1

Rockettes, EEGs, and Banana Cream Pie

We experience a dream as real because it is real. . . . The miracle is how, without any help from the sense organs, the brain replicates in the dream all the sensory information that creates the world we live in when we are awake.

—William Dement

BY THE TIME EUGENE ASERINSKY FOUND himself in a dungeonlike lab room at the University of Chicago in the fall of 1951, wiring his eight-year-old son, Armond, with electrodes to record his eye movements and brain waves as he slept, he was desperate. The experiment he was embarking upon absolutely had to work so that he could finally earn his degree and get a job. A perennial student at age thirty, with enough college course credits to qualify for the Guinness Book of World Records but no degree other than a high school diploma, Aserinsky was struggling to provide the basic necessities for his son and pregnant wife in an apartment so spartan that its only heat source was a potbellied kerosene stove. Hardly a candidate, it would seem, to make a discovery that would revolutionize scientific thought about the brain's activities during sleep and launch a research odyssey that would shed light on how the mind did everything from learning to regulating our moods.

But Aserinsky was hardly an ordinary student, and from early childhood on, he'd been living unconventionally, to say the least. After his mother died shortly following his birth, Eugene was brought up in Brooklyn solely by his father, a ne'er-do-well Russian immigrant who was a dentist by trade but whose true passion was separating people from their money in late-night card games. When Aserinsky was still in elementary school, it was already evident that he was extraordinarily bright, so his father recruited the boy as a card-sharking partner. Together, they developed a signaling system that fleeced countless unsuspecting chumps in pinochle games. Since the games usually went on until well after midnight, Eugene often skipped school so that he could sleep late. In fact, for about a third of the school year, his classroom seat was empty. In those Depression years, however, absences were often overlooked by school officials and his academic performance was so stellar that he skipped ahead a couple of grades. Enrolling in Brooklyn College at the age of fifteen, he soon transferred to the University of Maryland, where he managed to take courses in everything from Spanish to dentistry without ever getting a degree before dropping out to become a soldier when World War II began.

After he returned from England, where he'd served as a high explosives handler in the Army, friends persuaded him he was wasting his talent in the civil service job he'd taken in Baltimore to support his wife and two-year-old son, Armond. So he applied to the graduate program at the University of Chicago, which had a reputation for bending the rules to admit students who showed signs of brilliance. He apparently fit the bill. In later years, Aserinsky—a slightly built man with dark hair, a David Niven–style mustache, and a penchant for dressing formally in suit and tie even in the lab—loved to point out that he'd gone straight from a high school diploma to a Ph.D. without any degrees in between.

When he arrived in Chicago, however, he discovered that the only available adviser in the physiology department was Nathaniel Kleitman, the first and only scientist in the world who had devoted his entire career to the study of sleep. A Russian immigrant who lived to the age of 104, Kleitman was so devoted to his work that he'd spent a full month living in an underground chamber in a Kentucky cave to see whether the absence of environmental clues about time of day could shift the body's natural cycle to either a twenty-one-hour or a twenty-eight-hour day. (As he learned, the answer is no; our bodies have an internal clock that's naturally set to a sleep-wake cycle of twenty-four to twenty-five hours.) Later, he also served as a guinea pig in his own sleep deprivation experiment, staying awake for 180 hours straight, an experience that he concluded could be an effective form of torture.

Aserinsky loved physiology, but he had no intrinsic interest in sleep research. He became even less enthusiastic about his fate when he found that Kleitman—whom he described as "a man with a grey head, a grey complexion and a grey smock"—was usually tucked away out of sight behind his closed office door, responding with irritation whenever Eugene knocked. Kleitman may not have found him the best prospect for a graduate assistant, either, but as Aserinsky dryly observed, the primary criterion for selecting a graduate assistant "was that the candidate have a heartbeat." Since Aserinsky did qualify on that score, Kleitman immediately gave him a research task: observing sleeping infants to see whether blinking stopped gradually or suddenly as they fell asleep.

After several unproductive months pursuing Kleitman's goal, Aserinsky gathered his courage to knock on what he referred to as "the dreaded door" to propose a different project: studying eye movements of sleeping subjects throughout an entire night. He'd observed vigorous eye movements behind the closed lids of subjects who were sleeping, and he wondered whether those movements were haphazard or had some pattern and purpose. To his surprise, Kleitman agreed to the change, suggesting that Aserinsky pursue the project as a potential doctoral dissertation. He mentioned that there was an old polygraph machine stored in the basement of the physiology building that he might be able to use to record eye movements as well as brain waves and other physiological measurements on his test subjects. Well aware that he was taking a big risk—if the experiments produced no new data worthy of a doctoral dissertation, he would be continuing his pattern of collecting college credits without earning a degree—Aserinsky decided to proceed anyway.

"According to my anti-intellectual 'Golden Manure' theory of discovery, a painfully accurate, well-focused probe of any minutiae is almost certain to divulge a heretofore unknown nugget of science," he later said. "What lay ahead was a gamble—the odds being that since no one had really carefully examined the eyes of an adult through a full night's sleep, I would find something. Of course, the importance of that find would determine whether or not I would win the gamble."

Just as Eugene had been recruited into partnership with his father, Aserinsky enlisted the aid of his son, Armond, in his own brand of wagering. Starting in second grade, the boy began logging countless hours in the lab, first serving as a test subject himself and then helping his dad set up and calibrate the rickety recording equipment for other sleep subjects.

"The lab was horrendous—old and dark with stone walls—and the machine was ancient, so it was always breaking down," recalls Armond, who is now a clinical psychologist. "Getting prepped for the recording procedure was uncomfortable and I didn't like the all-night sessions, but I knew my dad needed help, and I was flattered that he talked over his findings with me and always took what I said very seriously."

The abandoned polygraph Aserinsky had rescued from the basement of Abbott Hall turned out to be one of the first machines of its kind. It picked up eye movements and brain waves through electrodes pasted on the subject's head and then translated those electrical signals into ink patterns scratched out by several pens onto long reams of paper. Recording a single night's sleep session consumed a stream of polygraph paper a half mile long.

This technique for recording electrical signals from the brain had been around since the early part of the twentieth century, when Hans Berger, a German neuropsychiatrist was able to record brain waves in subjects who were awake but relaxing with their eyes closed. He observed that these EEG (electroencephalogram) patterns showed consistent changes at sleep onset; subsequent studies in the 1930s at Harvard further classified differences in waking and sleeping brain wave patterns. But no one had tried all-night recordings of brain and eye movements as Aserinsky was doing, in large part because Kleitman and others mistakenly believed that sleep was a second-class state during which nothing important happened in the brain other than maintenance of basic body functions.

When Aserinsky hooked up Armond for a night's sleep session, he was startled to see that the pens periodically stopped tracing the patterns of slow, even waves that appeared in early stages of sleep and instead began wildly scratching out sharp peaks and valleys similar to patterns generated during waking hours. Since this finding contradicted the prevailing scientific view that the brain essentially shut down and remained in a passive state during sleep, Aserinsky at first assumed that the polygraph was simply malfunctioning. After consulting with engineering experts, including the man who'd designed the machine he was using, Aserinsky came up with a way to record movements from each eye independently and verify that the unusual patterns he was seeing were indeed real.

He repeated the experiment on adult sleepers and not only found the same spiky patterns he'd seen with Armond but confirmed that they occurred with clocklike regularity four or five times a night and coincided with rapid eye movements that were clearly visible beneath the sleeper's closed eyelids. Putting all of the evidence together, Aserinsky suspected that he might actually be seeing dreaming in action. His hunch was reinforced when he awakened a sleeping male subject who had begun crying out while experiencing wild eye movements that nearly unhinged the pens on the polygraph. The man reported that he had indeed been having a violent nightmare. As the study progressed, evidence mounted that when subjects were awakened in the midst of rapid eye movement periods, they almost always had vivid dream recall. But if they were awakened when no eye movements were present, they rarely remembered anything.

Kleitman was highly skeptical when Aserinsky first showed him the results he was getting on this strange sleep stage that he had begun to call the rapid eye movement (REM) period. Yet the consistency of the mounting body of evidence piqued the older man's interest, and he gradually became a believer, assigning another lab assistant to assist Aserinsky in making the REM recordings. But before presenting the new data publicly for the first time at a scientific meeting in 1953, Kleitman—who had a reputation as an extremely fastidious investigator—wanted to observe the experimental procedure first-hand with his own daughter as a test subject. When she experienced the same regular pattern of rapid eye movements throughout sleep, the case was sealed for Kleitman. The results of the REM experiments were published by the respected journal *Science* in 1953, and Kleitman granted his ultimate seal of approval: his name was listed behind Aserinsky's as joint author.

The landmark study forced scientists to completely rethink their assumptions about what happens during sleep. Far from merely idling all night, as they'd previously thought, the brain regularly revved up into a supercharged state akin to waking consciousness. Exactly what the brain was doing during these REM periods was a mystery, but dreaming unquestionably was an important part of the answer.

THE 1960S BECAME the golden age of dream research, as researchers from many disciplines rushed into the new field, exchanging ideas—some of them quite wild—and scientifically jamming like jazz musicians. But at the start, the crusade to answer the countless questions raised by the discovery of REM sleep was led almost singlehandedly by William Dement, who'd become fascinated by sleep research in his second year of medical school after attending a lecture by Nathaniel Kleitman.

When an enthusiastic Dement knocked on the infamous closed door to Kleitman's office in 1952 to see if he could become an assistant in his lab, Kleitman peered out, asked if Dement knew anything about sleep, and when the young med student replied honestly that he didn't, the taciturn Kleitman simply said "Read my book" and closed the door with a force just short of a slam. Dement quickly caught up on his reading and went to work in Kleitman's lab, where he helped Eugene Aserinsky complete REM sleep recording sessions for the study that finally earned him his long-awaited degree.

It wasn't long until Dement was on his own, however, because Aserinsky wasted no time clearing out of Chicago when he finished the REM experiments. Though his discovery had caused an initial flurry of public excitement, it certainly didn't bring him fame and fortune. Feeling increasing pressure to bring home a paycheck that would support his family, he took the first job he was offered in the summer of 1953—at the Bureau of Fisheries in Seattle. There, he conducted experiments to see whether the movements of salmon could be controlled by running electric currents through water. Though it was a far cry from sleep research, a job was a job, after all, and Aserinsky was happy for the moment to put the arduous demands of all-night sleep recording sessions behind him.

Dement was thrilled to be taking the lead in dream research at the Chicago lab. Unlike Kleitman and Aserinsky, he was a great believer in Sigmund Freud's theory that dream interpretation was the "royal road" to understanding the unconscious activities of the mind. "Freudian psychoanalysis seemed to permeate every nook and cranny of society in the 1950s and I was an ardent disciple," Dement wrote in *The Sleepwatchers*, an account of his early days in dream research. Since Freud had theorized that psychosis could erupt in the waking state if we didn't have dreams as an outlet to discharge the energy of the libido, Dement eagerly set about doing REM studies on schizophrenics in a state hospital, to see whether their mental illness might spring from an inability to dream. The theory didn't pan out—the EEG results showed they experienced normal REM cycles, and they reported having dreams.

But Dement was undaunted—he had so many other theories and unanswered questions to explore. During his final years of medical school, he spent two nights a week running sleep studies in Kleitman's lab to more precisely define the characteristics of REM and other sleep stages. Combining those sleepless nights with the other demands of life as a medical student meant that he frequently fell asleep in the back of the classroom the following day—a problem that landed him in the dean's office at one point—but the end result was well worth his troubles.

The paper that he and Kleitman published in 1957, describing the characteristics of REM and other sleep stages, laid the foundation for information about sleep and dreaming in most medical textbooks for decades to come, and Dement's infectious enthusiasm for dream research helped launch similar investigations in other labs around the United States and in Europe.

By meticulously charting nightlong EEG recordings, Dement found that healthy adults pass through predictable sleep phases, which have since been divided into five standard stages of sleep. In the relaxed presleep period, we begin to tune out noise and other external influences, and our brain generates the regular rhythm of alpha waves—the same kind of pattern displayed by the mind in meditation, a serene state devoid of purposeful thought. We then enter stage I sleep, also known as sleep onset, when we may experience what's known as hypnagogic imagery—brief, dreamlike visual imagery that often is drawn from that day's experience. Next comes stage II, a period of light sleep lasting from ten to thirty minutes, as the brain downshifts into the large, slow delta waves that characterize the deep sleep of the third and fourth stages, known as slow-wave sleep. While we may talk in our sleep at any point during the night, it is in these deepest sleep stages that sleepwalking typically occurs.

After fifteen to thirty minutes in this deep sleep, we move back up through the first two stages and enter the first of our REM periods, when our brain waves shift to the short, rapid patterns that resemble waking brain activity. When we're in REM, our muscles completely relax, and though our eyes move and hands or feet may occasionally twitch, we are essentially paralyzed so that we can't physically act out our dreams. Nevertheless we're highly aroused physiologically: our breathing becomes irregular, our heart rate increases, and genitals become engorged in both males and females. The initial cycle from waking to REM normally takes between fifty and seventy minutes, and thereafter REM returns about every ninety minutes. During the first half of the night, slow-wave sleep predominates and REM periods may be as brief as ten minutes, but as the night progresses, non-REM sleep grows lighter and REM periods last longer, stretching from twenty minutes to as much as an hour as morning approaches. All told, adults spend about a quarter of the night's sleep in REM, another quarter in deep sleep, and the remainder in stage II light sleep.

Perhaps most significantly, the early REM experiments by Dement, Kleitman, and Aserinsky showed that dreams were far more likely to be recalled when subjects were awakened from REM: dreams were reported on 74 percent of REM awakenings as compared to less than 10 percent in non-REM. These initial results led Dement and other researchers to conclude that dreaming occurs exclusively in REM sleep, while the minimal reports of dream recall they found in non-REM could be written off as fragments of dreams recalled from earlier REM periods.

The widely accepted assumption that REM sleep equaled dreaming brought the new field of dream research to life, and Dement was quite effective at spreading the gospel that for the first time it was possible to actually pinpoint when a dream was in progress. Having earned both his medical degree and his doctorate in physiology, Dement left Chicago in 1957 for New York City, where he conducted dream research at night while completing his internship and residency at Mount Sinai Hospital. In order to run his dream experiments without having to spend nights away from his wife, he converted part of his apartment to a sleep lab, running local ads to recruit test subjects. A member of the Rockettes happened to see the ad, and she spread the word among other members of the Radio City dance troupe that they could earn money for simply sleeping in Dement's lab—an idea with great appeal to many of the young women. Though the research was entirely aboveboard, the routine that ensued made Dement quite the object of curiosity in his apartment building as a steady parade of women came straight from the chorus line to do their nightly stint in the lab.

"A lovely woman, still in theatrical makeup, would arrive at the apartment building and ask the doorman for my room," Dement recalls. "In the morning, she would reappear, sometimes with one of my unshaven and exhausted male colleagues who had spent the night monitoring the EEG. One day, the doorman could finally stand it no longer. 'Dr. Dement,' he demanded, 'exactly what goes on in your apartment?' I just smiled."

Exactly what was going on in his apartment and in a growing number of other labs was an exciting new foray into uncharted territory, as Dement and others used all kinds of creative experiments to try to understand how dreams are created and how they are connected to our waking life. Since the Soviets had beaten the United States into space with the launch of the satellite *Sputnik*, government funding for basic research of all kinds was suddenly free-flowing as the 1960s dawned, and dream research was one of the beneficiaries. In 1964 alone, the National Institute of Mental Health funded more than sixty studies on sleep or dreaming. From New York to Boston, Washington to

Cincinnati and on campuses in Virginia, Texas, and Oregon, researchers were drawn to this hot new field, where so little was known that they were likely to come up with something new no matter what they chose to investigate.

There were countless intriguing questions to be answered and no limits to the creative methods researchers invented to get results. Could dream content be manipulated? Dement was the first to try this by ringing a bell while subjects were in REM sleep, but out of 204 attempts, only 20 dreams actually incorporated the sound of the bell as part of the dream plot. Researchers have had limited success in affecting dream content by spraying dreamers with water and—more recently—squeezing sleepers' arms with blood pressure cuffs while in REM, but the majority of dreamers ignored these manipulations too. On those occasions when real-world stimuli do make it through our sensory barriers, they are quickly and ingeniously woven into the ongoing plot of the dream. For instance, a sleeping test subject sprayed with water may report a sudden rain shower in the background of his dream, but there's no dramatic change in the dream's course.

Nor was there any significant effect on dream content from presleep experiences, such as serving sleepers banana cream pie or pepperoni pizza right before bedtime, depriving them of fluids to see whether they had persistent dreams of being thirsty, or showing them violent or erotic films. Dreaming brains appeared to be fiercely independent directors, relying on some yet-to-be-deciphered criteria for selecting characters, setting, and plot in their nightly internal dramas.

Other experimenters proved that even those who claim not to dream do in fact concoct dream scenarios throughout the night. If awakened while REM is still in progress, subjects remember their dreams, but if they are awakened several minutes after REM has ended, the memory of the dream typically vanishes. Yet another study probed whether dreams are different at different points in the night and found that dreams early in the night revolved around current events in the dreamer's life while, as the night progressed, dreams incorporated more events and characters from the past.

Did the jerky eye movements of REM sleep indicate sleepers were following the action in the dream as they would images on a movie screen? Early experiments by Dement suggested this was the case, but subsequent studies by other investigators found that eye movements did not in fact directly correspond to dream content.

One of the biggest preoccupations of the early researchers was understanding how visual imagery in dreams was produced, since the strongest sensory perception while dreaming is unquestionably visual. Investigations of dream content from the 1890s on consistently showed that nearly every dream contains visual imagery, while slightly more than half contain some auditory component. Among other sensations, touch or feelings of movement are present in less than 15 percent of dreams, while taste or smell rarely figure into dream experience at all.

One of the best-known experiments to test the source of visual imagery in dreams took place back where it had all begun, at the University of Chicago. After sleep research pioneer Nathaniel Kleitman retired, psychologist Allan Rechtschaffen used the lab before forming his own makeshift dream lab in an old gray-stone building around the corner from Abbott Hall. He ran cables from an EEG machine in his office to subjects who slept on foldout beds set up each night in other offices up and down the hallway after their occupants went home for the evening. Rechtschaffen created a lively atmosphere that encouraged rigorous but creative scientific thinking among the young researchers in his group. His wide-ranging curiosity and commitment to the highest scientific standards made him one of the most respected figures in the field. He was considered a tough reviewer for grant proposals or scientific papers, which made winning his approval all the more valuable. In the early days at his lab, young researchers often would come up with a new hypothesis about dreaming in the afternoon and test it that very night on the housewives and students who were paid to sleep while being recorded and periodically awakened—a process that went more smoothly with some than others.

"We once had a subject who was complaining about everything as we hooked him up to the EEG—he didn't like the surroundings, the electrodes, the smell of the acetone," recalls Rechtschaffen. After the problematic student finally was prepped for the EEG and tucked into bed, Rechtschaffen and his assistant returned to the office where they monitored the EEG recordings. The assistant wryly speculated that after all the trouble the subject had put them through, he probably wouldn't fall asleep. Unaware that the intercom to the sleeper's room was switched on so that the young man in bed could hear every word they said, Rechtschaffen replied, "If he doesn't fall asleep within two minutes, I'm going to electrocute him." With startling speed, the chronic complainer slid into stage I sleep.

Rechtschaffen came up with a novel way to test whether signals transmitted from the retina (the gateway for visual information from the outside world to the brain in waking) played a role in creating dream imagery. Amazingly he succeeded in getting test subjects to go to sleep with their eyelids taped halfway open. Once the sleeper entered REM, Rechtschaffen would sneak into the bedroom with a small light to illuminate objects such as a comb, book, or coffeepot that he would hold up in front of the sleeper's taped-open eyes. Then he would exit, and his research colleague David Foulkes would awaken the subjects via intercom and ask what they had been dreaming about. None of the dreamer's reports included images of the objects that had been dangled in front of their eyes. Clearly dream imagery was generated internally, though it wasn't yet clear how.

Additional experiments indicated that except for some decrease in the clarity of background detail and intensity of color, the quality of visual images we see in our dreams is nearly on a par with what we see when we're awake. Most dreams are also clearly experienced in color, though for some unknown reason, between 20 and 30 percent play out in black and white. While reports on dreams all the way back to Aristotle included references to color, from the 1930s to 1960, the prevailing opinion among research psychologists as well as among the general public was that we dream in black and white. Not coincidentally, this period was also when photographs and film images were primarily black-and-white. Though color photography was invented in the 1860s, it did not become readily available for public consumption until the 1940s. Similarly, Technicolor made a big splash beginning in the late 1930s with a few movies such as *The Wizard of Oz*, but full-color films didn't become common until the 1950s.

During this period, when psychologists asked their subjects if they dreamed in color, the majority said no: a 1942 survey of college students found only 10 percent claimed to frequently dream in color, and only 9 percent reported dreaming in color in a 1958 study at Washington University in St. Louis. But when sleepers in a 1962 study were actually awakened during REM sleep and asked directly about the appearance of color while their dreams were in progress, 83 percent reported color in their dreams. "It is surely not chance that this flourishing of black and white media coincided with the flourishing of the opinion that dreams are a black and white phenomenon," says Eric Schwitzgebel, a University of California at Berkeley professor who studied this curious trend and concluded that it wasn't the content of dreams that had changed during that period but public perception—or more accurately misperception—of dream imagery. In short, it was another example of the pervasive power of suggestion that can make eyewitness accounts in criminal investigations so unreliable.

While many investigators were focusing on unraveling the secrets of dreaming per se, others examined the underlying state in which it occurs, trying to understand why we need sleep at all. In addition to working on developing standards used today for classifying different stages of sleep, Allan Rechtschaffen and his students investigated what happened when animals were deprived of sleep. They conducted sleep deprivation experiments in rats and found that those deprived of all sleep died after two to three weeks. The sleep-deprived rats became extremely debilitated and had difficulty regulating body temperature, but the cause of death could not be isolated.

Less extreme studies in humans showed that when deprived of REM sleep, subjects automatically compensated by entering REM sooner and staying in it longer the next time they went to sleep. A similar rebound effect was seen for the deeper slow-wave sleep, so obviously both types are essential. In fact, nature itself provides evidence suggesting that total sleep deprivation can eventually cause death in humans. A rare genetic disease called fatal familial insomnia (FFI) was first identified in 1986 as the cause of death of thirty members of an aristocratic Italian family. Since then, the disorder has been identified in thirty other families around the world. Those suffering from the genetic disorder typically lose their ability to sleep when they reach middle age, though some have been struck in their teens. After weeks without sleep, FFI victims' pulse and blood pressure rise and they sweat heavily. They then have difficulty maintaining their balance, walking, and/or speaking and in the final phase—usually after several months without sleep—they fall into a state akin to a coma and die. The disease severely damages a portion of the brain called the thalamus (the sensory gateway to the cortex). Further research is needed to determine whether the insomnia or the thalamic damage directly causes death.

As Nathaniel Kleitman had established through his sleep experiments in underground caves, our biological clock (the specific location of which has been identified as a cluster of cells located in the brain where the optic nerves intersect) determines the body's rhythms for rising and falling body temperature, hormone secretion, and onset of drowsiness, which occurs not only at day's end but also typically between 2 and 4 P.M. While that internal clock generally runs through its repetitive rhythms "about every twenty-five hours" even when there are no environmental stimuli, such as the sun rising or setting to cue wake and sleep cycles, it does seem to go through some adjustments at different stages in life. During adolescence, not only does the need for sleep increase from eight hours to ten or more hours nightly, but drowsiness sets in later than usual, as well, leading to the desire to sleep later in the morning—which is why teenagers suddenly can sleep until noon. And in later stages of life, sleep becomes fragmented, with even healthy elderly people typically awakening for a few seconds scores of times during the night, though they may not recall doing so because the arousals are often so brief as to be detectable only on EEG recordings. Interrupted sleep in turn leads to increased daytime sleepiness and the stereotypical image of grandpa nodding off in mid-sentence.

Another crucial question that was answered in the early days of dream research was whether REM sleep was exclusively a human phenomenon. Dement did initial work on the sleep cycle of cats, which had been favored subjects for brain studies since the 1930s. Not only were their brain structures similar to humans', but their size and cost made them convenient research animals. After French neurobiologist Michel Jouvet demonstrated in 1960 that EEG patterns in sleeping cats were similar to the human REM pattern, other investigators probed how widespread the phenomenon was in the animal kingdom. Subsequent research has shown that reptiles don't experience REM sleep, but mammals do, and so do the few species of birds that have been studied. REM sleep duration varies from as few as forty minutes a day in cattle to as many as seven hours a day in opossums. Predatory carnivores spend a greater proportion of time in all stages of sleep, and domestic cats, freed of the need to hunt for food, can spend more than two hundred minutes a day in REM. Researchers still have not come to a consensus on whether these variations are significant.

In humans, REM sleep begins in the womb and changes as we age. It has been detected as early as twenty-six weeks in the life of the fetus and appears to go on for twenty-four hours a day. Among newborns, REM accounts for about 50 percent of total sleep and declines steadily until a child reaches the age of four, when it stabilizes at the normal adult level of 20 to 25 percent of total sleep time. When we reach middle age, REM begins to decline, dropping to less than 15 percent of sleep time in our later years.

What purpose REM serves was a mystery to these pioneering scientists, but early clues were provided in a novel experiment conducted by Jouvet's group in Lyon. Jouvet surgically disconnected the portion of the cat's brain that normally paralyzes its muscles during REM and found that the cats, though still deeply asleep, would rise and appear to be stalking imaginary prey or attacking invisible enemies when they entered REM. Jouvet found that acting out pursuit behavior sometimes continued for as long as three minutes while the cat was fully asleep. As a result, he theorized that this stage of sleep in mature animals provided an opportunity for them to mentally rehearse behaviors essential for survival, so that the necessary neural circuitry could be maintained in peak condition even if that particular survival skill—say, defending against an enemy—wasn't actually required on a daily basis in waking life. When deprived of REM sleep for more than three weeks, cats subsequently fell directly into REM sleep from waking and spent 60 percent of their time in that stage. Cats deprived of REM for periods of thirty to seventy days also experienced changes in waking behavior, becoming abnormally hungry, restless, and hypersexual.

Jouvet's work so electrified American investigators that in 1962 Rechtschaffen invited the French scientist to speak in Chicago at the second meeting of the professional association he and Dement had formed in 1960 for the rapidly growing multidisciplinary specialty of sleep and dream research. A year later, the group met in New York, and at that meeting, a figure who'd long been missing from the field wandered through the crowd, attracting little attention until a young researcher happened to spot his name tag and realized he'd just bumped into the man who discovered REM. The young man blurted out "You're Eugene Aserinsky? I thought you were dead!" Most scientists thought Aserinsky had dropped out because he'd simply lost interest, but the reality was that his career had been derailed by family tragedy. His wife suffered a mental breakdown after the birth of their second child while Aserinsky was still conducting the REM experiments in Chicago, and after being institutionalized several times, she committed suicide. Sadly, though he attempted a comeback, he died in a car accident in 1998 after retiring from a rather lackluster college teaching career.

But the field he'd launched continued to grow exponentially as researchers exchanged ideas in meetings such as those organized by Rechtschaffen and Dement. "At the meetings everyone tried to keep up with everything, no matter how seemingly remote it might be from their own workaday interests," recalled David Foulkes. "The group, despite the gradually increasing disparity of its interests, both worked and played well together."

In keeping with that inquisitive, anything-goes spirit, dream researchers were quick to go wherever the action was. In the early 1960s, that was Lyon, France, where Jouvet was conducting his innovative experiments with sleeping cats. Among those who made the pilgrimage was an ambitious young psychiatrist from Harvard Medical School. Brilliant and opinionated, alternately charming and abrasive, he was about to change the face of dream research.