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/mm²/sec.) until a dosage of 66,000 ergs/mm² 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/mm² is sufficient to kill the Paramecia after a lapse of 24 hours following irradiation. A dosage of about 9,300 ergs/mm² kills only a few Paramecia even after a lapse of 24 hours. Since the area of a Paramecium exposed is about 0.0106 mm² the energy incident upon a single Paramecium is the energy per mm² × 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/mm²/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/mm² 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/mm² 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/mm² at 3,660A (intensity: 100 ergs/mm²/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 wave-length 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/mm²) over that necessary to kill at 3,025 (16,500 ergs/mm²) 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.

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[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.