Environmental Radiation Effects on Mammals
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A Dynamical Modeling Approach
Dedicated to my advisor, N.V. Stepanova
The monograph is devoted to the theoretical studies of radiation effects on mammals. It summarizes the results obtained by the author over the past 30 years, most of them being of high priority. In the course of these studies, a single approach to the modeling of radiation effects on mammals has been elaborated. Specifically, in the framework of the developed deterministic mathematical models, the effects of both acute and chronic irradiation in a wide range of doses and dose rates on vital body systems (hematopoiesis, small intestine, and humoral immunity), as well as on the development of autoimmune diseases, are investigated. The radiation effects on the mortality dynamics in homogeneous and nonhomogeneous (in radiosensitivity) mammalian populations are also studied by making use of the developed stochastic models. The most appealing feature of these mortality models consists of the fact that they account for the intrinsic properties of the exposed organism. Namely, within these models the stochastic biometrical functions are calculated proceeding from statistical characteristics and dynamics of the respective critical body system (hematopoiesis or small intestine).

The performed theoretical investigations contribute to the development of the system and quantitative approaches in radiation biology and ecology. These studies elucidate the major regulatory mechanisms of the damage and recovery processes running in the vital body systems of exposed mammals and reveal the key parameters characterizing the processes. Proposed explanations of a number of nonlinear effects of low-level single/chronic irradiation on the vital body systems, on the organism as a whole, and on a nonhomogeneous mammalian population are of particular theoretical significance, since these effects still have no unambiguous interpretation.

The material presented in the monograph is a matter of interest for practical use, too. In particular, performed investigations of the dynamical models of granulocytopoiesis and thrombocytopoiesis in humans testify to the efficiency of employing these models in the investigation and prediction of effects of space radiation on these major hematopoietic lines. These models, as well as the developed models of other vital body systems (after appropriate identification), could provide a better understanding of the risks to health from the space radiation environment and enable one to evaluate the need for operational applications of countermeasures for astronauts on long-term space missions.
The models of radiation-induced mortality lay the theoretical foundations of a new individual-based approach to radiation risk assessment. These models enable one to predict the mortality dynamics and the average life-span shortening for an individual and for nonhomogeneous (in radiosensitivity) populations exposed to acute and, most importantly, to low-level chronic irradiation. Therefore, the properly identified mortality models could be employed as a tool for estimating the risks for persons subjected to occupational irradiation (power plant employees, radiologists, technicians, and others). This would allow one to carry out more effectively preventive and protective measures among them. Additionally, these models could be used to evaluate the radiation risks for a population residing in contaminated areas. In turn, this would help decision makers to distribute, in an optimal way, the available resources to reduce the hazard for the population. The elaborated models of radiation-induced mortality could also be applied to estimate the risk of long-term irradiation in manned space missions, such as voyages to Mars and lunar colonies.

In this monograph a wide range of fundamental problems in the fields of radiation biology and ecology are investigated in the framework of a single approach by making use of the methods of mathematical modeling. Therefore, the developed methodology of the studies, the elaborated models themselves, and the obtained theoretical results can be of benefit to academic institutions, scientists, and researchers working in the field of mathematical modeling of biological systems, as well as in the fields of radiation biology and ecology. The theoretical investigations presented in the monograph can find wide practical use. In particular, the monograph can be of benefit to aerospace agencies and to corporations that deal with the problems of ensuring the space environmental radiation safety, as well as to practitioners and professionals working in related fields. The monograph can be used as a basis for a lecture course on mathematical modeling in radiation biology and ecology. It can also be of benefit to graduate and postgraduate students of appropriate specializations.

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Olga Smirnova
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