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# PATTERNS OF DREAMING

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# PATTERNS OF DREAMING

## Dreams are accompanied by certain characteristic types of brain wave and eye movement. This discovery has enabled investigators to answer several of the long-standing questions about dreaming

by Nathaniel Kleitman

Dreams have troubled the waking hours as well as the sleep of men since time immemorial. These hallucinatory experiences have inspired soothsayers and psychiatrists alike, and their bizarre contents, variously interpreted as prophetic insights and clues to personality, are the subject of a considerable body of literature. The scientific value of even the most recent contributions to this literature, however, is seriously qualified: The sole witness to the dream is the dreamer himself. The same limitation confronts the investigator who would inquire into the process of dreaming, as distinguished from the contents of dreams. Only the awakened sleeper can testify that he has dreamed. If he reports that he has not, it may be that he fails to recall his dreaming.

Nonetheless, in the course of our long-term investigation of sleep at the University of Chicago, we found ourselves venturing into research in the hitherto subjective realm of dreaming. We discovered an objective and apparently reliable way to determine whether a sleeper is dreaming—in the sense, of course, of his "reporting having dreamed" when he wakes up or is awakened. The objective indicator of dreaming makes it possible to chart the onset and duration of dreaming episodes throughout the night without disturbing the sleeper. One can also awaken and interrogate him at the beginning of a dream, in the middle, at the end, or at any measured interval after the end. By such means it has been determined that there is periodicity in dreaming, and the consequences of efforts to disturb this periodicity have been observed. The results indicate that dreaming as a fundamental physiological process is related to other rhythms of the body. As for the folklore that surrounds the process, this work has answered such questions as: Does everyone dream? How often does one dream in the course of a night's sleep? Is the "plot" of a dream really compressed into a moment of dreaming? Do external and internal stimuli—light, noise, hunger or thirst—affect the content of dreams?

As so often happens in research, the objective indicator of dreaming was discovered by accident. During a study of the cyclic variations of sleep in infants, a graduate student named Eugene Aserinsky observed that the infant's eyes continued to move under its closed lids for some time after all major body movement had ceased with the onset of sleep. The eye movements would stop and then begin again from time to time, and were the first movements to be seen as the infant woke up. Aserinsky found that eye movements provided a more reliable means of distinguishing between the active and quiescent phases of sleep than did gross body movements.

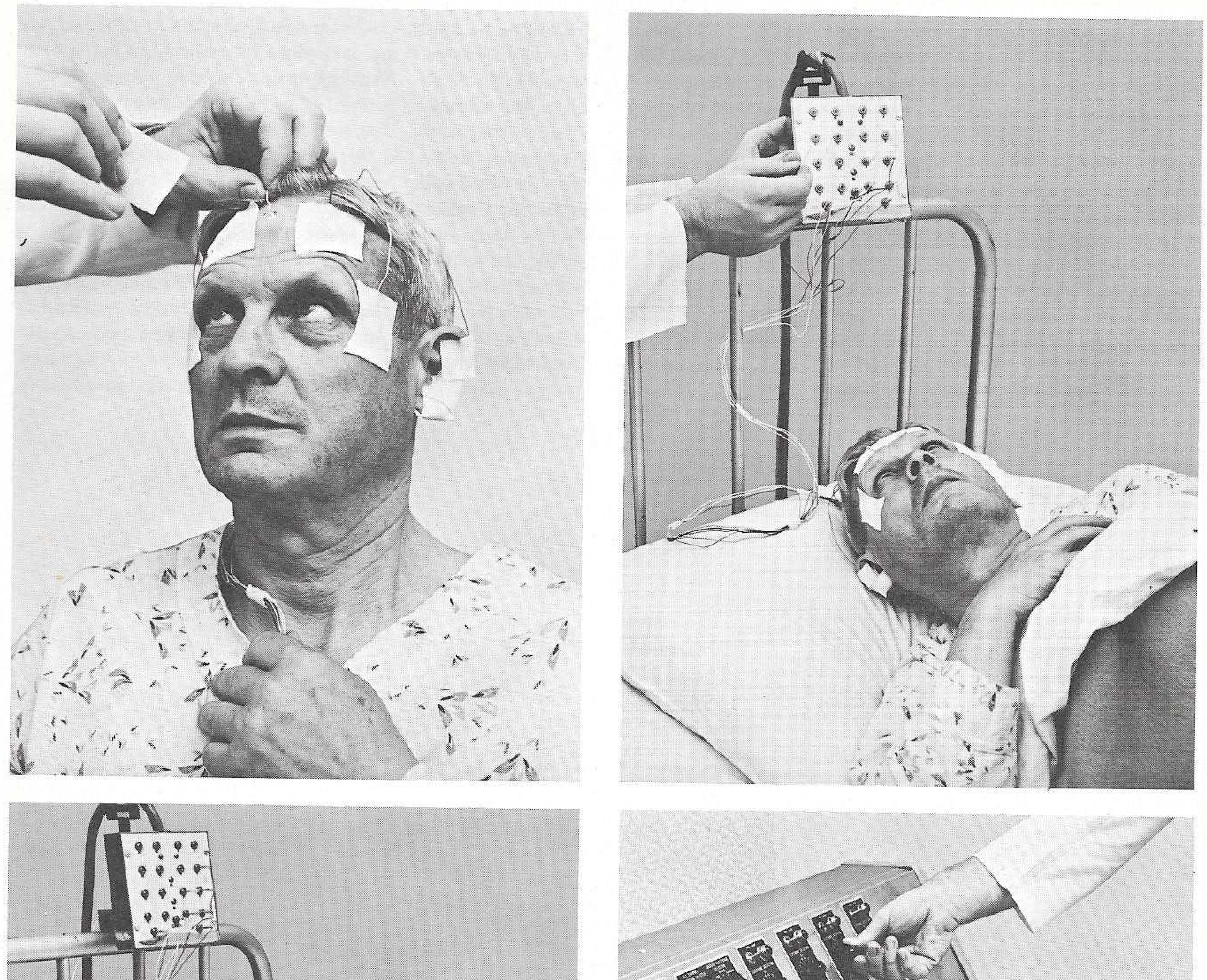
These observations suggested that eye movements might be used to follow similar cycles in the depth of sleep in adults. Disturbance to the sleeper was minimized by monitoring the eye movements remotely with an electroencephalograph, a device that records the weak electrical signals generated continuously by the brain. A potential difference across the eyeball between the cornea and the retina makes it possible to detect movements of the eyes by means of electrodes taped to the skin above and below or on either side of one eye. Other channels of the electroencephalograph recorded the sleeper's brain waves, his pulse and respiration rates and the gross movements of his body.

The tracings of the electroencephalograph showed not only the slow movements of the eyes that Aserinsky had observed in infants but also rapid eye-movements that came in clusters. Each individual eye-movement took a fraction of a second, but a cluster often lasted, with interruptions, as long as 50 minutes. The first rapid eye-movements usually began about an hour after the onset of sleep, and clusters appeared in cyclic fashion through the night [*see illustration on page 6*].

Coincident with this cycle of eye movement the electroencephalograph recorded a fluctuation in the brain-wave pattern. As each series of movements began, the brain waves changed from the pattern typical of deep sleep to one indicating lighter sleep. The pulse and respiration rates also increased, and the sleeper lay motionless.

Considered together, these observations suggested an emotionally charged cerebral activity—such as might occur in dreaming. This surmise was tested by the only possible means: arousing and questioning the sleepers. Those awakened in the midst of a cluster of rapid eye-movements testified they had been dreaming. Those awakened in the apparently deeper phases of sleep said they had not. Thus the objective indicator of dreaming came into use.

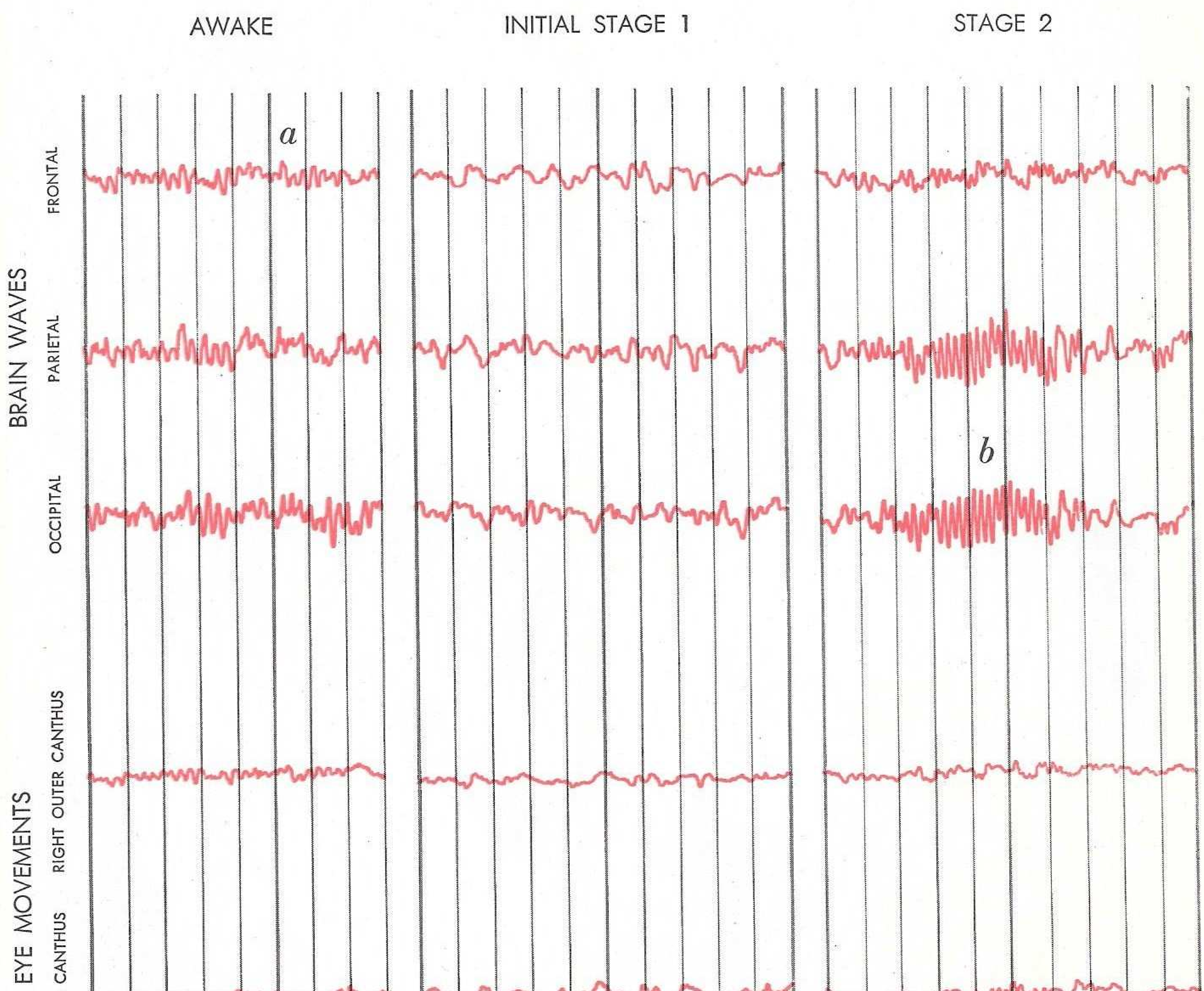
It is clear that such an indicator can reveal nothing about the content of dreams. But the process of dreaming is no more bound up with dream content than thinking is with what one is thinking about. The hallucinatory content of dreams would appear, in this light, to be nothing more than the expression of a crude type of activity carried on in the cerebral cortex during a certain phase of sleep. The contrast with the kind of cerebral activity that characterizes the waking state in healthy adults and older children is instructive. Responding to



**DREAMING IS DETECTED** by attaching electrodes to the subject's scalp and to the skin at the corners of the eyes (*top left*). Leads are connected to cable (*top right*) that leads to electroencephalograph in another room. As the subject sleeps (*bottom left*), his brain waves and eye movements are recorded by pens of electroencephalograph (*bottom right*). The subject here is the author of this article.

the impulses that stream in from the various receptor organs of the sensory system, the cortex first subjects them to analysis. It refers the present moment of experience to its memory of the past and projects past and present into the future, weighing the consequences of action not yet taken. A decision is reached, and the cortex generates an integrated response. This is manifested in the action of the effector organs (mostly muscles) or in the deliberate inhibition of action. (A great deal of civilized behavior consists in not doing what comes naturally.) In dreaming, the same kind of cortical activity proceeds at a lower level of performance. The analysis of events is faulty; the dreamer recognizes a deceased friend but accepts his presence without surprise. The memory is full of gaps and brings the past to the surface in confusion. In consequence the integration of the cortical response is incomplete, and the dreamer is often led into the phantom commission of antisocial acts. Fortunately the impulses from the sleeping cortex die out on the way to the effector organs, and no harm is done.

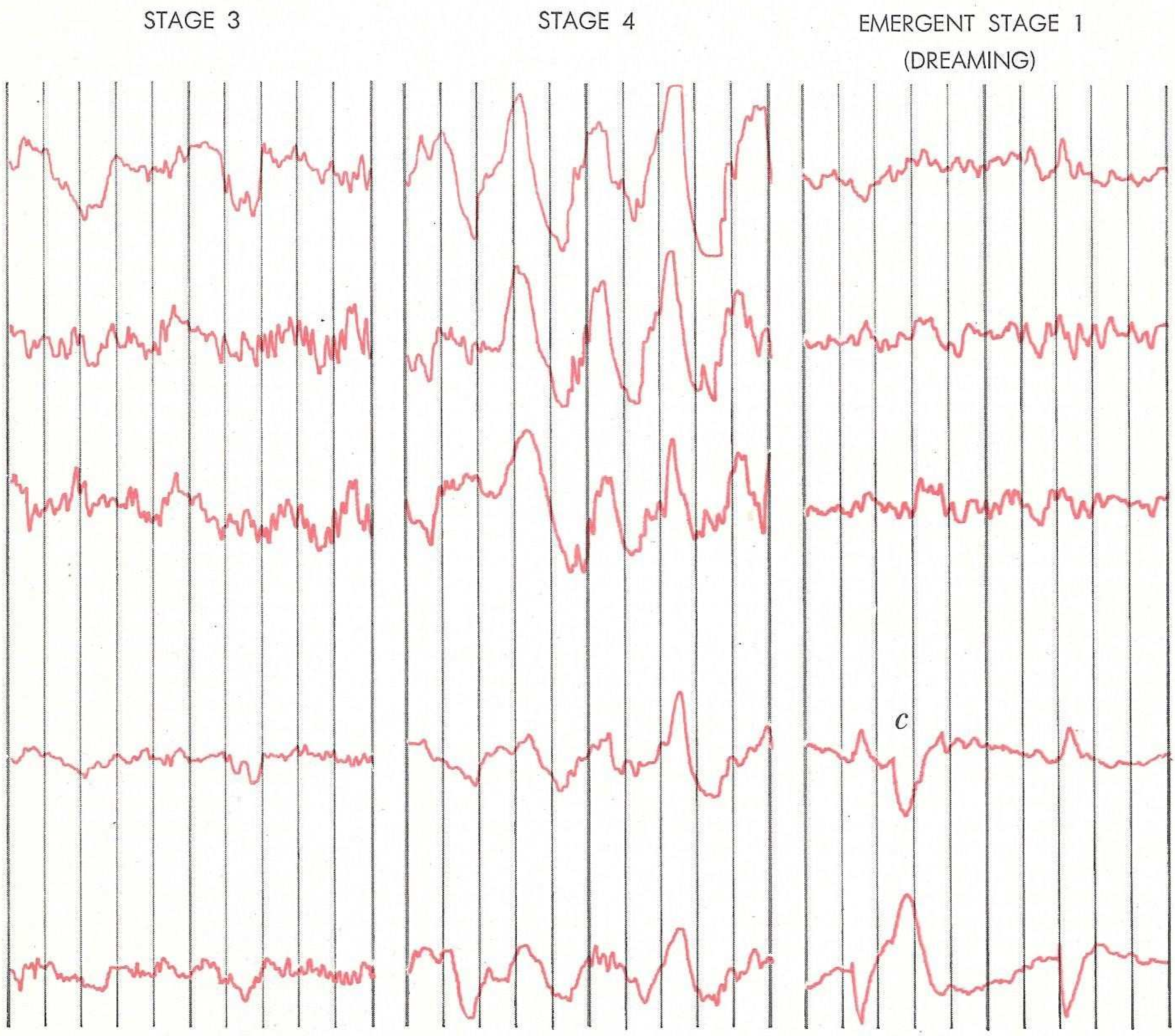
Such protoplasmic poisons as alcohol may reduce cortical activity to an equally low level of performance. A markedly intoxicated person misjudges the situation, assumes unwarranted risks in action and later does not recall what happened. Even when quite drunk, however, some persons stop short of foolish and dangerous extremes of behavior. So, also, a dreamer will accept absurdities in the imaginary series of events until they become too painful and ludicrous; he then wakes up to the comforting discovery that he was dreaming. The fantasizing of very young children, senile aged people and of persons suffering certain disorders of the central nervous system may also be likened to dreaming. After sudden awakening, even normal people may



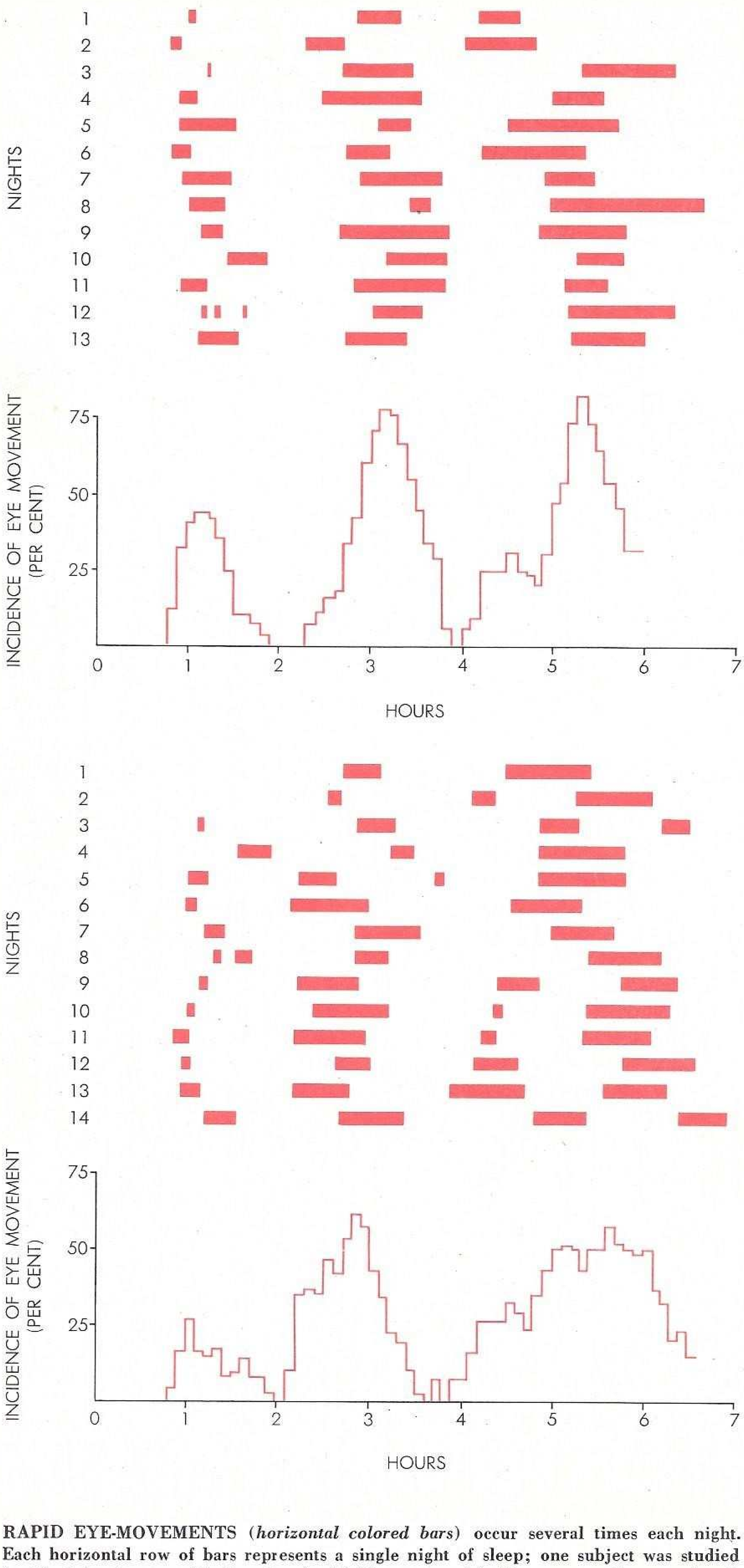

**ELECTROENCEPHALOGRAMS** show the patterns of brain waves (*top three tracings*) and eye-movement potentials (*bottom two tracings*) that are characteristic of each level of sleep. Labels at left indicate region of head to which recording electrodes are attached. Vertical lines are time-scale; 10 lines represent an interval of four seconds. A subject who is awake but resting with his eyes closed shows the brain-wave pattern known as alpha rhythm (*a*). As sleep begins, pattern known as Initial Stage 1 electroenbe bewildered and act in a deranged manner for some time. The content of dreams, explicit or hidden, may indeed have inherent interest. But for the purpose of an investigation of dreaming, it is sufficient to recognize the dream itself as a manifestation of low-grade thinking.

The objective indicator that a sleeper is dreaming, it must be admitted, is not infallible. Some subjects reported they had been dreaming during periods when they showed no rapid eye-movements. Others moved their bodies restlessly when the records on the other channels of the electroencephalograph indicated they were dreaming. Sometimes the heart and respiration rate slowed down instead of speeding up. Occasionally a subject claimed to have been dreaming when his brain waves indicated a deeper phase of sleep. William Dement, another student in our laboratory who is now at Mount Sinai Hospital in New York City, showed that of the four criteria the most reliable is the brain-wave pattern.

A person who is awake but resting with his eyes closed shows the so-called alpha rhythm—brain waves with a relatively large amplitude and a frequency of eight to 13 cycles per second [*see illustration on these two pages*]. As he falls asleep, the amplitude of the waves decreases, and the rhythm slows to four to six cycles per second. Dement called this pattern the Stage 1 electroencephalogram (Stage 1 EEG). Deeper sleep is characterized by the appearance of "sleep spindles"—short bursts of waves that progressively increase and decrease in amplitude and have a frequency of 14 to 16 cycles per second; Dement divided this level of sleep into two stages (Stage 2 and Stage 3 EEG). The deepest level of sleep is characterized by the appearance of large, slow waves (Stage 4 EEG). During a typical night of sleep,




**cephalogram (Initial Stage 1 EEG) appears. During deeper sleep subject shows short bursts of waves called sleep spindles (*b*). Deepest level of sleep (Stage 4 EEG) is characterized by the appearance of large, slow waves. EEG pattern changes from Stage 1 through Stage 4, then swings back to Stage 1. This "emergent" Stage 1 is accompanied by rapid eye-movements, as indicated by peaks in tracings of eye-movement potentials (*c*). Similar peaks during Stage 4 are not eye movements but brain waves that spread to eye electrodes.**



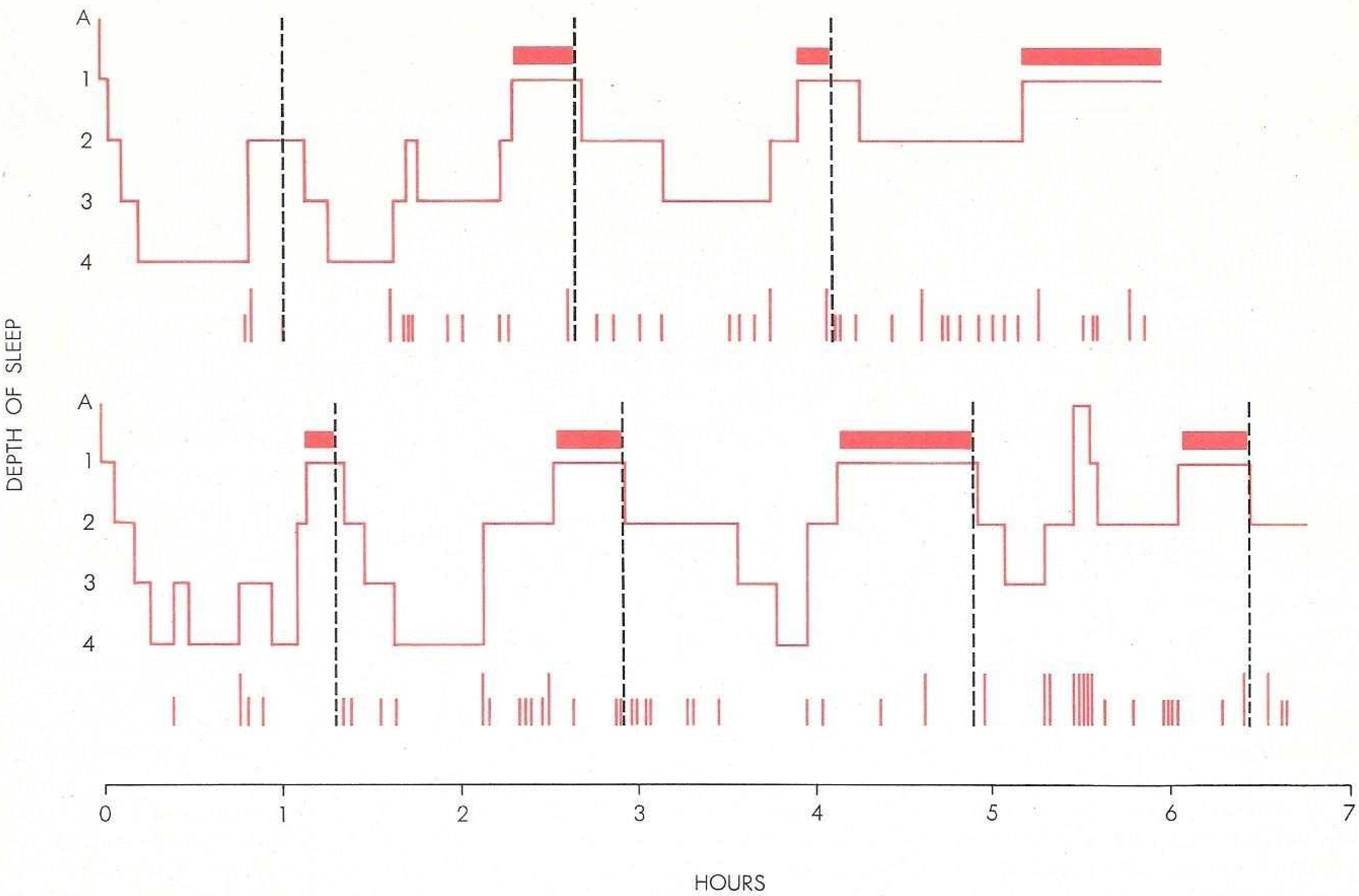

**RAPID EYE-MOVEMENTS** (***horizontal colored bars***) **occur several times each night. Each horizontal row of bars represents a single night of sleep; one subject was studied for 13 nights** (***top graph***)**, the other for 14** (***bottom graph***)**. Histograms at bottom of each graph show composite cycles of subject's eye movements during entire series of nights.**

the depth of sleep fluctuates on a cycle lasting roughly 90 minutes. The EEG pattern passes from Stage 1 through Stage 4, then swings back to Stage 1. During later cycles the sleep may not be so deep; the EEG pattern may dip no farther than the intermediate stages before it returns to Stage 1 [*see illustration on opposite page*].

Dement found that dreaming occurs during the Stage 1 EEG, but not when this brain-wave pattern first appears at the onset of sleep. Only when the cycle returns to the Stage 1 EEG from a deeper EEG level does it mark a dreaming episode. During this "emergent" Stage 1 it is much more difficult to awaken the sleeper than during the "initial" Stage 1 EEG.

The inconsistencies between the EEG record and the other criteria may be largely explained by the relationship of these other activities to the dream episode. For example, most of the rapid eye-movements are horizontal, and it is apparent that these movements represent a busy scanning of the scene of dream action. On the infrequent occasions when the rapid eye-movements were vertical, the sleepers reported dreams that involved the upward or downward motion of objects or persons. When the record showed few or no rapid eye-movements, and the EEG denoted dreaming, the subjects reported that they had been watching some distant point in their dreams. In other words, the amount and direction of the eye movements correspond to what the dreamer is looking at or following with his eyes. Moreover, rapid eye-movements seem to be related to the degree to which the dreamer participates in the events of the dream. An "active" dream, in which the dreamer is greatly involved, is more likely to be accompanied by rapid eye-movements than is a "passive" one.

The absence of gross body movements during dreaming seemed more difficult to explain. One would assume that a sleeper would begin to move about as his sleep lightens and that a good deal of activity would occur during dreaming. Actually the exact opposite was observed. Dreaming often began just after a series of body movements ceased. The sleeper usually remained almost motionless, showing only the telltale rapid eye-movements, and stirred again when the eye movements stopped. We were indebted to Georg Mann, a public-information officer at the University of Chicago, for the metaphor that captured the essence of this situation. He compared the dreamer to a spectator at a theater:




**EEG STAGES of two subjects show a cyclic variation during typical night of sleep. Measured in terms of EEG stages, depth of sleep fluctuates on a 90-minute cycle. Cycle begins when subject who is awake (A) falls into light sleep (EEG Stage 1), then into successively deeper levels of sleep (EEG Stages 2, 3 and 4). Cycle ends with swing back to Stage 1. Periods of rapid eye-movement (*horizontal colored bars*) occur during this stage. Vertical broken lines indicate when next cycle begins. Vertical colored lines at bottom of each graph indicate when body movements occurred; longer lines represent major movements; shorter lines, minor ones.**

fidgeting in his seat before the curtain goes up; then sitting quietly, often "spellbound" by the action, following the motions of the actors with his eyes; then stirring again when the curtain falls.

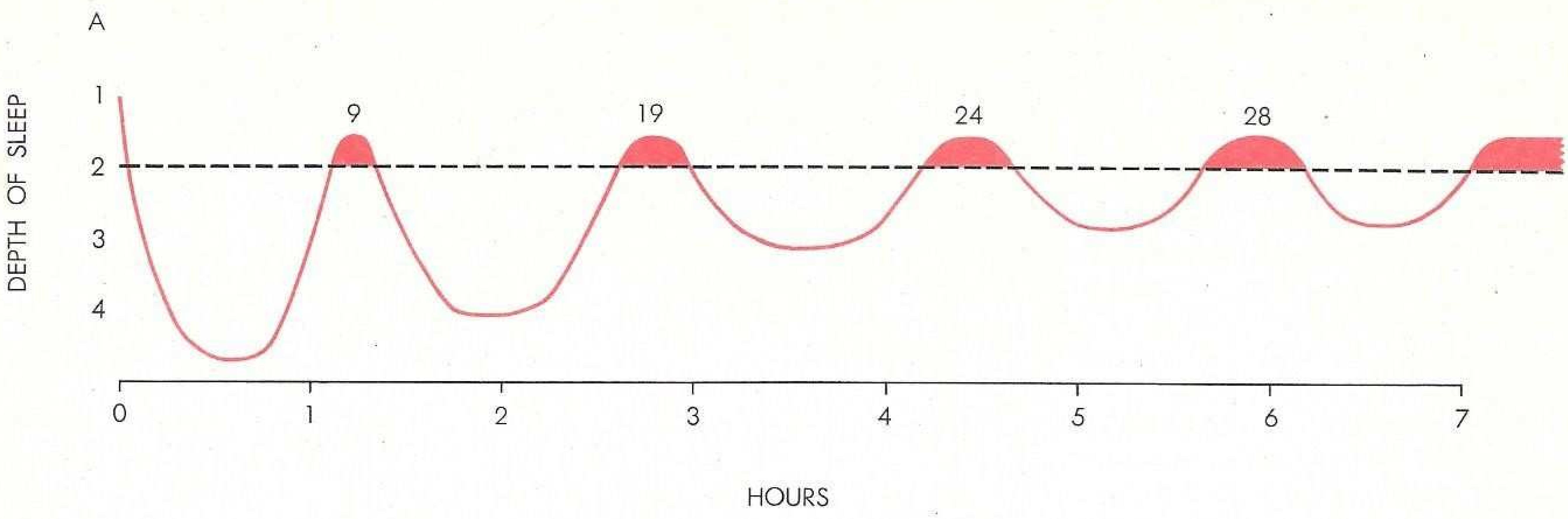
Some body movement may be related to dream content. Edward A. Wolpert of the University of Chicago attached electrodes to the limbs of sleeping subjects and recorded the electrical "action" potentials of the muscles. The record of one of his subjects showed a sequence of motor activity first in the right hand, then in the left, and finally in one leg (only one leg was wired for recording). When aroused immediately thereafter, the sleeper reported dreaming that he lifted a bucket with his right hand, transferred it to his left, and then started to walk. Sleepwalking may be an extreme expression of such motor outflow to extremities. Occasionally a subject would vocalize when he stirred, mumbling and even talking distinctly, but such activity usually occurred between episodes of dreaming.

Some people assert that they seldom or never dream. But all of the subjects—and all of those observed in other laboratories that employ the objective indicator—reported dreaming upon being awakened at appropriate times. It can be stated with some assurance, therefore, that everybody dreams repeatedly every night. Donald R. Goodenough and his associates at the Downstate Medical Center of the State University of New York compared one group of subjects who said they never dreamed with another group who said they always dreamed. Certain unexplained differences showed up in the EEG records of the two groups, and the "dreamers" were more likely to report dreaming in correspondence with rapid eye-movements than the "nondreamers." Rapid eye-movements were observed with the same frequency, however, in both groups. The evidence is overwhelming that the two groups should be classified as "recallers" and "nonrecallers."

These studies have also upset the notion that a long series of events can be compressed into a moment of dreaming. Whether the subject was loquacious or laconic in recounting his dream, the time-span of the narrative was consistent with dreaming time as indicated by our objective criteria. It appears that the course of time in dreaming is about the same as in the waking state.

It is often said that external events in the sleeper's immediate environment may suggest or affect the content of dreams. To test this idea Dement and Wolpert exposed a number of subjects to the stimuli of sound, light and drops of water during periods of dreaming. Elements suggestive of such stimuli appeared in only a minority of the dreams recounted thereafter. Drops of water, falling on the skin, proved to be the most suggestive. Falling water showed up in six dream reports out of 15 that followed arousal by this stimulus, and water had a place in 14 narratives out of 33 when the sleepers were subjected to the stimulus but not awakened by it. An electric bell used routinely to awaken the subjects found its way into 20 out of 204 dreams, most commonly as the ringing of a telephone or doorbell.

Internal stimuli from the viscera have




**EPISODES OF DREAMING** (*colored areas*) **alternate with periods of deeper sleep. Dreaming and rapid eye-movements begin when sleeper emerges from deep sleep to level of EEG Stage 1. Numbers over colored areas show length of successive periods of dreaming.**

been held to cause, or at least influence, dreams. Dreams about eating are said to be stimulated by contractions of an empty stomach. Dement and Wolpert had three subjects go without fluids for 24 hours on five occasions; only five of 15 dream narratives contained elements that could be related to thirst. In no case did the narrative involve an awareness of thirst or descriptions of drinking, although the subjects were very thirsty when they went to bed.

Most of the dream experience in normal sleep is never recalled. Recollection is best when the sleepers are awakened during the dreaming episode and becomes progressively poorer the longer they are permitted to sleep after a dream has ended. At the University of Chicago, Wolpert and Harry Trosman found that 25 out of 26 subjects had no memory of dreaming when they were roused for questioning more than 10 minutes after the Stage 2 EEG had superseded the Stage 1.

Once the objective indicator had shown itself to be a reliable measure of dreaming, it was employed to enact the pattern of dreaming through many nights of uninterrupted sleep. In a sampling of 71 nights of sleep, with 33 different subjects, the first emergent Stage 1 EEG—plus the accompanying rapid eye-movements and cardiac and respiratory changes—appeared a little over an hour after sleep had begun. This episode of dreaming lasted on the average less than 10 minutes. Three, four and even five dreaming periods followed at intervals of about 90 minutes. These lasted 20 to 35 minutes and added up to a total of one or two hours of dreaming for an average night's sleep. All of the subjects exhibited the cycle of alternate periods of dreaming and deeper sleep, some on a more constant schedule than others.

The mechanism that spaces the episodes of dreaming is unknown, but it may be related to the cycle of rest and activity which Aserinsky found in infants. The mean length of that cycle is approximately an hour, and at the end of a cycle the infants stir, either to awaken fully or to go back to sleep for another cycle. In infants on a self-demand feeding schedule, the duration of the period between feedings tends to be roughly whole multiples of the length of this cycle. Apparently the cycle lengthens with age, extending to the 90-minute dreaming cycles observed in adults. A similar increase occurs in the length of the cardiac, respiratory and gastric cycles, indicating that the dream cycle is in line with the basic physiological rhythms of the body.

What happens if the dreaming cycle is disturbed? This interesting question has been taken up by Dement and his associates. Monitoring the subject's cycle, they awaken him as soon as he starts to dream and thus keep him from dreaming. Since one must be certain that dreaming has started before attempting to stop it, such interference cannot completely deprive the subject of his dreaming, but total dreaming time can be reduced by 75 to 80 per cent. Dement established that the mean normal dreaming time of his eight male subjects was 20 per cent, or about 82 minutes in about seven hours of sleep. Attempts to curtail their dreaming in the course of three to seven consecutive nights required in each case a progressively larger number of awakenings—in some cases three times as many. During the "recovery" period after this ordeal, the dreaming time of five of the subjects went up to 112 minutes, or 27 per cent of the sleeping time, on the first night and gradually fell back to normal on succeeding nights. In six of the subjects arousal in the midst of nondreaming periods during "control" nights of sleep had no effect on dreaming during the recovery nights that followed. The curtailment of dreaming time produced anxiety, irritability, a greater appetite and a gain in body weight; the control awakenings had no such effects. As soon as the subjects of the experiment were allowed their usual dreaming time, they regained their emotional composure.

Dement tentatively interprets his findings as indicating that "a certain amount of dreaming is a necessity." Charles Fisher, a psychiatrist at Mount Sinai Hospital in New York, adds that "the dream is the normal psychosis and dreaming permits each and every one of us to be quietly and safely insane every night of our lives."

From the same evidence, however, one may equally well argue that the curtailment of dreaming engenders irritability and anxiety simply because it interferes with an acquired habit. Animals (and some people) that have acquired a "sweet tooth" may be similarly upset by deprivation of sugar. They will also consume excessive quantities of sugar after the supply is restored, just as Dement's subjects sought to make up for "missed" dreaming. In other words, the low-grade cerebral activity that is dreaming may serve no significant function whatever.

Further observation and experiment will have to decide which of these conflicting views is sound. The objective indicator is now available to help investigators find the answer to this and other questions about the nature and meaning of dreaming.

## The Author

NATHANIEL KLEITMAN retired this year as professor of physiology at the University of Chicago. Born and raised in Russia, he came to the U. S. in 1915 to study at the College of the City of New York, receiving his B.S. in 1919. After acquiring his M.A. at Columbia University in 1920 and his Ph.D. at the University of Chicago in 1923, he went abroad to study at the universities of Utrecht and Paris, returning in 1925 to join the faculty at Chicago, where he has taught for the past 35 years. Kleitman has been "thinking of going to Bali, whose inhabitants," he says, "have strange sleeping habits. I devote my free time to writing up data gathered many years ago and to the preparation of a revised edition of my 21-year-old monograph *Sleep and Wakefulness.*"

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