suitable means if so desired. The packing wings may be either plane or curved surfaces, or with suitable projections, and may be made of any of the usual materials of construction, such as stoneware, copper or wire screen.

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SPECIAL ARTICLES

POTENTIAL RHYTHMS OF THE CEREBRAL CORTEX DURING SLEEP

RECENT interest in brain potentials has induced us to put on record the results of experiments carried out in the Loomis Laboratory, Tuxedo Park, in which a new phenomenon in this fascinating field has appeared most clearly—namely, the very definite occurrence of trains of rhythmic potential changes as a result of sounds heard by a human subject during sleep. Since the work of previous investigators[1] has emphasized that rhythms which spontaneously appear in a person at rest with eyes closed disappear when an object is viewed or the attention concentrated, we believe the definite demonstration of a means of inducing rhythmic brain discharges to be of considerable interest. At the same time the method of continuous study and correlation with other body changes over periods of seven hours, described herein, greatly facilitates interpretation of results where many factors, difficult to control, are undoubtedly involved. Sleep was selected as a condition during which brain activity is at a minimum and physiological conditions most constant.

The records are made on paper wrapped on a horizontal drum 8 feet long and 44 inches in circumference revolving once a minute. Two high-speed dynamic siphon recorders describe a pair of spiral lines one fifth inch apart, as they move horizontally parallel to the drum at the rate of one foot per hour. Each heart beat, each respiration, each bed movement and any noises in the bedroom are recorded by one pen (red ink) as characteristic marks, while brain potentials are recorded by the other pen (green ink). In addition three rachet devices sum the heart beats, the respirations and the bed movements each minute, marking the rate per minute on the paper. The drum, driven by a synchronous motor, acts as its own clock, and stimuli may be sent to the sleeper each minute by electric contact on the drum, thereby placing a series of responses near together on the record and allowing easy comparison with the condition where no stimuli are sent in. The amplitude of the brain potentials are ascertained regularly by calibration with sinusoidal potentials of from 2 to 30 per second frequency and from 10 to 50 microvolts amplitude. The siphon recorder records have been checked from time to time by the cathode ray oscillograph.

The finished record is a sheet of paper 44 inches high and 8 feet long with vertical red and green lines, each pair representing a minute of time. Changes in the processes recorded can be seen at a glance. Either the red or the green lines can be rendered invisible by viewing the record through a red or green glass and inspection thereby simplified. The single sheet of paper, even though large, is a great improvement over the use of paper tape, which was abandoned because examination of the one half mile of tape necessary for an eight-hour run was too time-consuming.

The subject sleeps in a quiet, electrically screened room, containing a very sensitive microphone and a photo-electric bed movement recorder. Electrodes for detecting the various physiological processes are attached to the subject and the amplified impulses sent through shielded cables to the control room 66 feet away. Details of the apparatus will be described in a later paper. Facial movements, swallowing, clenching the jaws, etc., give rise to muscle potentials which appear on the record, but which are quite characteristic and easily distinguishable from brain potentials, as are also disturbances due to passive movements of the scalp.

Our investigation of the brain potential rhythms during night sleep (brain electrodes on high forehead and crown of head) has led us to the following conclusions:

(1) They are undoubtedly of cortical origin and distinct from muscle potentials and movement artifacts. Different persons show quite different potential records.

(2) In a night record certain hours of sleep show many "spontaneous" bursts of waves, while other hours show relatively few.

(3) They often appear in trains lasting 5 to 12 seconds, at intervals of ½ to 2 minutes.

(4) The frequency is on the average an irregular 10 per second, but frequently very regular bursts lasting 1 to 1½ seconds of 14 per second frequency appear. The amplitude builds regularly to a maximum and then falls regularly so that we have designated these "spindles," because of their appearance in the record. Shorter spindles or "balls" of ¼–⅓ second duration occasionally appear. Five other types can also be distinguished.

(5) They are not correlated with heart beat nor necessarily with respiration, but at times a definite characteristic potential change has accompanied each respiration.

(6) Regular snoring does not necessarily initiate

[1] Literature in paper by Adrian and Mathews, *Brain*, 37: 355, 1934; also Jasper and Carmichael, SCIENCE, 81: 51, 1935. See H. Berger in *Arch. f. Psychiat.*, 1929–35.

brain rhythms, but an occasional isolated snore may start a train.

(7) When asleep sounds of a certain character, such as rustling paper or coughing by a person in the bedroom, closing a door some distance from the subject or low conversation, which does not wake the sleeper, will quite regularly initiate a train of waves which may last for from 5 to 8 seconds (frequency 9 to 10/seconds) and then die out. Fig. 1 A illustrates this effect from the repeated closing of a door at one-minute intervals and allows comparison with regions where no sound stimuli were sent in. The depth of sleep and the noise level in the room determine whether this "sound response" will appear. One deep sleeper gave no response on closing the door but responded regularly on slamming the door.

(8) When awake, the same sounds that during sleep initiate a train of waves no longer give rise to them. Fig. 1 B clearly shows this.

(9) During sleep trains of waves appear which can not be correlated with any detectable external stimulus, but which may be connected with internal disturbances of unknown origin. The cause of these very regular bursts is now under investigation.

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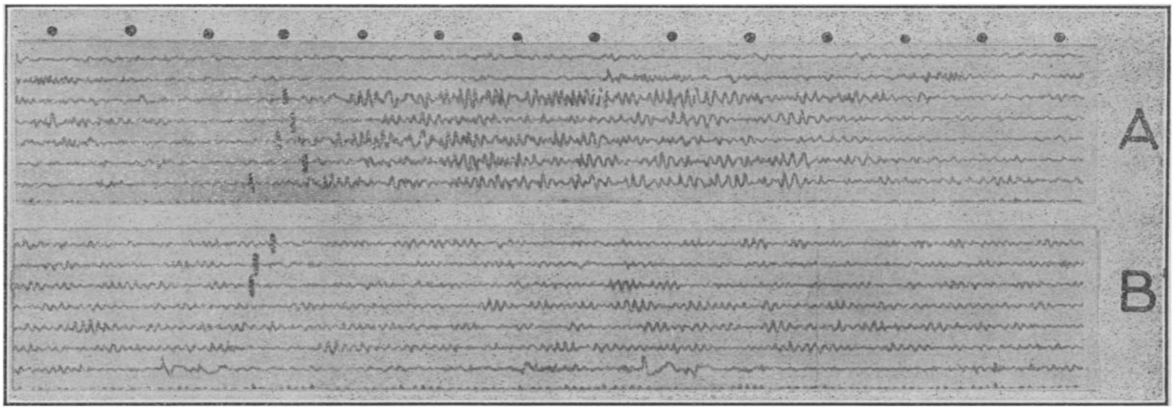

FIG. 1. Sections of brain potential records each taken one minute apart. Read from left to right. At vertical mark sound stimuli sent to subject. Note marked trains of brain rhythms in A when subject asleep but none in B when subject awake, although stimulated by same sound. Time in seconds given by dots at top.

THE CENTRIOLE AND ITS ROLE IN MITOSIS AS SEEN IN LIVING CELLS

THE centrioles in the various genera and families of hypermastigote flagellates[1] range in length from 2 or 3 microns to 80 or more and may be seen easily in living organisms, since they are 1 to 3 microns in width. The achromatic figure and the manner in which it arises from the centrioles also may be seen very clearly in living cells. These protozoa, then, furnish ideal cytological material. Unfortunately, however, there appears to be a tendency among some cytologists to disregard cytological observations on protozoa, although there is no justification for such a tendency, because protozoa are cells, and observations made on them furnish as valuable a basis for generalizations as those made on *Ascaris* eggs, grasshopper testes or other types of classical material. Indeed, most of the Hypermastigina show much more clearly than any other known cells the centrioles, the manner of their duplication, the formation of the achromatic figure from them and the rôle of the achromatic figure in chromosome movement. Furthermore, observations on living material of these organisms show beyond question that the observations on fixed and stained material deal with realities, not artifacts produced by fixation. And the close similarity between the behavior of these hypermastigote centrioles and the centrioles of other cells leaves no room to doubt the general application of the observations on these flagellates to mitosis in both animals and plants.

In some genera, particularly those with short centrioles as in *Joenia, Mesojoenia* and other genera of the Lophomonadidae, the achromatic figure arises from the greater portion of the centriole; in other genera, with longer centrioles, it arises only from the distal half or third of the centriole; and in those genera with elongate centrioles, it arises from only a small portion of the centriole, the distal portion. In certain genera, the distal portion of the centriole from which the achromatic figure arises is surrounded by a

[1] The names of the 29 genera and 6 families need not be given here, since they are given in a recent publication to which the reader interested in them is referred (*Mem. Amer. Acad. Arts and Sciences*, Vol. 17, No. 2, 1934).