

Analysis of the Two-Process Model of Sleep Regulation

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Sleep Theory

What happens as we fall into our nightly slumber?

There have been many efforts to answer this very question.

Although scientists are still trying to learn exactly why people need sleep, animal studies show that sleep is essential for survival. For example, one study showed that while rats normally live for two to three years, those deprived of REM sleep lived only 5 weeks on average, and those rats deprived of all sleep stages live only about 3 weeks. Rats deprived of sleep also developed unusually low body temperatures and sores on their tail and paws. The sores may develop because the rats' immune systems become weakened. Some studies suggest that sleep deprivation affects the immune system in harmful ways.

Sleep appears indispensable for our nervous systems to work properly. Too little sleep leaves us somnolent and unable to concentrate fully on mental tasks the next day. This factor can have grave implications for the body builder, as the nervous system is essential for demanding maximum physical exertion workout after workout.

Sleep deprivation has been shown to lead to impaired memory and physical performance and reduced ability to carry out mathematical calculations. If sleep deprivation persists, hallucinations and mood swings might develop.

Some sleep researches believe sleep gives neurons used while we are awake a chance to shut down and revamp themselves. Deprived of sleep, neurons may become so exhausted in energy or so polluted with byproducts of normal cellular activities that they begin to malfunction. Sleep also may give the brain a chance to exercise important neuronal connections that might otherwise depreciate from lack of activity.

Many of the body's cells also show improved assembly and reduced breakdown of proteins during deep sleep. As proteins are the building blocks required for cell growth and for repair of damage from issues like stress and ultraviolet rays, deep sleep may essentially be "beauty sleep."

Activity in areas of the brain that manage emotions, decision-making processes, and social interactions are considerably reduced during deep sleep, suggesting that SWS

sleep may help people maintain emotional and social functioning while they are awake. Another study on rats showed that particular nerve-signaling patterns which the rats generated during the day were recurring during deep sleep. This pattern repetition may help encode memories and enhance learning.

There is little doubt that the function(s) of sleep must entail restoration, and most probably mainly for the brain. Moreover, it has been proposed that sleep may not be a global phenomenon encompassing the entire brain, but that slow waves may reflect local recovery processes. Findings in the bottlenose dolphin contributed to this hypothesis.

These animals have the capacity to exhibit "deep" slow-wave sleep only in one brain hemisphere while the EEG (electroencephalographic (EEG) slow-wave activity (SWA, mean EEG power density in the 0.75- to 4.0-Hz range) in the other hemisphere exhibits a waking pattern.

Furthermore, after uni-hemispheric sleep deprivation, the deprived brain hemisphere showed a larger increase of deep slow-wave sleep. Also birds seem to have the capacity to exhibit minor hemispheric asymmetries in the EEG, but they last only a few seconds and are related to unilateral eye-opening.

Sleep could be regarded as a use-dependent local phenomenon serving to stimulate synapses insufficiently used during wakefulness to maintain neuronal connections. According to this hypothesis, synaptic connectivity is strengthened locally and modulates EEG synchronization during sleep. An alternative hypothesis proposed a restoration of brain glycogen levels during sleep, which are thought to be depleted during the brain activity related to wakefulness. Recent evidence supports the notion that a previous experience can affect the cell firing of specific neurons during sleep. Thus in rats an experience-dependent reversal of the phase of multiunit firing of hippocampal cells was shown in REM sleep following running in specific tracks.

Perhaps the most accepted theory of memory encoding comes from Dr. Gvorgy Buzsaki. His two-stage model (REM and non-REM- see [Z factor Part One](#)) of memory trace formation has stimulated deeper research that helps identify exactly what is happening during sleep.

With his understanding of neural networks, masterminded experiments on neuronal firing, and complex mathematical analysis of spatiotemporal firing patterns, Buzsaki concluded that both REM and NREM work together to merge memories.

The hippocampus, a tiny brain organ, is vital for memory formation. However, scientists have always had a difficult time understanding the relationship between the hippocampus from other areas of the cerebral cortex that also show synaptic plasticity (the ability to store memories). This is exactly where Buzsaki's ingenious two-part component theory comes into play!

The hippocampus performs as the central mainframe for the brain that can acts to store short term memory patterns. Moreover, these patterns have to be encoded in the neo-cortex to provide adequate space for coding new short-term memories.

Now comes the intriguing part! Sleep is responsible for the intricate process of re-organization of the neural network of the brain. As opposed to rest or conservation of energy, neural arithmetic requires the brain to be shut off from external environmental input!

This automatic rewiring program is the foremost reason for which we fall into sleep and why there is no conscious processing involved! Through the night's multiple sleep cycles the brain works as hard as during a physics exam. During sleep the brain rewires circuits to ensure all recently acquired knowledge is optimally stored for future utilization.

Ultimately, in spite of a century of scientific study of sleep, including three decades of modern intensive research, the function of sleep remains an enigma. This is not to say that there is a paucity of theories of the role of sleep. Much of what we know comes from sleep deprivation studies. One of the major goals of modern sleep research is to understand how sleep and wakefulness interact; another goal is to obtain an in-depth appreciation for what sleep really is! As such, the theories presented in this paper are subject to change as further research is conducted and analyzed.

Sleep Parameters

There are two biological factors that drive you to bed. Combined these factors are known as the biological clock, and referred to as "A Two-process Model of Sleep Regulation."

Abstract confirmation that the sleep/wake regularity is generated endogenously has been shown by studies utilizing a wide variety of experimental paradigms such as sleep deprivation, sleep disarticulation, isolating subjects in environments free of external influences, or imposing on subjects sleep/wake schedules widely deviating from 24 hours.

Factor one of the model is known as the circadian component which says that lethargy returns in cycles which are usually about one day long--To be exact, it varies between individuals, seasons, and other daily factors such as stress, timing of sleep, timing of the light period, intensity of light, exercise, and many more. There are a multitude of studies that attempt to give theories as the exact period of the

endogenous circadian pacemaker for regulating sleep patterns. Combined these studied tend to give ranges that fall into an area of 24.01 hours to 25.5 hours.

Besides sleep tendency, the circadian pacemaker has been shown to regulate sleep consolidation, sleep stage organization, and electroencephalographic behaviors. The pattern of light exposure throughout the 24 hours seems to contribute in the entrainment of the circadian pacesetter to the geophysical day/night cycle.

Melatonin, the pineal hormone produced during the "night" hours, partakes in communicating both between the environmental light-dark cycle and the circadian pacemaker; and between the circadian pacemaker and the sleep-wake-generating mechanism.

The second component of the model, the homeostatic factor dictates that lethargy increases with the length of time we stay awake.

The equilibrium of these two factors determines the most favorable time for sleep. For example strong tiredness resulting from the circadian component may not be sufficient to get good sleep if the timing goes against the sleep-high in the homeostatic component.

There are over 100 body functions that fluctuate between their maximum and minimum values once per day. These fluctuations in human functioning take approximately 25 hours to complete. In 1959 Dr. Franz Halber of Germany used the Latin term circadian, which translated means "about a day" to describe these changing body processes.

Circadian rhythms

Circadian rhythms are controlled by a circadian pacemaker, or a biological clock. This "clock" is the section of the brain known as the suprachiasmatic nucleus (SCN). The SCN is a pair of structures that contain about 20, 000 neurons and is located in the hypothalamus above where the optic nerves cross.

Among many of its roles, the hypothalamus plays a very important role in our daily cycles. Cued by a rise in the hormone melatonin, the suprachiasmatic nucleus in the hypothalamus will normally begin the process of lulling our bodies to sleep. The melatonin is produced by the pineal gland deep within our brain. This gland is regulated by light signals sent to it by way of the retina. Light exposure suppresses melatonin production and resets our daily cycle. Light in this instance is called a zeitgebers. This entire process is known as a circadian rhythm, (circa "about", dies "day").

Circadian rhythms include three different parts, a central oscillator, afferent pathways that carry environmental information to the oscillator, and efferent pathways that communicate the rhythm of the oscillator to the physiology and behavior of the organism. To accomplish this, various hormones, such as melatonin, and vital signs, like body temperature, fluctuate on a regular basis, creating "lows" and "peaks." Many rhythms bottom-out early in the morning, when people are asleep, and peak during the day, when most people are active. Without circadian rhythms, the body and mind would have no internal means of regulating cycles of activity and rest.

By excluding people of controls, such as light and other external time cues, researchers have learned that most people's biological clocks work on a 25-hour cycle more so than a 24-hour one. However since sunlight or other bright lights can reset the SCN, our biological cycles typically follow the 24-hour cycle of the sun, rather than our innate cycle. Circadian rhythms can be affected at some level by almost any kind of external time cue, such as the sounding of your alarm clock, the clatter of a dog barking, or the timing of your meals. Scientists call external time cues zeitgebers (German for "time givers").

Most of us are able to entrain this 25 circadian rhythm into a 24-hour cycle by using factors that reset the oscillation. These factors include intense morning light, work, exercise, etc.. As a result of the influence of zeitgebers, in a well-adjusted individual, the cycle can be set back by 30-60 minutes each day.

Under natural environments, our "body clock" or circadian rhythms are linked or "entrained" to an external clock time by the synchronizing effects of the physical world in which we live. The continual resetting of our internal rhythms to a 24-hour sun cycle is accomplished by environmental time cues (zeitgebers).

These zeitgebers may be physical or social in nature. The most powerful time cue for our bodies is the alternating light levels in our environment. When interruptions occur in our natural time patterns, these zeitgebers either act upon the circadian system to bring it into synchronization with the new time pattern or zeitgebers actually discourage adjustment to the new routine.

One of the most straightforwardly measured of these circadian rhythms is the body's temperature. Healthy humans experience rhythmic variations in their body temperature during the course of each day. For most people, the difference between high and low values is about two degrees Fahrenheit (97° to 99°), with the lowest value typically occurring in the early morning hours (2:00 a.m. to 5:00 a.m.) and the highest values commonly occurring in the evening (7:00 p.m. to 10:00 p.m.). Studies in which the body temperature has been monitored in a time-free environment have shown that our temperature level fluctuates in the same 25 to 26-hour pattern, no matter when we sleep or when we are awake. In short, our body temperature cycle operates independently of our sleep/wake cycle.

When the sleep/wake and body temperature cycles are no longer in phase or "in sync" with each other, we experience a condition known as internal de-synchronization. This de-synchronization usually is aggravated further by the influence of zeitgebers.

The general tendency to sustain sleep is subject to such a circadian rhythm. In most cases, the maximum sleepiness comes in the middle of the night, reaches the minimum at awakening, and again increases slightly at nap time in the afternoon.

However, the circadian drowsiness is often transferred in phase as contrasted with your desired sleep time. As a result, if your maximum sleepiness comes in the morning, you may find it harder to fall asleep late in the evening, even if you missed a lot of sleep on the preceding day. (2,8) In other words, the optimum timing of your sleep should take into consideration your circadian rhythm. Which understanding how will be the intention of this article.

Homeostatic component

The Homeostatic component of the two-stage model states that sleep is regulated in its intensity as a function of the duration of previous wakefulness. This component reflects the time that has elapsed since sleeping. In other words, the longer the time period that has elapsed since the last period of sleep, the greater is the tendency to feel tired.

Homeostasis is the idiom that refers to preserving equilibrium in physiological and metabolic functions. For example, if you consume liquids containing an abundance of calcium, homeostatic mechanisms will ensure that you expel calcium with urine or deposit it in the bones. This is used to make sure your blood levels of calcium remain constant.

Similar mechanisms are used to regulate overall sleepiness and its manifold subcomponents.

Several recent results show that sleep and sleep regulation are not only global phenomena encompassing the entire brain, but have local features. It is well established that slow-wave activity [SWA; mean electroencephalographic (EEG) power density in the 0.75-4.0 Hz band] in non-rapid eye movement (NREM) sleep is a function of the prior history of sleep and wakefulness. SWA is thought to reflect the homeostatic component of the two-process model of sleep regulation. According to this model timing and structure of sleep are determined by the interaction of a homeostatic process and a circadian process.

The effect of 24-h sleep deprivation on sleep was investigated in rats whose circadian rest-activity rhythms were extensively disrupted by bilateral lesions of the suprachiasmatic nuclei (SCN). Sleep deprivation caused an increase in total sleep, REM sleep and the slow wave sleep fraction of non-REM sleep. It is concluded that the homeostatic component of sleep regulation is morphologically and functionally distinct from the circadian component.

The homeostatic regulation of sleep is one of its most prevalent features of our bodies. Thus electroencephalographic (EEG) slow-wave activity (SWA, mean EEG

power density in the 0.75- to 4.0-Hz range) in non-rapid eye movement (NREM) sleep changes as a function of the previous sleep-waking history and may represent a measure of sleep intensity.

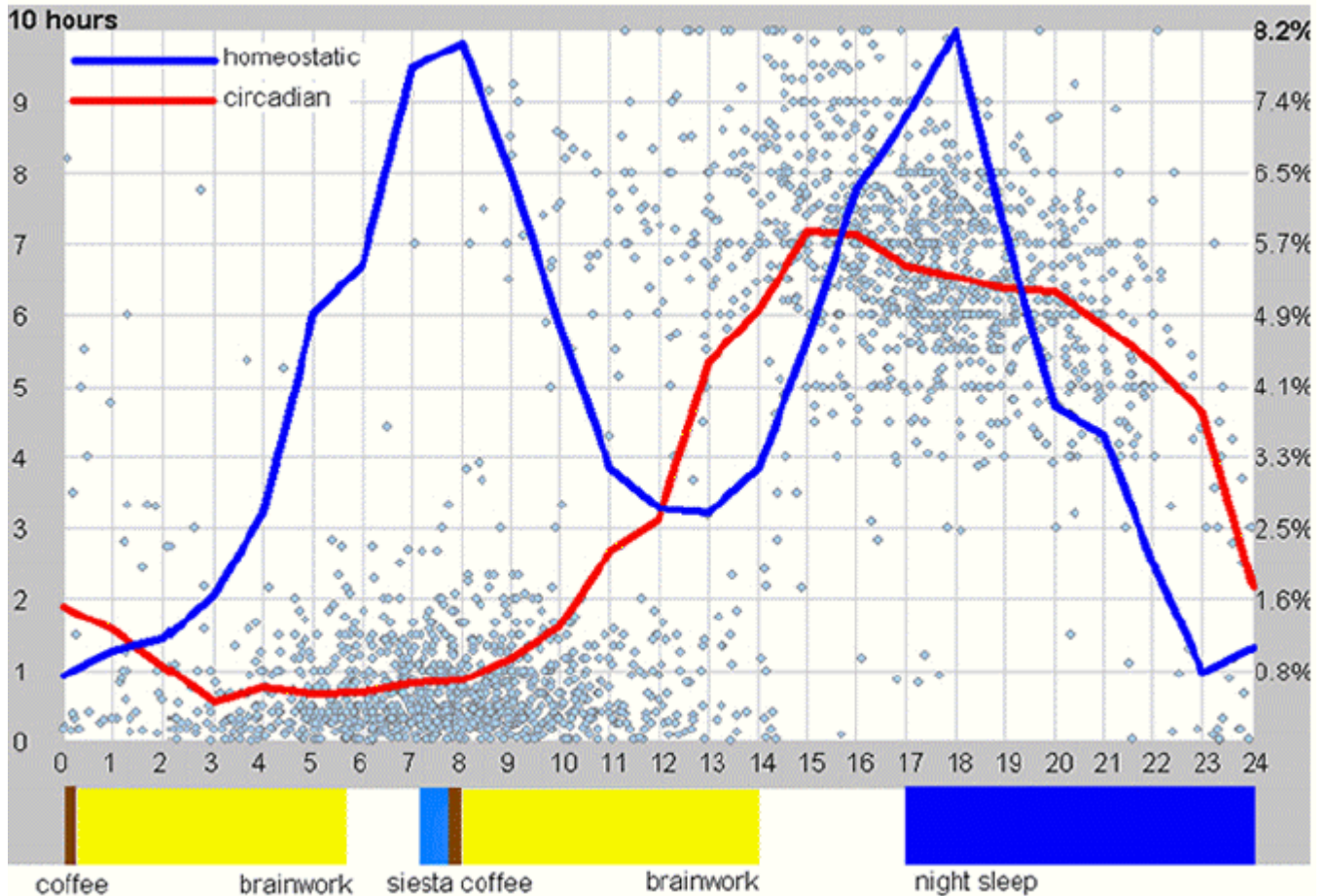
These factors can be temporarily masked by, caffeine, stress, exercise and other factors may temporarily reduce your sleepiness.

The homeostatic mechanism prepares you for sleep after a long day of intellectual and physical work. At the same time it prevents you from falling asleep in emergency situations.

In review, the homeostatic component of the sleep drive is a function of the duration of wakefulness. As one stays awake longer, the drive to sleep intensifies over time. The drive to sleep at night in humans also has a circadian (24-hour or daily) component governed by a biological clock located in the suprachiasmatic nucleus of the brain.

Putting the components together for Dynamic Slumber!

As the evidence shows, an optimal night's sleep requires a balance of both components. Dr. Wozniak has conducted a 3 year research project entitled, "Optimizing the timing of brainwork with respect to the circadian cycle". This research was generated on the basis of 3-year-long daily measurements of a free-running sleep rhythm. (Free running sleep discussed later)



"Optimizing the timing of brainwork with respect to the circadian cycle."

"This exemplary graph was generated on the basis of 3-year-long daily measurements of a free-running sleep rhythm. The horizontal axis expresses the number of hours from awakening (note that the free running rhythm period is often longer than 24 hours). Homeostatic sleepiness can roughly be expressed as the ability to initiate sleep. Percent of initiated sleep blocks is painted as a thick blue line (right-side calibrations of the vertical axis). Circadian sleepiness can roughly be expressed as the ability to maintain sleep. Average length of initiated sleep blocks is painted as a thick red line (left-side calibrations of the vertical axis). Adenosine-related homeostatic sleep propensity increases in proportion to mental effort and can be partially cleared by caffeine, stress, etc.. Circadian component correlates (1) negatively with temperature, ACTH, cortisol, and catecholamines, and (2) positively with melatonin and NREM propensity. Optimum timing of brainwork requires both low homeostatic and circadian sleepiness. There are two quality alertness blocks during the day: first after the awakening and second after the siesta. Both are marked yellow in the graph. For best learning and best creative results use these yellow blocks. Caffeine can only be used to enhance alertness early in this optimum

window (brown color). Later use will affect sleep (caffeine half-life is about six hours). Optimum timing of exercise is not marked as it may vary depending on the optimum timing of zeitgebers (e.g. early morning for DSPS people and evening for ASPS people). Gray dots are actual sleep block measurements with timing on the horizontal, and the length on the vertical axis."

From this data Dr. Wozniak has compiled two rules for optimal equilibrium of circadian and homeostatic sleep factors!

1. Strong homeostatic sleepiness: this typically means going to sleep not earlier than 15-19 hours upon awakening from the preceding nights sleep.
2. Ascending circadian sleepiness: this means going to sleep at a time of day when a rapid increase in drowsiness is experienced; No earlier and no later. Understanding the timing of your circadian rhythm is critical for good night sleep.

Furthermore, be aware that using the circadian component will only work when all its physiological subcomponents run in synch (as it is the case in free running sleep). Those with irregular sleep hours and highly stressful lives may simply be unable to establish the point of ascending circadian sleepiness as this point may not exist in their situation.

Lark/Owl prototypes?

Many would classify themselves as a morning person, commonly known as "Lark", or night personality, commonly referred to as "Owl"?

Research shows that 15% of people would classify themselves as "morning type" or lark. Another 20% would call themselves "evening type" or owl. The remaining 65% are indifferent or "mid-range". What prototype do you tend to fall under?

Dr. Wozniak claims one can easily adapt to a completely different schedule by means of chronotherapy (e.g. by shifting their sleeping hours by 30-45 minutes per day).

"If you ask a typical owl to go to sleep 30-45 minutes later each day, the owl will initially sleep during the day and soon will find itself going to sleep in the very early evening just to get up before the larks! Surprisingly, even the most committed owl can then comfortably stick to the early waking hours for quite long! There seems to be no natural preference as to the sleeping time of the day!"- Dr. Wozniak

However, there is a factor that drives people into believing they are of a given sleep-time preference type. This is the length of the circadian cycle and their ability to entrain it to 24 hours. As mentioned earlier, typical circadian period lasts about 25 hours. Those whose cycle is particularly long, tend to go to sleep later each day. They push the limit of morning hours up to the point when their compulsory wake-up time results in unbearable sleepiness. In other words, people with long cycles will tend to work during the night and sleep in the morning as long as it is only possible.

Larks and owls do not differ in their preferred timing of sleep in reference to daytime. The difference comes from the duration of the circadian cycle and sensitivity to zeitgebers. You can, without much difficulty, make a lark work contentedly late into the night and cause an owl get up at 3 am. This can be done by chronotherapy (cycle adjustment)!

A smaller quantity of people, will practice short circadian periods and experience extreme tiredness in early evening. This is the "lark type". Daily rituals force these lark prototypes to go to sleep slightly later than their natural partiality (family, work, light, etc.). Even with this prototype it is still possible to advocate a lark to progressively shift sleeping hours and perform like an owl.

As for "indifferent type", these are the percentage of the populace with a steady 24.5-25 hours circadian cycle and healthy sensitivity to zeitgebers. These prototypes tend to sleep in "normal hours" and can also be motivated to shift to getting up early or to going to sleep late.

As opposed to the "indifferent type", owls shifted to a morning routine will gradually tend to proceed to their norm of a "late-night" rhythm. Likewise, larks will rapidly shift back to sun-rise hours.

Free Running Sleep

Chronotype is the scientific name for your individual circadian rhythm pattern.

A majority of sleep disorders which originate within the body (for example insomnia) result from errors in synchronization of sleep with the body clock. Only a small portion of sleep problems are organic in nature and cannot be resolved with chronotherapy.

Chronotherapy is used to influence the sleep-wake cycle in an attempt to change the patient's core circadian rhythm.

One of the simplest solutions towards getting good sleep is free-running sleep.

In simple terms, free-running sleep requires throwing away your alarm clock. Free-running sleep can resolve the majority of synchronization-dependent sleep disorders.

Free-running rhythms were also observed in people isolated in caves for extended periods. Long periods of separation in caves were generally considered as a test of human endurance. Sleep diaries, however, kept by these volunteers spending times ranging from 15-205 days in isolation, and provided clear evidence of a lengthening of the sleep-wake cycle to 25 hours and even significantly longer. Similarly, free-running rhythms were reported in subjects living in isolation in the natural environment of the high arctic region under unvarying daylight lighting conditions.

Free-running sleep is sleep that is not artificially regulated. It is used as a form of chronotherapy that can help to cure some sleep disorders. Most people in the industrial world cannot afford free-running sleep. Only a small part of the population can sleep in a perfect 24 hour cycle and in synchrony with the schedules demanded by external influences.

The most typical violation of free-running sleep is the use of an alarm clock. Another violation is staying awake past one's accustomed bedtime in spite of drowsiness. (Staying up late when one is not sleepy does not violate free-running sleep.) Going to sleep too early (e.g. to force longer sleep before early arising) may also disturb the free-running sleep cycle.

Researchers agree that optimum sleep is realized with a "set" sleep schedule. That is going to bed each night at the same time, and awakening at roughly the same time.

The set schedule should also be in correspondence to both the circadian and homeopathic components.

REM sleep- Enter the Vortex

REM sleep, the chief contributor of the state of dreaming, is a fundamental player in encompassing a complete night's sleep.

Modern Research has revealed many tantalizing theories regarding dreams.

"A single definition for dreaming is most likely impossible given the wide spectrum of fields engaged in the study of dreaming, and the diversity in currently applied definitions. Many studies do not specify a definition, yet results are likely to be comparable only when comparable definitions of the topic are used. The alternative is to develop a classification system organizing the multiplicity of definitions for dream. A dream should not be exclusively defined as a non-conscious electrophysiologic state. Dreaming is, at least in part, a mental experience that can be described during waking consciousness. Definitions for dreaming should be utilized in research and discussion which address the various axes which define dreaming: Wake/sleep, Recall, and Content."

One interesting study entitled, "Personalized Method for Interpreting Dreams (PMID)—As Applied to Relationship Issues" showed an emotional connection:

"The purpose of this study was to develop a dreamwork model that would help individuals deal with relationship issues. Seventy dreams, involving seven major relationships, were selected from the woman participant's dreams. A dream interpretation model, the Personalized Method for Interpreting Dreams (PMID) was developed. Well-founded concepts in the PMID are: 1) dreams reflect emotions; and, 2) pre-dream thoughts, current circumstances, and personal definitions build dream meanings. The newest dreamwork concept of the PMID is the systemic perspective that relationship issues are best understood by discovering how relationship experiences influence our thoughts, emotions and behavior in other relationships. With a dreamwork systemic approach, the individual gathers together and studies series of dreams about major relationships in his or her life, primarily the family. Results of the thesis study show that the participant's use of the model was a factor in reducing stressful relationship issues."

G. William Domhoff believes:

"Discoveries in three distinct areas of dream research make it possible to suggest the outlines of a new neurocognitive theory of dreaming. The first relevant findings come from assessments of patients with brain injuries, which show that lesions in different areas have differential effects on dreaming and thereby imply the contours of the neural network necessary for dreaming. The second set of results comes from work with children ages 3-15 in the sleep laboratory, which reveals that only 20-30% of REM period awakenings lead to dream reports up to age 9 and that the dreams of children under age 5 are bland and static in content. The third set of findings comes from a rigorous system of content analysis, which demonstrates the repetitive nature of much dream content and that dream content in general is continuous with waking conceptions and emotional preoccupations. Based on these findings, dreaming is best understood as a developmental cognitive achievement that depends upon the maturation and maintenance of a specific network of forebrain structures. The output of this neural network for dreaming is guided by a "continuity principle" linked to current personal concerns on the one hand and a "repetition principle" rooted in past emotional preoccupations on the other." (31)

States, Bert O. in, "The meaning of dreams", Comments...

"To begin, I question whether random vs. meaningful (as in Globus's title) offers the best pairing of the alternatives. Order and disorder (to invoke the language of chaos theory) would probably be a cleaner opposition; and orderliness, as an antonym of randomness, does not in itself produce or contain meaningfulness, though it may be true that orderliness in some degree is a precondition of meaningfulness....It is not a question, then, of dreams meaning one or several things, but of the impossibility of equating meaning itself to possible interpretations. Indeed, we dream about things whose meaning we already know in an emotional and preconceptual sense, and that is probably why we dream about them and why dreams make a certain kind of essentialized sense. The dream is the instantiation of a felt meaning which is the cause of the dream, not its effect; it is brought directly into sleep from the day's experience, and what meaning one gets out of it on the waking side by way of interpretation is itself a new meaning (because a new symbolization) which leaves the experience behind in the act of conceptualizing it for waking understanding. If you dream that you are dancing, you may be dreaming about one of several things: how easy it is to dance, how graceful and exhilarating your effort, or how impossible and awkward; your dream-dance, then, will be the dancing of a feeling about dancing, which is to say about one of dancing's meanings to you. In any case, as Yeats might put it, you can't tell the meaning from the dance."

Nielsen, Tore A in, "Changes in the kinesthetic content of dreams following somatosensory stimulation of leg muscles during REM sleep." (*Dreaming: Journal of the Association for the Study of Dreams*. Vol 3(2) 99-113, Jun 1993.)

Observed,

"The notion that dreaming is isolated from sensory activity is challenged by demonstrations that somatosensory stimuli are frequently incorporated into dream content. To further study such effects, four volunteers were administered pressure stimulation to either the left or right leg during REM sleep and awakened to report their dreams. These dreams were rated and compared to non-stimulated dreams. Stimulated dreams more frequently contained leg sensations and references to the pressure stimulus than did non-stimulated dreams; dreamed leg activity, but not dreamed arm activity, was also rated as more intense. Incorporations of the stimulus were typically simple, direct kinesthetic sensations of pressure or squeezing but were also sometimes embedded in more extended 'problem-solving' sequences. Stimulation also increased bodily bizarreness. The latter included changes in kinesthetic quality of movement, instabilities of posture and the environment, and visual-kinesthetic syntheses. Although micro-arousals may be an explanatory factor, the results suggest that somatosensory stimulation influences 'kinesthetic fantasy', a dimension of dreaming associated with both central and peripheral sources of kinesthetic activity."

Another interesting theory presented by Kahn, David; Hobson, J. Allan, in "Self-organization theory of dreaming".

(Dreaming: Journal of the Association for the Study of Dreams. Vol 3(3) 151-178, Sep 1993.)

Stated,

"Our general hypothesis is that the brain self-organizes neuronal signals whose cognitive correlates produce discontinuities and incongruities in an on-going narrative. This could go on in any sleep-wake state but, according to our theory, it is qualitatively distinctive in REM sleep/dreaming. To demonstrate the origins of this idea, we review the cognitive psychology of dreaming and the neurophysiology of rapid eye movement sleep in terms of the self-organization concept. We also review mathematical models of self-organization for their relevance to dreaming. We then go on to test our hypothesis in a preliminary way at the level of neurophysiology. Bifurcation parameters were chosen to be the relative amounts of cholinergic and aminergic neurotransmitters, the burst frequency of pontogeniculoocipital (PGO) waves (producing noise-induced transitions), and an electrical activation parameter. A class of mathematical models universally applicable to self-organizing systems near the system's bifurcation points was found to model the neurophysiology in a formal manner isomorphic to distinctive and global cognitive features of dreaming."

Commenting on Bergson's theory of Dreaming ,

Patrick McNamara, Ph.D., "Bergson's Theory of Dreaming"

(Dreaming: Journal of the Association for the Study of Dreams. Vol 6(3) 173-186, Sept 1996.)

"Bergson's reflections (in "Le Rêve," 1901/1920) on the nature of dreaming anticipated modern cognitively-oriented accounts of the dream. According to Bergson dreaming is a selectionist process. When the brain relaxes its inhibitory powers with the onset of sleep, the cognitive system is rapidly flooded with a vast array of memory images. The cognitive system tries to arrange the proliferating memory images into some kind of narrative. A few of these memory images, by chance,

roughly match the affective and physical sensations that still occur in sleep and are "selected" as the raw material for the dream narrative. The discordant assimilation of memory images with the current affective and physical state of the organism constitutes the dream."

The interpretation and meaning of dreams may never be fully understood. But the fact that they are accompanied with REM sleep illustrates their significance to a complete night's sleep.

REM sleep is usually not subdivided into stages, however, "tonic" and "phasic" aspects of REM sleep are often distinguished.

Phasic REM sleep events are alternating (i.e., rapid eye movements and muscle twitches). Tonic REM sleep events are unrelenting (i.e., desynchronized [activated EEG] and striated [voluntary] muscle inhibition). As explained below, tonic versus phasic distinctions may be relevant to physiological changes that accompany sleep.

At this point only sleep-related changes in the brain that can be recorded from outside the head (EEG) have been measured.

However, a more thorough picture of brain activity materializes as changes deeper within the brain are considered. PGO waves, which are one of the most characteristic of these changes, are sharp waves that precursor the onset of REM sleep.

They start while the cortical EEG still illustrate the signs of NREM sleep and they occur most regularly during REM sleep, normally showing up in clusters. PGO waves are named for the positions where they can be easily recorded- the pons (where they begin), the lateral geniculate nucleus, and the Occipital (visual) cortex.

These are significant for two major reasons. First, they indicate that, previous to the cortical EEG signs of REM, acute changes in the neural activity are taking place within the brain and, secondly, they signify a powerful example of how other brain regions are influenced by activity stemming from the pontine brainstem.

Eye movement configurations are also able to distinguish sleep states. Involuntary, slow, rolling, pendulum eye movements occur during drowsy alertness and during the transition from drowsy sleeplessness to NREM sleep. This eye movement model can be simulated only by following a slowly moving target. Bursts of rapid eye movements occur during REM sleep; these bursts are mixed together with periods of no eye movements.

There are patterns of REM sleep eye actions that vary in a fairly consistent manner throughout the night. REM episodes occurring late in the night have more eye movement bursts than REM occurrence taking place early in the night. It has been suggested that the bursts of eye movements signify "scanning" of the hallucinated dream panorama.

The scanning hypothesis predicts that during REM sleep the sequence of rapid eye movement directions will be that required to watch the sequence of dream scenes. Nonetheless, most of the evidence does not validate the scanning hypothesis. However, striking correspondences between eye movement patterns and dream reports have also been distinguished, for example, in one report a series of horizontal eye movements were documented; when awakened the subject reported that he had been watching a ping pong game. In spite of such isolated reports, there is no considerable evidence that indicates that how our eyes move during a dream is immediately connected to what we "see" in the dream.

Perhaps the greatest mystery in the field of sleep and wakefulness is the function of REM sleep. It seems obvious that REM sleep must have some vital function. Virtually all mammals have REM sleep. In human adults it occupies approximately 90 to 120 minutes of sleep time each night. The intense brain activity during this state is mirrored by intense mental activity experienced as dreams.

Although sleep researchers are in disagreement of the role of REM sleep, they are all in agreement that it is clearly fundamental to fully perform the functions of sleep. It is difficult to believe that this physiological state does not have some vital survival role. (See [Z Factor part 2](#) for various theories).

Irreducible Complexity

Sleep has been described as a nightly miracle that baffles science.

The understanding of one of the most recurrent events that transpires in the human body is even now in its extreme scientific infancy.

"On average, human beings spend a third of their lives in sleep, yet scientists do not yet know precisely what sleep accomplishes. It is presumed to serve some restorative function, but just how sleep refreshes us is unclear"- Guinness.

"Scientists are still seeking answers to many questions about man's need for sleep. They do not know, for example, why man cannot simply rest, as insects do. Nor have they discovered exactly how sleep restores vigor to the body"- Hartman.

Multiple hypotheses have been presented in this paper that has endeavored to understand the advancement of current sleep theory.

However, as the results have shown, "*There are many theories about sleep, but none is universally accepted*" - Schifferes.

Recently the journal *BioScience* acknowledged that "*modern researchers are, at the most fundamental level, as confounded by the purpose and ultimate control of sleep as were Hippocrates and Aristotle more than 2500 years ago*" - Gillis.

Consider some of the origin theories that have been conjured up regarding the source and disposition of sleep.

Alemaeon, a Greek physician of the 6th century B.C., claimed that sleep is a direct result of blood draining from the head. When the cranial blood depletes to a certain point, we lose consciousness and fall asleep. Doctors dubbed it "cerebral anemia." Modern research has revealed this concept is totally unfounded.

Aristotle, the renowned philosopher of the 4th century B.C., in his work "*De Somno et vigilin*" ("*On sleeping and waking*") contended that the digestion process causes "vapors" to ascend to the brain as a result of a higher temperature in the head. As the brain cools down, these vapors move down into the heart, chilling the body's pump and generating sleep. This validity of this argument speaks for itself.

What is commonly called the "poison" or "chemical" theory alleges that sleep is the result of particular day-time waste by-products, which steadily amass to the point where a transitory state of unconsciousness is induced.

This view is disproved by several facts.

- A person can fall asleep at any time of the day.
- One who is sleeping naturally can be easily awakened – which demonstrates the body is not "drugged" by by-product poisons.
- Siamese twins share the same blood system, however one can be sleeping while the other is wide awake.

This assumption likewise fall shorts of explaining sleep.

Sigmund Freud, the father of "psychoanalysis" believed that nightly slumber is merely a regression from the hardships of life. He alleged that man subconsciously longs to withdraw to the sanctuary of "fetal life," and so he "developed" the sleep mechanism to adjust this need.

However, this philosophy is incredibly weak. One would presume, then, that someone enlightened on this subject, as Freud obviously thought he was, could have disowned the sleep "tradition" and lived life wide awake; Twenty-four, seven. (He didn't!)

Perhaps the silliest theory is the claim that "to understand sleep we need to understand its evolutionary need for adaptation". This approach to understanding sleep only causes more gaps than answers. And if continued upon as the sole reasoning behind sleep theory, the mystery will never be revealed.

Some evolutionists have claimed that sleep is a progress out of our animal ancestry. The claim is made that in our "pre-human" past, at night our "ancestors" would group together for security from predators. The darkness, shared with the body heat of the group, produced a sort of stupor, interrupted only by the rising sun. Over many ages this ultimately produced the habitual custom of sleep.

Thomas Edison, one of the greatest inventors of all time, adopted this view and asserted: "A million years from now, we won't go to bed at all. Really, sleep is an absurdity, a bad habit" (quoted from Webster). Edison accused that those who spend a lot of time sleeping are simpletons – which doesn't speak to highly of Albert Einstein, who had a daily prescription of 10 hours of sleep, or for that matter, body builders.

According to evolutionary chronology, "modern man" has been on the earth between two and three million years. Why hasn't "modern man" abandoned the sleep habit? The fact is, we still have the same sleep cycle that is evidenced in all the historical records of antiquity.

"Considering these facts of evolution and development, we are confronted with the question: What function does paradoxical sleep serve after all? As Kleitman reported in his article "Patterns of Dreaming," Dement found that when he repeatedly interrupted people's dreams by waking them, this had the effect of making them dream more during their subsequent sleep periods. These results indicated that dreaming fulfills some genuine need. What that need may be remains a mystery.- Michael Jovet- Scientific American

Critical thinking regarding the claim of "the evolution of sleep" reveals more scientific absurdity than a fundamental basis for understanding and establishing a solid sleep theory.

1. The need for sleep is inherent and vital to survival.
2. Evidence points that it is essential for circadian and homeopathic functions.
3. Evolutionists believe that sleep evolved, in other words there was a point in time when we did not need sleep.

For this conjecture to hold any ground as to apply to sleep theory, some vital questions need to be answered.

At what point did our "ancestors" go without the need for sleep, and once they did evolve the need for sleep, how did they survive with sleep deprivation in time to evolve the necessary brain functions for it compatibility? The evidence shows that the brain requires sleep. How did the brain go without sleep as it evolved the

Also why would evolution "create" more roadblocks for survival? If there was a point in time where sleep was not needed, why would evolution continue to mutate a more hindering adaptation, that would only create more hardships and unnecessary elements needed for survival?

If the claim is made that sleep was needed for the evolution of the human brain, how did these early ancestors brains optimally function before sleep was fully formed?

In order for this claim to be valid, the brain had to have evolved all the essential parts required of itself for the sleep process, along with the inherent needs of sleep simultaneously. It takes a multitude of operating systems for sleep to work. How did the brain simultaneously develop these systems, and in what way could the ancestor survive in the mean time? Which came first the need for sleep, or the complexity of sleep? And how did the independent factors exist without the support of the other?

Everyday living is evidence of the brain's inability to cope with sleep deprivation.

Parts of the brain, for instance the frontal lobe, did not function when the subject was severely sleep deprived. However, other parts of the brain, like the prefrontal cortex, exhibited more activity than normal, possibly to compensate for this non activity. The sleeper the subject, the more active the prefrontal lobe became.

This reversal of activity was evident in many regions of the brain. This reveals that the brain does try to compensate for the effects of sleep deprivation. However, lack of sleep does adversely affect the electrical patterns of the brain and it cannot function normally.

How did the evolution of the brain triumph over the effects of sleep deprivation while simultaneously developing the necessary systems to further enhance sleep's circadian and homeopathic complexities?

"It is possible that sleep may have evolved from rest to allow more flexibility within this rather rigid rhythm of rest and activity"

This is assigning an almost creative force to evolution. And this still begs the question. If the creature survived without sleep to start with, why would naturalistic evolution "create" more unnecessary adaptations? And in the mean time, if the parts of sleep were added a bit at a time, how did the brain cope with sleep deprivation in time to allow for the next mutations?

"Researchers think that sleep arose to allow organisms to conserve and restore their energy" (Irene Tobler, Scientific America)

Evidence reveals sleep has many more contributions to the body than restoration of energy, and again this is saying all the many components required for sleep and the need for them evolved simultaneously, fully functional and complete. What advantageous benefit would a energy restoration mechanism do if it was only half functional?

"It seems that the elementary features which characterize sleep in its most evolved state--as it is found in mammals and birds--are already present even in very primitive organisms." (Irene Tobler, Scientific America)

In other words, there is no evidence of evolution being any part of sleep theory.

There is no evidence for a naturalistic explanation which accounts for the origin of sleep. Sleep is a mechanism, designed by God, to assist the well-being of certain types of biological organisms, including man.

Eccentric effects occur when a person is sleep deprived. In the span of 24-48 hours, mood changes, e.g., depression, become apparent. As more time elapses, experimental subjects, in most cases, start to hallucinate and are even prone to violent behavior.

Though sleep appears to have been primarily designed for the health of the brain there are numerous physical side-effects as well. Contemplate the following observations from Miller and Goode:

"What happens in the body when we go to sleep, we know in considerable detail. There is a general slowing down of all the body's rhythms, a diminuendo of all its processes. Heartbeat and respiration retard to a leisurely pace; blood pressure and temperature fall to a lower level; the level of adrenaline in the blood and the volume of urine also fall".

Hartman stated, *"Sleep restores energy to the body, particularly to the brain and nervous system".*

Sleep also supports healing. Dr. Justus Schifferes, former Director of the Health Education Council, states that:

"sleep is more than a time of rest and relaxation. It is also a time of recuperation and repair, of growth and regrowth. During the normal course of living, cells of the body wear out and must be replaced. This regeneration takes place more rapidly during sleep. It has been shown, for example, that the epithelial cells of the skin divide and make new cells about twice as fast during sleep".

Empirical evidence supports that sleep performs its most vital functions on the brain. This is suggested by the fact that those who are deprived of sleep over several days experience minimal physical damage as compared to the mental havoc that distresses them. John Pfeiffer cites a study done on several hundred soldiers who stayed awake for more than four days. Medical examinations afterward revealed no significant physical debilitation. Sleeplessness has its most important effect on one organ, the brain.

Assorted experimental evidence appears to propose that sleep seems to activate the immune system. Scientific studies have shown that long term sleep deprivation can hasten fatal blood infections in laboratory animals.



The brain and sleep are ironic in nature. In essence the brain is a paradox. It needs sleep, but it does not sleep. The brain is quite active during sleep is demonstrated in a couple of ways.

The brain it is the control center that organizes all of the body systems, keeping them running automatically, (see [X-ray Vision Part 2](#)) even when we are not consciously thinking about these functions.

Also dreaming reveals that the brain is still very active during sleep.

Contemporary researchers are of the opinion that sleep helps keep "the brain's nerve networks up to par." This might justify why it is so difficult to think clearly when one has been deprived of sleep. Dr. Mark Mahowald, a neurologist and a specialist in sleep disorders, says: *"In a sense, sleep serves as an all-systems run-through that keeps the brain at optimal functioning."* Some suggest that sleep provides the brain with "cleanup time" in which the jumbled activities of the day are sorted and stored, much as in a computer.

The emotional benefits of sleep are evident. Shakespeare summed this concept up well –

*Sleep that knits up the ravell'd sleeve of care,
The death of each day's life, sore
labour's bath, Balm of hurt minds,
great nature's second course
Chief nourisher in
life's feast.*

As one reflects upon the matters discussed above, two facts stand out clearly.

1. Sleep is an absolute necessity for human existence.
2. Man has a long way to go in understanding this phenomenon. As Gills puts it, sleep is a complex behavior with probably no single, simple explanation.

The design of sleep is undeniable.

Every effect demands a sufficient cause. The data connected with sleep research reinforce the suggestion that there was an intelligent Source for this experience. There are far too many revealing evidences that reflect design in the process.

If sleep is ever to be wholly understood, and a sound theory put into place, it must start with the assumption of design.

ABC strives to present you the most up-to-date information regarding the science of body building, for the sole intent of accelerating your knowledge of the sport. We would also be foolish to not give a bow to the One whom we owe the irreducible complexity of the human body too.

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