Preface

The monograph presents the biologically motivated dynamic modeling approach to the study and prediction of radiation effects on mammals. This approach embodies the author's mathematical models, which are capable of predicting the dynamics of vital body systems in mammals (namely, the hematopoietic system in rodents and humans, the immune system in rodents, the small intestine in rodents, and the skin in young swine) under normal conditions and under various irradiation regimes (acute/chronic/fractionated/non-uniform irradiation). The developed approach also includes the author's mathematical models, which are capable of prognosticating the mortality dynamics and the average life-span shortening for homogeneous and nonhomogeneous (in radiosensitivity) mammalian populations exposed to acute and chronic irradiation in wide ranges of doses and dose rates on the basis of the statistical characteristics and the modeling dynamics of the respective critical body system (the hematopoietic system or the small intestine) in exposed specimens composing the population. The developed approach demonstrates its efficiency in the assessment of the excess relative risks for leukemia among acutely and continuously irradiated humans (the atomic bomb survivors and patients treated with brachytherapy) proceeding from two key characteristics of the respective modeling dynamics of human major hematopoietic lineages (the granulopoietic and lymphopoietic systems). The developed approach also proves its reliability in the prediction of the dynamics of the pathophysiological reaction (moist desquamation) in skin exposed to single and fractionated irradiation in wide ranges of doses and total doses on the basis of the respective modeling dynamics of epidermal cells of the upper skin layer.

The material presented in the monograph is of an evident theoretical significance. In particular, the performed modeling studies elucidate the basic regulatory mechanisms of the damage and recovery processes running in the vital body systems of exposed mammals and reveal the key parameters characterizing these processes. The proposed explications of a number of nonlinear effects of low-level single and chronic irradiation on the vital body systems, on the organism as a whole, and on a nonhomogeneous mammalian population are of a particular theoretical importance, since these effects still have no unambiguous interpretation.

The proposed explanation of experimentally observed distinctive features of effects of non-uniform and uniform acute irradiation on the major hematopoietic lineages in rodents is of an obvious theoretical significance, too. Furthermore, the developed models of radiation-induced mortality lay down the theoretical foundations of a new individual-based approach to radiation risk assessment. The most appealing feature of these mortality models consists in the fact that they account for the intrinsic properties of the exposed organism and the individual variability of radiosensitivity.

The material presented in the monograph is of a wide practical applicability, too. In particular, the developed models of the human hematopoietic system, as well as the developed models of other vital body systems (after appropriate identification), could be employed to investigate and foretell the effects of space radiation on these systems for astronauts on long-term space missions (e.g., voyages to Mars or lunar colonies). The obtained modeling predictions would 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. The models of the human hematopoietic system and the properly identified models of the other vital body systems could also be used for predicting the radiation injury of these systems for people residing in contaminated areas after nuclear power plant accidents. Obtained results would help the decision makers to evaluate the hazard for the health of the people and to take proper decisions for operational applications of all necessary countermeasures including their settling out, as well as for their subsequent resettling. Such models could be also applied to assessment of the health hazard for clean-up crew members taking part in the elimination of consequences of such accidents.

The demonstrated efficiency of the employment of the biologically motivated dynamic modeling approach in estimating the excess relative risks for leukemia among acutely and continuously irradiated humans attests to its applicability to the assessment of the radiogenic leukemia risk among people residing in contaminated areas after nuclear power plant accidents, among clean-up crew members taking part in the elimination of consequences of such accidents, among astronauts on long-term space missions, among person subjected to occupational irradiation (uranium miners, radiologists, and others), as well as among patients treated with radiotherapy.

The developed models of radiation-induced mortality (after appropriate identification) could be used to predict the mortality dynamics and the average life-span shortening for an individual and for nonhomogeneous (in radiosensitivity) populations of humans under various irradiation conditions, including low-level chronic irradiation. Therefore, such mortality models could be employed as a tool for estimating the risks for a population residing in contaminated areas. This would help the decision makers to distribute, in an optimal way, the available resources to reduce the hazard for the population. Such models could also be applied to estimate the radiation risks for astronauts on long-term space missions (e.g., voyages to Mars or lunar colonies). This would allow one to carry out more effectively preventive and protective measures among them.

In this monograph, a wide range of fundamental problems in the fields of radiation biology and ecology is investigated in the framework of the single biologically motivated dynamic modeling approach. Thus, 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, ecology, medicine, and radiation safety. 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 the 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.

Dubna, Moscow region
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May 2016

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http://www.springer.com/978-3-319-45759-8

Environmental Radiation Effects on Mammals
A Dynamical Modeling Approach
Smirnova, O.A.
2017, XXIII, 359 p. 203 illus., 4 illus. in color., Hardcover
ISBN: 978-3-319-45759-8