Sleep problems are common, reported by a quarter of parents with children under the age of 5 years, and have been associated with poor behavior, worse school performance, and obesity, in addition to negative secondary effects on maternal and family well-being. Yet, it has been shown that pediatricians do not adequately address sleep in routine well-child visits, and underdiagnose sleep issues. Pediatricians receive little formal training in medical school or in residency regarding sleep medicine. An understanding of the physiology of sleep is critical to a pediatrician’s ability to effectively and confidently counsel patients about sleep. The biological rhythm of sleep and waking is regulated through both circadian and homeostatic processes. Sleep also has an internal rhythmic organization, or sleep architecture, which includes sleep cycles of REM and NREM sleep. Arousal and sleep (REM and NREM) are active and complex neurophysiologic processes, involving both neural pathway activation and suppression. These physiologic processes change over the life course, especially in the first 5 years. Adequate sleep is often difficult to achieve, yet is considered very important to optimal daily function and behavior in children; thus, understanding optimal sleep duration and patterns is critical for pediatricians. There is little experimental evidence that guides sleep recommendations, rather normative data and expert recommendations. Effective counseling on child sleep must account for the child and parent factors (child temperament, parent–child interaction, and parental affect) and the environmental factors (cultural, geographic, and home environment, especially media exposure) that influence sleep. To promote health and to prevent and manage sleep problems, the American Academy of Pediatrics (AAP) recommends that parents start promoting good sleep hygiene, with a sleep-promoting environment and a bedtime routine in infancy, and throughout childhood. Thus, counseling families on sleep requires an understanding of sleep regulation, physiology, developmental patterns, optimal sleep duration recommendations, and the many factors that influence sleep and sleep hygiene.

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Introduction

Sleep is not just the absence of waking, but an active neurophysiological process and the primary activity of the developing brain. Sleep is necessary for survival, but the major function of sleep remains elusive. Sleep duration, quality, and architecture changes over the lifespan, particularly in the first 5 years of life. Newborns spend as much as 80% of their day sleeping, and most toddlers and preschoolers spend half or more of their day asleep. Sleep has been shown to be as important to animal survival as food. Animal studies show that rat life spans are decreased from 2 to 3 years to only 5 weeks if deprived of REM sleep, and to 2–3 weeks if deprived of all sleep. Human studies demonstrate that adequate sleep in children is essential to normal growth and development, maternal and family well-being, and child sleep is associated with significant predictors of adult health. In this review, we discuss sleep regulation, biological rhythms, and sleep architecture; the neurophysiology of sleep; the development of sleep patterns in infants and young children; sleep duration
and patterns: normative data, recommendations and influential factors; sleep problems; and recommended sleep hygiene.1–4

**Sleep Regulation, Biological Rhythms, and Sleep Architecture**

Sleep is regulated by two overlapping but distinct systems—the circadian system and sleep/wake homeostasis.5,6 The circadian system endogenously synchronizes biologic rhythms, including sleep, cyclically with the 24-h day and is adjusted through the influence of exogenous factors. Sleep/wake homeostasis describes the body’s internal neurophysiologic drive toward either sleep or waking. Homeostasis is governed by the principles of equilibrium; the body is driven toward a balance between sleep and wakefulness (i.e., there is a neurophysiologic drive to sleep after long periods of wakefulness and drive to wake after long periods of sleep).7

**Circadian System**

The circadian system consists of cyclic changes in the body—endogenously generated biological rhythms with a periodicity of 24 h. Such biological rhythms include the sleep and wake cycle, alertness, body temperature cycle, daily cycles of hormonal secretion (e.g., melatonin and cortisol), and blood pressure regulation.5,8,9 The circadian process is driven by the circadian clock that is located in the suprachiasmatic nucleus in the ventral hypothalamus. This clock is synchronized by daily exogenous environmental cues known as zeitgebers. The most powerful zeitgeber is light that activates photoreceptors in the retina inhibiting pineal gland secretion of the sleep-promoting hormone, melatonin. Other exogenous cues that help synchronize biological rhythms with the 24-h day are daily routines such as hearing an alarm clock and eating meals.5,9

**Sleep and Waking Homeostasis**

There are many endogenous and exogenous cues that help regulate and modify the circadian rhythm, but level of sleepiness and recent sleep do not directly influence the circadian system. Rather cumulative sleep influences sleep physiology through a concurrent but separate system referred to as the homeostatic system. This is the biological drive to maintain equilibrium between sleep and waking. This model assumes that sleep debt increases with cumulative waking hours, leading to an accumulation of sleep-promoting substances called somnogens in the central nervous system (CNS). Increasing somnogen levels during waking hours drive the body toward sleep, followed by the dissipation of somnogens during sleep, resulting in decreasing drive to sleep. Thus sleep is regulated through a biological drive to maintain equilibrium or homeostasis.5,7

Adenosine is widely accepted to be one such somnogen. Adenosine is a byproduct of biological activity in the brain (from dephosphorylation of ATP) and thus accumulates with activity, increasing sleep propensity, and then dissipates with rest and sleep. Adenosine promotes sleep by inhibiting arousal; it activates the hypothalamic ventrolateral preoptic nucleus (VLPO) neurons that inhibit arousal-promoting centers. In vitro studies show that adenosine binds to presynaptic sites, exciting the VLPO neurons and blocking inhibitory neurons. In vivo studies support this finding; in animal models, adenosine injected directly into the brain’s sleep centers results in increased sleep.10

**Ultradian Rhythms**

Thus, sleep and waking are regulated by a circadian process and by a homeostatic process.8 However, the sleep state itself has a cyclic or rhythmic organization. Sleep alternates between rapid eye movement sleep (REM) and non-rapid eye movement sleep (NREM), in sleep cycles or ultradian rhythms (Fig. 1).6,11
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