentropy information acquisition. In the first phase of accelerated encephalization supported the progression from high primates, to early subspecies like Neanderthal, to modern biological Homo Sapiens hunter gatherers. The second phase, the development of culture, was from early agricultural communities and the development of language, to living in complex civilized information structures. We may wonder if the most recently phase of modern life filled with massive communication internet and AI might also be a fundamental change.

Abbreviations

REM – Rapid Eye Movement Sleep
SWS – Slow Wave Sleep
AI – Artificial Intelligence

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