

Why Do We Sleep? Why Do We Dream? An Integrative Hypothesis Based on Current Neuroscience and Clinical Observations

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Abstract

Despite decades of research, the fundamental biological purposes of sleep and dreaming remain incompletely understood. Current evidence indicates that sleep plays essential roles in synaptic homeostasis, circuit restoration and memory consolidation. However, these processes are generally considered independently rather than as components of a unified functional model. This article proposes an **integrative hypothesis** in which sleep represents an iterative process of brain restoration analogous to the rebooting of a complex computational system. Within this framework, non-rapid eye movement (NREM) sleep constitutes the predominant restorative phase, during which neural circuits undergo synaptic reorganization, metabolic clearance through the glymphatic system, DNA repair, immune restoration, cellular repair and recalibration of functional connectivity. Rapid eye movement (REM) sleep is proposed to function predominantly as a recurrent physiological testing phase that evaluates the effectiveness of these restorative processes by transiently reactivating distinct neural networks involved in cognition, memory, emotion, and sensorimotor integration. The information generated during each REM episode may guide subsequent NREM cycles until restoration reaches a functional endpoint compatible with awakening. This conceptual model also provides a possible explanation for the progressive alternation in NREM and REM architecture throughout the night, the cognitive and emotional consequences of sleep deprivation, dream phenomenology, and the development of central mental fatigue following prolonged intellectual activity. Although hypothetical, the proposed framework integrates numerous known neurophysiological mechanisms into a **single coherent model** that may stimulate future experimental investigation.

Keywords

Sleep, Dreaming, REM Sleep, NREM Sleep, Brain Restoration, Neuroplasticity

1. Introduction

The purpose of sleep and the function of dreams have fascinated philosophers, physicians, and scientists for centuries. Despite remarkable advances in neuroscience over the past decades, the fundamental biological functions of sleep and dreaming remain only partially understood.

Sleep occupies approximately one-third of human life and is essential for normal brain function. Extensive experimental evidence has demonstrated that sleep contributes to synaptic homeostasis, memory consolidation, metabolic waste clearance through the glymphatic system, immune regulation, neuroplasticity, and cellular repair. Likewise, rapid eye movement (REM) sleep has been implicated in memory processing, emotional regulation, and learning, whereas non-rapid eye movement (NREM) sleep is generally and predominantly associated with restorative physiological processes [1]-[7].

Although these mechanisms are well supported individually, they are often described as separate physiological phenomena. Consequently, an important question remains unanswered: **how do these diverse functions interact within the cyclic architecture of sleep to produce a coherent biological purpose?** Moreover, the precise functional significance of dreaming, beyond its recognized roles in cognition and emotional processing, continues to be the subject of active investigation.

The present article reviews current evidence from the neuroscience literature together with relevant clinical observations and proposes **the hypothesis of an integrative physiological framework that seeks to unify several established functions of sleep and dreaming into a single conceptual model**. Rather than replacing existing theories, this hypothesis seeks to integrate them within a single physiological framework and thereby provide a coherent perspective that may explain the coordinated organization of sleep stages and stimulate further experimental investigation.

The following sections develop the hypothesis that brain restoration does not occur as a single uninterrupted event. Instead, restorative mechanisms are proposed to operate through an organized sequence of successive cycles in which periods of restoration alternate with periods of functional assessment throughout the night.

Within this framework, each sleep cycle contributes incrementally to the recovery of neural integrity, alternating between NREM and REM sleep in coordinated physiological roles.

Hence, brain restoration is proposed to occur through successive iterative cycles

in which NREM sleep predominantly supports restoration and REM sleep provides recurrent functional assessment until awakening becomes possible:

Central Hypothesis – Conceptual Roadmap

NREM: Restoration → REM: Functional Assessment → NREM: Further Restoration → REM: Reassessment → ... → Awakening

2. “Rebooting” Our Computer/Brain: A Conceptual Analogy

The analogy of rebooting a computer is a conceptual aid rather than a literal biological comparison. Although necessarily simplified, this analogy provides an intuitive idea for understanding how several established restorative processes of sleep may operate in an organized and iterative manner. The brain appears to perform analogous maintenance functions during sleep, similar to the older computers which routinely performed procedures such as disk scanning and defragmentation (S-D) to detect errors, reorganize stored information, and optimize system performance. It is proposed here that sleep performs an analogous function in the brain. But unlike a computer, however, the brain does not simply reboot and do the S-D once. Instead, this hypothesis proposes that brain restoration is an iterative process, during which **NREM sleep performs the restorative functions, and REM sleep assesses the effectiveness of that restoration before the next restorative cycle begins.**

Although numerous physiological functions have been attributed to sleep, no single mechanism fully explains why an organism spends nearly one-third of its life in a state of behavioral disengagement. Current evidence instead suggests that sleep simultaneously supports multiple processes that are essential for maintaining optimal brain function.

In the context of the present hypothesis, brain restoration refers collectively to the physiological processes that recover optimal neural function and have been demonstrated in several experimental studies. As it was mentioned above, sleep contributes to synaptic homeostasis, memory consolidation, metabolic waste clearance through the glymphatic system, regulation of immune responses, restoration of cellular energy balance, DNA repair, and neuroplasticity [1]-[7]. Although these functions are often investigated independently, they all converge toward a common biological objective: **restoring and maintaining** the structural and functional integrity of the brain for an optimal function.

The importance of this restorative process becomes evident during prolonged sleep deprivation. After remaining awake for 48 - 60 hours, mental function becomes altered and cognitive performance progressively deteriorates. Attention declines, reaction times slow, irritability increases, and higher executive functions become impaired [8]. Continuing the computer analogy, the brain appears to “freeze” or operate less efficiently when deprived of the opportunity to perform

its restorative maintenance.

Under normal physiological conditions, approximately a single period of 7 to 8 hours of sleep is sufficient to restore cognitive performance remarkably close to baseline, regardless of the intensity of prior intellectual activity. So, within the present hypothesis, incomplete recovery would indicate that functional restoration has not yet reached the level required for full waking performance.

Rather than representing independent aspects of sleep, these diverse processes may constitute complementary components of a single, coordinated restorative program. If so, the cyclic organization of sleep may not simply reflect alternating electrophysiological states, but rather successive stages within an integrated process of brain restoration. This leads to a fundamental question: if sleep restores the brain, why must restoration occur through alternating NREM and REM cycles rather than as a single continuous process? The following chapters explore this question: **why does it have to occur in alternating NREM and REM cycles?**

3. NREM Sleep: The Restorative Stages

Sleep is divided into two major types: non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep (this latter will be discussed in next paragraph), which is called so by the rapid movements of the eyes. NREM sleep manifests characteristic features on the electroencephalography (EEG) and is currently divided into three stages (N1, N2 and N3), following the 2007 revision of the former classical four-stage classification (**Figure 1**) [9]-[13] considered before.

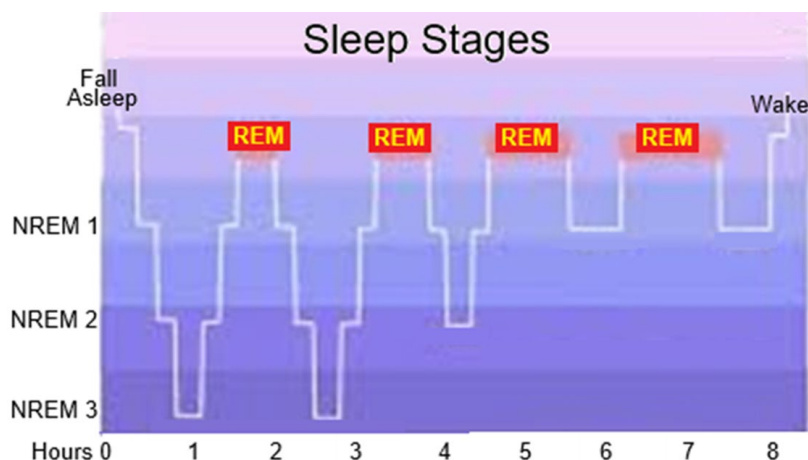


Figure 1. Stages of normal sleep. REM: rapid eye movement sleep; NREM: non-rapid eye movement sleep. As sleep progresses, NREM episodes become progressively shorter and less deep, whereas REM episodes become progressively longer. The physiological significance of this characteristic sleep architecture is explored in the present hypothesis.

During the descent, through the 3 stages, to the deep sleep, is when the brain restoration (S-D process) is taking place, and when it is hard to wake us up.

Thus, brain restoration is proposed to occur progressively during the descent through the NREM stages, reaching its greatest intensity during deep (N3) sleep.

An important observation is that successive NREM periods become progressively shorter and less deep throughout the night. Within the framework of the present hypothesis, this finding suggests that brain restoration is cumulative. As restoration progresses, progressively less restorative activity is required to approach an optimal functional state before awakening. In other words, the restorative process becomes progressively more complete during the night, and subsequent NREM periods are shorter and less deep than the initial cycle.

Brain restoration includes multiple coordinated physiological processes, among them synaptic homeostasis, remodeling of neural circuits, strengthening of relevant synaptic connections, elimination of redundant connections [1], and memory consolidation with the reactivation of hippocampal cells in relation of recent experience [14] [15]: learning, training, anticipation, prognostication, projections, and analysis.

But also, during NREM (and most probably during REM, too) there is a metabolic and waste clearance that removes metabolic waste from the brain with increased cerebro-spinal fluid (CSF) production and circulation during sleep [16] [17]. This is called the glymphatic system, resembling the clearance function of the lymphatic system in the body, adding the “g”, which stands for glial cells (the astrocytes). The astrocytes are an important effector of this mechanism [2]. Hence, sleep disturbances prevent this “cleansing” effect and can be related to several pathologies, such as those with autoimmune/inflammatory, neurodegenerative (such as Alzheimer’s and Parkinson’s) [18]-[20], neurodevelopmental, sleep-related, neurotraumatic and neuropsychiatric disorders [21]-[23].

Taken together, these observations suggest that NREM appears to constitute the principal and predominant, thus not the unique, restorative phase of the sleep cycle, during which multiple physiological mechanisms converge toward the common objective of brain restoration.

This concept naturally raises the next question: if NREM sleep performs the restorative work, **what is the physiological purpose of the REM periods that repeatedly interrupt it?** This question is addressed in the following chapter.

4. What Is the REM Stage for? Functional Assessment Phase and Dreaming

REM sleep is characterized by an electroencephalographic (EEG) pattern that resembles wakefulness, with mixed-frequency and -amplitude activity. During REM sleep, skeletal muscles are largely paralyzed (muscle atonia), whereas rapid eye movements occur beneath closed eyelids and breathing is maintained, as well, by the diaphragm. Because the brain remains highly active while the body is largely immobilized, REM sleep is often referred to as paradoxical sleep [24].

The present hypothesis proposes that, following the initial and deepest period of brain restoration during early NREM sleep, the brain enters a transient state of functional assessment represented by REM sleep. It transiently approaches a wake-like physiological state during REM sleep, while remaining behaviorally dis-

connected from the environment. During this state, widespread neural networks associated with cognition, memory, emotion, and sensorimotor integration may be reactivated within a virtual reality (dreams), in a manner that partially resembles wakefulness. Dreaming may represent the subjective experience of this internally generated neural activity, in order to provide information about the functional state of the neural systems that were restored during the preceding NREM stage or brain restoration phase. Thus, the brain is hypothesized to obtain an updated functional status of the restoration achieved during the preceding NREM stages once a REM stage is completed, resulting in a pattern of neural activity that may reflect the current status. According to the present hypothesis, this information could guide and contribute to subsequent restorative processes, including circuit recalibration, synaptic remodeling, memory consolidation, and other forms of neuroplastic adaptation that will occur during the following NREM cycle.

Thus, **each REM episode may generate information that guides the next NREM restorative cycle**. So, REM is proposed as an iterative diagnostic phase that may continuously update the restorative program.

Reactivation of limbic structures, including the amygdala and hippocampal circuits, may facilitate the integration of newly acquired information with existing memories during subsequent sleep cycles. This mechanism could also help explain why emotional themes are particularly prominent in dreams [15] [25] [26].

These neuroplastic processes are accompanied by characteristic neurochemical changes during REM sleep, including increased cholinergic activity and reduced norepinephrine and serotonin levels, which together favor widespread neural reactivation [27].

The first REM episode of the night is typically brief, often lasting only 5 - 10 minutes, whereas later REM periods may extend to 30 - 60 minutes [24]. At the same time, successive NREM periods become progressively shorter and less deep. Within the framework of the present hypothesis, this reciprocal pattern may indicate that brain restoration becomes progressively more complete throughout the night. Less restorative activity is required, while progressively more extensive functional assessment might be necessary.

Experimental studies of REM sleep deprivation have shown that irritability, impaired attention, reduced concentration, and emotional dysregulation may occur when REM sleep is disrupted [6] [27]. These findings support the hypothetical possibility that inadequate functional assessment during REM sleep may contribute to an impaired brain restoration, during NREM stages, and thus, to cognitive and emotional deficits observed after REM deprivation. So, in summary, it can be assumed that if these assessments are not adequately performed, the cognitive deficits appear.

The longest REM periods therefore occur immediately before awakening, when the brain may be approaching its optimal operational state. So, completion of this final assessment may indicate that the brain has reached an operational state compatible with awakening.

Interestingly, REM periods occurring near the end of sleep can incorporate external stimuli, such as a ringing telephone, into the content of a dream shortly before awakening. This phenomenon suggests that late REM sleep may operate in a state that is particularly close to wakefulness and highly responsive to external sensory input.

Proposed explanation for the progressive increase in REM sleep duration

Within the framework of the present hypothesis, each REM episode functions as a functional assessment of the restorative processes completed during the preceding NREM period. Early in the night, restoration is incomplete and residual functional deficiencies are expected to be relatively large and readily detectable. Consequently, only a brief assessment is required to identify the major processes that still require restoration, allowing the brain to rapidly return to NREM sleep.

After each successive NREM episode, the remaining deficiencies become fewer and progressively subtler. As a result, each subsequent REM episode must evaluate a progressively more refined functional state, requiring a broader and more thorough assessment to detect the small remaining imperfections. Although the restorative workload decreases with each cycle, the complexity and duration of the verification process increase because **confirming that a highly organized system is functionally intact requires a more exhaustive evaluation than identifying obvious deficits**. In fact, the closer we get to normality, the more exhaustive the examination becomes.

By the final REM episode, restoration is presumed to be essentially complete. Functional assessment therefore becomes the longest of the night, not because additional restorative work is required, but because the absence of significant deficiencies can only be established after a comprehensive evaluation of neural function. Successful completion of this final assessment would signal that the brain has reached an operational state compatible with awakening.

Accordingly, the present hypothesis predicts that the progressive lengthening of REM sleep reflects an increasingly comprehensive functional assessment rather than an increasing restorative demand. This interpretation provides a mechanistic explanation for one of the most consistent and yet incompletely understood features of normal sleep architecture.

5. Dream Content: Functional Simulation Rather than Symbolic Meaning

Since ancient times (centuries! millennia!), the dreams have historically been interpreted as symbolic, prophetic, or psychological experiences, and no single theory fully explains why the brain generates vivid internal experiences during REM sleep. Thus, the biological purpose of dreaming remains one of the least understood aspects of sleep.

In the present hypothesis, dream content is not the purpose of REM. **Dream content is the mechanism through which the functional assessment is performed**. Thereafter, the brain recruits available memories, emotions, perceptions,

and whatever it has “at hand”, and internally generated scenarios to construct a realistic virtual experience through which distinct neural systems can be functionally assessed. So, dreams might simply be the substrate needed to activate large neural networks simultaneously. They are the functional environment through which widespread neural systems are simultaneously activated and assessed: vision, emotion, memory. Spatial orientation, language, prediction, motor planning. How does the brain test all of them simultaneously? Creating a virtual realistic scenario! Not because the scenario matters, but because it activates the networks.

It can be a restful experience, a stressed moment we had at work, a moment of joy, a huge regret or fearful experiences we keep in ourselves, or even a challenge we are facing at these days. That is why dreams might reflect waking life concerns, thoughts, and emotions [28]-[31]. But, besides an assessment, the brain can take advantage of dreams to simulate threatening or challenging situations, allowing “practice” for real-life coping [32]-[35].

Our REM stages are longer, as our sleep approaches its end and our dreams can be remembered and we can even have what is called “lucid dreams”. The increased vividness and occasional lucidity of late-night dreams may be interpreted as a manifestation of the extensive neural activation associated with the proposed functional assessment phase. This interpretation remains speculative and does not imply that vivid or lucid dreaming causes restoration or demonstrates that restoration has been completed.

Since at the end of our sleep, our brain is ready to work in good conditions, as our mind is again “fresh and clear”, it occurs that, sometimes, during these last dreams, we can even solve some problems that kept us worried for days!

It has been found that dreams may occur during NREM sleep, too [36]. So, in the proposed framework, NREM dream may represent internally generated neural activity occurring during the restorative phase, whereas REM dream may involve more extensive recruitment and interaction of neural networks during functional assessment. REM therefore provides the most prominent context for vivid, complex, and simulation-like dream experiences. The distinction between NREM and REM should not be understood as an absolute functional boundary, since sleep-stage classifications are operational, based mainly on EEG signals, and underlying brain activity remains continuous and overlapping. This hypothesis assigns a special functional interpretation to the richer network activation characteristic of REM.

Accordingly, dream narratives need not possess an intrinsic symbolic meaning to fulfill their biological function. Within the present hypothesis, their principal role may simply be to provide sufficiently rich and dynamic virtual environments capable of simultaneously testing multiple neural systems during REM sleep, thereby allowing comprehensive functional assessment before awakening. Therefore, REM is hypothesized to provide the most extensive functional-simulation environment.

In summary, **dreams may represent the virtual environment through which the brain performs comprehensive functional assessment.**

6. Mental Fatigue: A Call for Brain Restoration

After prolonged intellectual activity, many individuals experience not only mental fatigue but also a subjective sensation of physical weakness, *i.e.*, we feel physically tired!, despite having performed little or no muscular work. Simple physical activities may even be postponed for the next day because of an overwhelming desire to rest and sleep.

Peripheral muscle energy stores remain largely preserved, and there is no evidence of significant peripheral fatigue. Instead, the reduction in motor performance originates within the central nervous system, *i.e.*, the brain itself. In fact, muscles are not depleted of adenosine tri-phosphate (ATP), which is the molecule of energy, there is no lactic acid accumulation and peripheral nerves are intact [37] [38], in contrast, the motor evoked potentials (MEPs) are reduced [37]. At the level of neurotransmitter, prolonged mental effort causes an increase in adenosine, while dopamine and noradrenaline drop down [37]. The adenosine suppresses cortical neurons and motor cortex excitability. That is why caffeine helps—it blocks adenosine receptors [39]. Long intellectual work heavily activates the prefrontal cortex and the anterior cingulate cortex, which are attention and executive networks. These regions consume a lot of energy, and thus inhibit other networks when overloaded, resulting in suppressed motor activation. The entire motor system is “downregulated” [40] [41].

Thus, the brain reduces motor output, even though the muscles are still capable. This is called: **reduced central motor drive** (Figure 2) [40] [42].

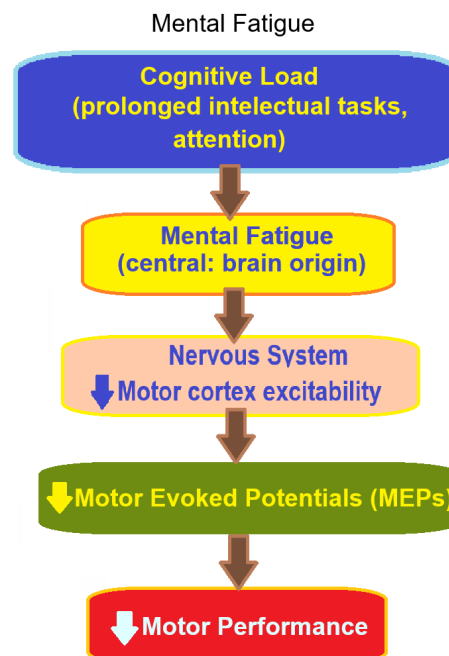


Figure 2. Central fatigue. Long intellectual work (cognitive load) leads to a reduction of motor drive by the brain, creating a sensation of muscle weakness, and a desire to go to sleep. Thus, when tested, the motor cortex excitability is reduced, as reflected by reduced motor evoked potentials (MEPs).

When prolonged cognitive overload becomes chronic, persistent central fatigue and **burnout may develop**, manifested by persistent exhaustion (physical and mental) and reduced cognitive and motor performance, further emphasizing the importance of adequate restorative sleep [39] [43]-[47].

Accordingly, during periods of overload, the brain protects itself by conserving energy and promoting fatigue (sensation of tiredness) to increase the drive to sleep. This will allow the brain to renew its functional capacity during 8 hours of full-quality sleep.

Within the framework of the present hypothesis, mental fatigue may be considered a related speculative extension of the model. Cognitive effort, prolonged mental, cognitive and/or emotional activity, and psychological stress may differ in their immediate physiological manifestations, since they are all based in neural circuits, and may all contribute to neural load, and may converge on a common state of mental fatigue and an increased need for sleep. Mental fatigue is therefore presented as a possible functional signal of increased restorative demand.

In summary, the **brain creates a central (brain-origin) fatigue to force us to go to sleep and to start the restorative process!**

7. Conclusions

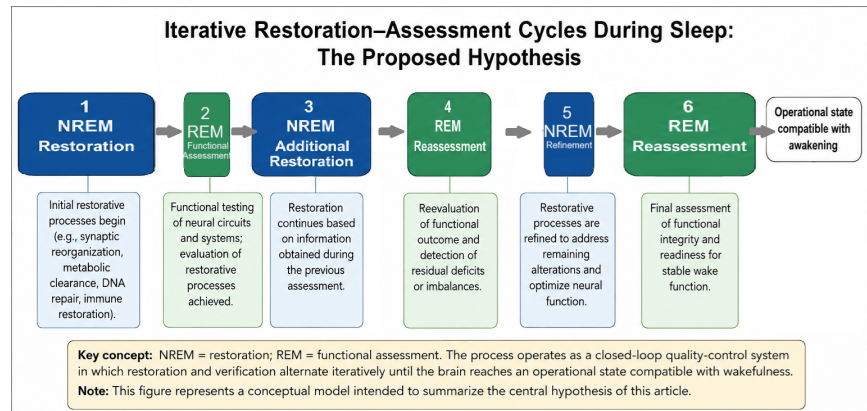
Sleep remains one of the most fundamental biological functions, yet its overall physiological purpose has not been fully explained despite centuries of investigation. Although numerous restorative mechanisms have been identified—including synaptic homeostasis, memory consolidation, glymphatic clearance, neuroplasticity, immune regulation, DNA repair, and metabolic recovery—these processes are generally considered independently. The present hypothesis proposes that they represent complementary components of a **single coordinated process of brain restoration**.

Within this conceptual framework, restoration is proposed to occur through successive, iterative sleep cycles rather than as a single uninterrupted event. **NREM sleep** primarily supports the restorative processes, whereas **REM sleep** provides recurrent functional assessment of the restoration achieved during the preceding NREM period. The information generated during each REM episode is hypothesized to guide the restorative requirements of the subsequent NREM cycle, thereby establishing a continuous cycle of restoration and reassessment throughout the night.

Accordingly, sleep may be viewed as an **iterative, cyclic quality-control process** in which brain restoration and functional assessment alternate until the brain reaches an operational state compatible with awakening (**Figure 3**).

Dreams are interpreted not as the primary purpose of REM sleep, but as the **functional virtual environment** through which widespread neural systems involved in perception, memory, emotion, learning, prediction, and cognition are simultaneously activated and assessed. Within this framework, the progressive shortening of NREM sleep together with the progressive lengthening of REM sleep

may reflect the gradual completion of brain restoration. As major deficits are addressed during the early cycles, subsequent cycles require increasingly comprehensive functional assessments. In a highly organized neural system, verifying optimal performance demands a more exhaustive evaluation than detecting gross abnormalities alone. This interpretation provides a mechanistic explanation for one of the most consistent features of normal sleep architecture.



Note: According to the hypothesis proposed in this article, sleep is an iterative process composed of alternating cycles of NREM sleep, which performs restorative functions, and REM sleep, which provides functional assessment of the restorative outcome. Information obtained during each REM stage guides the requirements of the subsequent NREM stage. These cycles continue until neural function has been sufficiently restored to permit awakening.

Figure 3. Iterative restoration-assessment model of sleep (proposed hypothesis).

The concept of **central fatigue** further supports this framework. Prolonged intellectual activity progressively increases the demand for brain restoration, producing mental fatigue and reduced motor drive despite minimal muscular work. Within the present hypothesis, this adaptive response represents a biological signal that mental/cognitive/intellectual function can no longer be adequately maintained during wakefulness and that sleep has become physiologically necessary.

The proposed restoration-assessment process **is not intended to replace established homeostatic and circadian mechanisms** regulating sleep duration, depth, stage distribution, and awakening. Rather, the hypothesis proposes a functional framework that may operate within these regulatory processes.

Similarly, this hypothesis is not to replace existing theories of sleep and dreaming, but to **integrate them within a single physiological framework** capable of explaining several established characteristics of normal sleep architecture while generating experimentally testable predictions for future investigation. If supported by future experimental studies, this framework may contribute to a more integrated understanding of the biological purpose of sleep and dreaming.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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