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## APPENDIX B: RADIATION DOSES AND DOSE RATES RESULTING IN MORTALITY

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Considerable information is available on the lethal effects of radiation on adult and young organisms from different phyla and different types of ecosystems. Although data are available for many species, there are entire phyla and groups within phyla for which none are available. The response to irradiation was expressed frequently as the median lethal dose or  $LD_{50/30}$ , which is the dose killing 50% of the population within 30 days.

### B.1 RADIATION DOSES RESULTING IN MORTALITY

Comparison of the responses of different species to acute radiation allows the identification of groups of organisms that appear to be more radiosensitive than others. Some representative data on mortality of vertebrate organisms are shown in Table B-1 and for invertebrate organisms in Table B-2. The results show that the range in acute doses that produce mortality in different organisms is very large (<3-→30,000 Gy), that the ranges in responses overlap, and that among animals, mammals are the most sensitive group. However, there is no indication that doses less than 1 Gy will result in mortality in marine animal groups, including mammals.

Mortality appears to be a very insensitive endpoint for measuring acute radiation effects compared to other endpoints. A study of the sensitivity of endpoints in the worm *Neanthes arenaceodentata* showed that endpoints characterizing responses at the cellular and molecular levels may indicate better the occurrence of irradiation damage (Table B-3). Also, in quantifying any response, experimental conditions are specially important when poikilothermic species (internal temperature not regulated) are examined. Temperature usually increases radiation sensitivity and lower temperature may slow the rate of development of lesions.

### B.2 RADIATION DOSE RATES RESULTING IN MORTALITY

The chronic effects of radiation on mortality were assessed in some mammalian and nonmammalian species, but the database is limited (ICRP, 1991; Rose, 1992; UNSCEAR, 1993). For *Physa heterostropha*, decreased survival was reported at dose rates of 0.1 Gy/h (Cooley and Miller, 1971) and in adults of the blue crab *Callinectes sapidus*, dose rates greater than about 0.3 Gy/h for 70 d were required to cause death (Blaylock and Trabalka, 1978). For juveniles of the clam *Mercenaria mercenaria* dose rates as high as about 0.37 Gy/h for 14 months only resulted in decreases in reproduction and growth (Chipman, 1972). For the freshwater cladoceran *Daphnia pulex*, Marshall (1962) observed increased mortality rates for the population at dose rates >0.48 Gy/h. For fishes, Erickson (1973) reported no increase in mortality of the guppy *Poecilia reticulata*

exposed to 0.05–1 mCi mL<sup>-1</sup> of tritium (total dose of 3.4–47 Gy). For mammals, the highest radiosensitivity was found in the rats *Perognathus formosus* and *Dipodomys microps*, which had a dose-rate limit of less than 0.34–0.68 mGy/h (Rose, 1992). While the range in dose rates documented to result in mortality is small, 0.1–>0.48 Gy/h, it indicates that dose rates less than 0.1 Gy/h will not result in mortality.

Table B-1. Range of LD<sub>50</sub>s obtained from acute radiation of adult vertebrate organisms from different taxonomic groups.

Phylogenetic Group	Lethal Dose (Gy)	References
Mammals		
Humans	3	Rice and Baptist (1974)
Monkey	6	" "
Dog	2.5	" "
Swine	2.5	" "
Hamster	6	" "
Mouse	6.4	" "
Rabbit	7.5	" "
Bat	150	" "
Pisces		
Goldfish	3.75 – 100	Etoh et al., 1974; Shechmeister et al., 1962; Hyodo-Taguchi, 1965
Mummichog	10 – 20	Angelovic et al., 1969
Tench	12 – 55	Lockner et al., 1972
Guppy	23.5	Erickson, 1973
Chinook salmon	25	Welander et al., 1948
Mosquitofish	37	Blaylock and Mitchell, 1969
Pinfish	50	Engel et al., 1967

**Table B-2. Range of LD<sub>50</sub>s obtained from acute radiation of invertebrate organisms from different taxonomic groups.**

Phylogenetic Group	Lethal Dose (Gy)	References
Bacterium	730,000	Day and Minton, 1995
Protozoa	>1,000	Bacq and Alexander, 1961
Coelenterata	20-120	in Polikarpov, 1966
Porifera	20-120	in Polikarpov, 1966
Platyhelminthes	55	in Polikarpov, 1966
Annelida		
Adult	100	Schmidt, 1946
	>500	Harrison and Anderson, 1992
Mollusca		
Early life	11	in Blaylock and Trabalka, 1978
Adult	50-500	in Templeton et al., 1971
Crustacea		
Adult	2.1	Engel et al., 1974
	17-100	in Chipman et al., 1972
	566	Engel, 1967
Echinodermata	100	in Templeton et al., 1971

**Table B-3. Comparison of sensitivity of different endpoints for the worm *Neanthes arenaceodentata* receiving acute irradiation.**

Dose (Gy)	Endpoint	References
>0.3	DNA strand breakage	Martinelli et al., 1990
>0.5	Reduced fertility Increased sister chromatid exchanges	Harrison and Anderson, 1994a Harrison et al., 1987
>2	Increased chromosomal aberrations	Anderson et al., 1990
>50	Sterility	Harrison and Anderson, 1994a
>100	Life-span reduction	Anderson et al., 1990
>500	Mortality	Anderson et al., 1990