cocytosis. If these findings prove verifiable, it may be that there is an optimal amount of stress affording maximal protection against tumor development.

In evaluating the results of this investigation it must be recognized that both the ascites tumor and the methylcholanthrene-induced sarcoma are extremely malignant and rapidly prove fatal. Moreover, a large dose of methylcholanthrene (1.0 mg) was employed. These factors would tend to minimize any inhibitory effects in the experimental procedure.

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A "Purkinje Shift" in Insect Vision

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The well-known Purkinje shift in vertebrates is due to the shift from cone to rod vision as the light intensity becomes subliminal for the cones. This phenomenon is manifested by a shift of the over-all spectral sensitivity of the eye toward the shorter wavelengths because of the different action spectra of the cones and rods. There has been no previous report, however, of a similar shift occurring in any invertebrate.

Hanström (*1*), having found both long- and short-axoned retinula cells in several Arthropoda, postulated that these are analogous to the cones and rods, respectively, of the vertebrate retina, and that the long-axoned retinula cells probably mediate color vision. This is, then, the anatomical basis for the application of the Duplicity Theory to the compound eye (*1*). Power (*2*) later demonstrated long and short visual axons in the optic lobes of the brain of *Drosophila* that were similar to those previously described by Hanström. More recently, Fingerman (*3*) has obtained highly suggestive evidence of true color vision in wild-type red-eyed *Drosophila melanogaster.* In addition, there was indication that the spectral response curve of Drosophila changes shape as the intensity of the monochromatic light stimulus is diminished. The present investigation was therefore undertaken to determine the manner in which the spectral response curve of Drosophila is altered as the intensity of light is decreased.

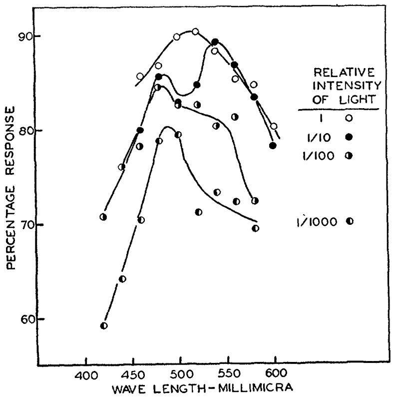

FIG. 1. The percentage response of wild-type red-eyed *Drosophila melanogaster* at each of four intensities of monochromatic light.

Wild-type red-eyed *D. melanogaster,*[1] not less than one week old, were used in the present investigation. The method employed here to determine the response of the flies to the colored light has been described in detail by Fingerman (*3*). The experiments were performed in a darkroom. Briefly, the test chamber consisted of a Y-tube the arm and stem of which had been covered with black tape to within 1 cm of their junction after cover glasses had been affixed onto the end of each arm. The Y-tube was then placed in a box the top and bottom of which had been removed, in such a fashion that the arms and stem of the tube protruded and the junction could be observed. As a result, the light beam could stimulate the flies at the junction only through one of the arms. Thirty flies were placed in the chamber and shaken down to the stem by two or three brisk taps. The apparatus was next placed on an observation box in such a position that a dim ruby-red light shining through a window on top of the box illuminated the junction, allowing only observation of the silhouettes of the flies for counting purposes. Simultaneously, one arm of the Y-tube was directed toward the stimulating monochromatic light source and the other arm was covered with an opaque vial. As a result, the flies were faced with monochromatic light in one arm and darkness in the other. The monochromatic light was obtained by the use of a constant deviation quartz-prism monochromator[2] in conjunction with an 8.5-v concentrated filament lamp. The distance from the end of the Y-tube arm to the slit of the monochromator through which monochromatic light was emitted was 63 cm. The number of flies entering each arm was then recorded. After about 25 flies were counted, they were again shaken down to the stem and the counting was repeated. The percentage response of the flies is expressed as the percentage of all flies counted that entered the arm directed toward the oriented beam of light. In the earlier experiments approximately 100 flies were counted for each determination. Later it was observed that equally replicative results were obtained when only 50 flies were counted for each determination, and this was done in approximately 75% of the experiments. Each point depicted in Fig. 1 represents the average of eight such determinations. The earlier data of Fingerman (*3*) are included in the averages, since all the experiments were performed

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[1] The authors are indebted to G. H. Mickey for the Drosophila used in this investigation.

[2] The authors are grateful to R. J. Cashman, of the Physics Department, Northwestern University, through whose generosity this instrument was made available.

under similar conditions. This was further justified by the similarity of the two sets of data. The spectral response of Drosophila was determined at four intensities of each of a series of monochromatic lights. These relative intensities were 1, 1/10, 1/100, and 1/1000. The intensity of the light was altered through the use of sector disks rotated by an electric motor. The speed of rotation was well above the flicker fusion frequency for the human eye; this factor would not be expected to influence the character of the results, inasmuch as a constant rate of rotation was employed.

It is obvious from Fig. 1 that when the percentage response of Drosophila at each of the four intensities is plotted against the wavelength of monochromatic light, the wavelength of maximal response and the over-all spectral sensitivity of the eye shift toward the shorter wavelengths, just as in the Purkinje shift of vertebrates. In response to monochromatic light of the relative intensities of 1 and 1/10, the maximal response is recorded in the region of 520–540 mμ, whereas, with the relative intensities of 1/100 and 1/1000, the maximal response is observed in the region of 480–500 mμ. It is readily seen from Fig. 1 that the shift is a gradual one. The shift in maximum response of approximately 40 mμ is nearly as large as the shift occurring in vertebrates.

An equal energy spectrum was not used in the present investigation because such a spectrum is unnecessary for the demonstration of a Purkinje shift. Himstedt and Nagel (*4*) demonstrated the Purkinje shift in the retina of the frog using light of unequal energy content.

Furthermore, the results of Fingerman (*3*) have demonstrated the questionable desirability at this time of reducing the data of Drosophila involving responses to monochromatic light to energies yielding equal response. However, if this were done, it would not be expected to alter the relative difference obtained between the wavelengths of maximum response at high and low intensities.

A shift of this sort can only be explained by a Duplicity Theory, the presence of two distinct photoreceptive mechanisms with photoreceptive pigments. Such a shift is not entirely unexpected because of the presence of two types of photoreceptor cells in the compound eye of Drosophila.

Drosophila has an apposition eye, which is better adapted for bright-light than for dim-light vision. This shift toward the shorter wavelengths with decrease in the intensity of the light stimulus is undoubtedly due to a visual pigment, different from that predominating in bright light, that can function in dim light. Such a shift of the spectral sensitivity of the eye toward the shorter wavelengths would also tend to increase the relative efficiency of the eye in dim light as compared with the efficiency in bright light, because it is at these shorter wavelengths that the eye pigments absorb most strongly light that has entered an ommatidium obliquely, resulting in an increased localization on the retina of the image of the orienting beam (*3*). This is the first description of a Purkinje shift occurring in the compound eye.

Experiments are now in progress to determine whether Drosophila has a true color vision and whether this is associated with one or both of the two types of photoreceptive cells.

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The Protective Effect of Glutathione against Radiation-induced Chromosome Aberrations[1]

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It has been known for some time that the sensitivity of chromosomes to breakage by ionizing radiation can be modified by the amount of oxygen present. Thoday and Read (*1*) showed that a decrease in the frequency of chromosome aberrations occurred when root tips of *Vicia faba* were exposed to x-rays in an atmosphere of nitrogen as compared to root tips exposed in the presence of oxygen. Hayden and Smith (*2*) demonstrated that barley seeds x-rayed in a vacuum gave a lower frequency of chromosomal aberrations than seeds x-rayed in air. Similar results were obtained by Giles and Riley (*3, 4*) in *Tradescantia* microspores, where a marked decrease in chromosome aberrations was obtained when the oxygen tension was decreased to 2% or lower.

Using survival as the criterion, Hollaender *et al.* (*5*) were able to decrease the susceptibility of *Escherichia coli* suspensions to x-rays by lowering the oxygen tension. Burnett *et al.* (*6*) showed that the sensitivity of *E. coli* to x-rays also could be reduced by the presence of chemical agents such as certain sulfhydryl compounds, glycols, and alcohols. These results suggest that chemicals also might be effective in reducing chromosome aberrations caused by irradiations. Barron *et al.* (*7, 8*) demonstrated an inhibition of the action of certain sulfhydryl-containing enzymes after exposure to x-rays and α-particles and showed that reduced glutathione had the ability to reactivate partially the irradiated enzymes. Glutathione has been used for the treatment of radiation sickness (*9*) and x-rays burns (*10*) and has been shown to increase survival and to limit loss of weight in irradiated mice (*11*) and other animals (*12*).

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