crease in field luminance would result in the appearance of flicker. Each observer made five successive settings at each frequency for the 14 wavelengths tested.

From the calibration data for the instrument, the average wedge settings were translated into relative energies. The reciprocal of the energy requirement for the normal observers at 555 mμ was taken as 100 percent and all other findings were computed as relative luminosities with reference to this one. The results are shown in Fig. 1, together with the CIE luminosity curve for the 1931 standard observer.

A striking feature of these curves is the unusual shape of each, with a sharp notch at 570 mμ and a hump at 590 mμ. The marked lack of similarity to the CIE curve is not unexpected, however, for irregularities of this general nature have been reported by many recent investigators, though the sizes and spectral locations of the variously reported humps and notches have varied considerably.

The results show that at four photopic levels CFF (and, hence, absolute luminosities) of lights of wavelengths shorter than about 520 mμ are substantially equal for protanopes, deuteranopes, and normals. For longer wavelengths protanopes show a loss in brightness, which agrees with the usual explanation of protanopia as a loss system in which the red receptors are absent or nonfunctional. Deuteranopes, on the other hand, show supernormal brightness at these longer wavelengths. The areas under the protanope curves average only 64.7 percent of the areas under the normal curves, indicating a luminosity loss in an equal-energy spectrum of 35.3 percent, while the deuteranopes show an average luminosity gain of 36.2 percent.

The theoretical implications of these findings are numerous and cannot be discussed here. Clearly, however, the finding of deuteranopic brightness *enhancement* (and in the spectral region where protanopes have brightness reduction) constitutes a strong argument against any theory of a "loss" basis for deuteranopia and will necessitate careful reexamination of other existing theories of color vision and color blindness.

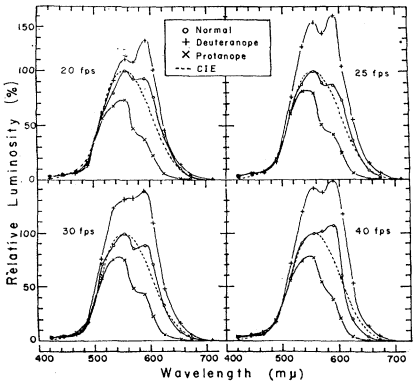

Fig. 1. Luminosity curves of normal and dichromatic observers, showing relative heights at each of four photopic levels. Plotted points represent reciprocals of relative energies required for flicker-fusion at the frequencies indicated. The luminosity curve of the CIE standard observer is included for comparison.

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4. The use of CFF in this way is not to be confused with flicker photometry, an entirely different procedure which utilizes a "standard" light and, hence, is useless for the type of inter-observer comparisons desired here.
5. A 5-deg field was used to minimize individual variations resulting from intramacular structural inhomogeneities (see *3*). Since photopic test luminances were used, it was not necessary to attempt to isolate cone function by means of a small field.

5 May 1958

Biosynthesis of Radioactive Mannitol from $C^{14}O_2$ by Fucus vesiculosus

It has recently been shown that *Fucus vesiculosus* plants produce large amounts of radioactive mannitol during photosynthesis in $C^{14}O_2$ (*1, 2*). Under favorable conditions as much as 95 percent of the radioactivity in alcohol-soluble compounds, or 65 percent of the total radioactivity in the plant, was found in mannitol. This observation suggested a possible method for the laboratory-scale production of radioactive mannitol to be used for subsequent metabolic studies (*3*).

It was found in earlier experiments that the most rapid synthesis of radioactive mannitol in *F. vesiculosus* took place when the plants were suspended in sea water through which air containing 10 percent CO_2 was bubbled (*2*). In the present experiment *F. vesiculosus* plants were collected on a sunny morning in October. A sample consisting of 40 g of sterile fronds cut into 6-inch lengths was immediately prepared and suspended in 700 ml of fresh sea water in the light chamber of a photosynthesis apparatus. A detailed description of this apparatus is given elsewhere (*1*). One gram of $C^{14}O_2$ with a total activity of 5 mc was released in the photosynthesis apparatus to give a gas mixture of 10 percent CO_2 in air. This gas mixture was continuously bubbled through the sea water, and its C^{14} content was automatically monitored and recorded. The plants were held at 16°C and illuminated by water-screened incandescent lamps giving 1600 ft-ca.

After 23 hours of photosynthesis 90 percent of the C^{14} offered had been taken up, and since the rate of photosynthesis had decreased considerably the experiment was stopped. The plants were rinsed quickly in distilled water and extracted thrice with hot 60 percent ethanol. The extracts were evaporated to a small volume in a vacuum and streaked to the short edges of two sheets of Whatman seed-test paper. These were run downwards with sewn-on wicks and stirrups (*4*) in phenol:water (21:8) for 5 days, when the solvent front reached the bottom of the sheets. The strongly radioactive mannitol-containing bands were located by autoradiography and cut out. They were twice eluted with water, and the combined eluates were concentrated to dryness in a vacuum. The crude material so obtained was extracted with 400 ml of boiling *n*-butanol, from which mannitol crystallized on cooling to room temperature. The product was washed with 95 percent ethanol and absolute ethanol followed by ether, and was then dried in a vacuum oven at 50°C.

The yield was 700 mg of mannitol with specific activity of 0.82 mc per millimole. The recovery of supplied C^{14} as mannitol was 63 percent. The isolated mannitol was tested chromatographically in butanol: acetic acid:water, butanol: ethanol:water, phenol:water, and pyridine:ethyl acetate:water solvents and was found to contain no detectable sugar, amino acid, or radioactive impurities. The sensitivity of these tests was sufficient to reveal 0.2 percent of such impurities. Nonradioactive mannitol prepared from *F. vesiculosus* in an identical manner, but using $C^{12}O_2$, was tested for specific rotation and melting point with the results: melting point (Kofler melting point apparatus, corrected), 163° to 164°C; authentic mannitol, 165° to 166°C; mixed melting point with authentic mannitol, 163° to 165°C; $[\alpha]_D^{26}$, +28.4° (c = 1.03, in borax); published value, +28.3°.

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