thick. No fossils have been identified, so its age is uncertain, but relations with beds above and below suggest that it may be Carboniferous or Permian. This unit of platy and carbonaceous shale is named the Discovery Ridge formation.

The youngest sedimentary rock unit of the Buckeye Range includes about 2000 feet of light gray and brown, arkosic sandstone, interbedded with dark shale and coal. This unit is called the Mount Glossopteris formation; its contact with the underlying Discovery Ridge formation is uncertain, but the lithologic change is sharp and it is also differentiated by abundant evidence of plant life and terrigenous accumulation. In addition to coal, leaves of *Glossopteris*, wood of *Dadoxylon*, spores, and other evidences of gymnospermous and cryptogamic plants are present. The age of the Mount Glossopteris formation, as indicated by the fossil plants, is probably Permian (*4*).

A diabase sill about 600 feet thick is the highest and youngest exposed unit. The sill was evidently intruded into the Mount Glossopteris formation, and subsequent erosion has removed an unknown thickness of sedimentary rocks and diabase from the present top surface. Coal from the upper part of the Mount Glossopteris formation has been devolatilized and become anthracite or semianthracite owing to the heat of igneous intrusion. A bed within 960 feet of the sill shows 18.9 percent volatile matter (moisture and ash free) (*5*). The diabase sill is similar in composition to the Ferrar dolerite (*6*) as designated by Harrington (*7*). The Ferrar dolerite occurs in large intrusions in Victoria Land, and similar sills along the Oates Coast have been dated as probably Jurassic (*8*). Sills of similar age have been found in other Gondwana areas.

In an earlier report (*9*) resulting from a single ascent of the section (Fig. 2), tillite was incorrectly identified as graywacke.

Continuing field studies in the area are being conducted during the 1961–62 Antarctic season by geologists of the Institute of Polar Studies at Ohio State University. A recent request for formal stratigraphic terms (*10*) has prompted the use of suitable names for formations of the Buckeye Range at the present time (*11*).

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References and Notes

1. A. J. Boucot, *Program of Annual Meeting Geol. Soc. Am.* (1961), p. 15A, abstr.
2. J. M. Schopf, personal communication.
3. L. C. King, *Quart. J. Geol. Soc. London* **114**, pt. 1, 47 (1958).
4. J. M. Schopf, "Report 825-2-Part XII" (field work 1958–59), *USNC-IGY Antarctic Glaciological Data*, in preparation.
5. Analysis by U.S. Bureau of Mines, Lab. No. H14232.
6. S. B. Treves, personal communication.
7. H. J. Harrington, *Nature* **182**, 290 (1958).
8. I. Ye. Starik, *Ann. N.Y. Acad. Sci.* **91**, art. 2, 576 (1961).
9. W. E. Long, "Report 825-2-Part VII" (field work 1958–59), *USNC-IGY Antarctic Glaciological Data* (1959).
10. This request was made by R. W. Willett, chairman of the Permanent Working Group on Geology, Special Committee on Antarctic Research, in a personal communication on 3 July 1961.
11. The material given here has also been presented in a master's thesis at Ohio State University (Department of Geology) with informal stratigraphic terminology used; that is "coal measures" rather than Mount Glossopteris formation, and so on.

12 October 1961

Basal Skin Resistance during Sleep and "Dreaming"

Abstract. Basal skin resistance was measured continuously in sleeping human subjects. Instead of a hypothesized fall in basal skin resistance during periods of "dreaming" or emergent stage 1 electroencephalographic activity, there was a rise which generally coincided with the "dreaming" period. This finding, along with other recent studies, indicates that this stage of sleep is not just a light stage of sleep but is unique neurophysiologically.

In 1955, Aserinsky and Kleitman found a high incidence of dream recall in subjects wakened from sleep during periods of rapid conjugate eye movements (*1*). Dement and Kleitman (*2*) and Goodenough *et al.* (*3*) subsequently showed that "dreaming" occurred during a particular level of sleep as indicated by the electroencephalogram, called stage 1. It was assumed that this stage, which occurs in four to five cycles during the night, represented a light stage of sleep.

Numerous investigators have demonstrated that the basal skin resistance is inversely related to level of arousal (*4*). States of relaxation are accompanied by high skin resistance, which reaches a maximum during sleep. Situations leading to increased arousal such as states of anxiety, presentation of emotionally charged words, or requiring a subject to perform mental arithmetic lead to decreases in skin resistance. This phenomenon, which is thought to be related to the permeability of the membranous lining of the sweat glands, is mediated by the sympathetic nervous system and seems to be related to the activity of the reticular activating system (*5*).

If the stage 1 level of sleep during which dreaming is presumed to occur is the lightest level of sleep, and if the inverse relationship of basal skin resistance to level of arousal is correct, it would be expected that there would be a fall in skin resistance as the sleeper passes from stages 2–4 to stage 1. It would also be anticipated that as the subject returns to stages 2–4 the resistance would rise again.

Fifteen "normal" young adult subjects varying in age from 19 to 35 years were studied in the laboratory during 2 to 3 nights of natural sleep for a total of 33 subject-nights. Continuous tracings were recorded on a Grass III-D eight channel electroencephalograph (EEG). Orbital leads were used to record eye movements. A model 201, Bio-Physical GSR amplifier was used to measure skin resistance. The instrument impresses a current of 10 $\mu a/cm^2$ of electrode. The electrode was a 1- by 2-cm lead electrode which made contact with the skin through 0.05*N* sodium chloride electrode paste. A 5- by 5-cm lead reference electrode was taped to the upper arm.

Basal skin resistance rose as the subject fell asleep. There was an overall

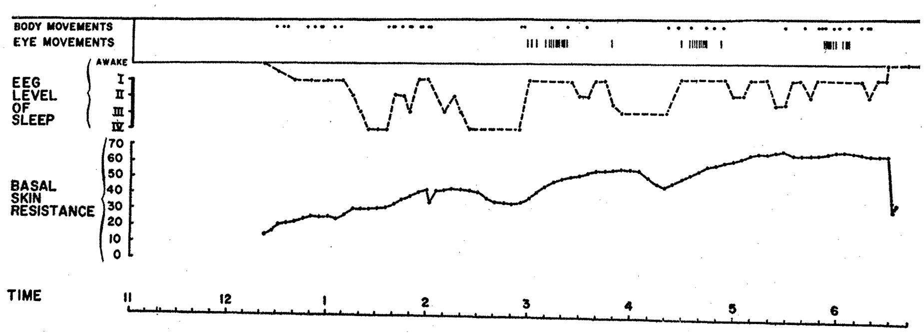

Fig. 1. Relationships between basal skin resistance, EEG level of sleep, rapid eye movements, and body movements during a night of uninterrupted sleep in the laboratory.

trend toward increase in skin resistance through the night so that the largest values were recorded during the last 2 to 3 hours of sleep, the period when stage 1 eye activity was also at a maximum. On awakening, skin resistance fell precipitously in all cases, usually returning to pre-sleep level.

Instead of the expected fall in basal skin resistance during periods of stage 1 eye activity, we found paradoxically that the usual event was a rise. In the typical case this was followed by a decrease in skin resistance as the EEG record returned to stages 2–4.

Two subjects showed a pattern in which skin resistance rose rapidly to a high level which was then maintained as a plateau during the rest of the night.

Typically, the skin resistance and level of EEG activity both began to change following a gross body movement occurring after a period of relative stability. In one subject this change was accompanied by brief precipitous drops in skin resistance indistinguishable from the pattern seen when the subject was awakened. The EEG pattern in this instance was not one of waking, however. The basal skin resistance then rose in the usual fashion.

Figure 1 is a graph of a typical night's events. This subject was a 28-year-old white married male medical student. His records on other nights were similar.

There is evident a general trend in elevation of basal skin resistance during the night; it reaches a maximum in the early morning hours. There are superimposed cycles of rising and falling which parallel the change in EEG level. At approximately 1:30, 3:00, and 4:20, the basal skin resistance starts to rise, as the EEG level shifts from stage 3 or 4 to stage 1. These beginning changes were usually accompanied by a large body movement. To the observers monitoring the recording devices these changes were quite striking and they were able to anticipate a period of stage 1 activity with rapid eye movements as the basal skin resistance started to rise after a level period.

These findings suggest that either the hypothesis of an inverse relationship between arousal and basal skin resistance is incorrect or the concept that stage 1 represents a light stage of sleep needs revision. We favor the latter view.

Jouvet has demonstrated two phases of sleep in the cat which are relatively independent of each other (*6*). The first phase, which occupies most of the sleeping time, is characterized by high-voltage, slow-wave activity in the EEG, the persistance of some tonus in the spinal musculature, and an absence of rapid eye movements. The second phase occurs after the slow EEG phase and is of brief duration. It has been termed by Jouvet the paradoxical or rhombencephalic phase and is characterized by asynchronous low-voltage, fast EEG activity, the complete disappearance of muscle tonus, and the presence of rapid eye movements. The slow-wave phase requires the presence of the neocortex. The paradoxical phase is dependent on a totally different system situated at the level of the pontile reticular formation. This phase can be triggered in sleeping cats by stimulating the lower part of the brain stem. During this phase all muscular activity disappears though there may be variation in respiratory and cardiac rhythms. The threshold of awakening is increased in comparison with that of the slow-wave phase of sleep.

Horovitz and Chow have confirmed Jouvet's findings (*7*). They showed that the paradoxical sleep stage is characterized by an increase in reticular stimulation arousal threshold. Moreover, sufficient stimulation to produce minimal behavioral arousal produced 5-to-6-per-second activity quite different from the electroencephalographic pattern found on arousal from slow-wave sleep. This definitely indicates that the asynchronized sleep stage is deeper in some ways than the stage of synchronized sleep patterns.

A number of observers including ourselves have found that while body movements ushered in and out stage 1 activity there was a relative lack of body movement during this phase. Berger has demonstrated that there is a striking decrease in tonus of the extrinsic laryngeal muscles during stage 1 sleep (*8*).

The evidence suggests that emergent stage 1 sleep is not simply a lighter stage of sleep, but represents a neurophysiologically unique phase, quite likely similar to the rhombencephalic phase of sleep in the cat. Our findings with regard to the basal skin resistance are confirmation of this (*9*).

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References and Notes

1. E. Aserinsky and N. Kleitman, *J. Appl. Physiol.* **8**, 1 (1955).
2. W. Dement and N. Kleitman, *J. Exptl. Psychol.* **53**, 339 (1957); *Electroencephalog. and Clin. Neurophysiol.* **9**, 673 (1957).
3. D. Goodenough and A. Shapiro, *J. Abnormal Social Psychol.* **59**, 295 (1959).
4. C. W. Darrow, *Psychol. Bull.* **33**, 73 (1936); E. Duffy, *Psychol. Rev.* **64**, 265 (1957); H. Schlosberg, *ibid.* **61**, 81 (1954); A. B. Carron, *Science* **129**, 784 (1959); A. J. Silverman, S. I. Cohen, B. M. Shmavonian, *J. Psychosomat. Research* **4**, 65 (1959).
5. G. H. Wang, P. H. Stein, V. W. Brown, *J. Neurophysiol.* **19**, 350 (1956).
6. M. Jouvet, in *Symposium on the Nature of Sleep*, G. E. W. Wolstenholme and M. O'Connor, Eds. (Little, Brown, Boston, 1961), p. 88.
7. Z. P. Horovitz and M. Chow, *Science* **134**, 945 (1961).
8. R. J. Berger, *ibid.* **134**, 840 (1961).
9. This work was supported by grant M-5543(A) from the National Institute of Mental Health.

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Estrogen-Sensitive Neurons and Sexual Behavior in Female Cats

Abstract. The stimulation of mating behavior by means of the stereotaxic introduction of small implants of solid C^{14}-diethylstilbestrol di-n-butyrate to the hypothalamus of ovariectomized cats is described. Autoradiographic examination of the brains of mating animals reveals that certain neurons in the region of these implants show a selective affinity for labeled estrogen.

It is known that estrogens are essential both for the expression of estrous behavior and for the state of sexual receptivity in female cats, since mating never occurs either during the anestrous phase of the cycle or after bilateral ovariectomy unless estrogens are administered. The clear-cut dependence of the behavioral pattern on hormone, together with the conspicuous and highly stereotyped character of the behavior itself, makes this species particularly suitable for the investigation of the possible sites of action of estrogens in the brain (*1*).

By using a technique by which small implants (0.1 to 0.3 mg) of solid estrogen are placed stereotaxically in different regions of the brain, it has been found that states of sustained sexual receptivity, lasting from 50 to 60 days, can be produced in ovariectomized animals carrying an implant in the hypothalamus (in different series, 60 to 90 percent positive results). The introduction of similar implants of estrogen to other sites in the brain (cerebellar hemisphere, frontal white matter, preoptic region, head of caudate nucleus, dorsomedial nucleus of thalamus, amygdala, and so forth) or the introduction of blank implants of control substances (paraffin wax or pro-