Preface

Our investigations began in the final decade of the last century when radiobiologists were debating whether the impacts of low-dose irradiation are harmful or beneficial. These discussions were incited by the Chernobyl catastrophe, after which large areas were polluted with radioactive materials. At that time, it was suggested that perturbed health in irradiated people was caused merely by irradiation phobia.

To move beyond this argument, we initiated investigations using plants: a pea pure line[1] and a natural population of plantain, which is a favorite subject of radioecologists due to its prevalence. The ability to conduct radiation experiments with plant seeds was also important, because seedling apical meristems are a good model of bone marrow stem cells. We used a pea pure line in laboratory experiments and we investigated plantain populations near the Balakovo nuclear power plant.

The State Committee on Protection of the Environment in the Saratov Region and the Ecology Department of the State Saratov University assisted us in choosing plantain populations in a 30-km zone around the nuclear plant and provided information on radiation and environmental conditions in this region. It is important that the nuclear plant performed normally at this time (1998–1999); its fallout in this region, if any, did not enhance natural ground radiation (0.10–0.15 μSv/h).

Cytogenetic,[2] dosimetric and chemical analyses[3] were performed at the Joint Institute for Nuclear Research (JINR). Laboratory studies and investigations of natural populations were analyzed in parallel. In both cases, increased numbers of chromosomal aberrations were registered, which can be understood because low-dose radiation induces chromosomal aberrations that can accumulate and then

[1] Seeds were kindly provided by Prof. G. Debelyj, Moscow Institute of Agriculture, Nemchinovka.

[2] Methods were provided by radiobiologists of the laboratory of Prof. V.A. Shevchenko (Vavilov Institute of General Genetics, RAS, Moscow) and the Russian Institute of Agricultural Radiology and Agroecology, RAAS (Obninsk).

[3] Correlations between the chemical pollutants, biological values and nuclear power plant fallout were analyzed.

lead to cell adaptation or death.[4] These results were verified by investigations of bystander effects[5] and hypermutagenesis.[6] We used statistical modelling to study regularities in the appearances of abnormal cells and chromosomes.

Fitting distributions of numbers of abnormalities in seeds and cells revealed combinations of Poisson and geometric statistics.[7] Poisson statistics describe the independent appearances of primary and late damages, and geometric statistics describe selection. Both together describe the processes of adaptation induced by primary impacts, which appears as time-dependent, non-random mutagenesis coupled with selection. These regularities were discussed with Profs. V.B. Priezzhev, G.A. Ososkov (JINR) and other mathematicians. The values of the Poisson and geometric distributions determine their biological interpretation. Thus, we studied the processes of adaptation induced in seed populations and in seedling apical meristems in terms of irradiation dose rates.

Our investigations inspired us, and we began to study problems of statistical modelling of the appearance of abnormal lymphocytes in the blood of individuals living in sites impacted by radiation. We verified that the distribution of individuals on the frequency of abnormal cells can be used to analyze instability processes.[8] We also wished to study instability processes across generations. For our modelling, we chose investigations of blood lymphocytes of individuals living in the settlements of Samburg (Tyumen region) and Maloe Goloustnoe (Irkutsk region), which experienced fallout from nuclear tests (1950) in Novaya Zemlya and Semipalatinsk, respectively. Cytogenetic studies of the blood of individuals living in these sites were collected over several decades at the Novosibirsk Institute of Cytology and Genetics of the Siberian Branch of the Russian Academy of Sciences.

Unfortunately, there are no data concerning cumulative doses by individuals from fallout in Samburg, although a dramatic increase in malignant changes of lungs and digestive organs was documented (investigations provided since 1960). In Maloe Goloustnoe, the accumulated dose by individual from fallout could be 10–40 cSv (an estimate by some authors). At present, ^{137}Cs contaminations are 153 and 118 Bq/kg (lichen and venison, respectively) in Samburg,[9] and 55 Bq/m^2 (soil) in Maloe Goloustnoe.[10]

---

[4]These ideas were based on investigations by Prof. V.I. Korogodin on chromosomal instability (1970) and transcription-regulated mutagenesis (1980).

[5]By Prof. C. Mothersill and Prof. C.B. Seymour.

[6]By Prof. S. Rosenberg.

[7]The methodology and methods of fitting were discussed with Prof. G.A. Ososkov (JINR).

[8]The proof was published in *J. Math. Biol. and Bioinformatics* (in Russian).

[9]Data of the Analytical Centre of the Siberian Branch of the Russian Academy of Sciences, which investigates radionuclide contents in lichen, moss, venison etc.

[10]Dosimetric analyses were performed independently by the radiation monitoring services of Irkutsk, Angarsk, and Novosibirsk, which study radiation effects of nuclear tests in the Semipalatinsk polygon on the South Baikal side.

The modelling clarified some conclusions: time-dependent adaptation proceeds constantly in the environment; it is coupled with instabilities and selection; and their risks can be estimated by statistical modelling. The statistical approach is qualified to investigate the processes induced by the low factors and accompanied by Darwinian selection in different systems. These notions are especially useful to specialists in radiation pollution, ecology, epidemiology, and radiology for the studies of radiation-induced processes. The offered method could be successfully developed by investigators of low-dose effects in other fields.

The ideas and investigations of Prof. Vladimir I. Korogodin were the basis of our adaptation modelling. In addition, we are grateful to several scientists who contributed significantly to these investigations: Prof. V.B. Priezzhev (notions on self-organization of the matter); Prof. G.A. Ososkov (methods of fitting); Prof. J.W. Drake (adaptive mutagenesis and evolution); and Prof. Yu.A. Kutlakhmedov (radioecology notions). We thank Prof. E.B. Burlakova, who supported us at the beginning of our investigations; this was very important. Professors C.Mothersill, G.G. Polikarpov, C.B. Seymour, and A. Yablokov supported our efforts to preserve Nature.

Dubna, Russia Victoria L. Korogodina

http://www.springer.com/978-94-007-6630-3

Radiation-Induced Processes of Adaptation
Research by statistical modelling
Korogodina, V.L.; Florko, B.; Osipova, L.P.
2013, XVII, 183 p.,
ISBN: 978-94-007-6630-3