Induction of Cataracts in Mice by Slow Neutrons and X-rays.* (18849)

K. W. CHRISTENBERRY AND J. FURTH.
(With the technical assistance of J. J. Lane.)
From the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

The causation of cataracts by large doses of X-rays(1,2), fast neutrons(2-5), and by radiation from nuclear explosion ("atomic bomb") (6) is known. It has been established that fast neutrons are more effective in inducing cataracts than X-rays(4), but nothing is known of cataract induction by slow neutrons.

In order to find out the relative efficiency of slow neutrons in producing cataracts, groups of mice of both sexes were placed in the thermal column of the Oak Ridge reactor for 80 minutes (which is about the LD-50 dose), 20, 5, and 2.5 minutes respectively. The slow neutron facilities at the Oak Ridge pile have been described and illustrated by Conger and Giles(7). Mice of the Rf strain were 8 to 10 weeks of age at the time of exposure. Siblings received equivalent doses (on basis of LD-50) of 250 Kv of X-rays, or were untreated. The onset and progression of lens opacities were studied by the slit lamp microscope. The degree of lens opacities was designated + to ++++ as illustrated in Fig. 1. In order to exclude subjective factors, all examinations here reported were made as unknowns. Table I shows the number of mice examined and the degree of opacities observed in relation to time, dose, and kind of irradiation. Examinations on a much large number of animals, not done as unknowns, were in essential agreement with the results shown in

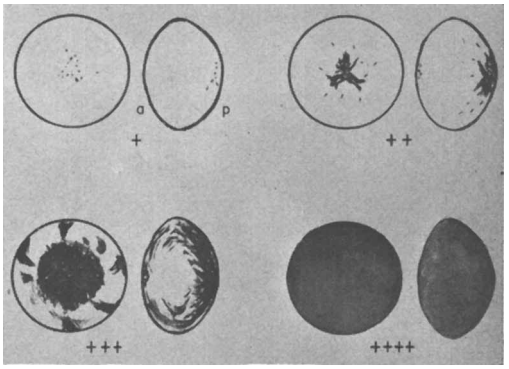

FIG. 1. Degree of opacities of the lens (used for tabulation in Table I).

Table I.

The earliest change noted consists of small dot-like opacities in the posterior polar region and in the subcapsular layer. They are clustered about the posterior lens suture and appear as an inverted Y-shaped lesion. Further advance of the lesion consists of increased density of the initial opacities and formation of linear opacities radiating into the posterior cortex of lens. In animals exposed to large doses these radiating opacities thicken to form a sunburst pattern extending into the equator of lens and thence around in to the anterior cortical region. Concomitantly, there is the development of anterior polar opacity and anterior subcapsular radiations of a lesser extent than the posterior lesions. The nucleus is spared until the cortical changes are far advanced. Advanced lesions with near total opacity of the lens are noted only in mice of the 80-minute exposure group and only one year after exposure.

In old normal mice cataracts of the type seen in irradiated mice were not observed. There were, however, senile changes consisting of condensation of the lens nucleus, consolidation of the lens capsule, and accentuation of the lens suture. These are not noted in mice examined 1 to 6 months after irradiation, are slight in the 7 to 10 months group, but are

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TABLE I. Incidence of Opacities of Lens of Mice Exposed to Slow Neutrons and X Rays.

Months after exposure	Degree of cataract	Duration of exposure (min) 0	N* 2.5	X† 2.5 (16r)	N 5	X 5 (32r)	N 10	N 20	X 20 (128r)	N 80	X 80 (512r)
6–10	0	37	2	11		4			1		
	±	9	9	5	1	6			3		
	1+	2	5	1	14	6		21	16	2	4
	2+				1			6		20	12
	3+									2	1
14–15	0	11			1	3					
	±	5			9	1	2			1	
	1+	7			8	7	2	1	2	1	
	2+				4		6	6	3		3
	3+									3	4
16–19	0	5	3								
	±	7	2								
	1+	1	4		3	2					
	2+				3	2		3	3		
	3+							2	1	5	2

* N = exposure at a slow neutron flux of $.9 \times 10^9$ per cm^2 per sec with an estimated 4 to 8 r of high energy gamma per min [Conger and Giles(7), Stapleton(8), and Darden and Sheppard(9)].

† X = exposure to X rays at a rate of 6.4 r per min. The factors of irradiation were 250 kvp; 12.5 ma; 3.5 mm Cu; TSD 93.7 cm; rate 6.4 r/min.

consistently present in mice of the 11 to 14 months group. Their presence obscures the opacities induced by slight radiation in mice exposed for 2.5 and 5 minutes. When mice of the 2.5 and 5 minute groups reach about 14 months of age the lesions in their lenses cannot be distinguished from those of normal mice of comparable ages because of the marked senile changes occurring concurrently.

The data here presented indicate that slow neutrons induce lens opacities sooner and in a higher per cent of mice and in smaller doses (on basis of LD-50) than equivalent quantities of X-rays. This difference between the effects of neutrons and X-rays was not evident in: (a) area of lens affected, (b) acute depression of hemopoietic organs, (c) recovery period of erythrogenesis as indicated by reticulocyte counts, (d) weight change after irradiation. In considering the slow neutron/X-ray efficiency ratio the very heavy gamma ray contamination of our slow neutron facility has to be taken into consideration.

It is now generally believed that the dose of X-rays necessary to induce cataracts is large and that men exposed to even as high a dose as LD-50 may remain free from cataracts. The studies of Evans(4) have already suggested that mice are much more susceptible to cataracts than man and the present study indicates that the threshold dose inducing lens opacities in mice is very small, below that required to induce other chronic changes such as leukemia.

Summary and conclusions. The lens of the mouse is extremely sensitive to the induction of opacities by both X-rays and slow neutrons. As small a dose as 32 r of total body X-rays causes a slight increase in the per cent of mice developing opacities of the lens. With larger doses the cataract induction rate approaches 100%, the lesions are more severe, and the latency period is shorter. The morphological features of the radiation and senile cataracts of mice are described. The cataracts develop in the immature part of the lens (cortex), while the more mature part of it (nucleus) is spared. Slow neutrons are, on basis of LD-50, at least twice as effective in inducing cataracts as X-rays.

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