ophthalmoscopy revealed that the red spot at the macula had turned pink with a distinct line around the periphery of the fovea. Both of these events suggest that there was a delayed vasoconstriction of the choroid.

There are several possible methodologic complications which need comment. The fundus picture could have resulted if there were an inadvertent increase in the intraocular pressure sufficient to produce a pressure block of the retinal vasculature. However, this seems unlikely given the presence of the pressure needle, and since less than 0.125 c.c. of fluid (amounting to about 5 per cent of the volume of the eye) had been infused prior to noticing the first signs of bleaching. Also, during a different experiment, only about 0.01 c.c. of sodium aspartate had been injected and then discontinued, but after one hour the fundus looked similar to that reported here. Furthermore, one effect of an increased intraocular pressure is a clouding of the cornea, and none was noted during the course of this experiment.

A change in osmotic pressure of the fluids surrounding the lens could cause a cataract, but again the amount of fluid infused, less than 0.7 c.c., by the time the cataract first began to appear, was insufficient (even if the tonicity of the infused solution were very far from that of the ocular humors) to cause a significant change in osmotic pressure between the lens and these fluids. Furthermore, a cataract so formed would be expected to recede with time after a normal equilibrium was again obtained.

Trauma as a causal factor for the cataractous changes can be ruled out due to the rate of maturation since, on occasions when the lens has been accidentally hit during the insertion of a needle into the globe, the resulting traumatic cataract has not formed until days later.

Two relationships may be of potential interest: (1) the cataract appears similar to lamellar separation which is a frequent precursor to some types of senile cataracts in humans, and (2) vascular insult in the macular region is related to senile macular degeneration. While these relationships may be merely coincidental, the role of amino acids in senile ocular changes could be of potential interest. On a more conservative note, it might be hoped that study of sodium aspartate-induced cataracts would aid in the understanding of lenticular biochemical processes.

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Near-ultraviolet light effects on the lenses and retinas of mice. Seymour Zigman and Thurma Vaughan.

Exposure of albino mice to near-ultraviolet (black) light for 12 hours a day over a period of 90 weeks led to pathologic changes in the lens and retina. In the lens, epithelial cell conversion to fiber cells is inhibited by 35 weeks, and accumulation of their pyknotic nuclei continues with time so as to permeate much of the lens cortex, even at the posterior pole. Opacities were observed from 50 weeks on. In the retina, outer segment thinning was first noted after 10 weeks. From 16 weeks on, many phagocytic wandering cells were observed to be digesting the outer segments. By 70 weeks, most photoreceptor cells (including the outer nuclear layer) were entirely digested.

Recent experiments in several laboratories have indicated that near-ultraviolet light can damage ocular tissues. We have observed biochemical changes in the lenses of mice exposed to near-ultraviolet light over a period of 90 weeks. Most of these mice also developed cortical lens opacities. This report describes the results of histologic examinations of the eyes of these animals, in which abnormalities of both the lenses and the retinas were observed.

Methods and materials. A population of several hundred seven-week-old A/J female mice were divided into three equal groups and maintained under three different conditions of lighting as follows: (1) total darkness, but with red dark room lamps turned on for 12 hours a day; (2) normal animal room illumination from standard plastic shielded fluorescent tubes, 12 hours a day;
and (3) near-ultraviolet light, 12 hours a day. The sources of near-ultraviolet light were 40 watt Westinghouse BLB black light tubes. The spectral characteristics of this light are shown in Fig. 1; its intensity in the mouse cages averaged 450 µW per square centimeter, as determined by an Ultraviolet Products, Inc. near-ultraviolet light meter.

At intervals of five to ten weeks, four mice were randomly selected from each group. These animals were killed with ether, and one eye of each animal was removed and fixed in 4 percent glutaraldehyde. After embedding in paraffin, 7 µ sections were cut and stained with hematoxylin and eosin. The other eyes were included in the samples used for biochemical studies.

Results. Survival rates and weight gain did not vary appreciably among the three groups. However, the mice maintained under ultraviolet light exhibited a golden discoloration of the hair, inflammation, erosion of the tips of the ears and tails (possibly due to nibbling), and skin tumors. Inspection of the eyes of the animals maintained under near-ultraviolet light revealed grossly visible cortical or subcapsular lens opacities in nearly every animal after an exposure period of 50 to 60 weeks. The weights of the lenses in the ultraviolet-light-exposed animals were noticeably lower than those of the other groups starting at about 30 weeks as described in another report.

Changes observed on histopathologic examinations occurred in the retina after 10 weeks of experimentation. At this time, a slight thinning of the photoreceptors of the ultraviolet and visible light-exposed retinas was found. A marked thinning of the photoreceptor outer segments occurred by 16 weeks in the ultraviolet-exposed mouse retinas. Wandering cells appeared in the outer segment layer of the photoreceptors at this time. Similar, but less marked changes occurred in the retinas of mice exposed to visible light.

Fig. 2 illustrates the histologic changes in the retinas. At 35 weeks of ultraviolet-light exposure, an increased number of wandering phagocytic cells is noted, and the destruction of outer segment material by them is markedly increased. By 60 weeks, much destruction of photoreceptors was observed in the retinas of ultraviolet-irradiated mice but not in those of the other groups of mice. By 87 weeks, a complete loss of photoreceptors was observed in the ultraviolet-irradiated group.

Discussion. The results reported show that exposure of mice to low dosages (1/10 that of sunlight) of near-ultraviolet light for 12 hours a day led to histologically observable destructive changes in the photoreceptors of the retina beginning at about 10 to 16 weeks. The sequence of pathologic changes observed in the retina are, initially, a thinning of the outer segments, followed by an invasion of wandering macrophagic cells which then disappear as the outer segments are totally destroyed. Following this, a complete loss even of the outer nuclear layer of the retina is seen. The time course of this sequence is much slower than that reported by other workers for rodents exposed to visible light, but the destructive process appears to be similar.

These near-ultraviolet light-induced changes in the retina may be related to an inhibition of the process of outer segment renewal. In preliminary in vitro studies, we have found that near-ultraviolet light and its tryptophan-derived photoproducts led to an inhibition of the uptake of amino acids by photoreceptors of dogfish and calf retinas and a diminished amino acid incorporation into photoreceptor proteins. Other mechanisms possibly involved here are the destruction by near-ultraviolet light of vitamin A, altered permeability of outer segment membranes, and damage to respiratory enzymes. Vitamin A deficiency recently has been shown to inhibit outer segment renewal in rat retinas.

In the lenses, no noticeable abnormalities were found in the ultraviolet-treated animals before 35 weeks, at which time an inhibition of lens epithelial cell differentiation into typical non-

Fig. 1. Emission spectrum of 40 watt BLB black light tubes.
Fig. 2. (A = dark controls; B = visible animal room light; C = ultraviolet-irradiated mice).
Sections (x450) of the retinas of mice exposed for 12 hours a day to near-ultraviolet light or maintained in darkness or ordinary animal room light, for 35, 60, and 87 weeks. At 35 weeks, note thinning of photoreceptor layer in both visible and ultraviolet-exposed mouse retinas and the presence of wandering cells especially in the ultraviolet group. At 60 weeks, note large-scale degeneracy of the photoreceptors and abnormal pigment epithelium in the ultraviolet-exposed mice. At 87 weeks of ultraviolet exposure, note absence of photoreceptors, pigment epithelium, and outer nuclear layer.

The accumulation of lens crystallins in mice exposed to near-ultraviolet light has been reported by us to be inhibited by exposure to near-ultraviolet light for 12 hours a day for 35 weeks. In other experiments, in vitro uptake and incorporation of labeled amino acids into dogfish lens proteins was also inhibited by exposure to near-ultraviolet light. Here again, diminished levels of vitamin A in lens epithelial cells due to near-ultraviolet light exposure could be involved, since Pirie and Overall have found that vitamin A deficiency in rats caused abnormal cell division of lens epithelial cells.

Experiments to better establish biochemical mechanisms of ocular tissue damage resulting from near-ultraviolet light exposure are in progress.

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Fig. 3. (A = dark controls; B = visible animal room light; C = ultraviolet-irradiated mice). Section (×300) at the bow region (upper row) and posterior pole (lower row) of lenses of mice exposed for 12 hours a day to near-ultraviolet light or maintained in darkness or visible animal room light for 87 weeks. Note extensive spread and large number of undifferentiated epithelial cell nuclei, and the presence of cell nuclei at the posterior pole only in near-ultraviolet-irradiated mouse lenses.

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Key words: mouse, retina, lens, near-UV light, epithelial cells, fiber cells, photoreceptors, outer segments, pyknosis, differentiation.

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