



Topic  
Better Living

Subtopic  
Health & Wellness

# Secrets of Sleep Science: From Dreams to Disorders

Course Guidebook

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Stanford University



**PUBLISHED BY:**

**THE GREAT COURSES**  
**Corporate Headquarters**  
**4840 Westfields Boulevard, Suite 500**  
**Chantilly, Virginia 20151-2299**  
**Phone: 1-800-832-2412**  
**Fax: 703-378-3819**  
**[www.thegreatcourses.com](http://www.thegreatcourses.com)**

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## **H. Craig Heller, Ph.D.**

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**P**rofessor Heller received his undergraduate degree from Ursinus College and his Ph.D. in Biology from Yale University. For two years, he was a postdoctoral fellow at Scripps Institution of Oceanography, and then he joined the faculty at Stanford University, where he has taught since 1972.

Professor Heller's research has ranged widely, including such topics as thermoregulation, hibernation, circadian rhythms, sleep, learning and memory, and human physical performance. He is the coauthor of more than 200 peer-reviewed research papers. His current focus is on the role of sleep and circadian rhythms in learning and memory as applied to the development of therapies for the learning disabilities of Down syndrome and Alzheimer's disease. The other focus of Dr. Heller's laboratory is the development of technologies for the efficient regulation of heat into or out of the body. His team is investigating many medical and nonmedical applications of this technology, including the protection of athletes from heat illness and the improvement of physical conditioning.

Professor Heller has held many positions at Stanford University, including Chairman of Biology, Director of Human Biology, Chairman of the Academic Senate, and Associate Dean for Research. Currently, he is the Director of the Wallenberg Network Initiative, which is a consortium that includes Stanford University and Lund and Umeå universities in Sweden. This network supports diverse research projects that involve the application of information technologies in the neurosciences, social sciences, and humanities. Beyond Stanford, Dr. Heller is a member of the Defense Science Research Council, which he chaired for the past two years. He also has served as Program Chair for the Associated Professional Sleep Societies.

Virtually all Biology and Human Biology undergraduates at Stanford over the past three to four decades have learned physiology from Professor Heller. In addition to his undergraduate core courses in neurobiology and physiology, he also has taught advanced courses in human physiology and in the neurobiology of sleep and circadian rhythms. He has received the Walter J. Gores Award for excellence in teaching and the Kenneth M. Cuthbertson Award for exceptional contributions to Stanford University.

Professor Heller's teaching in physiology extends far beyond Stanford University. He is a coauthor of a leading college textbook, *Life: The Science of Biology*, which is in its 10<sup>th</sup> edition and has been translated into six foreign languages. He is also a coauthor of a new biology textbook titled *Principles of Life*. Dr. Heller has led several other biology education projects, including HumBio, a multidisciplinary curriculum for the middle grades, and Virtual Labs, a set of interactive, computer-based instructional modules in physiology. ■

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# Secrets of Sleep Science: From Dreams to Disorders

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## Scope:

**W**e spend about one third of our lives sleeping, but scientists are only beginning to understand how and why. One thing, however, is clear: Sleep is just as essential to life as nutrition and exercise. In fact, lack of sleep impairs performance, exacerbates psychological and psychiatric problems, and contributes to a host of illnesses. And the consequences of too little sleep extend beyond the merely personal. From automobile accidents to lost productivity at work to major disasters, such as the *Exxon Valdez* oil spill, sleep deficits have levied a heavy toll on society as a whole.

This course examines the latest research on the crucial phenomenon of sleep. After an introductory lecture that quantifies the dire consequences of personal sleep debt and America's national sleep deficit, the course identifies the defining features of sleep and provides a clear blueprint of the "architecture" of sleep—that is, how the various stages of REM (rapid eye movement) and nonREM sleep are organized across the night.

From the nightly sleep cycle, the course turns to the issue of sleep across the human life span. We discover that circadian rhythms and sleep states emerge early in life but continue to change over the course of life. These observations lead to important reflections on the relationship between sleep and neuroplasticity.

Next, we address the question of sleep in the wider animal kingdom, where a variety of behaviors enable us to compare what might be sleep states in other species, including insects. Two lectures follow on the brain's circadian clock, which times most activities in the body, including when we sleep. Rich in experimental detail, these lectures provide crucial information for understanding the effects of jet lag, shift work, and seasonal affective disorder. The discussion of circadian rhythms also lays the foundation

for our lecture on hibernation, which manifests the most dramatic set of physiological changes that mammals undergo.

We then dive deep into the cellular and molecular mechanisms of sleep, using the basic concepts of electricity to understand what happens in our brains when we fall asleep. We also take a close look at the mammalian brain in an effort to make sense of the complex neural networks that control sleep and all its manifestations. The discussions of neuroanatomy, neurochemistry, and neurophysiology lead to lectures on narcolepsy and dreams. We learn how basic animal research has led to greater understanding of sleep in humans and to more effective treatments for sleep disorders. We also inquire into the possible functions of dreams and ask why amnesia for dreams might be important to mental health.

The lecture on dreams is followed by a group of lectures in which we explore the possible functions of human sleep. Of particular interest are experimental studies that suggest a strong connection between sleep and learning and memory. In addition to assessing the strengths and weaknesses of the various hypotheses that focus on sleep and the brain, we will examine the role that sleep has to play in maintaining the health of the rest of the body, including its effects on stress and blood sugar.

Next, we turn to another group of lectures, where the focus is on sleep disorders, including insomnia, sleep apnea, and the bizarre—and sometimes quite dangerous—world of parasomnias. Among the parasomnias we discuss are sleepwalking, night terrors, and REM sleep behavior disorder. We also investigate sudden infant death syndrome and post-traumatic stress disorder (PTSD). PTSD involves the common complaint of incessant, extreme nightmares. It appears that the emotional memory of traumatic experiences can become amplified through dreams, which suggests a possible therapy for the disorder.

The final lectures address possible therapies and treatments for sleep disorders, focusing especially on the behavioral options that are open to everyone. Increasingly, behavioral modifications are being used to counter insomnia and improve sleep. Our modern lives do not prepare us well for normal, healthy sleep. Recognizing the factors that impair our sleep makes

it possible to systematically mitigate them. Significant changes or sacrifices are not necessary—a surprisingly simple set of rules can solve most cases of insomnia. We close with a lecture on the future of sleep research and the questions it may be able to answer to improve sleep for us all. ■