in our records. This provides indirect evidence in support of the hypothesis of Adrian and Mathews, namely, that the large oscillations are the end result of potentials built up by several smaller oscillations at different frequencies.

The second record shows two recordings of the effect of light stimulation on the large alpha waves. The two records are taken across different parts of the head. It will be noted that these waves are markedly reduced by the light stimulation after a latency of 0.4 seconds. (The time line at the top of the record indicates 1/50 second intervals. The signal indicating the period of stimulation is marked by an upward deflection of the time line). When the light stimulus is turned off, the alpha waves return to normal after a short period. The duration of this after-effect of light stimulation seems to vary with characteristics of the stimulus, such as duration. It may most tentatively be suggested that this latency in the return to normal of the alpha waves is possibly associated with the phenomenon of the visual after-image.

As noted above, it is suggested by Berger that the alpha waves may indicate a fundamental characteristic of brain activity. In our experiments on normal individuals the frequency varies little from day to day when experimental conditions are maintained constant. Characteristic frequency of different normal individuals has varied from about 8 to 12 cycles per second. In 6 individuals from whom repeated records were secured on different days, up to five repetitions, variation of not more than one cycle per second was shown in the same individual on successive measurements. In one or two pathological cases which we have studied a frequency of alpha waves as low as 2 or 3 per second has been observed. We have also demonstrated that in certain normal individuals when the electrodes are placed so as to include part of the right side of the head between one pair and part of the left side of the head between the other pair the same frequency is observed in both records and under these conditions the waves are typically in phase. Other records indicate that some normal individuals, and especially certain pathological cases, show different frequencies or a lack of synchronism between the functioning of one side of the brain and that of the other. For example, in the case of a young girl who suffers from a convulsive disorder and is quite ambidextrous, the alpha-wave frequency was observed on repeated tests to be about 10 per second across the left side of the head and but 6 to 8 cycles across the right side of the head. These records were taken simultaneously by the use of two well-matched, non-interfering amplifier-oscillograph systems.

In conclusion, we may say it has been possible for us to confirm many of Berger's observational findings. With the improvement of recording techniques and with an increased understanding of the functional relationship between the results secured and other processes of the living organism, it may well be that electroencephalograms of the sort described in this note may prove significant in psychology and clinical neurology. It is even possible that this technique may provide information in regard to brain action which will be comparable in significance to the information in regard to heart function which is provided by the electrocardiograph. Further experimental studies of the phenomena described here are in progress.

H. H. JASPER
L. CARMICHAEL

PSYCHOLOGICAL LABORATORY
OF BRADLEY HOSPITAL AND
BROWN UNIVERSITY

THE LONG WAVE-LENGTH LIMIT OF PHOTOLETHAL ACTION IN THE ULTRA-VIOLET

SINCE the earliest observations on the lethal action of sunlight by Downes and Blunt in 1877,[1] the determination of the long wave-length limit of lethal action of light upon cells has been a subject of recurrent interest, as various investigators, failing to use a quantitative technique, claimed different limits. In 1924 Coblentz and Fulton,[2] measuring the incident intensities at different wave-lengths, showed that much less energy is necessary to kill *Bacillus coli communis* at wave-lengths shorter than 3,050A than at longer wave-lengths, although lethal action extended as far as 3,660A when the dosage was exceedingly large. Few studies on the wave-length limit of lethal action have been made upon protozoan cells. Swann and del Rosario[3] report that the wave-length 3,132A is only 1 to 4 per cent. as destructive to Euglena as is the wave-length 2,536A. On the other hand, Weinstein[4] reports that *Paramecium multimicronucleata* is killed about one ninth as readily at 3,130 as at 2,654A and about one half as readily as at 3,025A comparing the lethal action on the basis of the energy incident upon the exposure cell. As this appeared to be an unusually destructive effect for the wave-length 3,130A, it was decided to investigate its effects upon this species of Paramecium as well as upon several other protozoans.

The protozoans were obtained in sufficient numbers by inoculating individuals from a local pond into 0.1

[1] Downes and Blunt, *Proc. Roy. Soc.*, 26: 488, 1877.
[2] Coblentz and Fulton, *Sci. Papers U. S. Bur. Standards*, 19: 641, 1924.
[3] Swann and del Rosario, *Jour. Franklin Inst.*, 213: 549, 1932.
[4] Weinstein, *Jour. Op. Soc. Am.*, 20: 433, 1930.

per cent. lettuce infusion, buffered at a pH of 7.0 and incubated at 26° C. in a water bath. Rapid multiplication occurred. Paramecia were cultured in the controlled manner described in another paper.[5] The quartz mercury arc, the monochromator, thermopile, reaction cells, exposure chamber and the procedure followed have been described in another paper.[6] To insure purity of light at the wave-length 3,130A, a Cornu prism was used. Usually 50 or 100 animals were exposed at a time.

RESULTS

While *Stylonychia mytilus* and *Euplotes patella* did not become vesiculated at 3,025A (average intensity for all experiments at this wave-length: 22 ergs/mm^2/sec.) until a dosage of 66,000 ergs/mm^2 at the midpoint of the exposure cell had been given, *Paramecium multimicronucleata* became vesiculated after a dosage of about 33,000. A dosage of only 16,500 ergs/mm^2 is sufficient to kill the Paramecia after a lapse of 24 hours following irradiation. A dosage of about 9,300 ergs/mm^2 kills only a few Paramecia even after a lapse of 24 hours. Since the area of a Paramecium exposed is about 0.0106 mm^2 the energy incident upon a single Paramecium is the energy per mm$^2 \times 0.0106$.

On the other hand, even if many times the above dosages of energy at the wave-length 3,130A (average intensity: 40 ergs/mm^2/sec.) are given to these various protozoans, there seems to be no injury. Thus Stylonychia (including dividing forms), irradiated even with as large a dosage as 219,000 ergs/mm^2 at the midpoint of the exposure cell, showed no signs of destructive effects even after 48 hours; in fact a vigorous culture developed following irradiation. Paramecia irradiated with as high a dosage as 191,000 to 200,000 ergs/mm^2 divided actively following their addition to bacterized medium; and when placed under conditions favorable for conjugation[7] they conjugated comparably to controls 72 hours after irradiation. The ability to divide and conjugate entirely normally would indicate that the Paramecia were but slightly affected. Paramecia irradiated with a dosage of 206,000 ergs/mm^2 at 3,660A (intensity: 100 ergs/mm^2/sec.) seemed entirely unaffected.

At 3,025A, about 20 per cent. of the light incident upon a Paramecium is absorbed, whereas at 3,130A only about 3 per cent. is absorbed.[6] One would expect a proportionally weaker action of the longer wavelength for a given incident radiation on the basis of the absorbed energy. But even when the incident dosage at 3,130A is increased 12-fold (200,000 ergs/mm^2) over that necessary to kill at 3,025 (16,500 ergs/mm^2) the Paramecia were apparently unaffected. The energy absorbed must be voided without obvious injury.

Possibly at higher intensities lethal effects might be manifested at 3,130A. Such experiments are planned with the use of another light source. However, the intensities reported by Weinstein are low compared to those employed in the present work. It therefore seems probable that the strong lethal effects reported by him were due to impure light at 3,130A, since the large fused quartz prism in his monochromator may have scattered the lethal shorter wave-lengths to a considerable degree.

That there should be so sharp a difference in lethal action between regions of the spectrum so close together as 3,025 and 3,130A is not surprising in view of the partition of these wave-lengths in the sunlight at the earth's surface. According to Fabry and Buisson[8] the energy at 3,022A on June 7, 1920, with the sun at the zenith, was 2,700, whereas the energy at 3,143 was 22,400 (arbitrary units). Therefore, even at this time of the day, when the intensity of light of the shorter wave-lengths is greatest, the energy content at 3,022 is less than one eighth that at 1,143A. Earlier and later in the day the fraction is much smaller. One would therefore expect organisms to be so adapted to that part of the sun's spectrum in which light is present in relatively high intensities as to absorb little and to be able to get rid of the small amount absorbed without injury. The wave-length 3,130A is beyond the limit of the strong absorption band of the protoplasm of bacteria,[9] Paramecium,[6] and human skin[10] as well as of proteins[11] and of nucleoprotein derivatives.[12] And one finds little action at 3,130A; this is true not only for lethal action, but also for erythema production.[13] The small amount of energy which is absorbed under experimental conditions is apparently voided without noticeable injury.

A. C. GIESE
P. A. LEIGHTON

STANFORD UNIVERSITY

5 Giese and Taylor, *Arch. Prot.* In press.
6 Giese and Leighton, *Jour. Gen. Physiol.* In press.
7 Giese, *Physiol. Zool.* In press.

8 Fabry and Buisson, "L'Absorption des Radiations dans la Haute Atmosphere," 1930.
9 Gates, *Jour. Gen. Physiol.*, 14: 31, 1930.
10 Bachem and Kunz, *Arch. Phys. Therapy, X-ray, Radium*, 10: 50, 1929.
11 Henri, Henri and Wurmser, *Compt. Rend. Soc. Biol.*, 73: 319, 1912.
12 Holiday, *Biochem. Jour.*, 24: 619, 1930.
13 Luckiesh, Holiday and Taylor, *Jour. Op. Soc. Am.*, 20: 423, 1930.

BOOKS RECEIVED

ROOS, CHARLES F. *Dynamic Economics.* Pp. xvi + 275. Principia Press.
WHITBECK, R. H. and V. C. FINCH. *Economic Geography.* Third edition. Pp. x + 565. 331 figures. McGraw-Hill. $3.50.