

# This Week's Citation Classic

Williams R L, Agnew H W, Jr. & Webb W B. Sleep patterns in young adults: an EEG study. *Electroencephalogr. Clin. Neuro.* 17:376-81, 1964.  
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A composite picture of a typical night's sleep showed that EEG sleep stages do not appear in any consistent temporal sequence from night to night. However, stages 3 and 4 predominate in the first third of the night while stage 1-REM is most prevalent in the last third. [The *Science Citation Index*<sup>®</sup> (SCI<sup>®</sup>) and the *Social Sciences Citation Index*<sup>®</sup> (SSCI<sup>®</sup>) indicate that this paper has been cited over 220 times since 1964.]

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"My initial interest in human sleep, which culminated in a book establishing EEG norms for the ontogeny of human sleep,<sup>1</sup> was kindled by Wilse Webb, one of the coauthors of this paper at the University of Florida. While exploring the relationship of sleep to mental disorders, we discovered that psychophysiological norms for human sleep had not been established. Particularly lacking was an EEG composite of a typical night's sleep and evidence of whether sleep was consistent night after night. With Webb contributing the research design and Harman Agnew organizing a system for collecting and analyzing the data, we tackled these problems as a team.

"Our research in this pioneering field might never have 'gotten off the ground' (and into the bedroom) without the support of the aerospace industry. All scientific research had been sharply curtailed until the launching of *Sputnik*. In its wake came renewed support for scientific research having possible relevancy to space exploration. Whether astronauts could sleep in space was one of the questions to which the Air Force Office of Scientific Research was seeking quick

answers. When astronauts subsequently reported difficulty sleeping on the *Gemini* and *Apollo* flights, the need for an objective way to measure and evaluate the sleep-wake cycle became crucial. In turn, the rapid technological advances spawned early in the space era—e.g., microelectronic devices, computer automation—made our work more accurate.

"Sampling the citations to our paper revealed several likely reasons why our paper has been highly cited. It was the first to quantify the composite features of a typical night's sleep: sequencing of EEG sleep stages, length of each sleep stage, number of sleep stage changes, prevalence of sleep stages, and their distribution over the course of the night. Often cited in subsequent papers was our revised method of analyzing EEG records, which provided criteria for marking an epoch as one of five sleep stages or the waking state. This not only helped establish the consistent methodology that is so critical on any research frontier, but also provided a standard against which to check the reliability of automated sleep analysis.

"Our discovery of the highest incidence of REM sleep in the last third of the night and of stages 3 and 4 in the first third was also mentioned frequently. These distribution data were applied clinically to diagnose and treat poorly understood sleep and arousal disorders as well as to identify symptoms of diseases that could be detected only during sleep.

"As a result of my early work on normal sleep, in 1970 I was awarded a special Public Health Service Research Fellowship from the National Institute of Mental Health, which partially supported a professional development leave from my administrative and academic duties. This award enabled me to devote full-time study to the EEG of human sleep at both the Florida laboratory and the University of Edinburgh.

"More recent advances in normal human sleep have been in the exploration of regional cerebral hemodynamics<sup>2</sup> and sleep-wake periodicity. For current research findings in the sleep field, see *Psychophysiological Aspects of Sleep*.<sup>3</sup>

1. Williams R L, Karacan I & Hirsch C J. *Electroencephalography (EEG) of human sleep: clinical applications*. New York: Wiley, 1974. 169 p.
2. Sakai F, Meyer J S, Karacan I, Derman S & Yamamoto M. Normal human sleep: regional cerebral hemodynamics. *Ann. Neurol.* 7:471-8, 1980.
3. Karacan I, ed. *Psychophysiological aspects of sleep: proceedings of the Third International Congress of Sleep Research*. Park Ridge, NJ: Noyes, 1981. 225 p.