MODERN PROBLEMS OF RADIOBIOLOGY, RADIOECOLOGY AND EVOLUTION

Abstracts

Joint Institute for Nuclear Research

International conference

MODERN PROBLEMS OF RADIOBIOLOGY, RADIOECOLOGY AND EVOLUTION

dedicated to centenary of N.W.Timofeeff-Ressovsky

September 6-9, 2000

ABSTRACTS

Dubna, 2000

The Collection contains Theses of the reports presented at the Timofeeff-Ressovsky Centennial Conference dedicated to problems in Genetics, Radiobiology, Radioecology, Self-Organization of Matter and Biological Evolution. The Theses are published in the authors' wording.

The responsibility for misprints in the report thesis texts is held by the authors of the reports.

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PROGRAMME OF THE CONFERENCE

Genetics

1. Mutation processes in genes and chromosomes
2. Mutagenic factors
3. Mechanisms of mutation process
4. Links between DNA repair, mutation and transcription
5. Phenogenetics

Radiobiology

1. The genetic concept of biological effects of ionizing irradiation
2. The hit principle in modern radiobiology
3. Post-irradiation recovery and its mechanisms
4. Biological effects of low-dose irradiation

Radioecology and radiation biogeocenology

1. Terrestrial ecosystems and their sensitivity to contamination
2. Aquatic ecosystems and their sensitivity to contamination
3. Problems of cross-contamination between aquatic and terrestrial ecosystems
4. Problems of combined effects of radionuclide and chemical pollution
5. Environmental management and the use of biota to rehabilitate polluted aquatic areas and territories
6. Ecological assessment of consequences of countermeasures
7. Methodology of contamination assessment of large areas
8. Biological dosimetry and reconstruction of irradiation dose

Evolution problems

1. Self-organization of matter
2. Basic laws of biological evolution
3. Micro- and macroevolution
4. Criteria of evolution

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PLENARY PRESENTATIONS

ENVIRONMENTAL RADIOACTIVITY IN THE SOUTH URALS 1990-1997. -AN INTERNATIONAL STUDY SUPPORTED BY INTAS, EC AND NATIONAL FUNDING.

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Radioecological studies carried out in a joint cooperation between Russian, Ukrainian and Danish Laboratories are reported. The environmental impact of routine discharges as well as accidental events, notably the Kyshtym accident in 1957 and the Karachay wind dispersion in 1968 have been studied.

From measurements and based on model assumptions it has been estimated that the Ob river system outside Mayak, i.e. first of all the Techa and Iset rivers and their floodplains contain 0.1 PBq ^{90}Sr, 0.3 PBq ^{137}Cs and 0.8 TBq ^{239,240}Pu. The uncertainty of these estimates is a factor of 3-4. The present contamination from the Kyshtym accident outside the Mayak area is calculated to 0.1-0.5 PBq ^{90}Sr and from the Karachay incident the contamination is 0.05-0.1 PBq ^{137}Cs. The environmental contaminations with Pu from these two events are in the order of 1 TBq.

The occurrence of ^{99}Tc, ^{129}I and ^{237}Np in highly contaminated Techa river sediments collected outside Mayak is for the first time reported.

MODERN PROBLEMS OF RADIOECOLOGY

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LOW DOSES OF IRRADIATION. ARE THEY DANGEROUS ?

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The action of low doses of low-level irradiation show a number of specific features as compared to average (> 25 cGy) and high doses, namely:

- a nonlinear, nonmonotonic dose-effect dependence;
- an inverse dependence of the effect on a dose-rate in certain dose ranges;
- changes in the sensitivity of an object irradiated with low doses to the action of other endogenic and exogenic damaging factors.

As a rule, the sensitivity increases. That is why, biological objects irradiated with low doses suffer far more serious damages from other environmental risk factors, e.g., from chemical contaminations.

By many indices, low and high dose irradiation causes identical changes in the genetic and membrane apparatus of the cell, e.g., cytogenetic effects in the cell, structural changes in membranes, etc.. However, the mechanisms and pathways of effects of low and high doses on the cellular metabolism are different.

In the early stage, the effects of low doses are similar to those of high doses; they may exceed the latter quantitatively per unit dose or even in an absolute value. In later stages, the effects of low and high doses are different. This may be associated with a difference in a response of cells and organisms to low and high dose irradiation, the presence or absence of systems responsible for normalization of irradiation-affected metabolic indices by means of induction of corresponding cellular reactions.

The effects of low doses are similar in many respects to ageing processes.That is true for a disease incidence. The disease incidence for low-dose irradiated participants of liquidation of accident consequences (liquidators) approximates to control groups of more elderly people but not to their age control groups.

The scientists who believe in a radiobiological dogma that the higher the dose and the dose-rate, the stronger the effect, can not explain the observed changes in the state of health by the irradiation effects and try to discover other factors responsible for these changes. It is important that experimental studies furnish an explanation for the mechanisms of action of low doses of radiation on biomacromolecules, cells, organisms, and for their difference from the pathways of biological effects of high doses.

ON THE GENERATION OF THE WORTH INFORMATION

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The synergetic approach based on nonlinear dynamical modeling is used.

According to definition proposed by Quastler *information* is the remembered choice of one version among many possible ones. It differs very much from the *microinformation* which is unremembered choice. Microinformation is connected with physical entropy, but information has no relation to the entropy at all.

Usually information is applied for achievement of some goal. The worth of information depends on the probability to obtain the goal.

Process of generation of worth information is considered on the basis of a certain nonlinear mathematical model. It is shown that a quasichaotic mixing layer is needed to generate an information. Worth of this information depends gradually on time, being equal to zero at the initial moment.

The problem of the goal-self-setting in nonlinear systems is considered. It is shown that such phenomenon is possible in dynamical systems featuring the special properties. The dynamical models of such type do describe the appearance of the biological information in the process of Life origin. The basic goal of elements of such type systems is:

- *the storage of the proper information.*

Several applications of this model to problems of Life origin, of biological evolution and of creation are discussed.

RADIOECOLOGY: TRENDS AND FUTURE IN THE LIGHT OF SOCIAL CHANGES

Gilbert Desmet

International Union of Radioecologists

Radioecology is an unusual scientific discipline, in that there do not exist radioecologists, but that there exists a research domain with well-defined objectives! The science of Radioecology is per definition "multidisciplinary". The science of radioecology has a number of important objectives relevant to the radioactive contamination of the environment. A prime objective of radioecology is to understand how the interaction between radionuclides and the environment affects radiation dose. Such an understanding then permits a second major objective of radioecology, which is to provide suitable rehabilitation methodology to reduce radiation dose so that it is possible to restore the ecological and economic value of contaminated land. Do they now have to be adapted in the light of practical changes in the views of the users of the results of radioecological research and of changes in the societal perception of the impact of the production and use of nuclear energy?

There has, however, been a considerable advance in our understanding of radionuclide behaviour arising from the Chernobyl accident, which has clearly demonstrated that good science allows well-informed decisions. The radioecologist has a responsibility in environmental management and has the right and duty to give input to environmental decision support systems, and to claim a place on the road towards decision-makers. Here again the communication lines have to be given serious inspection and shortened at all.

Radioecologists never work in an environment, which is only contaminated with radionuclides, but would be confronted with a possibly complex contamination pattern, and certainly a very diversified pattern of use of the ecosystem and the food production system. Other pollutants maybe present, the agro-systems have their own characteristics etc. This reality forces again radioecologists to work in multidisciplinary teams, and pushes them to tackle real environmental problems in a holistic way. Another aspect of debate is whether the well-known ICRP statement that "when Man is protected the Environment is also protected" has not lost its rigour, and additionally whether Man's risk can be placed in a "standing-on-his-own" situation where his obvious relation with the environment is being minimised or

even ignored! The other important issue is the future of energy production by nuclear fission. In other words if the situation is such that atomic energy is no longer used for energy production is there then still a need for radioecological assessment. With respect to the role of the IUR in all these challenges, it means to be a platform where the above questions can be raised and discussed, where "neglected" connections with the direct user groups in dose and risk assessment can be improved, where the way can be paved to communicate with other environmental research groups, where lobbying in the direction of authorities can be streamlined, and where a spirit of "selling the radioecological products to interested industries" can be stimulated and created. Therefore the IUR works with a number of Task Groups that endeavour to encompass the needs of above. The objectives of these different Task Groups will be outlined in the full paper.

RATES OF SPONTANEOUS MUTATION: INSIGHTS GAINED OVER THE LAST HALF CENTURY

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Nikolai Timoféeff-Ressovsky understood well the need for both explicit theory and quantitation in biology. His adventures with Karl Zimmer and Max Delbrück and the somewhat romantic portrayal of those ideas by Erwin Schrödinger contributed notably to the development of population genetics and led to the modern theory of mutation. A central mystery in Timoféeff's time was the size and composition of the gene, which he probed by the methods of radiation mutagenesis. A subsequent central mystery has been whether order may somehow underlie the apparent chaos of mutation rates. Although the first hints of order appeared in the late 1960s, the robustness of certain formulations of mutation rates did not become apparent until the 1990s. It is now clear that each of four major groups of organisms has its own characteristic rate of spontaneous mutation. The riboviruses hover at the edge of mutational meltdown, the retroelements live a few-fold less dangerously, the DNA-based microbes maintain a very small genomic rate (except in special circumstances), and the higher eukaryotes seem to have adopted a rate only a few-fold higher than the DNA-based microbes (with remarkable consequences over the course of a sexual generation). The evolutionary forces driving these characteristic rates are poorly understood.

THE GENETIC BASIS OF HIGH BLOOD PRESSURE

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Model systems are important tools for genetic research. The rat is one of the premier model systems for complex, polygenic diseases. Since all epidemiologically important human diseases belong to this category, the potential for major advances through genetic investigation is substantial.

Over the past years multiple chromosomal loci have been identified in rat models that contribute to blood pressure regulation and hypertension. Independent from elevated blood pressure additional genetic factors contribute to end organ damage and stroke in these animals.

To localize these disease genes within chromosomal regions linked to quantitative traits (e.g. blood pressure), multiple congenic rat strains have been established. These congenic strains are being developed by introgressing disease alleles encompassing the quantitative trait locus (QTL) into a non-affected reference strain by successive backcrossing and molecular analysis. This strategy allows the observation of the phenotypic effect and the genetic analysis of a single QTL. The combination of congenic experimentation with the development of subcongenic animals, with only a fraction of the initial congenic segment will allow the successive fine mapping within a QTL.

The mapping efforts of complex cardiovascular traits by congenic experimentation and positional cloning is used jointly with the establishment of gene expression signatures in target organs of congenic animals and their parental progenitors employing high density arrays of cDNA clones or gene-specific oligonucleotides. A combinatorial approach of positional cloning and expression profiling provides a powerful tool to identify positional candidate genes within chromosomal regions for genetically determined cardiovascular diseases.

In order to study the functional relevance of genes linked to hypertension and stroke transgenic rats are produced with alterations in the expression of these genes. The power of this technology has been demonstrated in several transgenic rat models with modifications in the renin-angiotensin system. Rats expressing the mouse renin-2 gene have helped to reveal the physiological functions of local renin-angiotensin systems in tissues. Furthermore, transgenic rats carrying the human renin and angiotensinogen genes are excellent models to study hypertension-induced end-organ damage particularly in the kidney. These animal models also serve to develop human specific therapeutics.

GENETIC DISTURBANCES AND INSTABILITIES IN BLOOD DYNAMICS

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Blood is a substance of special property, which could rapidly change aggregate state from liquid to solid under the external influences. Phase transition relevant to intravascular thrombi formation takes place as a result of activation of the cascade of chain biochemical reactions of blood coagulation. The most important substances of the blood coagulation cascade involve proteolytic enzymes known as a blood factors II – XII. Widely distributed disease Haemophilia A (B) and various thromboses are specified by mutations of the genes responsible for blood coagulation factors production. In such a case we are dealing with genetically determined disturbances of coagulation cascade under given hydrodynamic conditions. It seems to be important to investigate the hydrodynamic pathways of activation of intravascular blood coagulation resulting to infarction and insult.

Theoretical analysis of phase transitions in blood revealed that intravascular clot formation could occur as a result of destabilisation of the regulatory blood coagulation system by both genetic and hydrodynamic factors. Few discrete typical scenarios of blood destabilisation were found. Some of them were detected experimentally *in vitro*. Spatio-temporal scenarios of growing clots were classified into strictly determined groups. It have been demonstrated that sometimes it is possible to switch a development of the system from one scenario to another by an appropriate hydrodynamic influence. It becomes clear that spectra of macroscopic spatio-temporal phenomena being considered as discrete dynamic manifestations of genes activity might be treated in terms of non-equilibrium phase transition theory. Mathematical treatment of relevant instabilities and transitions is based on the stability analysis of complex kinetic mechanisms responsible for the blood coagulation dynamics.

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PRINCIPLE OF POLYVARIANCY FOR TEMPLATE PROCESSES

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Originally formal genetics became strictly materialistic and very specific science during the past century. The same process produced a lot of ambiguity in understanding of terms which had been previously introduced for qualitative description and quantitative definition of phaenomena and mechanisms of inheritance *vs* variation. Many genetic processes appeared to be strictly connected with each other, e.g. inheritance and variability, mutations and reproduction. It became evident now, that different types of variability overlap, though they had been originally considered as incompatible ones. A good example is overlap between inherent variability and modifications, when we consider ontogenetic variations. Curren problems in prion inheritance produced paradox of inherent modifications on the protein level etc.

N.V.Timofeev-Ressovsky was the first who realized this problem no matter whether intuitively or rationally. This understanding was expressed in 60-ies in his "Principle of convariant reduplication", which gethered reproduction, inheritance and mutability as a single process.

Following to this tradition of N.V.Timofeev-Ressovsky we proposed "Principle of polyvariancy for template processes" for description of the primary couses of variability. It is well known that template processes: replication, transcription and translation may be carried on by different variants of the same or by different enzymatic machinaries. The different enzymatic systems conducting the same template process are working with different specificity, different precision and with different processivity. This statement is illustrated for replication/repair process cousing variations in mutability. Transcription is also served by a variety of transcriptases with interchangeable components. The consequence of this polyvariancy in RNA synthesis is poorly characterized from the point of precision. Nevertheless it evidently effects specificity of transcription, predominantly responcible for adaptive modifications through mRNA composition of the cell. Umbiguity of translation is evidently connected with polyvariancy of translation apparatus, with the balance of its components. Phenotypic suppression give many examples of alternative reading of genetic code. This facts would be considered from the points of either noninherent variability or physiological norm of gene expression and norm of reaction expansion.

TRANSPOSABLE ELEMENTS AND HOST GENOME EVOLUTION

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The nature of the roles played by mobile elements in the evolution of their host genomes is assessed considering numerous recent developments in many areas of biology. It is argued that easy popular appellations such as "selfish DNA" and "junk DNA" are both inaccurate and misleading and that the most enlightened view of the transposable element-host relationship encompasses a continuum from extreme parasitism to mutualism or symbiosis. The position occupied by an individual element in this continuum may vary according to many factors such as the stage in the host-element life cycle, chance, and the identity of the host species. From a broad perspective, Tes are increasingly being viewed as important players in the ability of genomes to enhance their own evolution and as a major source of tools for generating the diversity to respond successfully to changes in environment. The emergence of such tools has been termed second order selection. The very properties that lead some to label TEs as "junk DNA" may have in fact provided genomes with a plasticity otherwise unavailable to them. Given the opportunistic nature of evolution and recent evidence that morphological change is primarily a result of changes in regulatory networks, it would be surprising indeed if a ready-made tool-kit for the generation of diversity was not periodically exploited by the host species. It is argued that the dynamic interplay of selection on transposable elements at various levels provides genomes with a broad and flexible capacity to evolve.

RADIATION BIOLOGY - GLORY OF THE PAST, CHANCES AND CHALLENGES OF THE FUTURE

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The experimental investigation of biological radiation effects and the early attempts of a quantitative mathematical interpretation paved the way to modern molecular biology and the first clear description of the gene concept by Timofeeff-Ressowsky, Delbrueck and Zimmer in 1935. A further milestone was the discovery of repair processes in a damaged genome and their genetic background. These seminal studies stimulated not only the development of techniques culminating in the "human gene project" but prompted also new physical approaches in radiation research as for instance the subdiscipline of "microdosimetry". The understanding of radiocarcinogenesis is still the great challenge but significant progress has already been made. Modern computational techniques are used to predict the formation of DNA lesions, linking radiation effects with the molecular structure of DNA. Radiation induced mutations can be analysed also at the molecular level giving new insights into the importance of the micro-pattern of energy deposition. New challenges have arisen: genomic instability, the understanding of genetically determined predisposition to radiation sensitivity and its significance for human health and the role of intercellular communication for the expression of biological radiation effects. Radiation biology thus does not only present itself as vital as when it started but it offers also unique possibilities to contribute to the understanding of the miracles of life and its evolution. The combination of modern physics and molecular biology makes it a unique example of interdisciplinary research.

The paper attempts to link the historical development with present days achievements to illustrate the great potentials of radiation biology and to demonstrate its significance for both the understanding of fundamental processes as well as for the practical needs for the protection of people and the environment.

MUTATION IN NATURAL POPULATIONS: 1925 - 2000 AND BEYOND

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Timofeev-Resovsky made two fundamental contribution into studying spontaneous mutation. In 1925, in order to test a hypothesis propesed by S. S. Chetverikov (which was published a year later) E. A. and N. V. Timofeev-Resovsky reported the results of a screening of wild-caught Drosophila for recessive visible mutations. A lot of such mutations were found. Several years later, Timofeev-Resovsky and co-workers discovered that mutations causing only mild changes in the phenotype are substantially more common than drastic mutations. These findings initiated two major lines of quantitative research concerned with spontaneous mutation: 1) studying mutations segregating in natural populations and 2) studying de novo spontaneous mutations.

Even today, we do not have enough data on either of these subjects. How many recessive lethals and drastic recessive mutations are hidden, as heterozygotes, within the diploid genome of an average human (or any other vertebrate)? What is the genomic rate of appearance of spontaneous de novo deleterious mutations? How many mildly deleterious mutations are fixed within natural populations due to mutational pressure and/or random drift? We do not yet know. I will review the latest results in this area.

RADIOBIOLOGICAL RESEARCH AT JINR ACCELERATORS

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The Joint Institute for Nuclear Research possesses unique accelerators which allow to obtain nuclei beams of different elements in a wide energy range. A variety of ionizing radiation sources makes it possible to conduct radiobiological studies whose urge is determined by a wide range of scientific and practical tasks. At JINR the radiobiological research concerns the solution of two main problems: the study of regularities and mechanisms of genetic action of ionizing radiation with different physical characteristics and the work out of new method of target therapy of cancerous diseases.

Radiation-genetic experiments using charged particles with different linear energy transfer (LET) are conducted at various types of bacteria, haploid and diploid yeast lines, mammalian celis in culture, human peripheral blood lymphocytes. The main task of this research is the determination of regularities and mechanisms of the formation of gene and structure mutations in pro- and eukaryote cells under the action of different LET radiation. Various strains of microorganisms (bacteria, yeast cells) are used to investigate the induction of gene mutations as they possess different capability to repair DNA damage. The regularities of the formation of eukaryote cells' structural mutations are studied at mammalian cells in culture and human peripheral blood lymphocytes. Stable chromosome aberrations in human lymphocytes are studied with the method of fluorescent hybridization in situ (FISH technique). It is shown by the results of the studies that biological effectiveness with different LET, based on the criterion of mutagenic action, is determined by the physical factor, connected with micro distribution of radiation energy in genetic structures, as well as by the biological factor, which refers to DNA damage repair. Moreover, the influence of the biological factor on the value of the biological effectiveness of radiation is dependent on LET.

The development of new methods of target radiotherapy of cancer is determined by the search of approaches in the treatment of man pigmented melanoma. A radionuclide complex is established at JINR on the basis of methylene blue and astatine-211 for the aimed radiotherapy of this type of cancer. Astatine-211 is a pure alpha radiator with the period of

half-life of 7.2 h. The mean energy of alpha particles is 6.8 MeV, the range in tissue is 65 mkm, LET in tissue is 70-160 keV/mkm. The experiments on the man pigmented melanoma cells, line BRO, showed that the lethal effectiveness of melanoma cells at the action of astatine-211 alpha-particles together with methylene blue exceeds the effectiveness of alpha irradiation in the ion form more than twenty times.

Prospects of radiobiological research at new JINR facilities are discussed in the report.

THEORY AND MODELS OF RADIOCAPACITY OF ECOSYSTEMS IN MODERN RADIOECOLOGY

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Korogodin Vladimir (Joint Institute of Nuclear Research, Dubna, Russia)

1. This report considers universal approach to ecosystems of different types, basing on representation of their radiocapacity. A concept of ecosystem includes reproduction of components (bioproductivity) and conditioning as maintaining of an environment quality. Radiocapacity in a case of a radionuclide pollution appears in accumulation and redistribution of radionuclides in the ecosystem. The radiocapacity is such maximum amount of radionuclides, which can be contained in given ecosystem, without breaking main trophic properties, i.e. productivity, conditioning and reliability. The models of radiocapacity estimation of water and terrestrial ecosystems are represented. The calculations of a radiocapacity factor of water ecosystems are performed and high factor radiocapacity of freshwater reservoir (F=0.6-0.8) and extreme high radiocapacity of cascade of reservoirs (F_c=0.99) is shown on the material of the Dnieper's cascade reservoirs. The methods of radiocapacity estimation of agroecosystems, wood and marine ecosystems are developed. The measure of radiocapacity and also factor of radiocapacity are convenient, universal and reflect main properties of ecosystems. Using mathematical means of stationary and dynamic models is rather simple and is suitable for ecosystems of any complexity. This approach allows to receive the important prognostic evaluations of quality and condition of ecosystems.

2. In this report the theory of radiocapacity of natural ecosystems (other than the mankind) is applied to the definition of ecological standards on the permissible releases in the environment. A concrete limit of radionuclide contamination of wild life, which can be considered as the basis of an ecological standardization (100-1000 kBq kg^{-1}) is proposed. Basic equations of evaluation of maximum permissible releases into a lake ecosystem have been determined. Ecological standards for benthos are 10 to 100 times less than the ecological standards for inhabitants of the water column. It is shown that, the existing levels of radionuclides contamination of terrestrial slope ecosystems in 30-km zone of Chernobyl Nuclear Power Plant (NPP) exceed the proposed ecological standards.

3. It was shown, that in conditions of noticeable at a physiological level effects on ecosystem as stress, suppression and/or depressing though of one species, it is necessary to expect an anticipating defeat of ecosystem and change in the values of the radiocapacity factors and radiocapacity of ecosystem as a whole. The strategy directed on preservation and/or increase the radiocapacity of ecosystem and the radiocapacity factors of composed biota species of ecosystem is an optimum method of ecological-ethnic management of the ecosystems. Thus well-being and viability of ecosystem testify to its high radiocapacity. To the contrary, high radiocapacity, and stable high values of the radiocapacity factors of ecosystem biota species testify to well-being and reliability of ecosystem. The control of radiocapacity and the radiocapacity factors and especially of their time changes and after effects can serve an objective anticipating criterion and method of an assessment of a well-being any ecosystems (water, continental, wood and marine ecosystems).

N.V.TIMOFEEV-RESOVSKI AND THE PRINCIPLES OF GENERAL BIOLOGY

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The general or the theoretical biology can not be created without formulating of main principles characteristic of all living objects. Such axiomas should follow from the physical laws. In 1982-84 I have proposed the system consisting of 5 axiomas which could be the base for all rules and tendencies of living nature. Here are there axiomas:

1. All living organisms posses phenotype and genotype (genetic hereditary programme) - the axioma by A.Weismann, A. von Neimann. 2. Genotypes (genetic programme) are transformed from generation to generation by matrix principle - the axioma by N.K.Koltsov. 3. During the transmission of hereditary information in generations it changes in an indirected, unpredicted way and may be adaptive or accidental - axioma by Ch.Darwin and N.V.Timofeev-Resovski. 4. During phenotype development these changes increase termodinamically in million times - the axioma by N.V.Timofeev-Resovski. 5. Such multipled changes of genotypes are the object of natural selection - the axioma by Ch.Darwin. Consequently, N.V.Timofeev-Resovski took a part in formulating of the third rule and proposed the fourth one, that solved in the case of living nature the Maxwell phenomenon's contradictions. This is why he should be mentioned among founders of the general or the theoretical biology like Weismann, Koltsov and Darwin.

CONVERSION AND RECOVERY OF CHROMOSOME DAMAGE

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Primary mutation damage may be undergone recovery or conversion at chromosome aberrations that is depended on of all from phase of cell cycle and processes of DNA repair and replication. The chromosome aberrations do not be homogeneous group. We gave the evidence that chromosome aberrations are to be divided into the exchanges and fragmentation of chromosome that is ground by the mechanisms of their formation. Under investigation of cells in G_2-phase was shown that the processes of formation of exchanges continued 4 hours on average and for some cells - 6 hours for various objects. There are received additional data on presence of the difference between various exchanges.

The chromosome fragmentation is more complicate group then exchanges. Sometimes the chromosome fragmentation is badly separated from gaps. The chromosome fragmentation aries already through 1 hour after impact of ionizing radiation. The specific inhibitors of DNA synthesis produce in mass fragmentation and pulverization of chromosomes if they force on cells in S-phase. The damage that arise under force of 5-fluorodeoxyuridine in G_2-phase can be recovered during 1 hour. This damage have converted only in chromosome fragmentation. However recovery from some damage which can be converted into fragmentation goes slowly. Ionizing radiation and alkylating agents cause such damage.

We described that the fragmentation has the trait of incompleteness.

At favorable conditions cells can completely are recovered from damage converting into chromosomal fragmentation, even if they are produced by ionizing radiation.

A chromosome fragmentation is a more variable component of number of aberrations then exchanges. Recovery of cells from chromosome aberrations takes place mainly at the expense of chromosome fragmentation recovery.

PERSPECTIVES OF RADIOCHEMOECOLOGY, BIOSPHERE-HUMANITY CO-EVOLUTION, AND THE SIGNIFICANCE OF ECO-ETHICS

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Nikolai W. Timofeeff-Ressovsky has formulated and developed fruitful pioneer work on 'Radiation biogeocenology' at the end of 1940th and in the beginnings of the 1950th in the USSR, and he has conducted pioneer studies on the use of radiotracers and ionising radiations in experimental genetics in Germany during the 1st half of the 20th century. Both initiatives have greatly influenced and advanced the fields of radioecology and radiochemoecology in the USSR/CIS in the 2nd half of the 20th century. Nikolai W. Timofeeff-Ressovsky has benefitted from international cooperation. He went to Denmark under the aegis of Niels Bohr in 1920th-1930th, while the Dane Asker Aarkrog went to Russia under the aegis of IUR in 1980th-1990th). For details see Aarkrog et al. :'Development of radioecology in East and West' (1996); Aarkrog et al. : invited paper at this Conference (2000).

According to Otto Kinne (1997), there is urgent need now for a critically re-assessment of the relationship between nature and humanity, and for investigating and defining priorities in biosphere-humanity co-evolution. Fundaments for addressing these problems were considered by Nikolai W. Timofeeff-Ressovsky (1968) in his teachings on mutual inter-influences and developments of the biosphere and the humanity. As biological species, we 'have achieved' a critical disequilibrium with basic ecological processes. In addition we are suffering from disballanced ideas and concepts, which tend to increasingly dominate the relationships between the growing number of nuclear powers. For radioecologists it has become time for joining our research efforts with those of colleagues working in adjacent fields of science.

It is extremely important to consider the complex problem of unifying radioecology and chemoecology by way of comparative equi-dosimetric assessments of the ecologically most sensitive effects influenced by physical (including ionising radiations), chemical and biological factors of contamination. We must futher elaborate on and develop radiochemoecological conceptual models. In March 2000 (Brussels) the IUR Board of Council decided to organise the Task Force 'AROC' (Application of Radioecology to Other Comtaminants), which directly relates to radiochemoecology (UIR Newsletter, No. 35, May

2000, p. 3). There are two approaches of AROC: 'Protection of Man', supervised by Gilbert Desmet, and 'Protection of Ecosystems', supervised by myself. Interest in AROC is already growing in Europe and Asia.

Employing the ' equivalent approach' in experiments and in conceptual modelling for the purpose of comparing the effects of nuclear and non-nuclear contaminants on ecosystems, we must develop a comparative theory of ecological equivalency of different kinds of deleterious substances and their impacts. Finally, it is necessary to replace the former (and still existing) 'antropocentric' approach of radiation protection by 'ecocentric radiation protection'. Progress in nuclear energy and nuclear weapons require more application of and support for radioecology; in turn, radioecology needs more emphasis on ecological ethics (Polikarpov, 2000).

I conceive 'co-evolution of biosphere and humanity' in terms of 'their mutual, interconnected evolution'. Every species co-evolves in context with changes in the biosphere. The biologically young species Homo sapiens (about 40 thousands years old) annihilated and survived all other species of the genus Homo and evolved into a new 'geological power' (Vladimir I. Vernadsky ,1965). Humanity more and more distorted nature's biogeochemicalcycles, replacing cycling processes by linear processes, proportional to the intensity of exploitation of natural resources, accumulation and disposal of wastes which are foreign to the nature. Originally a fully integrated ecosystem component, H. sapiens transformed into a potentially dangerous creature capable of bending ecosystem laws to its own advantage (Kinne ,1997 and Brochure of the Eco-Ethics International Union ,1998). In other words, the 'conflict co-evolution of biosphere and humanity' has been transformed into a 'confrontation co-evolution'.

There are two prospectives: either the ecosystem will annihilate its most dangerous component, transfering it into the sphere of paleontology, or H. sapiens will re-adjust to a life in harmony with the biosphere. Only in the latter case can our species expect to continue to exist in what I would call 'wise co-evolution'.

Radiochemoecology, as all other sciences devoted to the study of nature and her ecosystems, should adopt and apply principles of ecological ethics as outlined in the Brochure of the Eco-Ethics International Union (1998) and the Union's publication organ, the newly established international electronic journal 'Ethics in Science and Environmental Politics' (2000).

SELF-REPRODUCTION OF ASSEMBLES OF MACROMOLECULES: COMPARATIVE ANALYSIS OF A PROBLEM

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Macromolecular universal SYstems of SElf-Reproduction (SYSERs) exemplify the kernel structures of Molecular Genetic Regulatory Systems organization. The types of macromolecular assembles variously composed are being considered. Moreover, an ability of such an assemble to be the kernel of a system's stable organization is estimated. The following criteria were evaluated: a) template synthesis of macromolecules; b) enzymatic catalysis of molecular processes; c) the presence of a syser; d) upper boundaries restricting the size of coding macromolecules and limiting the "catastrophes" of mutational errors and other losses; e) requirements for dynamical, structural, and evolutionary stability of assembles. It was shown that (i) ribozyme-replicase may be the basis for an RNA-assemble organization for a short time period and under condition that the length of RNA fractions does not exceed that of a gene; (ii) syser RNA-protein may be the basis of organization of an assemble with the overall length up to RNA-virus genome; (iii) syser DNA-RNA-protein may serve as a basis of cellular organization with the huge reserves of evolutionary scenarios. The viruses, phages and cellular plasmids have no complete syser structures.

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INTERACTIVE STRUCTURE FORMATION IN BIOLOGICAL SYSTEMS

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The self-organized formation of structures can be observed on different levels of biological organization. Among the various examples are (i) the formation of aggregates, such as clusters of cells, gathering of insect species for group feeding, (ii) the formation of tracks for directed movement, such as the track pattern of gliding bacteria or the trail systems of ants for the common exploitation of food sources, (iii) the formation of coherent motion in an ensemble of individuals, such as swarms, flocks of birds or schools of fish.

The structure formation is in most of these cases based on some kind of local feedback interaction among the individuals (generally denoted as ``biological agents"). For instance, the agents are able to change their environment locally, i.e. by producing a chemical field, which in turn influences their further behavior. In terms of self-organization, this field plays the role of an order parameter which governs the structure formation. Other cases involve collective interaction via the coupling of a (time-dependent) mean-field parameter, which may account for swarming.

The talk will present different examples of interactive structure formation in biological systems both in terms of computer simulations and theoretical investigations. These are based on a particle-based model of collective interaction using coupled Langevin equations, while for the particle density Fokker-Planck equations are derived. We show how the emergence of structures among the agents can be understood as an interplay of local communication and global selection.

ASSESSMENT OF GENETIC RISK FROM HUMAN EXPOSURE TO RADIATION

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The evolution of views about the genetic risk of human exposure to radiation for the last 40 years is considered. The methodology of assessing the genetic risk of radiation exposure is based on the concept of "hitting the target" in development of which N.V. Timofeeff-Ressovsky has played an important role. To predict genetic risk posed by irradiation, the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has worked out direct and indirect methods of assessment, extrapolational, integral and populational criteria of risk analysis that together permit calculating the risk from human exposure on the basis of data obtained for mice. Laboratory mice are the main objects in studying radiation mutagenesis due to the fact that the data on the frequency of radiation-induced human mutations are rather scarce. The method of doubling dose based on the determination of a dose doubling the level of natural mutational process in humans is the main one used to predict the genetic risk.

Till 1972 the main model for assessing the genetic risk was the "human-mouse" model (the use of data on the spontaneous human variability and data on the frequency of induced mutations in mice). In the period from 1972 till 1974 the "mouse-mouse" model was intensively elaborated in many laboratories. This model was also used in this period by UNSCEAR experts to analyze the genetic risk from human irradiation. Recent achievements associated with the study of the molecular nature of many hereditary human diseases as well as the criticism of number fundamental principles of the "mouse-mouse" model for estimating the genetic risk on a new basis. The estimates of risk for the different classes of genetic diseases have been obtained using the doubling-dose method. The estimate of doubling dose used in the calculations is 1 Gy for low dose/chronic low-LET radiation conditions.

The work presents the estimates of genetic risk for the population and nuclear specialists exposed to radiation in some emergency radiation situations obtained on the basis of data of biological dosimetry with the use of the "human-mouse" model.

SPATIAL DYNAMICS OF CHROMOSOME CENTROMERIC LOCI IN CELL NUCLEUS AND STATE OF READINESS TO REPAIR DNA DOUBLE-STRANDED BREAKS (DBS)

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It is known that chromosome loci in spatial of the cell nucleus are subject to the movement. Displacement of this loci to the new position can reflect the change of both physiological and differentiation state of cells. Especially it is reflected to centromeric loci because the last, in particular for lymphoid cells, are colocalized with Ikaros complexes, which switches the transcription of genes. We set up hypothesis that above-mentioned movement is necessary for activation of repair genes and coming together of homologous DNA sequences aligned of different chains of homologous chromosomes in pre-starting process in cells for following DNA DSB repair. A simple model can account the validity of this hypothesis. Adaptive response (AR) reaction presents such model. As known AR has two stages. First stage of AR (FSAR) – influences of low (adapting) dose that most likely transfers the cells to the condition of readiness to DNA DSB repair. A mechanism of FSAR is unclear. In our studies (with I.V.Kuzmina, T.A.Talyzina, A.H.Salimov, A.V.Karpukhin) it was first show that adapting doses of γ- and X-radiation induce the directed movement of all centromeric loci from periphery toward the nucleus center in human G_0-lymphocytes. Using image analysis system and nonradioactive in situ hybridization we have show that 1q12 loci of homologous chromosome 1 which is disposed near nucleus membrane in normal cells, under the influence of adapting dose X-radiation (3-25 cGy) moves into the internal nucleus region and the distance between 1q12 of homologous chromosomes decreases. finishing of this movement by entry of normal lymphocytes into S_1-, G_2-stage of mitotic cycle. But in the last case cells can lose their basic function typical for differentiated resting cells. Therefore it may be assumed that under the chronic exposure of low doses the functional changes may be sustained for a long time and can finally bring some organic change, if it is involved a sufficient part of cells in FSAR. In this case we deal with nonstochastic effects and correspondingly with existence of the threshold which lies in range of low doses. A pathology that heppends due to non-repaired DSB is not unexpected if the displacement of genetic reason is absent in FSAR.

PHENOGENETICS OF GRAPTOLOID COLONIES

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A colony of planktic graptolites (graptoloids) is a clonal system integrated by physical continuity of zooids (= modules), which are subject to common morphogenetic control and share a common genotype. Graptoloid colonies display a distinct polar organization, expressed in a regular morphological gradient. This gradient may be explained by diffusion, over the long axis of the colony, of a morphogen produced by the founder-zooid. The gradient theory of the organization of the graptoloid colony has been supported by convincing comparative evidence. In accordance with the colony's polar organization, phylogenetic novelties are introduced from either its proximal or distant end. Further evolutionary changes in the colony, observed by generations of palaeontologists, involve both the progression (spreading) of a newly introduced character over a greater number of zooids and an increase in the degree of phenotypic manifestation of a given character. Forty years ago (Urbanek 1960-1966; I973) I suggested that the evolutionary changes in graptoloid colonies might be conveniently described by using the terms *expressivity* and *penetrance* introduced by Timofeeff-Ressovsky as early as 1931. While expressivity is a measure of the relative degree (severity) of the phenotypic manifestation, penetrance defines the percentage of individuals carrying the responsible gene and manifesting its effect (percentage of phenotypic effect). The application of Timofeeff-Resssovsky's classical studies on *vti* in *Drosofila* to graptoloid colonies was an audacious idea, indeed. Doing this, I proceeded from a simple assumption that the colony as a clone consisted of zooids with the same genotype. All zooids carry the same genes, but only in some individuals they are expressed phenotypically. Hence we can speak of incomplete penetrance of certain genetic factors. Progression of phylogenetic novelties may be interpreted as increasing penetrance of genetic factors. When all zooids express a given character at least to some degree, the colony features complete penetrance. From the above considerations emerges a clear picture of phenogenetics in graptoloid colonies. One should, however, remember that an increase in penetrance and that in expressivity are distinctly correlated and related to a definite spatial pattern. In other words, in the evolution of graptoloid colonies changes in penetrance and expressivity are functions of the gradient in the distribution of the morphogen which supplies positional information to the growing zooids.

RADIATION CATARACT: A STOCHASTIC EXPRESSION OF GENOTOXIC DAMAGE.

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The collective experience from the study of radiation action on biological systems leaves no doubt that ionizing radiation is highly genotoxic. That this is also true for lens cells, was demonstrated by increased sister chromatid exchange frequency and micronucleation in the epithelium. Both are universally accepted indicators of genomic instability and damage. There are several lines of evidence, which buttress the view that injury to the genome is the fundamental process in the development of radiation cataracts.

Our laboratory has been developing methodologies that would permit assaying for genotoxicity in individual lens epithelia. Despite some success in applying the sister chromatid exchange (SCE) technique, poor mitotic yields and necessary post-extraction manipulations severely limited its usefulness. However, an alternative cytogenetic tool, the micronucleus (MN) assay, a major method for determining relative mutagenicity *in vivo*, has been successfully adapted to the lens.

Micronucleation is the result of the failure of chromosomal fragments and/or of whole chromosomes to be included in the spindle directed segregation of the chromosomes during anaphase. While the cell is in telophase, the orphaned chromatin may be incorporated into one of the daughter nuclei or form independent, but much smaller, secondary nuclei called micronuclei (MNs). Clearly, MNs can arise from two primary causes: chromosomal breaks or spindle dysfunction.

Because the former usually involve acentric fragments, the resultant MNs tend to be smaller than those produced by spindle interference. They also would not contain the centromeric region easily detectable by the appropriate assays. On the other hand, the exclusion of entire chromosomes or groups of chromosomes (intimating damage to the spindle apparatus) typically results in larger MNs, each with one or more centromeres present. Thus, the MN test provides not only the means to assay for genotoxicity, but also can, potentially, identify the responsible agent as belonging to one of two classes of genotoxin, chromosome breakers (clastogens), of which ionizing radiation is an example, or spindle damaging agents (aneugens). The ability to distinguish the basis of the MN is very important when investigating populations wherein a multiplicity of confounders to the radiation effect

may be operative. The MN "test" in human blood has become the primary assay in two STEP (Science and Technology for Environmental Protection) research studies of the Commission of the European Communities. While blood cells have become the study tissue, *sine qua non*, other tissues have been exploited for this application. However, none offer the long-term radiation monitoring possibilities provided by the lens epithelium of the eye. In experimental studies MNs have been closely correlated to radiation dose. In human studies the longevity of MNs was found to be extraordinary and perhaps lifelong.

We have turned our attention to calibrating in humans the dose-response relationship between radiation and MN frequency. To do so we have expanded our studies to include the Chernobyl Liquidator population under the umbrella of the Ukrainian/American Chernobyl Ocular Study (UACOS). Lens epithelia removed during routine cataract surgery are recovered and fixed for later MN analyses. The study, which eventually will incorporate the data from 600 subjects, has just been initiated. Yet already there are tantalizing indications that the Lens MN Assay may prove to be a valuable biological indicator of radiation exposure. The assay itself and the results of the UACOS work will be discussed.

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MICROEVOLUTION AND POPULATION BIOLOGY

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DISORDERS IN THE THYMUS-DEPENDENT COMPARTMENT OF IMMUNE SYSTEM AFTER ACTION OF LOW DOSE IONIZING IRRADIATION

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It has been shown that ionizing radiation (especially in low doses) induces an increase of serum level of various natural autoantibodies. These antibodies in physiological concentrations do not rouse any negative effects but their increased concentrations can evoke some functional disorders. It may be assumed that the increase of natural autoantibody concentrations above physiological limit is a cause of some alterations, which are developed after the action of low dose ionizing radiation. Especially it concerns the disorders, which does not display clear dose-dependency. We observed increased level of autoantibodies reactive with thymic epithelial cells (TEC) in the participants of clearing-up procedures in the Chernobyl NPP ("liquidators"; doses of external irradiation of 10-49 mGy), inhabitants of regions polluted by radionuclides as a result of Chernobyl disaster (accumulated doses of internal irradiation reached 0.1-1.0 mGy) and the persons with experience of long-lasting professional contact with radionuclide preperations. These antibodies have dual specificity: they recognize N-acetyl-glucosaminyl residue of carbohydrates and peptide epitope of cytokeratines. They inhibit TEC proliferation and secretion of thymic hormones, alfa1-thymosine and thymulin in vitro. Repeated injections of purified antibody preparations to mice induce the decrease of thymic hormone level in their serum. The lowering of serum level of thymulin was observed in all above mentioned groups of persons; decrease of alfa1-thymosin level was observed only in the group of liquidators. The fall of thymic hormone level is characteristic of natural aging and decrease of their serum concentrations in the persons affected by the factors of Chernobyl disaster may be considered as manifestation of so-called "radiation-induced aging of immune system". The main consequence of the decrease of thymic hormone level is weakening of the functional activity of T cells. One of its display is the low prolifertive response of T cells on the action of mitogens and especially adhesion stimules. Thus, some disorders which are developed after action of low dose radiation can be explained by natural autoantibody accumulation above physiological limit. However the mechanisms of the autoantibody accumulation are unknown.

CLASSICISM AND CRYSIS IN RADIATION BIOLOGY

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The shift of intensity of radiobiological studies from effects resulting from large, damaging doses, to effects of small doses, which we observe during the last decade, is determined by the following three factors:

1. - Rather modest progress in the prophylactic and treatment of acute radiation disease, as well as tremendous decrease in the probability of the nuclear armed conflicts;

2. - Rather slight advance in radiation oncology irrespective of use of the wide spectrum of radiation sources and clinico-radiobiological approaches, including dose fractionation and radiomodyfying agents;

3. - Impetuous development of nuclear power industry accompanied by the tremendous increase of human contingents exposed to low level radiation, and unavoidable risk of the radiation incidents, even if their probability is utterly small.

The intensive studies at different levels of biological organization have resulted in the discovery of several new phenomena, sometimes operating in opposite direction (for example, an increase in effect of radiation per unit of the absorbed dose in the specific dose range, and radiation hormesis in the other dose range, etc.), which seem not to conform with the existing conceptions. There exist a wide range of data showing numerous effects of small doses at the molecular and cellular levels, which are considered as indicators of the damaging effects of radiation on the organism by many investigators. However, up to the present there are no convincing indications of such connection.

This situation has led some scientists to reason that we have to revise 'the radiobiological paradigm'. This has also resulted in aggravation of the 'panic' attitude of the society to radiation, which is nourished by unfair politicians and mass media. This groundless attitude is detrimental to the society.

The crisis which modern radiation biology is facing may be resolved on the grounds of classic ideas of N.V.Timofeev-Ressovsky. This will be illustrated in the lecture by the concrete scientific data collected in the methodologically correct experiments.

A REVIEW OF MODELS OF SELF-ORGANIZED CRITICALITY

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THE CURRENT STATE OF THE THEORY OF PHYLOCOENOGENESIS

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It was often doubted that the evolution of the biological communities (phylocoenogenesis), can be principally described in the same terms as the evolution of populations and taxa. However, this view is mainly a result of important conceptual puzzling about the theoretical backgrounds in evolutionary synecology.

The organic communities may be described with a number of complementary models regarding each some particular aspects of their organisation. The only model well suitable for evolutionary analysis represents the communities as the biocoenoses (i.e., the systems including the living organisms and the products of their activities but not any components of non-biological origin) integrated into a self-reproducing successional system which is the minimal evolutionary unit at the community level. The realised niches of populations are considered as the elementary structural units forming various functional blocs (e.g. the functional guilds, consortions, serial communities, etc.) within the successional system. The changes in configuration of the realised niches and their interrelations are the elementary phylocoenogenetic events comparable with the genetic mutations. Five basic types of such events can be recognized, including the esogenesis, speciogenesis, elision, invasion, and substitution of a niche.

Any elementary phylocoenogenetic event may induce a number of secondary effects within the system resulting in large-scale changes in its organisation. At this macroevolutionary level three modes of phylocoenogenesis are established, namely the phylocoenogenetic constructions (a self-organisation of the system with increasing co-adaptations between its components), destructions (a destruction of co-adaptative

interrelationships between the niches), and transformations (a combination of relatively small-scale destructions and constructions).

Though there are some important differences between the phylogenesis of taxa and phylocoenogenesis of communities, the both phenomena are fundamentally similar and can be regarded as special cases of biological evolution. At the same time, they differ principally from the processes called the evolution in natural sciences others than biology (e.g., the evolution of stars, rocks, or relief) which resemble rather the ontogenesis in the biological systems.

GENETICS

GLOBULAR STRUCTURE OF INTERPHASE CHROMOSOMES AND RADIATION INDUCED INTRACHANGES

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Intrachromosome exchange aberrations (intrachanges) following low as well as high-LET radiation exposure are studied on the basis of new modeling approach *(Radiats.Biol.Radioecol. 1999,v39,10-20).* Induction of intrachanges is considered in the framework of contact first-and-exchange mechanism with incorporation of information about interphase chromosome territory and computer simulation of charged particle tracks. Possible structures of human interphase chromosomes are studied by Monte-Carlo technique. A various globular states of interphase chromosomes are observed in computer simulation of flexible chain of chromosomal subunits (superdomains) with excluded volume. Exchange between damaged superdomains in the same chromosome is proposed to occur at a points of intrachromosome contacts with a finite probability p. For low LET radiation a high frequency of centric/acentric rings is predicted in globular chromosome compared with coiled one. The nonrandom distribution of intrachange breakpoints along the chromosome is observed in computer experiments for the globular chromosome in spite of the random induction of initial DNA damage by low LET radiation. For high-LET radiation, 100 keV/μm alpha particles, a dose dependencies for intrachanges, both intraarm and interarm, are computed for human chromosome 6. At given dose interstitial deletions are formed more frequently in globular than in coiled structure. It is shown that linear dose dependence for alpha particles intrachanges measured in human and rodent cells is obtained in computer simulation only for globular state of interphase chromosome.

GENETICS OF THE ANTIOXIDANT DEFENSE SYSTEMS IN THE CYANOBACTERIUM *SYNECHOCYSTIS* 6803

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The organisms possessing oxygenic photosynthesis have developed highly efficient systems for protection against oxidative stress, a complex injurious effect of the reactive oxygen species produced by endogenous mechanisms and various environmental factors. Cyanobacteria being similar to plants by many metabolic pathways are suitable model organisms for studying genetic control and molecular mechanisms of an adaptive response of the photosynthetic cells to oxidative stress. At least four genes encoding antioxidative enzymes can be identified in CyanoBase containing the complete sequence of the *Synechocystis* 6803 genome: *sodB* (Fe-superoxide dismutase), *gpxA* and *gpxB* (two glutathione peroxidases), and *katG* (catalase HPI). According to the experimental data obtained these genes are activated by oxidative stress inducing agents, such as hydrogen peroxide, amitrole and superoxide anion generator, paraquat (Pq). It has been shown that regulatory gene *prqR* encoding protein of TetR family of transcriptional repressors controls negatively its own expression and expression of three genes of antioxidative enzymes, *sodB*, *gpxB* and *katG*, and two genes, *norM* and *norP*, encoding putative Pq antiporters. Autorepression of the *prqR* gene is induced by Pq and coupled with derepression of *sodB* and *norP* genes in the wild type cells. Inactivation of the *prqR* gene either by insertion or by missence mutation L17Q impairing DNA-binding domain of PrqR protein results in resistance of the mutant cells to Pq. In the *prqR*L17Q mutant, transcription of closely linked and possibly co-transcribed genes *prqR* and *norM* is strongly elevated. Inactivation of the *norM* gene leads to the loss of Pq resistance in this mutant and the development of sensitivity to Pq in the wild type strain. Thus, the *prqR* gene encoding putative global redox-sensitive transcriptional regulator is involved in control of certain genes of oxidative stress response and Pq efflux systems in *Synechocystis* 6803.

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DNA LOOP ORGANIZATION AND RADIATION-INDUCED DNA FRAGMENTATION IN HUMAN LYMPHOCYTES

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DNA loop structure, immediate DNA fragmentation induced by γ-rays at doses up to 15 Gy and apoptotic DNA fragmentation was studied in human lymphocytes. Lymphocytes were either irradiated or treated with the topoisomerase II inhibitor etoposide. Morphological changes characteristic for apoptosis were determined with fluorescent microscopy. Fragmentation of DNA and DNA loops sizes were analyzed with pulsed field gel electrophoresis (PFGE). The genomic DNA was cleaved into DNA loops at the topo II mediated attachment points using short treatment of cells with etoposide. Most part of DNA in resting lymphocytes is organized into loops about 1 Mbp and longer, but loops of sizes down to 50 kbp were also observed. Directly after irradiation, DNA fragments of Mbp-size appeared. These fragments disappeared 3-6 h after irradiation. Whether the sizes of these fragments are randomly distributed after doses up to 3 Gy, when fragmentation is relatively weak, remains to be elucidated. After disappearance of the Mbp-fragments, apoptotic fragmentation with a distinct cut-off around 50 kbp appeared. A new PFGE protocol, simple and sensitive, was developed to analyze apoptotic fragmentation. With this protocol, the effects of doses 5 cGy and higher were detected and quantified. Similar apoptotic DNA fragmentation was also observed after treatment of cells with etoposide. All DNA was fragmented into the 50-kbp fragments at the final stages of apoptosis. During the whole course of apoptosis no high molecular weight fragments comparable with DNA loop sizes were observed. A sharp border between size distributions of DNA loops and apoptotic fragments was found. The pattern of apoptotic DNA fragmentation is not random and mechanisms for control of loop structure during apoptotic chromatin condensation may be involved. We suggest that distinctive 50-kbp fragment may be a unique unit both for DNA fragmentation during apoptosis and for chromatin condensation. The kinetics of secondary enzymatic DNA fragmentation should be taken into account in studies of repair of primary radiation-induced DNA breaks.

PHENOGENETICS OF MEIOSIS IN RYE, *SECALE CEREALE* L.

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Evolutionary conservative process of meiosis is controlled by hundreds of genes. Among them there are common cell division cycle genes and those specific for meiosis only. The genetic collection of rye *S.cereale* (2n=14) developed in Peterhof [1] provides good material for studying the expression of meiotic genes. Here, we discuss two types of meiotic mutations affecting the process of meiotic chromosome synapsis. Expression of these mutations was studied at the level of ultrastructure of cell nuclei. The mutations of both types affect the formation of the synaptonemal complexes (SCs) involved into chromosome pairing and chiasma formation during meiotic prophase I. Mutation ***mei6*** is of a minute type. It leads to local anomalies in the development of the proteinaceous lateral elements of SCs, namely to formation of unusual bars between the lateral elements of SC and protrusions of the lateral elements (underdeveloped bars, possibly) [2]. The mutation has 100% penetrance in three generations of self-pollinated mutant plants, and in average, 69% penetrance among the meiotic cells of the individual anthers. In all the cases, the mutant character has low expressivity: from 1-10 bars per complement of seven SCs in each meiotic cell. Indirect evidences indicate that ***mei6*** could be a slightly selective mutation. The series of mutations, ***sy2, sy6, sy7, sy8, sy10, sy19***, is found which lead to the loss of homology during chromosome synapsis and formation of partially heterologous SCs [3]. Two mutations, ***sy2*** and ***sy10***, are prooved to be non-allelic. Allelic relations of the others are under study. All the mutations decrease chiasmata number, inducing appearance of univalents at metaphase I and plant sterility. The mutations differ in their penetrance and expressivity at the cellular level. Examples of variable expressivity of the mutant alleles were found in the progenies of the individual heterozygous self-pollinated plants from the different plant families that indicate to the role of genotype factor in modification the mutant characters. Supported by RBRF, project ## 99-04-48182; 00-04-48522, and the Netherlands Research Centre (NWO), project # 047-006-008. [1]. Sosnikhina S.P. et al., Russ. J. Genet. 1994. 30: 1043-1056. [2] Bogdanov Yu.F. et al., Genome 1998. 41:284-288. [3] Fedotova Y.S. et al., Theor. Appl. Genet. 1994. 88:1029-1036.

THE EFFECT OF RADIOACTIVE IODINE ON HEN OFFSPRING

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The research work has been carried out with hens of Russian white breed and 6 generations of their progeny. The parental flock was divided into 4 experimental (163 birds) and 4 control (150 birds) groups. The experimental hens of groups 1, 2, 3 and 4 received iodine-131 orally for 30 days in equal quantitites at daily dosage of 0.15, 1.5, 3.1 or 7.4 MBk. The hens bred 3 or 12 months after the isotope administration. No any essential changes both in exterior attributes or behavioral reactions were seen in the 1st, 2nd, 3rd, 5th and 6th generations of the radioiodine-irradiated hens. Some abnormalities of head with frequency 0,75 % were detected in the 4th and 5th generations of hens that received daily 1,5 MBk of the isotope. The offspring of radioactive iodine-affected hens had decreased survival rates reciprocally dependent on the isotope doses that had been administered to the parents. The highest mortality rates among the progeny of the hens treated with 0.15, 1.5 or 3.1 MBk of iodine^{131} were observed within the first month of life. The progeny of hens that were orally given isotope at a daily dose 7.4 MBk daily, lacked survival and perished within the first two months of life. The factors for experimental offspring death were the diseases affecting gastro-intestinal tract, liver, heart or kidney. In the 1st, 2nd , 3rd and 4th generations aged 6 months or older, tumors were found in soft tissues at a frequency of 0,8-4,7 %, similar to reticulosarcoma in structure. Alterations in sexual composition of the experimental hen progeny was also registered, namely increase in female numbers. The experimental hen offsrping had decreased growth rates and weight gains. The offspring body weights lowered through generation sequence. Most of the generations had accelerated juvenile molts. Thyroid gland functional activity in the offspring of hens that had received iodine-131 at daily doses of 0.15 and 1.5 MBk was increased up to their sexual maturity, and was decreased within the following months up to 18-month age. The chickens from the hens that had received 3.1 and 7.4 MBk of radioactive iodine, differed in their lowered thyroid gland activity.

BASES OF CODING AND MANAGEMENT IN MOLECULAR BIOLOGY - I.

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An attempt of creating of general theory for molecular coding in biology is made in the work. Presence of a control and address information layer in DNA is shown. Technique for constructions of the control UBC is revealed and presented. Its role in providing of addressing and synchronization is shown. The minimal quantum of the control information, minimal and maximal size of the control file is calculated. A new way of representation and interpretation of the Universal Biochemical Code (UBC) is given. Is shown that the DNA sequences relate as inverse. Role of inversion in the control information layers for control and correction of DNA and mDNA is shown. We showed that both the whole DNA and the control layer are based on the binary information structure. Significance of the control layer for engineering and medicine is discussed. It is shown that the DNA is not a result of the evolutionary process. The work is illustrated with some examples.

HOMOLOGY-DEPENDENT LIGATION IS THE PATHWAY OF DNA DSB REPAIR IN YEAST DEFECTIVE IN *RAD55* OR *RAD57* GENE FUNCTIONS

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Mutations in *RAD55* or *RAD57* genes of yeast *Saccharomyces cerevisiae* reveal a novel recombinational mechanism of DNA double-strand break (DSB) repair – homology-dependent ligation. This mechanism results in plasmid DNA DSB rejoining without recovery of DNA double-strand gap (DSG) originally situated in DSB region. However it requires a presence in DSB region of the sequence homologous to chromosomal DNA.

It was found that cold-sensitive mutation *rad55-3* resulted in a significant reduction of preciseness of DSG repair under restrictive condition (23°C): full restoration of plasmid DSG was observed only in 5-7% of cells, whereas about 50% of cells carried the plasmids with full recovered DSG under permissive condition (36°C). In the case of cold-sensitive mutation *rad57-1*, a proportion of plasmids with full recovered DSG was similar (5-10%) under both permissive and restrictive conditions. In wild-type (*RAD*) cells, the general efficiency of plasmid DNA DSB or DSG repair was one order of magnitude higher in comparison with *rad55-3* or *rad57-1* cells. Furthermore, plasmid DNA repair in wild type was accompanied by restoration of DSG in more than 90% of cells.

Taken together, these results show that the defects of *RAD55* or *RAD57* genes result in sharp increase of contribution of the homology-dependent ligation, a minor alternative pathway of recombinational repair, to DNA DSB repair in *S.cerevisiae*.

THE INFLUENCE OF LOW-DOSE CHRONIC IRRADIATION ON REPRODUCTIVE PARAMETERS OF CIPRINUS CARPIO STRIPPED FISHES AND ON THE QUALITY OF THEIR PROGENY

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Up to now the questions on the threshold-free ionizing radiation impact and forms of dose curve in the range of low doses are disputable. At the same time the standards of radiation protection are based on interpretation of low dose radiation effects. Knowledge on peculiarities of low dose radiation impact on reproductive parameters of animals and human is particularly important, however their investigation is practically impossible due to some reasons in laboratory experiments in mice. The most suitable object for such investigations is Ciprinus carpio where it is possible to study fertilization process and to obtain an enormous quantity of germ cells, embryos and larvae under strictly controlled conditions during artificial incubation.

The values of reproductive parameters of pond carp stripped fishes as well as cytogenetic and morphological characteristics of their offspring at earlier developmental stages were found to depende on the radionuclide content in germ products of the stripped fishes (in hard roe – 48–157 Bq/kg, in milt roe – 133–281 Bq/kg) and on the absorbed dose rate from internal and external irradiation (from 4.7 to 5.4 μGy per day). Direct dependence between the values of cytogenetic and morphological parameters of carp fry and incorporated radionuclide concentration, and an increased radiation background was proved (the calculated absorbed dose from the external and internal irradiation was 0.4–5.5 μGy per day).

The data obtained demonstrate biological efficiency of extremely low doses of chronic irradiation for germ and somatic cells of fish and point to the absence of threshold. Genetic radiosensitivity of fish was revealed to be similar to that of mammals.

Significant biological effects of extremely low doses of chronic irradiation, great vagueness in low-dose response patterns for dose curves, and existence in some cases dose-response curves exhibiting a plateau effects cannot be satisfactorily accounted for by the target theory supplemented by availability of indirect effects. Elaboration of new theories for accounting for the above-stated phenomenon is required.

GENETIC BASIS OF RADIORESISTANCE (STRESS AS A LOADING)

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Problem of relative roles of genetic characteristics and environmental factors in the mammals radioresistance could be investigated at the base on the radiosensitivity' comparison of animals with the different genotypes similarity. Genotype input to the radioresistance is revealed with the interspecies and interlinear differences at the same radiation doses. Between-strain differences are considered to be determined mainly by genetic factors and those within a strain - by environmental ones. We analyzed the relative roles of genetic and environmental factors in the formation of mammal' radioresistance in inbred mice and outbred stock. One of the stress factor was sub-lethal doses of adrenaline during 10 days with the following acute total gamma-irradiation. The second stress factor was a long-termed hypothermia during 30 days, preceding the acute γ-irradiation in each line leading to equal effects ($LD_{50/30}$). 30-days observation period was used to determine lethality and death dates dispersion. Animals lethality in all experimental groups was higher but slightly (5-7%) as compared the control groups. It was found a synchronization of the post-irradiation death dates in all variants inbred mice (adrenaline and hypothermia). A comparison of dispersions by χ^2-test was significantly ($p<0.01$) lower than in the control. This phenomenon could be explained by the stress-caused "unification" of neuroendocrine and others systems functional interaction in inbred mice organisms, which originally possessed by the different functional states due to hierarchy in the artificial terrarium community. We assume also a presence of hidden genetic structurization of linear mice by radiosensitivity, which possibly displayed by epigenetic shifts. The variation of lethality distribution between the experimental and control outbred stock did not differed and registered during the month. It might be a result of their genetic heterogeneity. Thus we suppose that the stress as a functional loading "level off" the inbred mice with the different physiological states. These data enable us to conclude that the radioresistance depends upon mainly by genetic components and their realization during regular onthogenetic development (epigenetic shifts), but environmental factors modify organism' reaction on irradiation.

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PLEIOTROPIC EFFECT OF *ade1* AND *ade2* MUTATIONS IN YEAST *SACCHAROMYCES CEREVISIAE.*

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Recently we have developed a simple selection technique for spontaneous *ade1* and *ade2* mutations using yeast strains with a deletion in the *GCN4* gene encoding the transcription activator - the Gcn4p protein [1]. It is known that under conditions of both amino acid [2] and purine starvation induced by purine analogs [3] the Gcn4p-dependent activation of genes encoding enzymes participating in purine and amino acid biosynthesis in yeast *S. cerevisiae* occurs.

Now we studied the influence of *ade1* and *ade2* mutations (these mutations induce purine starvation) on expression of reporter genes *ADE1::lacZ, ADE2::lacZ* and *HIS4::lacZ.* Isogenic strains with leaky and non-leaky *ade1* and *ade2* mutations were obtained using the selective system that has been developed recently [1]. It was shown that *ade1* and *ade2* mutations in the strains both with *gcn4* deletion and normal allele of this gene, lead to changes in reporter genes expression. The repression level of reporter genes by exogenous purines is also changed. Such regulation evidently is caused by endogenous purine nucleotides disbalance: Gcn4p-dependent activation is caused by increase of uncharged tRNA concentration as a result of decrease of ATP concentration (since ATP is a substrate for aminoacyl-tRNA-synthetases). Changes of ATP and ADP concentrations lead to Gcn4p-independent regulation of expression probably by Bas1p and Bas2p proteins.

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INFLUENCE OF DNA REPAIR MECHANISMS ON THE GENE EXPRESSION OF IRRADIATED PEANUT CALLI CULTURE

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Damages induced by ionizing radiation on the DNA level are the most frequently studied in the mammalian cells and yeast. The level of damage in eukaryotic cells after irradiation depends on the dose, energy of γ-rays/particles used and dose rate. Removing of DNA damages (single and double strain breaks) is done with the multiprotein complex of repair mechanisms. The rate and quality of DNA reparations affect the gene expression and regulate input of cells to the division. Mistakes in DNA repair can lead from the point mutation to lessions with lethal effect. Oxygen radicals and ions originated along the particle (γ-quantum) track have complemented effects which can help to switch on apoptosis pathway.

Effect of ^{137}Cs γ-radiation doses (D = 1; 5; 10; 100 and 500 Gy) used on partially synchronized peanut calli cultures showed that gene expression when compared to untreated control was influenced immediately after irradiation. Quantitative content of soluble proteins was not changed linearly. Decrease in the protein content was noted in the interval of small doses D≤1Gy while for doses D≥100Gy was received its increase . Content of soluble proteins for all doses reached the level of untreated control at 28 days after irradiation (in the stationary growth phase). SDS-PAGE protein patterns showed that qualitative and quantitative content of proteins with Mr≥70kDa were depressed immediately after irradiation. Content of tubuline and actine sub-units was not renewed even twenty eight days after irradiation (stationary growth phase). De novo synthesized proteins with Mr ~ 16 and 24 kDa were appeared. Proteins from apoptosis pathway were synthesized at the end of lag-phase. Inhibition effect was very strong for dose D=500Gy. The exponential growth phase was not present for this dose. Necrosis spots in the calli and phenolic compounds in the culture medium were not detected. LD_{50} was ~250±50Gy. Protein patterns analyses as well as growth curve indicated that repair mechanisms were complemented by protection effect of exogenous growth factors and vitamins contained in the cultivation medium.

THE INHERITANCE OF DIFFERENT STRUCTURAL rDNA VARIANTS IN *BLATTELLA GERMANICA* CULTURE.

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It was shown that the Hind III restriction enzyme may be used for the analysis of the interspecies polymorphism in the *Blattella germanica* rDNA and it was demonstrated that variable restriction sites are located within NTS (nontranscribed spacer).

The Hind III rDNA polymorphism of three cockroach laboratory strains was analyzed. It was shown that the cockroach individuals from different laboratory strains may have similar Hind III rDNA patterns; at the same time the level of similarity within certain laboratory strain is higher then between strains. From our point of view, this is an important finding for the future analysis of natural cockroach populations. We propose that the Hind III restriction rDNA polymorphism may be used for measuring the genetic distances and for the analysis of the interactions between natural cockroach populations.

To analyze the inheritance of different structural rDNA variants, we conducted some individual crosses. The ribosomal gene cluster is known to be localized within the X chromosome in *Blattella germanica*; females have two X chromosome and males have a single X chromosome. Our data indicate that two chromosomes of the female parent differed one from another in the structure of rDNA repeats. It was analyzed the inheritance and evolution of the rDNA variants in mass *Blattella germanica* culture.

IONIZING RADIATION INFLUENCE ON THE ONTOGENESIS AND PHENETIC STRUCTURE OF NATURAL AND MODEL COLORADO BEETLE POPULATIONS

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Our research has sought to establish the potentialities of using phenetic and ontogenetical approaches to reveal the reaction of natural populations and laboratory groupings of the Colorado beetle to the ionizing radiation influence.

Natural populations have been studied in south-western Belarus (Brest region), where a number of districts have been under the influence of ionizing radiation since the catastrophe at Chernobyl Atomic Power Station. The phenetic peculiarities comparison of the samples from contaminated by radionuclydes and non-contaminated districts showed that the increase in radiation leads to the increase in frequency of rare colour elements and phenes with higher melanism degree.

The influence of γ-radiation on the ontogenesis and phenetic structure of the Colorado beetle has been studied in the laboratory conditions by means of irradiation of the procopulated females on the "Agat" unit by doses of 0.5; 1; 5 and 10 Gray. When irradiated by the minimum and maximum doses, the death-rate at the stage of ovum and larva in the experiment sample is lower than in the control one. Irradiation by doses of 1 and 5 Gray leads to an increase in the death-rate at these stages of the development. All the experiment samples show the shortening of the ovum and larva stages. At the imago stage the irradiated groupings show a far greater number of beetles with wing morphoses and hardened body. As well as in the natural populations there is observed an increase in frequency of rare elements and phenes with higher melanism degree.

The results of laboratory and natural investigations show that ionizing radiation increases phenetic variety, influences the ontogenesis and intensifies the process of the formation of melanin, which is known to be an effective radioprotector in living organisms and reflects vitally important physiological processes in the Colorado beetle.

CHECKPOINT CONTROL IN THE YEAST *SACCHAROMYCES* AND THE *SRM* GENES

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Eucaryotic cell growth normally assumes that the cell cycle events follow each other in a strict order. For instance, the events that are characteristic of mitosis may take place only after the S phase is completed. The mechanisms that regulate the cell division cycle and block the beginning of one of its steps before the previous one is not completed use the so-called checkpoints. These mechanisms ensure cell cycle arrest when cellular structures (e.g. hereditary ones) are damaged and their damage prevents the respective step of cell cycle from completion in time. The arrest gives a cell a chance of repairing its damaged hereditary structures and is expected to influence both the fidelity of mitotic transmission of these structures and the cell sensitivity to DNA damaging agents, e.g. ionizing radiation.

We have previously identified mutations of the nuclear *SRM* genes in the yeast *Saccharomyces cerevisiae* that led to coordinate changes in the fidelity of mitotic transmission of the nuclear and mitochondrial genetic structures. The cell mechanisms mediated by these genes are of undoubted interest. Mutations in the *SRM5/CDC28*, *SRM8/NET1*, and *SRM12/ADA1* genes have been shown to increase the cell sensitivity to ionizing radiation. Some data have also been obtained that suggested a role in checkpoint mechanisms of the p34 protein kinase encoded by the *SRM5/CDC28* gene. This idea was further tested in the present study. We also tried to make out whether the two other *SRM* genes, i.e. *SRM8* and *SRM12* are also involved in checkpoint control.

An analysis of i) interactions of the *srm5, srm8*, and *srm12* mutations with the *rad9*, *rad17*, *rad24*, and *rad53* mutations in the well-known checkpoint genes; ii) cell division arrest after UV irradiation of normal and *srm* mutant cell cultures synchronized at G_0 and G_1 phases of cell cycle and iii) effects of *srm* mutations on gamma-ray-induced G_2 arrest of cell cycle has clearly supported the idea of the *SRM5*, *SRM8*, and *SRM12* genes being involved in the DNA damage checkpoint. The *srm5*, *srm8*, *srm12* and *rad9* mutations most probably belong to the same epistasis group.

GENETIC EFFECTS OF ^{3}H-DECAY IN VARIOUS POSITIONS OF DNA: SOME THEORETICAL AND EXPERIMENTAL ASPECTS.

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A systematic study of mutagenic action of tritium (^{3}H) incorporated into DNA was started in the 1960s (1). There are at least 10 definite heavily exchangeable positions in DNA where ^{3}H incorporated instead of ^{1}H remains for a long time until its nuclear disintegration which is followed by β-particles emission /"radiation component"/ and daughter $^3He^+$ nuclear formation followed by a rearrangement of organic molecules /"transmutation component"/. The accepted theoretical scheme of molecular rearrangements after ^{3}H-decay predicts the formation of some important modified bases (MB): 5-hydroxymethyl-U; 6-hydroxy-T; 5-hydroxy-C; 6-hydroxy-C; 8-hydroxy(oxo)-A(G), which are interesting because: 1)similar MB form in DNA under the action both of ionizing radiation and of other oxidative agents and 2) for each of the above MB specific DNA glycosylases initiating base excision repair (BER) of DNA were discovered in the cells. Therefore, we find it promising to study the genetic effects of ^{3}H-decay using the E.coli strains defective in corresponding DNA-glycosylases. We have studied the induction of the forward c-mutations in extracellular λ*cI*857 phage due to the decay of ^{3}H incorporated into 7 different positions (2). It was shown that the mutagenic efficiencies Em (frequencies of c-mutations per one ^{3}H decay in phage genome) were different for all studied positions and were found to be in the range from $6 \cdot 10^{-6}$ to $6 \cdot 10^{-4}$ per decay. The induction of mutations was studied in more detail on phage labelled with 8-^{3}H-adenine, where principal products of transmutations were 8-oxo-A and high-mutagenic 8-oxo-G. Using the E.coli strains deficient in the DNA-glycosilases MutM(I), MutY(II) and in both MutY and MutM (III) we have found that the Em of ^{3}H-purines were 2.4-, 3.8- and 55-fold high in the (I), (II) and (III) mutants, respectivly, in comparison to the wild-type host. The obtained data suggest that the MutM and MutY DNA-glycosylases and particularly their cooperation play an important antimutagenic role in the repair of the damage of λ-phage caused by the ^{3}H-decay in position 8 of purine residues. It is suggested that BER is the principal way of the repair of DNA damage due to the decay of tritium incorporated in any other positions.

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THE ROLE OF THE YEAST *HSM3* GENE IN UV-INDUCED MUTAGENESIS.

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Mutation in the *HSM3* gene, controlling one of the mismatch repair pathways and acting in slowly dividing cells, increased the level both spontaneous and UV-induced mutations in the yeast *Saccharomyces cerevisiae*, but this mutation did not alter the sensitivity to the lethal action of UV-irradiation. Some mutations in the genes controlling three principal pathways of damaged DNA repair can alter the level of UV-induced mutations, and consequently, it is concluded that the products of these genes take part in UV-induced mutagenesis. To clarify the possible role of the *HSM3* gene in the control of UV-induced mutagenesis, we studied the interaction of the mutation *hsm3-1* with mutations blocking excision repair (*rad1, rad2, rad4* and *rad14*), error - prone repair (*rev3*) and recombination repair (*rad54*). For this purpose the frequency of appearance of UV-induced Ade^- mutations in 5 *ADE* loci was measured in the double mutants. UV-induced mutagenesis was completely blocked in the *hsm3 rev3,* showing epistasis between *rev3* and *hsm3* mutations. The *hsm3* also epistatically interacts with *rad54*. These data show that error-prone and recombination repair pathways supply substrates for the repair controlled by *HSM3* gene. The double mutants *rad1 hsm3* and *rad2 hsm3* are characterized by very high level of induced mutagenesis. To a lesser degree this effect is observed for the single *rad* mutants and double mutants *rad4 hsm3* and *rad14 hsm3*. On the basis of the data obtained, we developed a model for the appearance of mismatch bases in the process of the repair of UV-induced DNA damage and determined the role of *HSM3* gene in UV-induced mutagenesis.

ONTOGENETIC ASPECTS OF FLUCTUATING ASYMMETRY OF BILATERAL-SYMMETRIC STRUCTURES OF DROSOPHILA MELANOGASTER.

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The fluctuating asymmetry of eye-antennal and dorsum-mesothoracal imaginal disks and their derivatives at a larva stage of late third age and imago was studied, taking into account the sexual differences. With this purpose, at every fly the square of four imaginal disks was analyzed, the total calculation of number facet was carried out, the general area of a wing and its separate cells was measured, the level of correlative communications on 25 parameters of wing plate was traced. The series of morphological mutations of Drosophila were used for studying of influence of genotypical medium, where eye-antennal and wing disks (and their derivatives) represent itself as tissues - targets. The influence of level of fluctuating asymmetry of imaginal disks and their derivatives, such cytostatics as Mitomicinum C, Actinomycinum D, colchicine, series of chemical substances rendering influence on processes of a metabolism — acetamide, glutamic an acid, formic aldehyde on growth and development of Drosophila was investigated. Also, the influence of high and low temperature of cultivation was investigated.

The analysis of the square of 10 thousand of imaginal disks allows revealing the specificity of morphogenetic effect, both morphological mutations, and all set forth above factors. Nevertheless, both in the control group, and during experiments it was not revealed, as a rule, the high meanings of fluctuating asymmetry factor. At imago, the total calculation of facet number, the analysis of the square of a wing and its (imago) other parameters allows, alongside with high individual variability to reveal (depending on character of influence) the high level of fluctuating asymmetry.

It was made the conclusion, that the level of fluctuating asymmetry of bilateral-symmetric structures as a parameter of canalization degree of morphogenetic processes, is appreciably determined by processes of a determination and differentiation. The realization of these processes is carried out during a metamorphosis and, to a lesser degree, during larval development.

REARRANGEMENTS OF *C-RET* PROTOONCOGENE IN THE THYROID CANCER CELLS OF BELARUSSIAN PATIENS AFTER THE CHERNOBYL CATASTROPHE

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The incidence of thyroid cancer detected in children of Belarus increased to a great extent after the explosion of the Chernobyl atomic power station. In the present research we have investigated the frequency of *c-ret* protooncogene rearrangements in the thyroid cancer samples that were diagnosed in Belarussians in 1996 and 1998.

Postoperative samples of papillary carcinoma and histologically normal tissues were received from the Minsk oncological dispensary. These samples were used for the extraction of the total RNA and cDNA synthesis. The cDNA was used for the detection of two *c-ret* gene rearrangements: *ret*/PTC1 and *ret*/PTC3r1. For this purpose we conducted polymerase chain reaction with the primers specific for these types of rearrangements.

A great number of *c-ret* gene rearrangements was detected in the samples of thyroid cancer. 19% of thyroid cancers that were diagnosed in 1998 contained *ret*/PTC1 and 14% - *ret*/PTC3r1 rearrangements. For the cases diagnosed in 1996 the frequency was 29% and 7% respectively. Patients whose age at the moment of catastrophe ranged from 1 to 10 years contained far more *ret*/PTC1 rearrangements in contrast to those whose age was from 10 to 20 years. It was found for the papillary carcinomas diagnosed both in 1996 and 1998. We also found that the majority of patients who contained *ret*/PTC3r1 rearrangements lived in the Gomel region of Belarus. This region is contaminated by the radioactive fallout in the greatest extent.

PCR ASSAY OF DNA DAMAGE AND REPAIR AT THE TRANSCRIBED AND NON-TRANSCRIBED GENES IN TISSUES OF γ-IRRADIATED ANIMALS.

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The damage produced by γ -radiation in DNA of tissue cells of exposed animals was shown to block the polymerase chan reaction (PCR) with *Tth*-polymerase. This block was registered as a decrease in the level of amplification of the fragments of a transcribed gene (β -actin), an inducible gene (p53), and a non-transcribed one (IgE, heavy chain). For comparison, we used in PCR *in vitro* γ -irradiated DNA as well as DNA templates with UV-damage, 8- oxy-2'-deoxyguanosine (8-O-dG), and apurinic sites (AP-sites). It was shown that γ- and UV-irradiated DNA as well as DNA with AP-sites blocked *Tth*-polymerase in PCR, whereas 8-O-dG did not effect the level of PCR amplification of gene fragments. The most pronounced decrease in the amplification of the gene fragments was observed on the DNA template isolated from rats immediately after their γ -irradiation (13.2 Gy, ^{137}Cs-source). When DNA was isolated 0.5- 5.0 h after exposure, the amplification level was restored, no matter what transcription activity the genes possessed. According to our observations, the rates at which the lesions able to inhibit *Tth*-polymerase in PCR are eliminated from the actively transcribed β -actin gene and the inactive IgE gene are equal in brain- and spleen- DNA of γ -irradiated rats, that is, there was no preferential fast repair of lesions in the actively transcribed β -actin gene as compared to the non transcribed IgE gene. At the same time, comparative analysis of amplification data showed that the repair rates in the amplified gene fragments in brain DNA and spleen DNA differed significantly both during the first 0.5 h after irradiation and in the subsequent postirradiation period (up to 5 h). The data demonstrate that the DNA lesions induced by ionizing radiation in brain tissues are rather efficiently repaired at the level of these gene fragments. These results suggest that repair of ionizing radiation –induced DNA damage in the genome of mammalian cells does not occur preferentially in transcriptionally active DNA.

GENETIC EFFECT OF COMBINED EXPOSURE TO INCORPORATED ^{137}CS AND EXTERNAL GAMMA- RADIATION IN MICE.

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In emergency situations, such as the accident at the Chernobyl nuclear power station, living organism are simultaneously exposed to external and internal irradiations from various radioactive sources. The genetic effect of the combined action of radiation and other agents may depend on different biological factors and on the germ cell stage in particular.

The aim of this study has been to analyze the genetic effect of the combined action of ^{137}Cs β-radiation and external γ-radiation in germ cells of (CBA x 57Bl) F1 male mice. Cesium nitrite solution was given to males perorally with 3.7 x 10^4 Bq/g activity. The dose of external γ-irradiation made up 1.5 Gy. In the variant with combined exposure the animals received ^{137}Cs solution immediately after external irradiation. The genetic effect was estimated by the frequency of dominant lethal mutations (DLM) induced at different stages of spermatogenesis. To study the DLM frequency the males were mated after the exposure to untreated females during 6 weeks to study embryo mortality. It has been found that in exposed postmeiotic cells (the first three weeks of mating) the DLM frequency was practically the same upon combined and separately used external irradiation. In irradiated premeiotic cells (4-6th weeks of mating) the DLM level in the case of combined exposure considerably exceeded the total DLM frequency induced by separately used exposures. Thus, a synergistic interaction of external and internal irradiations was revealed in germ cells at early stages of spermatogenesis.

GENETICO-EPIDEMIOLOGICAL APPROACH TO DETECTION OF INDIVIDUAL RISK OF RADIO-INDUCED CANCER

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Genetic heterogeneity of irradiated population provides different sensitivity to radiation exposure and can result in biased estimate for risk of radioinduced cancer. Individual approach to risk assessment of radiogenic cancer is real with the help of moleculo-epidemiological methods introducing genetic and molecular levels of detection of biological parameters to epidemiological studies.

To clear up molecular-genetic mechanisms of predisposition to cancer (decrease level of DNA reparation synthesis, high level of endogenous mutation process, inheritance of suppressor genes) can make it possible groups with hereditary determination of onkodisease to be found out in genetically heterogeneous population. It is suggested that onkorisk in this cohort might be much more increased under exposure of chronic low-dose irradiation having mutagenic effect. However, population-based studies had not been conducted due to lack of enough information about irradiated population before Chernobyl nuclear accident.

The results of the first stage of genetic screening of breast cancer among women living on radio contaminated territory using genealogical analysis of families with supposed onkorisk will be presented.

COMPUTER MODELLING OF EVOLUTION OF POPULATION DYNAMICS OF MGE PATTERNS UNDER SELECTION OF THE QUANTITATIVE CHARACTER

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The computer model of population dynamics of the polygenic system of additive character and MGE pattern under directed truncation selection for this character was developed. It was shown, that MGE-modifiers were fastly and adaptively fixed (or lost) together with the modified polygenes, and MGE-markers and independent copies were fixed (or lost) so fast, but random. The method of specific labeling of all initial haploid genomes, was used to show, that under strong selection for quantitative character , controlled by polygenic system, and under high value of multiple progeny production in the finite population, the coefficient of nonsystematic inbreeding increased quickly up to the values of 0.7-0.9 for 15-20 generations. The adaptive homozygotization of polygenes and MGE-modifiers, and random homozygotization of MGE-markers and independent copies, and of all the other parts of genome, occured. These results grounded the hypothesis of the "pattern-champion" of polygenes, formulated earlier for explanation of results of selection-genetic experiments. The building of the trees of pattern similarity is convenient, approbated in the theory of molecular evolution, method of representation of their diversity, useful for quantitative estimates and comparisons. The method UPGMA was used. The trees of similarity of MGE patterns, and also of identity labels for consequent generations, were built. It was shown that under selection the diversity of these patterns dramatically decreased in the first generations; then up to 10 generation population is represented by one big "family"; and in the final (50-th) generation there is only one group of tightly related genotypes. The final united pattern-consensus contains of different blocks including the segments of common origin (common labels of identity), each of them containing the active allele of polygene modified by the MGE-copy.

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PERSPECTIVES OF MOLECULAR-GENETIC RESEARCHES ON THE BASIS OF THE KEPT GENETIC MATERIAL OF THE IRRADIATED PEOPLE.

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It was shown, that after 30-40 years increased level of chromosome aberrations is kept in genetic structures of somatic cells of exposed people. These markers of radiating influence are determined for the workers, who had chronic radiation in doses more than permissible doses. The integrity of DNA structure is provided by a complex of reparation system working at different stages of DNA functioning. However literary data testify to changes in realization of the genetic information. The preservation of structural violations characterizes a long condition of genome instability, therefore the mutation process in exposed organism can pass more intensive, than in the control and to be appeared at a different level of organization (cell, subsell, molecular levels). The modern molecular-genetic technologies are necessary for revealing molecular changes and damages of DNA structure, the possibilities of equipment which are accessible for small number of the research centers. The unique cohort of the workers of the first in the country PA Mayak nuclear enterprise is under observation in Branch N1 of State Research Center of Russian Federation. This unique cohort was exposed by chronic, predominant external gamma-radiation and internal irradiation from incorporated plutonium in doses exceeding permissible doses at the first years of start-up and becoming of the enterprise. Now average age of the workers has reached 70 years and there is a natural loss of probands. The system on creation of DNA Bank was developed for preservation of a unique genetic material of exposed workers. The basic stages of this system: attraction of the workers with reception of the informed consent on participation in research, questionnaire, reception of a biological material (blood), DNA extraction with definition of its quantitative and qualitative characteristics, statement on a long storage. Now DNA Bank contains some hundreds samples of a genetic material. Basic cohort of the people involved in creation of DNA Bank, is presented by the workers of PA Mayak (85 %). In this cohort 60 % of the people have begun to work at the first decade of start-up and becoming PA Mayak (1948-1958). According to the data of individual dose control the annual doses for 35 % of the people were below than permissible doses, and summary doses for the period of worker's activity was equal to 0,1-100 cGy. In 41 % of cases the annual doses were above than permissible doses, and summary doses for all professional experience was equal to 100-700 cGy. The opportunity of the further expansion of DNA Bank is present, and the work on its updating is carried out constantly.

DYNAMICS OF GENETIC PROCESSES IN CHRONICALLY IRRADIATED POPULATIONS OF SMALL MAMMALS

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Dynamics of mutation process, and genetic radioadaptation were studied in natural populations of bank vole (*Clethrionomys glareolus*) living in areas with different densities of contamination with Chernobyl radionuclides under chronic low-intensive irradiation (2–700 μGy/day).

Distinctive features of dynamics of radiation mutagenesis in populations of mammals were first shown (data of 1986–1996). In particular, a gradual rise in the frequencies of chromosome aberrations in somatic (bone marrow) cells was revealed by approximately 22nd irradiated generation of animals. The number of polyploid bone marrow cells increased from the 1st to the12^{th} generations and then decreased by the 22nd generation. The frequencies of embryonic lethality rose up to the 22nd irradiated generation of animals. An increase in mutation process in chronically irradiated populations can be caused by accumulation of genetic load and by an increase in genome instability.

At the same time, a formation of genetic radioresistance was revealed in studied populations at additional acute gamma-irradiation (10–400 cGy) of 21st–26nd animal generations (data of 1996–1998). Besides, a slight tendency for increase in genetic radioresistance was observed in these generations of animals.

According to our data, a rise in radioresistance of chronically irradiated populations could be related to the changes in functioning repair system and mechanisms of biological protection of tissues. So, functioning the repair system "adaptive response" was established in the 21st–24th post-accidental generations. Besides, very low frequencies of cells with cytogenetic injuries (micronuclei) was observed in peripheral blood of chronically irradiated animals in comparison with hematopoetic tissue (bone marrow). It can indicate the elimination of cells with cytogenetic damages and in this way demonstrate the efficiency of biological mechanisms of tissue protection against defective cells.

The data obtained point to oppositely directed processes in chronically irradiated populations during approximately 22 generations of animals: on the one hand, accumulation of genetic (mutation) load of populations and increasing in genetic instability, and on the other, formation of genetic radioadaptation. The frequencies of genetic damages in populations could be higher in the absence of radioadaptation.

SEX-LINKED MOLECULAR MARKERS IN *SALIX VIMINALIS* L.

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The molecular markers associated with sex in basket willow were searched by screening variations in a few full sib families with about 100 AFLP primer combinations. Combined sample of males and combined sample of females were compared each to other in studied families. Bulked segregation analysis revealed four AFLP fragments associated with sex in *Salix viminalis*. All four fragments showed the same patter: they were present in females and absent in males. This is also true for the sex-linked RAPD marker that was found earlier (Alström-Rapaport *et al.*, 1998) and it suggests that males differ from females by the absence of some chromosomal fragment or some chromosome. Strong evidence of this is provided by the fact that RFLP probes derived from two of the AFLP's (TA-CCG and AA-CAG) associated with sex produces specific to female bands in hybridization experiments. This was tested for randomly taken, non related individuals as well as for some of the families investigated in AFLP experiments and also for additional family that is not related to families - source of these probes. The pattern in *Salix viminalis* is therefore exactly the opposite to that observed in *Dioscorea tokoro* (Terauchi amd Kahl, 1998), *Asparagus* (Jiang and Sink, 1997; Reamon-Büttner et al., 1998), *Atrilex garrettii* (Ruas et al., 1998), *Actinidia chinensis* (Harvey et al., 1997), *Cannabis sativa* (Mandolino et al., 1999) and *Humulus lupulus* (Polley et al., 1997) where the AFLP/RAPD fragment was present in the male and absent in the female, but similar to that observed in *Pistacia vera* (Hormaza et al., 1994). In the first case it was known or could be concluded that the male was the heterogametic sex (XY) and the female the homogametic one (XX). This case can likely be ruled out in *Salix viminalis*. Possibly the data indicate the presence of heterogametic female as in *Fragaria elateria* where the female is WZ and the male WW.

EXPERIMENTAL MUTAGENESIS FOR SEA-BUCKTHORN *(HIPPOPHAE RHAMNOIDES L.)* BREEDING.

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According to the data of FAO/IAEA, more than 1200 plant varieties were bred on a base of induced mutants during the last decades. About a half of those varieties were obtained through direct reproduction of induced mutants with a following selection, while for others various combinations of crossings were used with mutants participation. Sea-buckthorn is a unique plant due to its biological characters and various practical applying. The investigations on its experimental mutagenesis started in 1959. The program of the study in sea-buckthorn goals: a) to analyse the sensitivity to ionizing radiation and chemical mutagenes; b) to work out the methods of mutation identification in M1; c)to analyse the induced mutations frequencies and spectrum in M1; d) to reveal the possible ways of induced mutants applying for breeding purposes. Sea-buckthorn is considered to be a radioresistant species. The ability to produce progenies by seed reproduction is kept by the seeds collected in Altai wild populations after ?-rays treating in dose of 100 kR. Our researches in sea-buckthorn have affirmed it, that experimental mutagenesis can extremely accelerate the process of new varieties breeding through widening the range of characters variability and appearing the new valuable traits being very rare in natural conditions. The seeds of wild Altai sea-buckthorn were irradiated by ?-rays in dose of 15 kR with the following treating of selected M1 seedlings by 0,01% nitrosomethylurea. Then the initial forms for mutagene treatment were selected again in M2. As a result the mutant forms №120 and №118 (Zyryanka variaty) have been created. Later a range of varieties has been originated on a base of those prominent genotypes. All the varieties (Druzhina, Podrugha, Zolotoy Kaskad, Ivushcka, Ognistaya, Zarnitsa, Krasny Fakel) possess such valuable traits as large delicious fruits; high yield; high content of vitamins and other biologically active substances; long fruit-stalks; low thornness. The variety Zyryanka and others obtained on its base became widespread for both commercial and individual gardening of different regions of the country. The history of sea-buckthorn breeding demonstrates the abilities of experimental mutagenesis to be far from exhausted.

EVOLUTION BY GENE FUSION: THE AIR CARBOXYLASE, ENCODED BY THE *ADE2* GENE IN YEAST *SACCHAROMYCES CEREVISIAE*, IS A TWO-DOMAIN, BIFUNCTIONAL PROTEIN.

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The fungal aminoimidazole-ribonucleotide (AIR) carboxylase catalyzes step 6 in the pathway for *de novo* purine nucleotide synthesis. Previously we have supposed that this enzyme contains two functional domains [1]. High-level expression of the *ADE2* was achieved in *S. cerevisiae*, which enabled the production and purification of AIR carboxylase. Biochemical assays and mutational analyses indicate that the enzyme is a two-domain, bifunctional protein. The N-terminal domain (K) is related to *E. coli* PurK [2] and a series of kinetic experiments show that the K domain activity uses AIR, ATP, and HCO_3^- as substrates. The biosynthetic product of the K domain reaction was identified as N^5-carboxy-AIR, thus confirming that the C-terminal domain contains a catalytic activity similar to that of the *E. coli* PurE. The mechanisms of CO_2-stimulation of some *ade1* and *ade2* yeast mutants are discussed. According to recent discoveries, AIR carboxylase from *Cryptococcus neoformans* possesses similar properties [3]. Evolution of the AIR carboxylase from bacterium to man is discussed.

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VARIABILITY OF AP-PCR DNA FINGERPRINTS IN THE PROGENY OF MALE MICE EXPOSED TO LOW-LEVEL γ -RADIATION

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By assaying the polymorphism of multilocus PCR fingerprints generated on genomic DNA templates with the use of arbitrary primers (AP-PCR method), the possibility for arising of genomic instability in somatic cells of the progeny (F_1 generation) of male mice exposed to low-level chronic gamma-irradiation was investigated. Males BALB/c mice were irradiated with γ-rays (^{137}Cs) at the doses of 10 cGy, 25 cGy, and 50 cGy at a dose rate of 1 cGy/day. Fifteen days after completion of irradiation, males were mated with unirradiated females. DNA was isolated from biopsies taken from tail tips of male mice before and after irradiation, of unirradiated females and of two-month old offspring. AP-PCRs were carried out with 17 primers representing core sequences of micro- and/or minisatellites or their flanking oligonucleotides. Best quantitatively reproduced AP-PCR fingerprints of genomic DNA were obtained by using of a 20-mer oligonucleotide flanking the microsatellite locus Atplb2 near p53 gene on mouse chromosome 11. In order to analyze AP-PCR fingerprints obtained for a variety of mice individuals, we created a computer program essentially facilitating the comparative analysis of variability of discrete bands. The assessment of the average number of bands in DNA fingerprints per animal in a group demonstrated an increase in AP-PCR product number by 30% and 50% in the progeny of males irradiated with 25 cGy and 50 cGy, as compared to the control consequently. Comparative analysis of individual AP-PCR fingerprints from the progeny of irradiated and intact males revealed as an increased variability of microsatellite-associated sequences as an increased frequency of «non-parental bands» (from 12 to 37%) in DNA fingerprints from the progeny of males irradiated with 10 cGy and 25 cGy (at the postmeiotic stage of spermatogenesis) 15 days before conception. The results of the present study indicate the possibility for alterations increasing genomic instability to be transmitted from male parents exposed to low-level gamma radiation prior to mating to the somatic cells of the progeny. This work was partially supported by the Russian Foundation for Basic Research (Grant 97-04-48243).

INDUCTION OF MOBILE GENETIC ELEMENT (MGE) TRANSPOSITIONS BY STRESS FACTORS

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The phenomenon of transposition induction by heavy heat shock (HHS) was studied. Males of a Drosophila isogenic line with a mutation in the major gene *radius incompletus (ri)* were treated by heavy heat shock (HHS: 37°C for 1 h followed by 4°C for 1 h, with the cycle repeated three times) and crossed to untreated females of the same line. The males were crossed 5 days after heat shock, and also 9 days after HHS. Many transpositions were seen in the F_1 larvae by *in situ* hybridization. The rate of induced transposition was at least two orders of magnitude greater than that of the control sample, and was estimated to be 0.11 events per MGE-copy per sperm. Two "hot" subdivisions for transpositions, induced probably during postmeiotic stage of spermiogenesis, were found: 43B and 97DE; 3/4 of all transpositions were localized in these positions. In other sites the rates of induced transpositions were (1.3-3.2) $\times 10^{-2}$ events per occupied segment per sperm, one order of magnitude greater than those of the control. Similar phenomena of induction were revealed after separate treatment by heat and cold shock on the different stages of spermatogenesis, by γ-irradiation, by some genetic crosses – inbreeding, outbreeding, isogenization, etc. This stress-induced transpositions produced the new source of regulatory variability of the genes and polygenes in Drosophila.

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POPULATION DYNAMICS OF THE PATTERNS OF MOBILE GENETIC ELEMENT (MGE) LOCALIZATION: RESPONSE TO SELECTION *vs.* GENETIC DRIFT

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An isogenic line of *Drosophila melanogaster* was subjected to selection in the (+)- and (-)-directions for the quantitative trait (the total length of two fragments of the wing interrupted radial vein, *radius incompletus*) after heavy heat shock (HHS). Directional selection was inefficient in the control group not treated with HHS, but was highly efficient in experimental group, the offspring of males that responded to HHS by induction of MGE transpositions. This was taken to mean that HHS, being a nonmutagenic agent, induced genetic variability in the quantitative trait through transpositions and excisions of MGE copies. The variability was more plausibly due to "mild" modification of polygene expression by copies of adjacent MGEs. Selection for the quantitative trait was associated with altered MGE *412* location pattern in the genome of an isogenic line of *Drosophila melanogaster*. In a population of effective size N_e = 160, individuals subjected to strong truncation selection for 50 generations, of 35 polymorphic (HHS-induced) location segments of MGEs, 26 behaved as independent copies and markers, 9 as selective copies. **43B** and **97DE**, among other "hot" segments of HHS-induced transpositions, were referred to the latter group. Thus, the final consensus pattern of induced transpositions of MGE in the *F50** generation of (+)- and (-)-selection had a random and an adaptive components. Among the latter, there probably occurred modifier MGEs creating induced genetic, regulatory variability in polygenes of the selected quantitative trait in the isogenic line after HHS. The genomic system of MGE is suggested to participate in evolutionary reconstruction of Molecular Genetic Regulatory Systems.

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RADIATION RESISTANCE OF *ESCHERICHIA COLI* DEPENDS ON THE *cspA* GENE ENCODING THE MAIN COLD SHOCK PROTEIN

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CspA was originally found as the major cold-shock protein in *Escherichia coli*. Its dramatic but transient induction upon cold shock is regulated at the level of transcription, mRNA stability and translation. CspA may facilitate translation by acting as an RNA chaperone to block the formation of secondary structures in mRNAs. Furthermore, being relevant for radiation resistance, RecA, DNA gyrase α-subunit, Hsc66 and H-NS are induced two to 10 times upon cold shock. The role of CspA in radiation resistance has not yet been investigated.

Influence of two mutant alleles of *cspA* gene, encoding the main cold shock protein CspA, on sensitivity of *Escherichia coli* cells to lethal effects of radiation was studied. Plasmid pCspA::Km carrying a cloned allele *cspA*::Km (insertion of kanamycin resistance cassette Km^r from Tn903 transposon in the middle of *cspA* coding sequence) enhances 2.3-fold γ-radiation resistance of wild-type ($cspA^+$) cells. This protective effect of pCspA::Km is abolished or drastically reduced in *recA13* and *rpoH15* mutants deficient in RecA protein or in induction of heat-shock regulon. Plasmid pCspA::Km elevates 1.3-fold the levels of γ-radiation resistance in two *E.coli* mutants having an intermediate γ-ray-resistance (Gam^r445 and KS0160) but slightly diminishes radiation resistance of a highly radiation-resistant Gam^r444 mutant. The same *cspA*::Km mutation in homozygotic state on the *E.coli* chromosome enhances resistance of cells with normal DNA repair systems to lethal effects both of γ-rays and UV light (2.9- and 1.4-fold correspondingly). Deletion *ΔcspA* increases 2.3-fold sensitivity to γ-rays in a strain $recBC^-sbcCD^-$, i.e. on the RecF-pathway of repair.

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COMPARISION OF DOSE-RESPONSE FOR DICENTRICS AND TRANSLOCATIONS AFTER IN VIVO AND IN VITRO IRRADIATION OF HUMAN LYMPHOCYTES.

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The objectives of study were to compare in vivo and in vitro dose responses for stable and unstable chromosome exchanges detected by FISH and FPG methods in lymphocytes of cancer patients undergoing protracted whole body irradiation at low doses before local radiotherapy at high doses. The study was performed on 5 patients with advanced cancer and distant metastases, exposed to 90Co gamma-rays at a single dose 10 cGy each day up to total dose of 50 cGy. Blood was collected prior whole body irradiation and after each exposure. Blood sampled before patient treatment was irradiated in vitro at the dose range 8-40 cGy. FISH analysis was performed using 1, 4 and 8 chromosome specific DNA probes together with pancentromeric probe. The dose-responses for both translocations and dicentrics induced in vivo and in vitro followed a linear function. No difference between in vivo and in vitro response was observed for translocations. The yield of dicentrics estimated by both methods increased significantly faster with the dose in lymphocytes irradiated in vitro as compared to those irradiated in vivo. Thus when for dose reconstruction the individual frequency of dicentrics is refereed to in vitro calibration dose-response curve the real amount of absorbed radiation in case of protracted exposure is likely to be underestimated. In contrast translocations being independent on the regimen of irradiation seem to be more adequate end point for early as well as for retrospective biodosimetry based on in vitro dose-response calibration curve. The yield of translocations was found to be higher than the yield of dicentrics in lymphocytes irradiated in vivo.

MUTATIONAL PROCESS AND GENE POOL OF NATURAL POPULATIONS OF *DROSOPHILA MELANOGASTER*

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A question on the constancy or fluctuation of mutation occurrence frequency during the species life-time is a principal one for understanding the genetic basis of evolution. The data on more than a half of a century monitoring of gene pool of natural populations of *Drosophila melanogaster*, obtained in the Laboratory of Populations of IC&G SB RAS, together with the results of the previous research in the same regions of the former USSR, demonstrate that the bursts of mutability are enough regular events in the life-time of *Drosophila melanogaster* species. It was established that the bursts could be local or could quickly span through numerous geographically remote populations, by causing a phenomenon denoted as "fashion for mutation". This phenomenon means that for a short period of time, practically in synchronism, the mutation spreads in many geographically remote populations. The bursts may concern separate loci or a group of genes with similar phenotypical realization. In particular, the following bursts were registered and studied: two bursts in the *yellow* gene, the global one in 30-40-ties and the local one – in 80-ties; the global burst of mutability in the *singed* gene in 1973-1979; and the burst in different genes with the similar phenotype abnormal abdomen. The bursts are of temporal character, and after 7-11 years, they damp out. There was fixed the repeated burst or "repeat of the fashion for mutation" in the *yellow* gene. The bursts of mutations are accompanied by appearance of unstable alleles. Perhaps, mutability bursts are caused by periodical activation of mobile elements in genome. Which processes launch activation, what is the reason of their regularity, how does synchronization (distribution) of these processes go on in geographically remote populations, what causes site-specificity of mobile elements insertion? The answers may be only preliminary.

RADIOBIOLOGY

RADIATION RISKS AND CONFUSIONS

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The dealing with the so-called „linear no-threshold hypothesis", dating from the thirties, has clearly come to a head. According to the famous publication from Timofeeff-Ressovsky, Zimmer and Delbrück 1935 "no minimale or threshold (*subliminal*) dose of irradiation can be expected and therefore the curve of dose-proportion can be extrapolated to zero.

Refering to the questions (1) about the nature of the radiation-induced mutations and (2) about the contribution of naturally ionizing radiation to the spontaneous rate of mutation it was concluded in this publication, that a far reaching parallelism exists between these both kinds of mutations, but the naturally ionizing radiation is by far to small for generating the spontaneous rate of mutation.

At that time there was no reason to ask whether or not the naturally induced rate of mutation could be in competition with the spontaneous mutation-rate. This situation changed in the course of making progress in the investigation of the DNA-double-helix and the discovery of the repair gens in the fifties and sixties. The latter ones realize an effective control and maintenance process of the DNA-integrity. Latest assumptions are that these processes become active in human cells ten-thousand times per hour.

The growing understanding of mechanisms of the maligne transformation of cells, caused by mutations in different genes and not only in a single gene, gave room to ask more intense the above mentioned question. In the light of the extremly high rate of spontaneous events in the DNA and also the intensive activity of DNA repair the question of limiting interactions between spontaneous and radiation induced events in the DNA, including maligne cell-transformations appears to be not unjustified. The chairman of the ICRP, Roger H. Clarke, sets against this consideration, that only a few and defined spontaneous events in the DNA are resulting in a maligne cell-transformation, consequently their limitations by naturally induced mutations seem to be unlikely.

The rational angle of this dealing is intelligible. It's based on gaps in the findings. Its irrational widespread angle is however nourished by disproportionalities in the presentation of safe knowledge and still existing gaps. This problem will be subject of the report.

RBE-LET RELATIONSHIP FOR CELL INACTIVATION AND UNREPAIRED CHROMATIN LESIONS

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The LET dependence of relative biological effectiveness defind as a ratio of initial slopes of survival curves (RBE_{max}) may be predicted in the framework of the biophysical hypothesis. Inactivation efficiency per unit dose is suggested to be determined by the microdistribution of complex DNA and chromatin lesions following a passage of single charged particle track. To explore this proposal the computer modeling technique is described to simulate a pattern of DNA double strand breaks (dsbs) clusters nonrandomly induced by tracks of different LET in higher-order chromatin structures. To include a role of damage processing, a model of dsbs repair in clusters is proposed. Rejoining of individual dsbs within the cluster is considered as a single repair event. Unrejoining of several dsbs in a cluster results in unrepaired chromatin lesion (break). Model suggests that slower repair kinetics observed after high-LET radiation is being a manifestation of dsbs clustering. The correlation of RBE data with calculated incidence of multiple unrepaired chromatin lesions is demonstrated for a wide range of particles LET. On this basis a possible explanation of different RBE_{max}-LET relationships for radioresistant and radiosensitive cells with different repair capacity is proposed.

SYNCHROTRON RADIATION IMPLEMENTATION IN BIOLOGY

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Synchrotron radiation (SR) has a number of unique properties which allow us to use it to successfully investigate phenomenon important in biology and medicine. The wavelength in the range 0.7 - 1000 Å in the SR spectrum is of particular interest. SR has high intensity, sharp coherence and high degree of polarization making it a unique tool for structure investigations of biological objects [1-5].

In the Laboratory of Radiation Biophysics and Biosensors at the Yerevan Physics Institute (YerPhI) in Armenia, there is much experience in SR implementation for structural [6-10] and radiobiological [11-15] investigations of biological objects using the 4 GeV synchrotron ARUS since 1974. Investigations of different biological objects such as enzymes, aminoacids with the use of EXAFS, EPR, and roentgenostructural analysis methods, have been conducted. The atomic short-range order of Copper-Albumin protein complexes in the freeze-dried form has been investigated by EPR and EXAFS spectroscopy using SR. The superhyperfine structure of EPR spectra of these complexes testifies to the fact, that the copper atom is surrounded by four ligand atoms of nitrogen. Especially very interesting results were obtained on the action of SR on the virus of Tabaco Seeds [11] allowing us to understand how to study other viruses. Our theoretical investigations show that SR can be used for obtaining information about the enzyme's active center structure, which is further used to modify the active centers.

The important aspect of studying enzymes with SR is its effect on fermentative reaction kinetics, namely enzymes' transition from Michaelis-Menten kinetics regime to the cooperative regime. This circumstance may have a wide practical implication in the field of manufacturing and application of biosensors. We have also conducted theoretical studies on effects of SR for investigating the binding of ions and ligands with the DNA. In particular quite important is the understanding of the binding mechanism of platinum complexes and porphyrine with the DNA in collaboration with other research centers. The mentioned ligands

possess very important anticancer activity properties. Investigation with the help of SR allows to determine the exact place of the binding of the above-mentioned ligands with the DNA. These investigations will have a wide practical application in medicine.

The metabolic pathways and intermediate products formed during nitroaromatic compound destroying by aerobic bacteria are in progress at YerPhI [16]. It is planned to isolate highly active mutants from wild types of bacteria. A well known way of producing mutant organisms is the irradiation of cells by diverse types of ionizing radiation. According to previous results, SR is a more powerful and effective tool for mutagenesis than traditional X- and UV-irradiation sources. It is proposed to perform the study of enzymes and enzyme-substrate complexes involved in above mentioned metabolic processes using SR.

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THE EXPRESSION OF SOMATIC CELLS MUTATION IN CHILDREN OF DIFFERENT MONITORING COHORTS AFTER RADIATION INFLUENCE

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One consider mutagenesis and cancerogenesis the most serious effects of radiation influence. Radiosensitivity in children is high because of the activity of cell`s growth, absence and immatureness of regulatory and protectuve mechanisms, immunologic tension. The peroxydation`s intension after radiation influence causes the activity of protective and recovering processes in organism. Genetic particularities and deepness of peroxydatic stress definite these processes. The chronic influence of low-doses radiation increases the risk of free-radical and genomic damage, those lead to disadaptation and following after radiation-induced pathology.

While having compared the results of investigation in different children`s cohorts of somatic mutation`s levels, it occurred that the mostly high they were in those who had been born in 1990-1995 (in comparison with those who had been born early). Probably it was so as the result of the following facts: mothers of those children had been living in the regions of radiation contamination for the most long period; they had been pregnant also in the same conditions. There were particularities of that period, when the role of internal radiation influence increased. One can suppose that the summa equivalent doses in those women-mothers were rather high. In the chain of somatic mutations in those children groups we observed mostly rings, translocations and delations. We must point our the fact that the maximum changes have get children, those mothers were teen-agers at the moment of Chernobyl accident (it was one of the most radiosensitive perods in ontogenesis).

The expression of mutation process is a characteristic feature of genomic unstability that can be the base for radiation-induced pathology.

BYSTANDER EFFECT AND GENOMIC INSTABILITY – CHALLENGING THE CLASSIC PARADIGM OF RADIOBIOLOGY

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Until recently, it has been commonly accepted that the biological consequences following radiation exposure are attributable to direct DNA damage. According to this paradigm, DNA damage occurs during or very shortly after irradiation of the nuclei in targeted cells, and the potential for biological consequences can be expressed within one or two cell generations (Grosovsky 1999). Some evidence has now emerged that challenges the classical effects resulting from targeted damage to DNA. These effects have also been termed "non-targeted" and include bystander effects and radiation-induced genomic instability. The essential feature of "non-targeted" effects is that they are particularly important at low doses. The radiation-induced bystander effect is a phenomenon whereby cellular damage (sister chromatid exchanges, chromosome aberrations, micronucleation, transformation, gene expression) is expressed in unirradiated neighbouring cells near to an irradiated cell or cells. Radiation-induced genomic instability is defined as a persistent elevation in the rate of *de novo* appearance of genetic changes (mutations, chromosome aberrations and micronuclei) within a clonal population.

There is as yet no evidence that the bystander effect persists for many generations. On the other hand, it was reported (Lorimore, Kadhim et al. 1998) that persistent genomic instability can be induced via a bystander mechanism. It demonstrates that the initial cross-section for radiation damage could be increased by the bystander effect, and cells that are affected by the bystander mechanism may remain at an increased risk of genetic change for many generations. The mechanism of bystander effect is not known yet. However, there is evidence that the bystander effect may have at least two separate pathways for the transfer of damage from irradiated cells to unirradiated neighbours: through gap junctions (Azzam, de Toledo et al. 1998) or by cell culture mediated factors. The second mechanism of the bystander effect proposed is mediation by secretion of factors into the culture medium (Mothersill and Seymour 1997). The bystander effect does not demonstrate a linear

relationship to dose (Michael, Belyakov et al. 1999). It is maximally induced by very low doses, suggesting a switch on/off mechanism for its activation.

The main aim of our project is to investigate the mechanisms involved in the bystander effect and how it contributes to instability, after low dose microbeam irradiation in normal human urothelial cell lines and primary explants.

The Gray Laboratory charged particle microbeam (Folkard, Vojnovic et al. 1997; Folkard, Vojnovic et al. 1997) technique is a powerful tool for investigating mechanisms of genomic instability and bystander effects. It allows us to irradiate single cells with a precise number of particles. We have recently found direct evidence for the bystander effect in normal human fibroblasts by targeting individual cells with $^{3}He^{2+}$ particles (Prise, Belyakov et al. 1998). These pilot results prompted us to use an *in vivo* like, ureter and bladder primary explant technique (Mothersill 1998). The ureter and bladder primary explant technique enable us to study bystander effects and genomic instability under *in vivo* like conditions where stem and differentiated cells are present. Results of our experiments, with targeting of single cells in the explant's outgrowth and tissue sample irradiation, demonstrated a significant bystander effect measured as an increased fraction of damaged (apoptotic and micronucleated) cells (Belyakov, Folkard et al. 2000).

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GENOME DAMAGE AT CONSTANT HUMAN EXPOSURE TO LOW DOSES RADIATION

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The purpose of this study was to identify the influence of continuos permanent low intensity irradiation on the human peripheral blood lymphocytes genome indices in conditions of residence in the 30 km Chernobyl NPP exclusion zone. Studied were the frequencies of HPRT mutations, micronuclei, unstable and stable (G-staining) chromosomal aberrations in the blood of 33 individuals residing in zone villages, with the level of soil contamination with ^{137}Cs and ^{90}Sr being 2-13 Ci/km^2 and 0,9 –7,8 Ci/km^2, respectively. Reconstructed self-settlers effective whole body irradiation doses are: 19,5 – 626,2 mSv. Residents of Yagotin district, Kiev region (soil contamination with Cs < 5 Ci/km^2), and the city of Kiev were evaluated for comparison. The groups were formed to match age, sex and smoking status of the self-settlers. Zone residents mean group indices are significantly higher than spontaneous frequencies in the comparison groups. Frequency of chromosomal aberrations increases due not only to the radiation markers but also to chromatid type aberrations. Ratio between chromosome and chromatid types aberrations is similar to that for the clean region group. Also revealed was the significant increase in the micronuclei frequency, the latter being formed mainly from fragments. This testifies to the significant role of non-specific reactions in genome destabilization in the condition of low dose rate irradiation of the body. Frequency of the non-stable exchanges in self-settlers lymphocytes is 0.33 % at 0.09 % in the control, two thirds of exchanges being accompanied by fragments. Stable radiation markers were identified in all the self-settlers. Ratio between symmetrical and asymmetrical exchanges is 3:1. In some individuals cells with several exchange aberrations were found, and two individuals each had one multiaberrant cell with 8 and 12 aberrations. Repeated studies revealed the trend to damage accumulation in self-settlers lymphocytes. Younger individuals showed higher radiosensitivity. Analysis of correlation between the frequency of self-settlers genome damage with density of radionuclid contamination of the area and irradiation doses revealed relationship only between micronuclei frequency and the red bone marrow dose (ρ=0,65, *p-0,05*). Absence of correlation between other indices studied is due to their high individualized variability which might be determined by different individualized reparative ability and rate of damaged cells elimination, unequal distribution of the irradiation dose in time.

MUTAGENIC ACTION OF RADIATION WITH BROAD REGION OF LET ON BACTERIAL CELLS

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The mutagenic effect of different types of radiations (gamma-rays and heavy ions) on various strands of *E.coli* and *B.subtilis* cells has been studied. The induction of point and deletion mutations was analyzed. It was shown that effectiveness of helium ions with LET 22-78 keV/mm to induce point mutations is greater than that of gamma-rays. Further increase of LET leads to decreasing mutation rates. The dependence of the mutation rate on the dose of radiation can be described by linear-quadratic function. The coefficient of relative biological effectiveness (RBE) as a function of LET is described by the curve with a local maximum. The maximum of RBE was found under ~20 keV/mm.

The induction of deletion mutations in *E.coli* cells was studied after gamma- and heavy ion irradiation. The test system is based on the definition of mutations in both flanking genes: *tonB* (the stability of cells to infection by phage the *φ80vir* and to the action colicins) and trp (auxotroph on tryptophane). It is shown, that in range 26-260 Gy, the frequency of formation of induced deletions will increase linearly with an exposure dose, while the kinetics of an induction of genetical changes is featured by nonlinear function. It can testify that the different mechanisms are involved in the formation of gene and structural mutations.

Taking into account the important role of SOS system in radiation mutagenesis the new test system SOS-lux test was used for measurement of the SOS response in bacterial cells after irradiation. The induction of the SOS-response was assayed by monitoring bioluminescence in E.coli cells carrying the multicopy plasmid pPLS1. This plasmid contains a promoter less Luciferase operon of the luminescent bacterium Photobacterium Leiognathi under the control of the SOS-promoter of the cda gene responsible for colicin D production. Gamma?rays and heavy ions gave positive response in bioluminescent assay. The SOSIP coefficient as a function of LET increase with growing of LET up to 40-60 keV/mm. It is reflects the important role of complex DNA lesions in radiation mutagenesis in bacteria.

THE DISTANT EFFECTS OF IRRADIATION ON TREES' SPECIES

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We have been investigating the cytogenetic effects of irradiation on forest trees species, such as Pinus sylvestris and Quercus robur, from 1986 on some areas of Russia, Belarus and Ukraine suffered after Chernobyl Accident. Among oak seed progeny which had been formed under conditions of highest gamma-background in 1986 many different mitotic disturbances took place in some plantlets, which may be considered as consequence of sharp irradiation, such for example as kariopycnosis, karyomixis, agglutination, fragmentation and pulverisation of chromosomes. Their frequency reached to 30 %. For next years we have observed in survived seedling, which were planted on clear area in Voronezh region, the significant decreasing of the frequency of mitotic disturbances and their spectrum was not so dangerous . The bridges and lagging chromosomes were the more common types of mitotic disturbances in such seedlings and also persistent nucleoli during all stages of mitotic division took place very quickly. In oak seed progeny, which maternal trees grow in the village Stary Kurlak (Voronezh region), where in 1986 the soil contamination by Cs-137 was (3 Ku/km^2) and to 1996 – 1998 the level of contamination dropped to 0,07 – 0,74 Ku/km^2 we could observe that the number of mitotic cells on the stages of metaphase , anaphase and telophase was increasing as compared with control and the bridges were prevaling type of mitotic disturbances . On one of the test areas, where in 1996 the contamination was the highest (0,74 Ku/km^2) , the frequency of mitotic abnormalities was 8,4±1,6 % and on the other – the frequency of such abnormalities was not different from control. In seed progeny of Pinus sylvestris from Bryansk region in 1996 we observed many micronuclei and such unusual disturbances as like-amitotic figures. We consider that it may be the result of synergic effects of low doses of irradiation and chemical pollution from exhausted gases of motor transport, because the maternal trees grew near the big highway. We observed also some like-amitotic figures and micronuclei in pine seed progeny from village Repijevka (Voronezh region) in 1998. However the common frequency of mitotic disturbances in this progeny was lower (2,8±0,7 %) and the mitotic index was higher (12,1±0,6 %) as compared with control , apparently due soil contamination by Cs-137.

THE EFFECT OF GAMMA RADIATION ON THE REPRODUCTIVE POTENTIAL OF EGYPTIAN COTTON LEAF WORM

(*Spodoptera littoralis* Bois.)

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S. littoralis Bois. is a harmful insect on cotton in the Mediterranean region of Turkey.

For sterilization of insect in pupa stage ^{60}Co gamma rays were used.

45 Gy for males and 30 Gy for females were found as sterility doses.

Sterile male ratio in F_1 generation was higher than that of their parents irradiated with 30 Gy of gamma radiation which is substerility dose. But fertility came to normal in F_2 males.

F_1 sterility is recommended for the control of *S. littoralis* because lower radiation doses causes less somatic demage.

Mediterranean region of Turkey is under the risk of contamination from the middle east countries. Therefore, it is not seem to be possible complete eradication of *S. littoralis* from the region, but it can be controlled by this method.

CLINICAL-CYTOGENETIC STRATEGY FOR IDENTIFICATION OF RADIATION INDUCED LEUKEMIAS ON RADIONUCLIDE CONTAMINATED AREAS.

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It was developed 255 cases of acute myeloid leukemias for subjects of three groups: 1-secondary leukemias after radio- or chime therapy; 2-residents of radiation contaminated areas after Chernobyl accident; 3-subjects with no contacts with radiation.

The analysis of the study of first group allows us to notice a number of indications mostly specific for induced leukemias. They are 1) high frequency of low-percent leukemias (66,6% of all cases, 100% than if radial therapy was the only inducing factor); 2) high frequency of clone abnormalities of chromosomes 5 and 7 in bone marrow (monosomias and deletions of long shoulder) - 67,7% of all cases; 3)high level of stable chromosome aberrations in blood lymphocytes (more than 8,2 / 100 cells). If all three indications are found, it allows us to classify a leukemia as radiation induced with high probability.

The comparison analysis of leukemias of subjects groups 2 and 3 was not reveal any statistic significant differences between these groups. The frequency of 5 and 7 chromosomes abnormalities notification in leukemia clone of bone marrow was 4,2% (for subjects with no radiation contacts – 5,3%).

The frequency of stable chromosome aberrations interdepended from the area of residence. For radionuclide contaminated areas it was 5,27±1,22 / 100 cells so it is significantly higher than the controlled level (0,81±0,15 / 100 cells). However, it was no significant difference between the frequencies of stable chromosome aberrations between healthy subjects and leukemia subjects habitants of contaminated areas. From all developed cases there was no any with all three indications of induced leukemia. The carried out analysis of comparatively small group of leukemias is not imply the absence of radiation induced leukemias on contaminated areas as a result of Chernobyl accident, there is watchout of their further identification. We propose to use investigated approach for future studies.

DATA ANALYSIS AND MODELLING RADIATION EFFECTS OF LOW DOSES

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Quite a number of observations made after the Chernobyl accident has forced to consider application of probability theory and mathematical statistics in a new fashion and to begin the search for mathematical apparatus and models more adequate to experimental material.

One of the possible ways in this trend can be an original method of "six classes" (Kvitko, Perepetskaya, 1991) complementary to the conventional statistical analysis of experiments results of which have different direction of deviations (on "plus" and "minus" sides). The method developed for analysing weak effects of magnetic field can be used for analysing weak effects of chronic low-dose ionizing radiation impact following the Chernobyl accident.

In the case of large complex systems a single means for getting information on existing interactions can turn out a formalized cybernetic approach based on the principles of information theory (Dromashko, Frenkel, Dubovskoy, 1995). Quite a number of radiobiological problems is associated with the analysis of experimental findings represented by the sole realization. Application of a standard apparatus of mathematical statistics, based on the supposition of validity of the hypothesis on general population, results in this case in trivial conclusion on unreliability of the data obtained due to their small number. Only exceeding the bounds of statistics concepts and applying representations of information theory founded on another methodological basis make it possible to approach the analysis of such data, moving from a formal analysis to understanding of the mechanisms of the described phenomena, though devoid of direct clearness.

CHANGES OF LYMPHOCYTE MECHANOLUMINESCENCE UNDER THE EFFECT OF LOW-LEVER IONIZING RADIATION

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Ionizing radiation exerts a significant influence on lymphocyte mechanoluminescence (ML) Peripheral blood lymphocytes (PBL) possess high radiosensitivity dependent on the stage of the cell cycle, and this paper presents a comparative investigation of the features of ML during various stages of the PBL cell cycle in rats after irradiation with low-level dose of ionizing radiation.

We conducted studies of PBL on 50 unbred male rats weighing 140 ± 20 g. Lymphocytes were resuspended in 0.2 mL of 0.9 % NaCl solution at the concentration of 10^6 cells/mL. Chromosomal aberration was determined 4 h before the end of the culture. We used ^{60}Co irradiation at the dose rate of 0.75 Gy/min. The values of absorbed dose were 0.25 and 1 Gy, due to radiosensitivity of lymphocytes. ML of lymphocytes was measured by film AM-1 (Svema, Ukraine) in a device, comprising a tribogenerator quartz glass (8KY-1) which had a coefficient of passage in the range of 200 - 650 nm.

We observed that the ML of non-irradiated PBL had characteristic features in five stages of the cellular cycle. The effects of ionizing radiation in the in vitro experiments resulted in alterations in PBL ML. When the dose of lymphocyte irradiation was increased from 0.25 to 1.0 Gy the intensity of PBL ML during cell incubation significantly decreased (6-fold). The dose dependence was also observed in stage G_2. We also observed a significant increase in the frequency of chromosomal aberration (by 4 and 12%) in G_2 stage after irradiation at 0.25 and 1 Gy, respectively. We found changes in the kinetic parameters of ML from isolated PBL MT related to the dose of lymphocyte gamma-irradiation. When the dose of PBL irradiation was increased from 0.25 to 1.0 Gy the concentration of ATP measured by the bioluminescent technique was reduced. We suggest that depending on the dose the effects of low-level ionizing radiation result in distortions of DNA structure and a significant increase in cellular chromosomal aberrations. In its turn this influences mechanoemission processes in the chromosomal DNA, modulating the ML parameters from lymphocyte surfaces. Generally, our studies also suggest of the pioneering work of Timoffeff-Ressovsky that the absence of a minimum dose below which mutations were not observed.

ABOUT THE FEATURES OF BIOEFFECTS OF ONE KIND OF NONIONIZING RADIATIONS

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The investigations of effects caused by infra-red low-energy laser radiation (IR LLR) in insects still considerably lag behind a general level of the development of nonionizing radiations radiobiology. The investigations have been carried out on Drosophila melanogaster of several genotypes. The following equipment was used: ALT "УЗОР" and "УЗОР-2К", biophotometer "УНИК-01". It's established, that doses $7.122 \cdot 10^{-4}$ (genotype yellow; f = 300 Hz, I = 1.3 Wt, T = 32 s), $1.899 \cdot 10^{-4}$ (genotype ebony; f =80 Hz, I = 1.3 Wt, T = 32 s) and $1.140 \cdot 10^{-2}$ J/cm^2 (genotype vestigial, f = 600 Hz, I = 1.3 Wt, T = 256 s) cause optimum fertility stimulation. In these and many other cases the small energy doses were effective enough. For genotypes yellow, ebony and vestigial the natural change of character of IR LLR bioeffects shown at a fitness characteristics level has been revealed. It is rather well coordinated to the theoretical model of the mechanism of LLR bioefficiency, offered by V.Ye. Kuzmitchyov, G.V.Tchernova and M.A. Kaplan (1996). However, in some cases an extended site of stimulating and inhibiting effect absence has been revealed distinctly after a descending shoulder of bell-shaped site on the curves "dose - effect". Hence, in these cases the change of LLR bioeffects looks as follows: absence of effect - increase of stimulating effect - optimum stimulating effect - decrease of stimulating effect to zero - absence of effects (plateau at the level of control figures) - increase of inhibiting effect. While males were irradiated 2 optima of stimulation were usually found out. For the dose of $1.37 \cdot 10^{-1}$ J/cm^2 (f = 800 Hz, I = 3.2 Wt, T = 600 s) the increase of the yield of sex-linked lethals was established up to 2.08 %. The yield of sex-linked semilethals was kept at the control figures level. The comparison of the bioeffective absorbed doses for different genotypes has been made on the basis of measurement of basic biophotometrical bioobject characteristics. Thus more essential differences (up to 20 times) of absorption coefficients have been revealed for the imago of several genotypes in comparison with other individual development stages. The received results have both theoretical and practical importance (for example, for applied entomology).

THE MECHANISMS OF CYTOGENETIC ABERRATIONS INDUCTION IN *TRADESCANTIA* (CLON 02) STAMEN HAIR CELLS BY LOW DOZES OF CHRONICAL γ-IRRADIATION. THE PROBLEM OF REESTABLISHMENT OF DOZE DEPENDENCE «DOZE-EFFECT» FORM.

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The empiric base of the evaluation of genetic risk of low doses irradiation consists the data of radiobiological experiments. The theoretic base must be established on a dose-dependence model, by means of which they carry out the extrapolation to inaccessible for immediately observation field. In natural conditions animal's and plant's populations are under action of various doses, and because of it in the most of interest is the exploration of «dose-effect» dependence where dose is the function of radiation intensity. The *Tradescantia* plants were irradiated by ^{226}Ra source with various dose power. After the 72-hour exposition the doses came to significancies of 0.02, 0.11, 0.25, 0.91, 2.22, 5.49, 9.1, 26.74, 42.24 cGy. During the 30-days period the somatic mutations (SM) and the loss of reproductive ability (LRA) of stamen hair cells using the agried-upon method (Underbrink et al.,1973) were registered. The obtained data analysis revealed the similar for SM and LRA dose sections (0.02 — 0.91; 2.22 — 9.10; 26.74 — 42.24 cGy) where the mechanisms of cytogenetic aberration's ratio substantially differ. On the basis of the data and on the comparison of various doses effectiveness it might be concluded that the observing dose-dependence effect is the result of bistable mechanisms of cell's activity transition to another function regime in some specific doses intervals. The results of regression analysis show that though the dependence of SM and LRA from radiation intensity in all explored dose interval satisfactorily described by linear function it is inapplicable in 0.01 — 0.91 cGy range and in limits of 2.22 — 9.10 cGy plateau. That fact doubts the prognostic value of linear model and points the impossibility of correct estimation of low-doses irradiation genetic risk on it's base.

THE EFFECTS OF SPACE FLIGHTS IN HUMAN BLOOD LYMPHOCYTES IN VIVO

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The purpose of the conducted researches was to study cytogenetic aberrations in cosmonauts' peripheral blood lymphocytes resulted from low doses of space radiation, and also to elucidate possible modifying influence of prolonged antiorthostatic hypokinesia (AH), frequently used to simulate weightlessness in ground experiments, on the frequency of radiation-induced chromosomal aberrations in donor blood lymphocytes. For this purpose a part of blood samples obtained from the donors subjected to a single-pass transient exposure to Co-60 gamma-irradiation at a dose of 1,5 Gy. A total of 13 healthy men aged from 23 to 42 years were engaged in the AH experiment lasted for 60 or 120 days. The cytogenetical analysis was conducted of blood lymphocytes from 36 cosmonauts . On the average a 4-fold increase in the frequency of dicentrics and centric rings was established compared to the pre-flight level after space flights . Thus the relative frequencies of dicentrics were as high as 0,12 0,02 and 0,47 0,06 % before and after the 1-st space flight accordingly.

A statistically significant increase in the frequency acentric twin fragments (p=3,2r10-2) was scored after the 120-day AH, whereas statistically reliable increase in the frequency of aberrations of other kinds was not detected. The frequency of dicentrics on the average in blood lymphocytes from the experimental subjects in vitro irradiated with gamma-rays was scored to be as high as 10,5 %, and the total frequency of chromosomal-type aberrations - 18,8 %, that corresponded to a dose about 1,3 Gy of acute gamma radiation according to a calibration curve.

THE PROBLEM OF ESTIMATION OF CYTOGENETIC EFFECTS OF LOW-LEVEL AND COMBINED ACTION AT PLANTS

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The estimation of biological consequences of low-level exposure is complex problem including many unsolved problems of modern biology. The development of new concept of radiating protection of human and biota should be based on clear understanding of regularities of formation of biological effects of low-level ionising radiation. In our message we will accent on a number of fundamental peculiarities determining basic features of plant response on low-level ionising radiation, namely:

- non-linearity of the dose-effect dependence;
- increased (per dose unit) efficiency of irradiation at low dose-rates;
- non-linear (synergistic, antagonistic) effects of combined action of the different nature factors;
- replicative instability of genome caused by irradiation;
- radioadaptation phenomenon.

The irradiated cell responses registered in experiments are reflection of certain principles of organisation and functioning of eucaryotic cell. From these positions regularities of cytogenetic damage yield are epihenomenon of global structural and functional genome reorganisations induced by low-level exposure. Non-specific character of revealed regularities and wide spectrum of objects on which they are observed gives evidence on it is common biological phenomenon reflecting evolutionary fixed complex of adaptive responses of cell to external influence. From these positions increased genetic efficiency of low-level exposure has evident and natural explanation as one of manifestations of cytogenetic adaptation processes occurring in living organism populations response to stress influence. As well the DNA molecule repair phenomenon discovered by radiobiologists has developed scales of this science and has undoubted all-biological importance as the regularities of biological action of low-level exposure have been established in radiobiological investigations are not artefact or some exotic "anornalous" response but serve one of the natural demonstrations of fundamental mechanisms of stability of living systems underlying life that allows from other positions to estimate radiobiology place in system of natural sciences.

GENETIC EFFECTS OF LOW-DOSE IRRADIATION IN MAMMALS AND COMPARISON OF EFFICIENCY BETWEEN CHRONIC AND ACUTE IRRADIATION

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Study on biological effects of low-dose ionizing radiation physical criterion of which was given by Kelleler and Booz (1976–1978) and accepted by ICRU (1983) is central radiobiological problem. The study on genetic effects of chronic low-intensive irradiation in some generations of mammals living under high radiation background conditions is of great interest. We have studied genetic effects in somatic and germ cells of mammals over the period of 1986–1997 for some tests in bank vole, whose natural populations are exposed to increased radiation background impact due to the Chernobyl accident. The analysis of the dose–effect relationship was carried out by taking into account individual frequencies of recorded parameters and individual radiation exposure.

The frequencies of cytogenetic and other damages of hereditary structures were revealed to depend on concentration of basic dose-forming radionuclides (4–145410 Bq/kg for $^{134+137}Cs$), on absorbed dose rate (2–730 μGy/day) and on the total absorbed dose in the range from 0.02 to 7.3 cGy.

So, causality of the studied parameter frequencies by low doses of external and internal irradiation was proved. In most cases dose–effect relationships were better approximated by nonlinear functions.

According to the latest information on cancerous and non-cancerous risks acquired by survivors of nuclear bombardments, significant effects of acute irradiation were observed in the range of 0.005–0.2 Sv (Preston, 2000). Our finding s demonstrate effectiveness of chronic irradiation in much lower range and indicate the absence of threshold (Goncharova, 1997).

For comparing effectiveness of chronic and acute irradiation, the dose–effect curve of acute irradiation (10–100 cGy) was obtained for bank voles from two chronically irradiation populations. Extrapolation of the obtained dose–effect straight lines to the dose range of chronic irradiation has shown their much higher efficiency as against low doses of acute irradiation. Possible causes of such disagreement are discussed.

INDUCTION OF STABLE AND UNSTABLE CHROMOSOMAL ABERRATIONS IN HUMAN BLOOD LYMPHOCYTES INDUCED BY DIFFERENT TYPES OF IONIZING RADIATION

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Conventional metaphase and FISH-methods were used to analyze chromosomal damages in human blood lymphocytes after irradiation by γ-rays, 1 GeV protons (LET–0.218 keV/μm) at the synchrophasotron and ^{14}N-ions (E–50 MeV/nucleon, LET~77 keV/μm) at the U-400M accelerator. The high frequencies of stable aberrations of chromosomes 1 and 2 were noted. The dose-dependence of translocation frequency was linear-quadratic after irradiation by 1 GeV protons and γ-rays and with the tendency to linear after ^{14}N-ions. The fraction of translocations induced by protons and γ-rays is about 40–50% of the total aberrations detected by FISH-method and decreases to 30 % after ^{14}N-ions with the high level of arising fragments. The relativistic protons don't differ essentially from γ-rays on the biological effectiveness. The coefficients of RBE of ^{14}N-ions estimated on different cytogenetical tests were about 3.0 and more. The frequencies of chromosomes 1 and 2 aberrations detected by FISH and recalculated on the whole genome according to their DNA contents were compared with the frequencies of aberrations detected by the conventional method. The results have shown that the aberration frequency of the chromosomes 1 and 2 induced by different types of radiation is higher than for the rest of genome.

PECULIARITIES OF BIOLOGICAL EFFECTIVENESS OF 6 MEV NEUTRONS AT SINGLE AND FRACTIONATED IRRADIATION

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The effects of single irradiation of rat-males with 6 MeV neutrons (150, 550 rad) and fractionated (176 rad x 6 fractions) total and local irradiation have been investigated. Fractionated local irradiation of the back legs does not have essential influence on the rat survival, vereas irradiation of "head-neck" area accelerates mortality (the period of survival approximates to the oneof total irradiated animals with lrthal doses). Observed changes in the chemiluminescent indices of blood after local fractionated irradioation of "head-neck" area and back legs during first 7 days are connected with peculiarities of the peroxidation lipid oxidation. The peculiarities of development of radiation injury connected with different conditions and terms of exposure are discussed.

INVESTIGATION OF INFLUENCE OF LOW-INTENSIVE RADIATION AND CHRONIC STRESS FACTOR ON THE INHABITANTS OF RADIATION CONTAMINATED TERRITORIES

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Using epidemiological investigations we have studied the combined influence of chronic low-intensive irradiation and stress on the inhabitants of Kozelets district Chernigiv region, contaminated after Chornobyl accident. Substantial disturbances in health state of both adult and young population have been detected. The increased level of cardio-vascular diseases (hypertension, ischemic disease of heart, miocardial infarction, stenocardia) and diabetes mellitus has been detected among the adult population. The increased level of general morbidity, diseases of thyroid and anemia has been detected among the young population. There is a correlation between diseases and the level of soil contamination with radionuclides of Chornobyl origin. It suqqests that observed increase of morbidity has been caused by combined influence of ionizing radiation and chronic stress. We now offer the method for discrimination the radiation components and assesstment of their role in increased morbidity. Using this method we have estimated the likelihood of risks of additional morbidity (all clases of diseases induced by radiation) per 1 man ⊙ Sv of collective dose. The predicted additional appearance of these diseases, latent periods and realization terms have been estimated. The mechanizms of disease appearance are supposed. The ways of reabilitation of ill people are proposed.

RADIATION INDUCED 8-OXO-DG IN DNA AND NUCLEOTIDES; A NEW MECHANISM OF ACTION FOR RADICAL SCAVENGERS.

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The formation of 8-oxo-deoxyguanosine (8-oxo-dG) has been studied in vitro for DNA and deoxyguanosine, and the effects of different radical scavengers have been evaluated. Our data show that during irradiation added thiols or ascorbate, protect DNA in solution from radical damage as expected. However, in nucleoside (deoxyguanosine) in solution, the addition of these scavengers caused an 11 to 116 fold increase in the yield of 8-oxo-dG. This could be due to the reducing properties of thiols / ascorbate or the formation of thiyl and / or thiol peroxyl radicals. For irradiated deoxyguanosine triphosphate (dGTP) in solution, the increase in yield of 8-oxo-dG correlated with the charge of the scavenger added. Glutathione (charge= -1) yielded less 8-oxo-dG than when cysteamine (+1) was added. This could be due to a counter ion effect

We also irradiated CHO-cells and analyzed the levels of 8-oxo-dG in DNA and in the nucleotide pool. The G-value for the formation 8-oxo-dG in the nucleotide pool was 20 times higher as compared to nuclear DNA, suggesting that the nucleotide pool could be a significant target for radiation induced genotoxicity.

RADIOLOGICAL CONSEQUENCES OF THE JCO CRITICALITY ACCIDENT IN TOKAIMURA, JAPAN

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The first criticality accident in Japan began at a building of the JCO Company Limited in Tokaimura, located at 120 km NE from Tokyo, at 10:35 a.m. on 30 September, 1999, when three workers were pouring uranyl nitrate solution of 18.8 % enrichment into a precipitation tank. They were heavily exposed and immediately showed symptoms of acute radiation syndromes. The criticality had continued for about 20 h until the next morning when the water in the cooling jacket around the tank was purged out by argon gas.

There was no equipment to measure neutrons in the JCO site when the accident occurred. A gamma-ray dose rate of 0.84 mSv/h was measured at 11:30 outside the site fence (about 80 m from the conversion building where the accident took place). At 15:00, according to a decision by the mayor of Tokaimura, about 200 residents within 350 m from the conversion building began to be evacuated. At about 17:00, persistence of criticality was confirmed by detecting neutrons with portable neutron surveymeters. The maximum neutron level of about 4 mSv/h continued outside the site fence throughout the midnight. At around 22:30, the governor of the Ibaraki prefecture issued an instruction to stay indoors to about 310,000 residents within a 10 km radius.

A major characteristic of the radiological consequences due to the JCO accident is that neutron played a main role in its environmental impact. Neutron contributed about 90 % of the total external exposure while gamma-ray did about 10 %. Neutron transport in the air-over-ground geometry was calculated up to over 2 km from the conversion building using DOT3.5 and MORSE-CG codes. A dose distribution curve obtained as a function of the distance from the conversion building was fitted to the measured values. A cumulative neutron dose of 81 mSv was estimated at 100 m from the conversion building. The distances corresponding to neutron dose of 1, 0.1, 0.01 and 0.001 mSv were about 450, 700, 1000 and 1300 m, respectively. The total power released by the accident was estimated to be about 17 kWh, or 1.9×10^{18} fissions of ^{235}U.

INFLUENCE OF PERMANENT IRRADIATION IN CHORNOBYL ZONE OF ALIENATION ON THE LIFESPAN OF EXPERIMENTAL ANIMALS AND THEIR PROGENY

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Investigations have been perfomed in the Chornobyl exclusion zone since 1989. Laboratory three-month-old animals (white rats of no breed F_0) were delivered to Chornobyl where they and their posterities (F_1 - F_6) were permanently kept, thought the lifetime. Animals were exposed to external irradiation (increased radiation background) and internal (incorporated radionuclides, which were supplied to the organism with food). Activity of radionuclides supplied to the organism with food has been determined on the base of radioactivity of food compounds. Determination of body izotope content has been carried out according to their real activity in organs and tissuies. The values of the total absorbed dose of external and internal irradiation was 0,3 Gy per generation. The control animals were kept in the identical conditions in the Kyiv vivarium.

The indices of lifespan and dynamics of mortality of the animals have been studied. The indices of rats and their progeny lifespan have been determined using the life table methology.

Our results have showen no essential difference in indices of mortality and lifespan between control and experimental animals of F_o generation. The expectating lifespan of rats of F_1-F_2 generations increased in the age interval of 300-600 days. It's necessary to note that decrease of this index in the chornobyl groups of generations F_3 - F_6 has been observed. The obtained data show that the substantional increase in the number of animals with neoplasms was more in the group of F_0 generation than in control group. No difference in the number of animals with solid tumors in F_1 -F_6 generations in comparison with control has been determined. The averege lifespan of both control and experimental animals with solid tumors has been was longer than the lifespan of animals without tumors.

THE INFLUENCE OF LOW-LEVEL X-RAYS IRRADIATION WITH DIFFERENT DOSE INTENSITIES ON THE DNA DAMAGES ISSUE IN TOBACCO PROTOPLASTS

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Many experimental dates testify the non-linear character of biological response on low dose irradiation. The level of genetic damages in the range of low level dose may be for example more higher than it expected . We hypothesis that this effect could be caused by the existing of some dose range when the existing DNA repair systems are unable to eliminate all DNA damages induced with ionising radiation and additional inducible repair systems do not switch on. Some fixed number of DNA-damage formed per time interval may be required for the activation of these additional repair system. The aim of our study was to investigate the influence low dose irrradiation with different intensity on DNA damage issue and DNA repair system abilities. These experiments were curried out with isolated tobacco protoplasts We suggest that effect of dose intensity is one of most important factors that modificate DNA-repair activity in cell. Tobacco protoplasts have been irradiated by X-ray devise at dose of 9.6 cGy, 24 cGy and 48 cGy with X-rays intensities ranged from 4 cGy/min to 118 cGy/min. In order to estimate the DNA-damage level hydroxilapatite chromatography was used. The cell lysis per different time interval after irradiation was carried out for repair efficiency estimation. The experimental dates have arised the DNA-damages after the irradiation at dose of 24 cGy. Such effect could be conditioned that the activation of inducible repair system at this dose of irradiation. The activation of additional repair systems at dose of 48 cGy was observed. The increasing of DNA-damage level in the conditions of irradiation with relative high dose intensities ranged from 24 cGy/min to 118 cGy/min. In the case of irradiation with exposure intensities of 4 cGy/min and 8 cGy/min the raised level of DNA-damage at dose of irradiation as 9.6 cGy have been marked. The inducible repair systems begin already to work at dose of irradiation as 24 cGy. The obtained results could testify that the value of radiation press on genome play an important role for the induction of additional DNA repair systems in the isolated plant cells.

ON THE PROBABILITY OF TRANSLATION OF CYTOGENETIC EFFECTS IN HIGHER EUCARYOTES AFTER THE CHERNOBYL ACCIDENT

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Genetic effects of low doses of ionising radiation manifest themselves as uni- or bifilament DNA ruptures, chromosome and chromatide aberrations, etc. The remedy of DNA injuries in cells occurs through continuous reparation processes, and a wide variety of these processes are available, the resolving ways for which depend on radiation and nonradiation factors. In higher eucaryotes, the results of heterologic recombinations are registered at the systemic level.

Long-time studies in areas of the Bryansk region affected by radionuclides indicate alterations in some parameters of hemopoietic and immune systems in higher eucaryotes (cattle). The annual exposure dose, depending on the contanunation density of area, amounted to between 1.5 and 12 mGy. The data for animals irradiated up to 3mGy did not differ from those for animals in the noncontaminated areas in the Kaluga region. Pronounced changes in some parameters were registered in animals grazing pastures with the conntamination level of 1110 kBq/m^2 and higher. In this case dose burdens amounted to 9-12 mGy.

Damage to erythrocytes appeared as an increased sedimentation rate. In the contaminated area it reached the value of 27$\pm$3. In "clean" zone it was 15$\pm$2. Leukocyte stability dropped from 50$\pm$5 to 30$\pm$5 %. Reported were changes in the blood globuline fractions and bactericidal action of nasal mucous membrane. Common origin of blood formed elements from truncal cells, their subsequent differentiation make it possible to consider the observed alterations as a aresult of translation of cytogenetic effects on radiation exposure.

MONTE CARLO SIMULATION OF DNA DAMAGE INDUCED BY DIRECT AND INDIRECT EFFECTS OF IONIZING RADIATION

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A computer simulation is aimed to get more clear mechanistic interpretation of DNA damage effects induced by charged particles irradiation. The Monte Carlo track structure simulation code DeTrack was used to obtain spatial distribution of initial excitation and ionisation events in unit density water medium. The electron tracks of 1 keV initial energy, proton tracks of 1 MeV and alpha particle track of 1.2 MeV/amu were simulated. Ionised and exited water molecules give rise to the formation of free radical species during short-time pre-chemical stage. The reactions and spatial distribution of all main radical species at different time scale were computed by means of Independent Reaction Time (IRT) stochastic algorithm. DNA damage produced by direct energy deposition in the DNA volume and attack on DNA of the diffusing hydroxyl radicals from the water surrounding the DNA were taken into account. Two models of internal DNA structure (canonical linear double stranded B-DNA) were considered. First, atomistic hydrated DNA model was the repeated sequence of ATGC nucleotides including water molecules in the first hydrated shell. Second, more simple volumetric model was comprised of (0.34 x 2.3) nm cylinder subvolumes of sugar-phosphate and bases occupied by one nucleotide pair without specifying the detailed atomistic structure of the oligonucleotide. The energy deposition in sensitive DNA subvolumes, as to atoms of sugar phosphate group in atomistic model and sugar phosphate subvolume in volumetric DNA model, was scored to calculate the yield of different types of single strand breaks (SSB). The combination of SSB on opposite strands result in double strand breaks (DSB) formation with different level of complexity. The yield of DNA lesions as a function of various parameters was predicted for both DNA models and different types of radiation. Simplified volumetric DNA model provides predictions similar with atomistic model by adjusting the threshold energy parameter

ESTIMATION OF RADIATION RISK FOR POPULATION OF CONTAMINATED REGIONS OF BELARUS BY USING DIFFERENT DOSE-EFFECT RELATIONSHIPS

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The results of the last years' studies need correction of the dose-effect relationships presently used for radiation risk estimation. Recently the new dose-effect relationship have been derived by Komochkov M. (Proc. of NATO Sci. Ser.:2 – Vol.55, p.25-34, Dordrecht, 1999) in framework of the model that takes into account an unified protective mechanism (Two Protective Mechanisms model). Given importance of the assessment of Chernobyl accident consequences, an evaluation of relative risk coefficients was undertaken in the present work by using dose-effect relationships based on different approaches: linear model (LM), linear-quadratic model (LQM), ICRP recommendation (Recommendations of ICRP (1990)) and TPM model. The relative risk coefficients were calculated on the basis of mean effective doses for population of settlements placed on contaminated territory of Belarus.

The relative risk estimations for population of Gomel region obtained by using of doses evaluated for different periods after the accident are given as an example in the table. The results show that the risk excess values predicted by the TPM model are larger than the assessments obtained in terms of ICRP recommendations and the other models (LM and LQM). The TPM model gives thus the most conservative assessments of radiation risk excess caused by the Chernobyl accident.

Model	Period after the accident (in years)			
	5	10	15	20
ICRP (1990)	1.0093	1.0106	1.0112	1.0113
LM	1.0345	1.0380	1.0383	1.0384
LQM	1.0363	1.0380	1.0383	1.0384
TPMM	1.0554	1.0590	1.0610	1.0620

THE ESTIMATION OF THE DOSES OF BETA-RADIATION IN THE EYE LENS FOR POPULATION OF CONTAMINATED REGIONS OF BELARUS

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After the Chernobyl accident the large part of Belarus was contaminated with complex mixture of radionuclides many of which emitted beta-particles. Given importance of beta-particles for radiation injuries, beta doses in the eye lens from radionuclides released from the reactor were estimated in the present work. The calculations were carried out in the framework of the model by Osanov D. P. (Rad. Prot. Dos. 74 (235-238) 1997) by using different dose distribution functions for description of beta ray point source. The levels of soil contamination with the radionuclides used for beta dose rate evaluation were obtained on the basis of data on isotope ratios presented in "Chernobyl accident", ed. Baryahtar V. G. Kiev. p. 21-23, 1995).

The calculation results show that in April-May 1986 the radionuclides I^{131} and Te^{132}+I^{132} made the dominant contribution to the beta-dose in eye lens. It was shown that the beta-dose rate decreases two times in four weeks due to the radioactive decay. The total beta-dose in the eye lens taken during the first week after the accident by the children lived on the territories with Cs^{137} deposition density 30 Ci/km^2 may exceed the accepted permissible value of effective dose in the eye lens 15 mSv/y (1990 Recommendations of the ICRP, p. 46). The comparison of beta-doses calculated in terms of various approaches show that the average difference is about 20 %. Thus, according to the dose assessments obtained, beta radiation formed the substantial component of external exposure of the population lived in regions with high level of radioactive contamination at the early period after the Chernobyl accident.

THE INFLUENCE OF THE LOW DOSES RADIATION ON THE CONDITION OF THE POPULATION OF WILD RODENTS

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The problem of studying the impact mechanisms of low ionizing radiation and the search for informative methods of bio-indication of radioactive contamination of the territory are key problems in modern radiobiology and radioecology. Long-term investigations have been carried out on the state of the population of wild rodents trapped in the region of Chernobyl NPS accident and in the areas contaminated with Ra, U and Th in Uchta region of Komi Republic. It was aimed at defining the level of possible radiation effects and at forecasting the radiation damage depending on the contamination degree. Ecological, radioecological, morphological, hystological, biochemical, biophysical and cyto-genetic methods were used in the complex analysis of state of animal populations. We analyzed such indices as number of mouse rodents; age-and-sex structure of populations; accumulation of radio-nuclides in the organism; morphological analysis of blood cells, liver, spleen and endocryne system organs; hystology of these organs; activity of dehydrating enzymes and enzymes of anti-oxidation defense; anti-oxidizing activity of lipids; composition of phospho-lipids and general indices of lipid exchange in various tissues; chromosome aberrations in somatic and sexual cells; micro-nucleuses and abnormal spermium heads. The monitoring of radiation-contaminated natural animal populations in the radioactives zone displayed the high effectiveness and specific features of low exposure doses. Basic regularities and mechanisms of radioactive damages are discovered in the systems under study. Two long-term periods of radiation development are identified. It testifies to high vulnerability of all organism systems and proves the destructive effect of radiation. It is noted that even on the initial monitoring stage the destructive processes go hand in hand with compensatory-restoration processes. Nevertheless many indices would not display complete restoration. Alongside with that, genetic, biochemical analysis of structure of animal populations formed under radioactive contamination give us a reason for suggesting the self-purification processes which began in natural population. Self-purification results from elimination of genetic damages in the course of generations and from qualitative changes of state of natural animal populations. The

complex analysis of different indices affords to assess the state of natural biocenoses under complex and multi-component radioactive contamination. It can become a baseline for forecasting the biological effects and remote aftereffects of technogenic impact upon the biota.

KARYOTYPIC ABNORMALITIES IN HAVI IRRADIATED TUMOR CELL POPULATIONS

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Rat transplantable rhabdomyosarcoma Ra-23 (patent №2026344, Russia) is characterized by high metastatic potential (5-7 experimental lung metastases per 100 i.v. injected cells) and high frequencies of spontaneous chromosome aberrations. Cells of this tumor have D_0 = 2.4 Gy (at doses 0-12 Gy, lung colony formation technique) but are able to grew progressively after high doses of irradiation. We studied frequencies of karyotypic abnormalities in progenies of the RA-23 cells which were obtained from 5 – 45 Gy gamma-irradiated cell suspensions (*in vitro*, ^{137}Cs, 28 Gy/min) inoculated into anterior chamber of ayes (15-90 days after irradiation) and in subcutaneous tumors which were exposed to 5-45 Gy X-rays (*in vivo*, 52 h after irradiation). We observed the following mean percents of abnormal nuclei:

Gamma-rays, Gy	0	5	10	15	20	25	30	35	40	45
Index of micronuclei*	22	24	27	34	32	38	49	52	60	-
Nucleus protrusions	15,7	11,8	17,0	26,6	17,7	29,1	36,8	41,7	53,3	-
Chromosome bridges	0,6	1,3	2,2	3,7	3,1	8,5	12,7	15,7	21,0	-
X-rays, Gy	0	5	10	15	20	25	30	35	40	45
Index of micronuclei*	28	45	81	127	142	131	147	204	231	248
Nucleus protrusions	24,5	31,7	44,9	68,6	67,3	62,7	60,9	76,4	81,3	94,6
Chromosome bridges	5,4	7,5	10,7	13,8	21,2	18,7	31,6	32,9	36,3	35,8

*number of micronuclei per 100 cells.

We believe that high irradiation inhibits not only "the program of apoptosis" but also "the program of reproductive cell death" and for this reason some cells with crude chromosome damages can safe the ability to proliferate even after very high doses of irradiation.

RADIOGENIC EFFECTS OF LOW DOSES ON POSTERITIES OF IRRADIATED CELLS

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The purpose of present work was to investigate the vitality of posterities cells exposed to low intensive γ-radiation (^{137}Cs, a dose rate of 0.0025 cGy/minute) in 0-generation.

Investigation has been carried out using the unsynchronous cell culture of L_{929} line. Cells in culture were cultured in medium RPMI supplemented with 10% embrional calf serum and gentamycin. Cells irradiated in 0-generation with dose 10 cGy were subcultured every 5 days. Proliferative and mitotic activity, presence of gigantic polycaryocytes, membrane receptor expression to different lectins, changes in electric charge on the cell surface, activity of gammaglutamiltranspeptidase (the main enzime in glutation metabolizm) have been analysed in each passage. Radiosensitivity of posterities of irradiated cells has been estimated according the kinetics of cell growth (after additional irradiation with high dose of 5 Gy) and presence of adaptive response (after exposure to X rays with doses 0.2+0.9 Gy).

It has been detected that low doses of low intensive ionizing radiation cause different changes in cells in vitro. These changes appeare not immediately after exposure, but in remote generations. Moreover, the increase radioresistance of posterities of irradiated cells indicates the predominant mortality of radiosensitive cell population. The observed phasic changes in structure-functional properties of cell membranes indicate the substantial disturbances of cell surface during the incubation, which have influence on vitality of cells in culture.

ANALYSIS OF APOPTOSIS INDUCED BY UVC AND UVA IRRADIATION: À FLOW CYTOMETRIC STUDY

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Apoptosis has been reported as an efficient mechanism to eliminate cells that have sustained mutations resulting in unsheduled division and cancer risks. Apoptosis induction by UVC and UVA-irradiation in rat thymocytes and in U 937 (histiocytic limphoma) cells was studied. Cells was exposed to 20-200 J/m^2 UVC or 50 J/m^2 UVA irradiation. In order to determine the mode of cell death DNA-binding fluorescent dyes (acridine orange and ethidium bromide) were utilized along with flow cytometry. The different uptake of these two DNA-binding dyes allowed for identification of apoptoticic cells. Two mechanism of apoptosis was shown in thymocytes after both UVC and UVA irradiation. The one of them (fast) was charachterized by cell death in some hours (< 4 h) after irradiation. Little increasing of cell size and membrane permeability was shown in early stage of this mode of cell death. Early increasing of membrane permeabiliry followed by DNA fragmentation in late stage represent typical features of this mode of apoptosis. The second mechanism (delayed) was characterized by cell death 24 h after irradiation. One of the early changes during this apoptosis was cell shrinkage followed by DNA degradation. The permeability of plasma membrane was increased in late stage in this case. The integrity of plasma membrane was preserved to the late stage of apoptosis. Cycloheximide, an inhibitor of translation, increased the number of thymocytes undergo the fast apoptosis and prevented the other apoptotic mechanism. In opposite to thymocytes only one apoptotic mechanism was induced by low dose of irradiation in U 937. U 937 cell death after low dose of irradiation begun from late S phase of the cell cycle and had been developing 6-24 h after irradiation. UVC-irradiation only in high dose range induced the other -fast- apoptosis (2 h after irradiation) in U 937. Cell death begun from G_1 phase in this case. UVC-irradiated U 937 after cycloheximide pretreatment showed effects similar to thymocytes: undergo fast apoptosis, however it was different from fast apoptosis in thymocytes. Cycloheximide prevented delayed apoptosis in U 937 also. Presented data let us to suppose that protein biosynthesis modulate the mechanisms of apoptosis induced by UV-irradiation in lymphoid cells.

PHYLOGENETIC STRESS

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In the report the terminological means of the common theory of systems and radiobiology to reviewing phylogenetic appearances and their mechanisms is applied. The given approach has allowed more strictly to present performances operating the phylogenetic factors (physical, chemical and biological). So, if the speech goes about ionising radiation, as about probable the phylogenetic factor (PF), it is necessary first of all to describe it from a point of view of a doze (exposition, absorbed and effective). Besides, as the speech goes about various on the nature the factors with a dominance at each power, material or information components of influence, that, accordingly, it is necessary to speak about dozes of an absorbed energy, the substances or information. Are necessary also to taken into account the potency, quality and condition of an operation the phylogenetic factors. PF is capable to render on phylogenetic system (PS) neutral, supporting (stabilising) or stress influence. Besides, it is necessary to distinguish the obligatory (supporting, stabilising), facultative and indifferent PF, last of which can be in neutral, stimulating, inhibitory or lethal doze. First two factors in a neutral doze can not be, as obligatory factor at a zero doze completely inhibits the system, and the facultative - partially. Using a radiobiological nomenclature, it is expedient to consider a problem of the relative phylogenetic effectiveness of PF with same level of organisation. For example, at a defined stage of the phylogenesis the temperature factor can be more significant, than factor of ionising radiation. At reviewing influence PF on PS it is necessary to take into account control (initial) a condition PS. By analogy to concept "doze" PF, probably, is expedient to apply concept "doze" PS, reflecting initial (on a moment of a beginning of interaction with PF) performance PS. Actually, the doze PS reflects a level of its stability and sensitivity to an operation PF (as "stabilities" on a ratio stimulating PS to dozes PF). From concept of a stability PS it is logical to pass to concept of a threshold of a stability PS. Each level PS has the threshold of a stability, which also depends and on a parameter used for an evaluation of a stability. The threshold of a stability tightly connected with concept of critical phylogenetic subsystem (structure, sublevel) of PS, defining character and outcome of interaction PF with PS. Probably, selectogenetic and opthogenetic the manifestations of phylogenetic processes should be considered as an outcome stochastic and - or of a determined operation

PF on PS. Purely, the phylogenetic process can be presented as an outcome of phylogenetic stress, namely in quality concerning an irreversible component of a modification (quantitative, qualitative or relative) in PS, complex, which has arisen under influence, of the exterior and interior factors. As in an association from a doze of the operating factor, the raise of a stability of an initial system (adaptation) is possible, progressive phylogenesis it is possible to consider as manifestation of phylogenetic adaptation with all from here by implying terminological and ideological "consequences" (adaptive and test - action, transitional phylogenetic the process, phase of transitional phylogenetic process, overshoot, irreversible components etc.). There is also possibility more strictly to speak about the phylogenetic adaptive potential and phylogenetic regress as the manifestation of the phylogenetic dezadaptation.

RADIO-INDUCED LIFESPAN ALTERATION OF *DROSOPHILA MELANOGASTER* MUTANT LABORATORY STOCKS

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It should be said, that the research of ionizing radiation influence on lifespan is conducted already some decades. Nevertheless, despite the abundance of hypotheses about mechanisms of radioinduced aging, non of them has not taken any leading position. The majority of diverse hypotheses considers different molecular-cellular processes (DNA damage, biolipids, and mitochondrion) as the reason of the phenomenon, which is on the organism level. However, in our opinion, many of accumulated incomplete data and suppositions are compiled into clear picture, covering the process of radioinduced aging from molecular to an organ-tissue level. Assuming the important role of a genome destabilisation and apoptotic cell death in the lifespan control, we consider, that the induction of these processes by ionizing radiation can essentially speed up natural aging.

There was investigated *Drosophila melanogaster* lifespan, exposed to the chronic effect of ionising radiation in this work. We used several *Drosophila* laboratory stocks, three of which belong to wild phenotype (*Canton-S*, *GB-39* and *Oregon-R*) and four to a mutant type. The line *mei-41[D5]* is characterised by genomic instability. The stock *ruprica* contains a set of mutant genes located on the 3-rd chromosome. Besides in the experiment two *Drosophila* stocks, bearing mutant alleles of a gene wingless (wg), wgl-7 / CyO and wg7L74 / CyO are used. These lines are characterised by a violation of development and increased sensitivity to an apoptosis induction. For the purpose of irradiation we used a source of gamma-irradiation, containing 226Ra. The doze absorbed for generation was 0,6 Gy.

After low dozes effect of chronic ionizing radiation on wild type stocks Canton-*S*, *Oregon-R* and *GB-39* the statistical significance of life span alteration ($p < 0,05$) is shown. The exposure of the *mei-41*[*D5*], *ruprica* and *wingless* lines has reduced lifespan as compared to non-irradiated individuals of the same line ($p < 0,001$). Thus, in the given experiment the lifespan increasing at wild type lines and its decreasing in lines with mutant genotype are shown.

The given effect can be connected with a general violation of genome integrity and stability and can be induced by apoptosis deregulation in the lines described by the increased sensitivity to apoptosis induction (such as *ruprica*, *wg [1-7]* and *wg [7L74]*).

ON THE POSSIBILITY OF MELANIN APPLICATION FOR PEOPLE PROTECTION AGAINST LOW RADIATION DOSES.

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Long-term exposure of large population groups to ionizing radiation with low doses due to environmental radiocontamination has set radiobiologists the task of searching for radioprotective substances of a new type — capable of reducing remote effects of chronic irradiation. We found that melanin considerably decreased rates of different types of mutations induced by radiation in germ cells of animals (drosophila, mice) and decreases the mutation load accumulated in Drosophila populations as a result of X-ray irradiation for 115 generations. Melanin is effective in reducing aberration frequencies, induced by radiation in cultured human lymphocytes. The melanin influence on genetic effect of chronic irradiation was even more effective than of acute one. Radioprotective action of this pigment is connected with its ability to accept and to give back electrons and with antiradical activity. It's clear that when low-dose irradiation is used, the possibility for melanin to catch free radicals or electrons is higher. In order to study melanin influence on low radiation doses phenomenon of radioadaptive response had been used. We have found this phenomenon in mice bone marrow cells in vivo. Irradiation of mice with a fractionated dose (0,2 Gy + 1,5 Gy with 4 hours interval) led to a double decrease in the mutation level in comparison with single 1,7 Gy dose effect . Melanin injection 2 hours before irradiation with 1,7 Gy decreased the mutation rate also twice. If melanin was injected 2 hours before the first conditioning dose, the mutation level was the same, as after the pigment application before single 1,7 Gy dose. Perhaps this means the absence of an adaptive response. Obviously, melanin removes 0,2 Gy effect completely, that's why an adaptive reaction doesn't appear. In order to prove this version, melanin application between conditioning and challenging doses was tested. In this case the chromosome aberration level was 4-fold lower than the mutagenic effect of single 1,7 Gy dose. Thus, both adaptive response and melanin protection has been observed. Thus melanin is able to remove completely low radiation dose effect. Complete toxicological tests have been conducted. The pigment melanin is not toxic and doesn't possess a mutagenic, teratogenic or carcinogenic activity. Melanin could be used in medicine for people protection against genetic consequences of long-term irradiation.

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN RADIATION-INDUCED CHROMOSOME ABERRATIONS AND MICRONUCLEUS YIELD

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Radiation dose estimation are mainly based on cytological examinations of Peripheral blood lymphocytes in biological dosimetry. Measuring micronucleus (MN) frequency has always been attracted to many investigators because the technique ewes its attraction to having an easy scoring criteria. We have in this study intended to see if there is any relationship in radiation dose estimations measured by MN technique and asymmetrical exchange type chromosomes.

Control dose-response curves for chromosome aberrations and MN frequency were established from blood lymphocytes of healthy non-radiation workers following X-rays irradiation. Absorbed radiation doses were estimated from medical radiation-workers.

Dose-response curves of two different cytological measures of radiation differed as reflected in the linear-quadratic (LQ) parameters. The linear-component of LQ (α=1,61 $X10^{-1}$ Gy^{-1}) was higher and the quadratic –component (β= 5,47$X10^{-3}$ Gy^{-2}) was lower in MN induction curve compared to the relative parameters of dicentric chromosome aberration curve.

Absorbed doses of radiation workers were consistently higher in MN frequency-based dose estimations at low-dose points. Therefore monitoring, large populations with MN technique may only be useful when a statistical comparison is made between MN frequency of an individual and background levels. Otherwise estimating an absorbed dose should be based on chromosome aberrations.

THE ESTIMATION OF THE GENOME STABILITY IN THE LATE PERIOD OF OCCUPATIONAL RADIATION IN DIFFERENT DOSES

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The radiation mutagenesis was demonstrated in experiments on different vegetation and animal objects. The aim of the present investigation is to estimate the ginome stability of somatic cells of personnel who had the professional contact with the external and internal radiation sources at the first atomic plant PA "Mayak". The cytogenic investigation started at the beginning of 60 ies. It was shown that the chronic external radiation in doses less than permissible (5 s Sv per year) do not couse the elevation of the chromosome aberrations frequency.

The chronic gamma-radiation in the doses which significantly exceed the permissible doses (0.7 – 3.6 Sv per year and summary doses 1.0 – 10.0 Sv) leads to the long conservation of the heightened chromosome aberrations frequency in the peripheral blood lymphocytes. Forty years after cessation of the contact with ionizing radiation sources the chromosome aberrations frequency exceeds the spontaneous level in 4-6 times. The stable aberrations are the leading type of the chromosome rearrangements. Forty years after acute radiation sickness (ARS) of different severity (external acute radiation doses from 0.9 to 9.0 Sv) the correlation of the stable chromosome aberrations with the radiation dose was shown.

Pu-239 has the expressed mutagenic effect. At inhalation of transportable compounds of the radionuclide (433 workers were examined) the chromosome aberrations frequency depends on the bone morrow absorbed dose. At inhalation of nontransportable compounds (198 workers were examined) the frequency of unstable as well as stable aberrations depends on the lung absorbed dose.

In the cases of oncological deseases evaluated in the late period after external chronic radiation in doses more than permissible doses any specific chromosome rearrangements were not shown except of the Ph-cromosome in the cases of chronic myeloleucosis. The significantly evaluated level of the chromosome aberrations was demonstrated in the Pu-239 carriers, which developed lung cancer.

THE IMMUNOLOGIC EFFEKTS OF THE PERSONNEL AFFECTED WITH THE FACTORS NUCLEAR–ENERGY ENTERPRISE

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The laboratory and immunologic examination of large group of people exposed to the factors of nuclear-energy industry was carried out during many years. Two contingents were investigated: the first group – personal of the nuclear enterprise of Middle Ural who have been exposed to radiation, chemical and stress factors; the second group – non-affected inhabitants of the territory, adjoining to the enterprise. In the course of immunological monitoring some tendencies were displayed: 1. Many examined person (39-70%) worked at different workshops of nuclear enterprise showed increased values of T-helper subpopulation (CD4+) while a number of persons with decrease indices was small. This change of quantitative distribution of T-helper cells were accompany by decrease of cytotoxic cells: T-lymphocytes cytotoxic subpopulation (CD8+) and natural killer (CD16+). This tendencies were observed earlier and were typically for people exposed to radiation factors in low doses. Phenomena of activated influence of radiation in small doses particular over T-helpers chain of immune state in humans, which was found for the first time among groups of the liquidators of disaster aftereffects, who worked in different zones of Chernobyl catastrophe. Later it was proved at the personnel of 30km CHNPP zone, inhabitants of districts contaminated with radionuclides in Bryansk region, as well as personnel of plant with professional contacts with plutonium-239.

2. Disbalance in indices of cytotoxc cells: CD16+, CD8+ characterised by increase and decrease of values periodically were registered. Every year we observed inversion distribution the number (%) of persons with change (↓↑) indices and development of immune deficiency (ID) on natural killer cells (NKC). This revealed with increasing duration of contact with risk factors of nuclear enterprise.

3. Dissociation in absolute and per cent values of T-cell chain and NKC were established.

4. We revealed the resemblance of immune state phenotypes of enterprise's personnel and people living at the territory adjoining to the enterprise and also healthy personnel and persons with clinical signs of ID. It can be supposed that region antropogenic risk factors which define the ecologic situation and region peculiarities and more influence on immune state parameters then clinical signs of immune system dysfunction.

SINGLE-STRAND DNA BREAKS AND DNA-PROTEIN CROSS-LINKS IN THYMOCYTES OF MICE INDUCED BY THE COMBINED ACTION OF Pb AND γ-RADIATION.

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The global pollution of the environment has led to the fact that humans and other living organisms are exposed to the action of various technogenic factors, including ionizing radiation and heavy metals. Of exclusive importance in estimating the action of these agents and of their combinations on living organisms is the study of their influence on genetic structures.

In the present work the level of single-strand DNA breaks (SSB) and DNA-protein cross-links (DPC) in thymocytes were studied in mice exposed to γ-radiation and/or Pb. The experiments were done using SHK male mice weighing 20-22 g. General irradiation was performed with Gammacell -220 γ-ray units, the γ-source - ^{60}Co. The dose-rate during the course of these experiments was 1.0 Gy/min. Selected dose of γ-radiation was equal 1.0 Gy. Solubilized in isotonic solution $Pb(CH_3COO)_2$ (28 mg Pb/kg body wt) were injected in animals intraperitonealy in volume 1.0 ml. Control animals obtained such volume of isotonic salt solution.

The results of the studies have demonstrated that injection of solution $Pb(CH_3COO)_2$ prior to irradiation results in decrease the SSB level in thymocytes in comparison which exposure to Pb or γ-radiation alone. While the DPC level was same as under the action of γ-radiation. It is believed that decreasing in the SSB level at combined exposure are conditioned by activating of protective mechanisms of cells, the expression of the genes of antioxidant proteins such as the metalotioneins, acceleration of DNA repair etc. However, measurements of the number of thymocytes have demonstrated that the number of cells in the thymus at the combined exposure decreases as compared to the separate action of Pb or γ-radiation. Thus, most probable explanation of results obtained at combined exposure to Pb and γ-radiation is elimination of the cells with high-level of DNA lesions that masks genetoxic action on a common pool of cells creating observed effects.

THE STUDY OF DNA LESSIONS AND CITOGENETIC EFFECTS IN MICE EXPOSURE TO LONG-TERM GAMMA-RADIATION AT LOW DOSES

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The level of DNA single-strand breaks (SSB) and DNA-protein cross-links (DPC) in mouse spleen lymphocytes, the number of abnormal sperm heads (ASH) and the number of micronuclei (MN) in normochromatic erythrocytes (NCE) of peripheral blood were studied in mice exposed to long-term (20 to 180 days) low-intensity gamma-radiation (24-720 μGy/day). The results of the experiments have demonstrated that the dependence of DNA lesions level on the total dose (exposure time) of γ-radiation is nonlinear. The maximal level of DNA lesions in cells was recorded on the 20-60-th days of experiments. Special notice should be made of a character of changes in the DPC and SSB level on 120-180-th days of experiments. In this term was recorded secondary increasing in the DPC level, but not for SSB. The long-term exposure to γ-radiation caused an increase in the ASH frequency. No increase was found in the frequencies of MNs in NCEs.

It has been established in a number of works that chronic exposure to ionizing radiation at low doses leads to nonmonotonous changes in the metabolic parameters of cells (in the activity of cell enzymes, in particular). It is probable that irradiation, acting indirectly as a peculiar stress-factor through the neurohumoral system, induces a cascade of metabolic changes at the cell and organism levels.

Summing up the results obtained it can be concluded that the action of γ-radiation at the applied doses induces metabolic changes in the organisms of animals. These changes manifest themselves as a nonlinear increase in the DNA lesions level in thymocytes and splenocytes and as an increase in the ASH frequency, but that do not cause a pronounced cytogenetic effects.

IMPACT OF IRRADIATION ON THE TUNDRA NENTSI POPULATION IN PUROVSK DISTRICT OF YNAO

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Tundra Nentsi of the Purovsk district of the Yamalo-Nenets Autonomous Okrug (YNAO), with population of about 1500 individuals, are well-studied from the populational-genetical point of view. A seria of factors enables to consider this population as an ideal model for radiological-ecological and medical-genetical researches: 1) relatively close neighbourship to the sources of technogenic pollution (including the polygon «Severny»); 2) relatively small population number and the lack of migration out of the limits of habitat; 3) ethnic purity and conserved traditional lifeway; 4) simplicity of food chains (reindeer moss – deer - person; water – fish - person). Beginning from 1992, the planned complex studies of this ethnic group were provided, which have demonstrated both the ubiquitous contamination of its habitat by radionuclids and migration of ^{137}Cs and ^{90}Sr across the food chains. In particular, the average activity of ^{137}Cs equals to 117 Bq/kg in peatbogs, to 197 Bq/kg in mosses; to 44,5 Bq/kg in soil; to 120 Bq/kg in reindeer moss; to 215 Bq/kg in ground litters. In deer meat, which is the main dietary component of Nentsi, the content of ^{137}Cs varies from 64 to 315 Bq/kg, whereas the content of ^{90}Sr in deer bones – from 148 to 555 Bq/kg. No wonder the actual activity of ^{137}Cs was registered in placentae of Nentsi females, within the range from 1 to 27 Bq/kg. Teeth specimens of children and adults from the settlement of Samburg were collected. The results of preliminary EPR-analysis enable to expect the dose loadings of internal irradiation close to "small". Thus, the data obtained give the evidence that the Tundra Nentsi population of the Purovsk district of YNAO is exposed to the pressure of irradiation impact resulted from specific ecological conditions across the habitat. As the medical-genetical consequences of this impact, may serve the sharp increase in oncologic diseases, secondary immunodeficient states, and visual organ disturbances. Cytogenetic blood analysis (N=170) has revealed the occurrence of markers (i.e., rings and dicentrics) indicating to irradiation impact.These markers are mostly pronounced in the group of adults (0,57%), the value being significantly higher than in control (0,05%), $p < 0,001$. DNA samples database is collected for the further research on estimation of genetical long-term effects of irradiation.

INDUCTION OF MITOTIC CROSSING-OVER IN YEASTS UNDER COMBINED EXPOSURE TO ALPHA-PARTICLES AND GAMMA-RAYS

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Cells of Saccharomyces cerevisiae strain T1 (PG-154) carrying two different alleles of the gene ADE2 were exposed as monolayer to ^{239}Pu α-particles (3.5 MeV, 23.4 Gy/min) followed by ^{60}Co γ-rays (96 Gy/min), or in the reverse order. The interval between exposures did not exceed 30 sec. The initial exposure dose was adjusted to provide the survival levels of 100%, 92-96%, or 10-14%. The data from 2-3 independent experiments were pooled together and compared with the effect of each single type of radiation at the isoeffective doses. No mitotic crossing-over was detected in unexposed cell (over 20,000 colonies scanned). It was shown that the total mutation frequency constantly increased in the same manner for any type of exposure. The doses efficacies of γ-rays and α-particles differed 3.5 times for both the survival and the total mutation output. In contrast to other mutations, the mitotic crossing-over frequency increased up to peak at moderate exposure doses and the turned down rapidly. The effect strongly depended on the type, sequence, and doses of the radiation. In the α + γ sequence the crossing-over frequency was always greater than induced by γ -rays only at the isoeffective doses. Similarly, more crossing-overs were induced in the γ + α sequence in comparison with the α-particles, except for a single case of protective effect of the preliminary low-dose γ-rays exposure. Yet we have not enough data to pay special attention to this protective effect so it will not be considered for the further analysis.

The results obtained allow us to suppose that α-particles and γ-rays have different ability to induce «trigger events» (TE) leading to crossing-over. Some TE can be launched by γ-rays only or by α-particles only; others can be evoked by both kinds of radiation. In addition, for any kind of radiation there exist at least two effects of increasing the exposure dose. The first one is the increase in the TE number that is evidently conditioned by enhanced chromosome damage. The second effect is the reduction of the detectable crossing-over events frequency, and it may be accounted for more often occurrence of other mutations in the gene ADE2, that disguised crossing-over. It is also possible that damage induced at high doses repairs other ways than recombination.

RADIOBIOLOGICAL STUDIES WITH SOFT X-RAYS

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Forschungszentrum Rossendorf is building a superconducting **E**lectron **L**inear accelerator of high **B**rilliance and low **E**mittance (ELBE). Besides other applications, it will be used to produce secondary X-rays in a wide energy range (100 eV - 100 keV). Such an unconventional X-ray source is rather compact, tuneable and allows the possibility of delivering a picosecond pulse beam. In the first stage of radiobiological studies at ELBE, quasi-monochromatic X-rays in the energy range 10 - 50 keV will be obtained by planar channeling of relativistic electrons in a diamond crystal. The relative biological effectiveness (RBE) of the X-rays in this energy range will be determined by cell survival studies. Precise RBE values are required for risk assessment in diagnostic radiology, such as mammography, and radiotherapy with soft X-rays, but also for the application of novel radiotherapy approaches (miniature X-ray devices, X-ray phototherapy). For the determination of RBE of the low-energy X-rays, estimation of the biological effect after irradiation with a reference photon source (in this case, 200 kVp X-ray tube) is required. The reference cell survival curve for 3T3/NIH mouse fibroblasts revealed SF2-values of -53 ± 3 %, and values for α and β (linear-quadratic model fit) of 0.24 ± 0.02 Gy^{-1} and 0.022 ± 0.002 Gy^{-2}, respectively. These are in agreement with published data. Results for human neonatal keratinocytes are going to be presented. Irradiation with a soft X-ray radiotherapy device (25 kVp) of fibroblasts and keratinocytes is also being performed.

Some aspects of precise dose application to cell monolayers at ELBE photon beam have to be considered: the dose rate must be in the order of 1 Gy/min; the dose must be distributed homogeneously over the entire monolayer and sufficiently low contribution from background radiation must be guaranteed. Therefore, a monochromatisation system for the ELBE photon beam is required. Presently, highly oriented pyrolitic graphite (HOPG) crystals for monochromatisation are tested. Current status of cell irradiation at ELBE will be presented.

INVESTIGATION OF LOCAL CENOPOPULATION OF *TARAXACUM OFFICINALE S.L.* FROM RADIOACTIVE CONTAMINATED AREAS OF THE URALS REGION

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The problem of low rate ionizing radiation influence on living organisms and their communities is one of the key issues in radiobiology and radioecology. The ecological approach to the solution of this problem demands taking into account various types of intraspecific variability of organisms. The difficulty of study with cenopopulations lies also in the fact that the degree of landscape pollution, as a rule, is very heterogeneous, hence the dose loads differ essentially. The purpose of this work is to study answerback reaction of plants (*Taraxacum officinale s.l.*), growing in the conditions of radioactive contamination in the Urals region, for small doses of permanent exposure. In the process of research the levels of soil contamination with long-living radionuclides of ^{90}Sr and ^{137}Cs, their transfer into overground parts of plants and dose loads were taken into account. The biological effects were estimated according to a complex of cytogenetic, ontogenetic and population criteria. The comparison of different plots considering the content of long-living radionuclides shows, that density of soil contamination with ^{90}Sr exceeds the background 13-440 times, and with ^{137}Cs - 2-500 times. Additional dose loads exceed the natural gamma-background level 1,4-40 times, due to artificial radionuclides thus they do not overstep the limits of small doses range for vegetative objects. The overground plants mass accumulates less ^{137}Cs, than ^{90}Sr. The coefficients of biological transfer decrease with increase of radionuclides concentration in soil. It is fixed that the plants with high level of chromosomal aberrations exceeding the background 4-7 times develop at all radioactive contaminated sites. Essential differences in survival of seed posterity and the number of abnormal plants in cenopopulatons from various zones are found out. One can not observe monotonic linear relation of chromosomal aberrations output, survival of plants and the number of abnormal forms with increasing of the irradiation. In the investigated cenopopulations there prevail plants with low rate of growing. The influence of acute doses of provocative irradiation has differed for various cenopopulations. Seeds, formed in conditions of maximal radioactive contamination have shown the most radioresistance.

COMPARATIVE ESTIMATE OF THE INFLUENCE OF LOW DOSES OF ACUTE AND CHRONIC γ-IRRADIATION ON THE HOMEOSTASIS OF INTRACELLULAR CALCIUM IN LYMPHOCYTES OF THE PERIPHERAL BLOOD OF RATS IN DIFFERENT TIME PERIODS OF THE POSTRADIATION PERIOD

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Calcium is the main intracellular ion participating in the regulation of many metabolic processes. In this connection the particular attention is paid today to the defections of the systems of the regulation of its level in the cell, which observed at different pathologic states of an organism including the influence of ionizing radiations. The research has shown, that under the influence of large doses of ionizing radiations the increase of the content of ions $[Ca^{2+}]_i$ in the cytoplasm of cells of various organs and tissues is observed.

The measurement of the concentration of cytoplasmic $[Ca^{2+}]_i$ in lymphocytes of was carried out by using the fluorescent probe Fura2 (Sigma). The content of the calcium ions in the intracellular calcium depot and the physicochemical state of the membrane were investigated. The object of study was the lymphocytes of the peripheral blood of rats, after the influence of acute and chronic γ-irradiation (in doses 0,25, 0,5 and 1,0 Gy) on the 1st, 3rd and 10th days after the irradiation.

After the acute γ-irradiation (0,25; 0,5; 1,0 Gy) the increase of the concentration $[Ca^{2+}]_i$ was observed in incipient periods after the influence of the radiation (1st and 3rd days) with the subsequent tendency to regeneration (reduction) by the 10th day of observation. It could be connected with the observed changes in the physicochemical state of the plasmatic membrane of the cell. At the same time we have detected the increase (10th day) of the content of ions Ca^{2+} in the intracellular depot. The research of the influence of prolonged γ-irradiation on intracellular calcium homeostasis has revealed absolutely opposite effects in comparison with acute γ-irradiation. These data confirm our hypothesis that the effect of the activity of low doses of γ-irradiation on homeostasis intracellular $[Ca^{2+}]_i$ depends first of all, on the power of radiation, the time period after the radioactive action and the exposure dose. Thus the inverse relation between the studied effect and the power of a radiation dose has been observed.

THE MODIFYING ACTION OF PARA-AMINOBENZOIC ACID ON THE LETHAL EFFECT OF RADIATION IN MICE.

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In recent years much attention has been given to searching for radioprotectors of natural origin that have no accessory effects. One of such substans is para-aminobenzoic acid (PABA) which is synthesized by bacteria and participates in the synthesis of folic acid. PABA has been found to display a polyfunctional activity including radioprotective and antimutagenic effects in different organisms. However, the data on the protective activity of PABA against the radiation lethal effect in mammals are insufficient.

The aim of our work has been the study of PABA action on the lethal effect of radiation in mice of three inbred lines (BALB/ c, 101/H, C3H/He) and hybrids (C3H/He x 101/H). Over 1000 male and female mice have been used in the work.The PABA solution was given to the mice intraperitonealy in single doses of 10 mg/kg, 50 mg/kg and 100 mg/kg 40-50 min. prior to irradiation with doses of 5 to 7 Gy depending on the line and sex of mice. The used doses of γ-radiation were roughly LD75/30.

The radioprotective effect of PABA was observed in all variants of the experiment but it was relatevely low. The protection coefficint varied from 0,10 to 0,40. Besides, the protective effect depended on the line and sex of mice and on the dose of the injected substance. The highest protective effect was recorded upon irradiation of hybrid mice.

Analysis of the obtained data and their comparison with the available literature evidence permit us to suggest that being an antioxidant PABA may affect the repair processes in the irradiated organism.

ROLE OF ENDOGENOUS INTOXICATION AS "OF FACTOR OF INTENSIFICATION" OF IJURY OF BONE MARROW HEMOPOIESIS FROM INTERNAL IRRADIATION OF THE ORGANISM (EXPERIMENTAL RESEARCH).

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The radiobiological effects on the animals living at the territories contaminated with radionuclides are caused, first of all by internal irradiation. Mostly radionuclides among those of accidental and technogenic origin are radionuclides of osteo- and myelotropic kind. It allows to determine the injury of medullar hemopoiesis (MHP) and the development of system diseases in the definite part of population.

The main mechanisms of bone marrow hemopoiesis injury are probably the following:

1. Influence of osteotropic radionuclides, such as ^{90}Sr and ^{239}Pu, which accumulate in the endosteal bone layer and have direct influence on the all MHP cells. Truncal and committed pools are predominantly injured but the cells at any stage of differentiation including mature and stromal cells of hemopoietic microenvironment also can be injured.

2. Permanent irradiation of the blood and hemopoietic organs has also geometrically "reverse" way of influence - either irradiation directly by particles run from radioisotopes fixed in tissues, or irradiation from radionuclides located in the cells and tissues, which penetrate back to the blood by all classical ways of transcapillary interchange. In other words, there occurs permanent exchange of ionizing radiation energy between circulating blood and the organism's tissues.

It initiates the cascade of events which cause the formation and accumulation of radiotoxins with following intoxication and syndrome endogenous intoxication. This syndrome significantly amplifies injury of MHP and plays a role of amplifier. In our futher report we will demonstrate the data about injury of MHP of animals kept in the Chernobyl exlusion zone and it's modification using the method of intensive organism desintoxication (extracorporeal hemoperfusion, enterosorption, forced diuresis mineral water such as "Naftusya"). Simultaneously with detoxication effect the decorporeal one has been detected.

APPLICATION OF HIGH ORDER (D^{VIII} - D^{XVI}) DERIVATIVE SPECTROPHOTOMETRY FOR THE FINE ANALYSIS OF UV-SPECTRA STRUCTURE BY AROMATIC AMINO ACIDS IN THE STUDYING OF THEIR RADIOLYSIS MECHANISMS

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The advances of derivative spectrophotometry (dSP) used in analytical biochemistry are accompanied by the corresponding progress in analytical practice of the damage influences investigation on the fine spectra structure of phenylalanine <Phe>, tyrosine <Tyr>, tryptophan <Tryp> under influence of high doses of γ- radiation (0.6 - 12 kGr). In region from 230,5 up to 300 nm 16 basic and 32 additional new stripes of DVIII–XVI-spectrum of Phe were selected. The stripes 251,44; 257,68 and peaks 260,15; 261,32; 263,27; 267,1 nm inherent for Phe attract special attention for analytical purposes [1]. In distinction from the earlier known facts of integrated change in absorption peak, the separate strips of a spectrum not changing the meaning size of optical density are established. There were selected 17 basic and 12 additional bands for Tyr in spectral region from 243,1 up to 298,08 nm. The stripes 245,88; 251,48; 256,52; 260,72; 267,16; 272,2; 275,28; 283,1; 289,0; 292,36; 298,08 are to be of and special interest for the analytical procedures [2]. Hydroxilic radicals oxidize the aromatic ring of Tyr with 3,4 - DOPHA formation. 17 basic bands in region from 270,12 up to 290 nm and 16 stripes in UV-region from 250,3 up to 269 nm and 16 stripes in distant UV-region from 292,5 up to 309 nm were established for Tryp [3]. Owing to the dSP IV-XVI it is possible to detect the traces of Phe in Tryp- and Tyr-solutions as well as to determine the Tyr-traces in Tryp-solutions. It became possible to obtain indolieacetic acid among of Tryp radiolysis products and serotonin which can determine behavior reactions both in vegetative and in animal populations in zones of radiating accidents.

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POSSIBLE MECHANISMS OF POSTRADIATION CHANGES OF AIBUMINS AND GLOBULINS

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The reduction of active and passive immunization efficiency at γ-irradiated organisms and the development of pathological states are accompanied by changes of γ-globulin (γ-Gl) and albumin (Al) blood protein fractions. The use of the high order derivative spectra(dSpVIII-XVI) in a combination of Graph Digitizer 1.0, Micro Call Origin 3.0 - 5.0 and Spectra Calc software have ensured the new data of character of kinetics changes of separate bands of a complex harmonic of Al and GL spectra under γ-irradiation(0.6 - 25 kGy) [1,2]. For the first the data on dSpVIII-XVI for Al and Gl were described and the specificity of a spectrum bands (SB) was established. Tryptophane, 5-hydroxytryptamine (serotonine, 5-HT) were detected in radiolysis products of γ-Gl. The received data indicated on the necessity of the extremely cautious attitude to the statements about an invariability of spectral contours for Phe, Tyr, Trip as well as for Al and γ-Gl under γ-irradiation. The equations of polynomial regression, describing kinetic curves of radiolysis for Phe, Tyr, Trip as for Al and γ-Gl are presented. At quantitative calculations of clinical coefficient of Al/γ-Gl it is necessary to specify the time interval of measurements and action and after-effect of a γ-irradiation as well as to take into account common for Al and γ-Gl stable SB at λ being equal to 259.5; 269.6; and 285.2 nm [2]. The qualitative changes of fine structure of Al and γ-Gl spectra established by us contrast with the statements accepted earlier in the literature. In connection with an opportunity of occurrence in Al and γ-Gl radiolysis products of 3,4- DOPHA, IAA, tyroxine, 5-HT, adrenaline and some others neiromediators the attention is attracted to necessity of thorough control of medicines and foodstuff containing γ-Gl and Al at γ-sterilization and radiating accidents.

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THE FEATURES OF CHANGE OF LIGHT HARVESTING COMPLEX OF PHOTOSYSTEM-2 UNDER γ- RADIATION INFLUENCE

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Within the framework of development of theoretical representations about the localization of damage influences of the extreme factors of external environment (EFEE) and anthropogeneous stressors (AS) at the reaction centeres of photosystem-2 (RC PS-2) [1] action of high dozes of γ-radiation on light harvesting complex (LHC) of PS-2 of vegetative objects with various radioresistance have been investigated The data on kinetic changes of LHC PS-2 optical density have shown, that the stability of LHC occupies an intermediate position between a leaf chlorophyll-protein complex in vivo and solutions of its pigments [2]. The stable set is revealed at allocation of LHC spectrum bands (SB) and the existence of SB common for different objects is shown; our the data indicated that the action of high dozes of γ - radiation induces significant smaller changes in kinetics of change of sizes of optical density in comparison with the short-term temperature shock; the set of stable SB not connected with hypsochromic or bathochromic (effects) shifts are found out under the action of γ-radiation; SB connected to realization of functional properties of Chl-protein complex at transformation of energy in RC of electron-transport chain of photosynthesis were established. This data are coincided with the spectral determination of a link P_{680}Phe Q_AQ_B, which is characteristic for photosynthetic procaryotic and eucaryotic organisms. Our experiments are illustrated by the schema, upright arrows pointing the probable places of damage influence EFEE in RC PS-2 :

$$e^- \rightarrow ZP^+_{680}Phe^-Q_AQ_B \rightarrow ZP^+_{680}Phe^-Q_A^-Q_B \rightarrow ZP^+_{680}PheQ_A^-Q_B \rightarrow Z^+P_{680}PheQ_A^-Q_B \rightarrow$$

[diuron, *EFEE, AS,* Na^+, Cl^-, $SO_4^{=}$, SO_2, NO, NO_2, NH_4^+, O_2, CO_2 etc.]

$$e^- \rightarrow Z^+P_{680}PheQ_A^-Q_B^- \rightarrow ZP_{680}PheQ_AQ_B^- \rightarrow PQ \rightarrow Cytf \rightarrow PC \rightarrow PS\text{-}I$$

KCN

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COMPARATIVE CYTOGENETIC EFFECTIVENESS OF PULSED AND CONTINUOUS NEUTRON IRRADIATION

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The existing data on biological action of pulsed neutron radiation are scanty and controversial. We showed previously using human lymphocytes in culture that the effectiveness of pulsed neutron expose was a function of pulsed frequency, i.e. effectiveness was sufficiently higher at 100 Hz in comparison with 5 and 1 Hz. In the present work for the first time effectiveness of pulsed neutron irradiation was studied when duration of exposure was 65 μs and dose rate was about 10^5 Gy/s. The nuclear reactors 'BARS-6' and 'BR-10' at the Institute of Physics and Power Engineering were used as sources of continuous and pulsed neutron radiation. The parameters of sources were as following: mean neutron energy 1.44 and 0.85 MeV, dose-rate (1-4) 10^5 Gy/s and 0.17 Gy/min, contribution of γ-radiation ranged from 30 to 40 % depending on dose and less than 5 %, respectively. The blood samples were exposed with doses 0.65-2.05 Gy and 0.5-2.0 Gy. It was shown that the frequency of radiation induced aberrations after pulsed neutron radiation (without contribution of γ- radiation in the total effect) was about two fold higher in comparison with continuous radiation with the same doses. The spectra of radiation induced aberrations observed were slightly different. The average yield of points and acentric rings observed after pulsed neutron irradiation was sufficiently higher than the yield of the same type deletions after continuous irradiation. The yields of chromosome aberrations observed after both pulsed and continuous irradiation were fitted well with a linear dose response curve. We offered several hypotheses to explain a higher biological effectiveness of pulsed neutrons. It was significant contribution of accompanying γ- radiation in dose with pulsed radiation. It was suggested also that interaction of γ- and neutron radiation could take place and, as a consequence a synergetic cytogenetic effect. The influence of dose-rate effect was considered too, but this cause seems to be insignificant on the basis of routine dose-rates in radiobiological studies. However, new peculiarities can be expected in the range of ultra-high dose-rates used in the present study.

THE INFLUENCE OF THE CHRONIC GAMMA-IRRADIATION ON THE TRATES OF GENETIC VIABILITY IN LABORATORY STRAINS OF *DROSOPHILA MELANOGASTER*

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Drosophila melanogaster is an usable model organism for investigation of low dose irradiation genetic effects.

In experiments were used the laboratory strains of *Drosophila melanogaster*, distinguished by active copies of transposable elements of hybride dysgenesis systems: *GB-39* (has P-elements), *Oregon-R* и *LA* (have *hobo*-elements), линия *Canton-S* (has not the copies of active *P*- и *hobo*-elements). The flies were chronically irradiated by ^{226}Ra source in 0,17 sGy/h of dose rate. The dose rate per one generation was 80-90 sGy. It has been investigated the rate of recessive sex-linked lethal mutations in *GB-39*, *Oregon-R* and *Canton-S* and the consentration of autosomal recessive lethal mutations in *LA* stock.

The laboratory strains of *Drosophila melanogaster* were chronically irradiated by ^{226}Ra source in 0,17 sGy/h of dose rate. The dose rate per one generation was 80-90 sGy. It has been investigeted the rate of recessive lethal mutations and strains characteristics in P-M and H-E systems of hybrid dysgenesis: the rate of hybrid dysgenesis sterility induction and the frequency of activation of P and *hobo* defective copies in stocks with genetic markers sn^w and $h(w^+)$.

It is shown that the rates of recessive lethal mutations in *Drosophila melanogaster* chronic irradiated strains as well as the characteristics in hybrid dysgenesis systems are dependent from the presence of the transposable elements. In P-M hybrid dysgenesis system the rate of gonadal dysgenesis sterility and the frequency of sn^w mutations increases after irradiation. In H-E hybrid dysgenesis system we observe an increase of dysgenic sterility and $h(w^+)$ transposition rate as well as decrease of these characteristics.

The obtained results suggest that transposable genetic elements play an important role in genetic response to low dose irradiation.

SELECTIVE ACTION OF ^{211}AT - METHYLENE BLUE ON HUMAN MELANOMA CELLS IN VITRO.

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Methods of "target" therapy by irradiation with α- and β-radionuclides find a growing application in oncological practice alongside with traditional methods of tumor therapy. α-emitters possess some optimum radiobiological characteristics of charged particles, which allow to effect selectively tumor cells with minimum damage in normal tissue. The ^{211}At is an α-emitter which possesses a half-life period of 7,2 h, the particle path in tissue is 60-65 μkm (it's about several cell diameters), an average energy of α-particles is 6,72 MeV, LET is 80-120 keV/μkm (which let to obtain the highest relative biological effectiveness). It is also known that 3,7-(dimethylamino) phenothiozin chloride (methylene blue, MTB) is capable to conjugate selectively with melanin of pigmented cells and in that way can be used as a radionuclide carrier to deliver it accurately to pigmented melanoma cells. The purpose of the paper is a study of accumulation degree and biological action of the ^{211}At radiation in the ion form and in composition with MTB on pigmented human melanoma and non-pigmented cells. The experiments were carried out in vitro on BRO melanoma cells and Chinese hamster V79 fibroblasts. ^{211}At in the ion form and in MTB composition was induced into the cells medium. The cells clonogenic ability was used as a criterion of evaluation of the action efficiency. A more effective inclusion of the ^{211}At-MTB was shown by the pigmented melanoma cells, in comparison to the V79 cells. The maximum ^{211}At-MTB accumulation was observed in the melanoma cells after 30-60 min. The ion ^{211}At inclusion is not significant for the cells of both types and the cells survival action was equal for the human melanoma cells and Chinese hamster cells after the ion ^{211}At treatment. At the same time ^{211}At-MTB action on pigmented tumour cells was observed one order more effective in comparison to the ion ^{211}At and normal non-pigmented cells.

The obtained results allow to affirm that ^{211}At-MTB is capable to act selectively, damaging melanoma cells with selective accumulation in pigmented cells. Thus, the MTB tagged ^{211}At can be regarded as an affective adjuvant aimed at preventing the metastase process, in the complex therapy of disseminated melanoma.

CHROMOSOME ABERRATION ANALYSIS IN PERSONS LIVING IN THE VICINITY OF THE NUCLEAR POWER PLANT KRÜMMEL IN NORTHERN GERMANY

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Exceptional elevation of children's leukaemia appearing 5 years after the 1983 startup of the Krümmel nuclear power plant, accompagnied by a sigificant increase of adult leukaemia cases, led to investigations of radiation exposures of the population living near the plant. The rate of dicentric chromosomes in peripheral blood lymphocytes of seven parents of children with leukaemia and in 14 other inhabitants near the plant was significantly elevated and indicated ongoing exposures over the years of operation. These findings led to the conclusion that chronic reactor leakages had occured. This was supported by identification of man-made radioactivity in air, rainwater, soil, and vegetation by the environmental monitoring program at the nuclear power plant. Calculation of the corresponding source terms show that emissions must have been well above authorized annual limits. The chromosome studies had also shown a significant overdispersion of dicentric chromosomes in the affected cells which is an indicator of exposition by high LET radiation. Alpha emitters are not controlled specificly by routine monitoring in the environment. We therefore looked for transuranic contaminations. Samples of house dust taken from roofs in the proximity of the plant were analysed by gamma and alpha spectroscopy. They showed elevated amounts of Am 241 and Pu isotopes including high levels of Pu 241 which are to be explained neither by fallout of the former atomic bomb tests nor by Chernobyl contaminations.

OXIDATION STATE IN THE ORGANS AND BLOOD AT PROLONGED ACTION OF SMALL DOSES IONIZING RADIATION IN 30-KM ZONE OF CHERNOBYL ACCIDENT

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It has revealed the essential quantitative and qualitative changes of cell membranes also in the oxidation state in the organs and blood at prolonged permanent action of smal doses ionizing radiation on animals in the 30-km zone of Chernobyl Nuclear Power Station accident. Prolonged continuous influence of low-intensity ionizing radiation incorporated radionuclides has been shown by chemiluminescence method to cause the intensification of peroxide radical processes in the organs and blood system. The balance of prooxidant-antioxidant state has consistently moved towards strengthening of free radical peroxide processes. Using ESR spectroscopy and spin traps have revealed increase of superoxide anion-radical generated rate and hydroxyl radical contents in the electron transport circuit of liver endoplasmatic reticulum membranes. It has revealed some data about disturbances of coordination of the antioxidative enzymes (SOD and catalase) functioning by elimination of radical oxygen forms. Radical forms of the oxygen initiate lipids peroxide oxidation (LPO) reactions, and regarding this fact it should be noted that there exists conformity between superoxide anion-radicals generation rate increase and content of hydroxyl radicals, on the one hand, and LPO intensity, on the other hand. By all that, the pathological changes in the organism are realized via intensification of peroxide processes. Actually, prolonged permanent influence of small doses ionizing radiation of low intensity is characterized by high biological efficacy.

INVESTIGATION OF THE ABNORMAL MORPHOGENESIS AMONG THE CONIFEROUS PLANTS FROM THE CHERNOBYL ZONE

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Chernobyl accident led to the different disturbances of the plant development. The appearance of different morphological anomalies among coniferous may be also caused with irradiation. The changeability of needles length seems to be the most typical example or the morphological abnormalities. This phenomenon was revealed during the first years after the accident and it is indicated again since 1992-1993 among young planted trees. Our investigation was aimed to carry out comparison analysis of *Pinus sylvestris* and *Picea abies* morphological abnormal needles in term of some morphological, biochemical and cytogenetic features. Length of *Pinus sylvestris* and *Picea abies* abnormal needles is differed from control samples in 2-3 times. At the same time differences between length of *Pinus sylvestris* abnormal needles and *Picea abies* control samples and between *Picea abies* abnormal needles and *Pinus sylvestris* control samples were not observed. Results of immunochemical researches showed the same numbers of the alpha- and beta-tubulin, actin-, hsp-70- and phosphotyrosine-isotypes for the proteins isolated from the control spruce leaves and morphologically similar abnormal pine leaves and for proteins isolated from the abnormal spruce leaves and control pine leaves as well. We have also performed the cytogenetic analysis in meristematic tissues of *Pinus sylvestris* needles formed morphological anomalies. The increase of the number of chromosomal aberrations and mitotic abnormalities was observed. Total rate of chromosomal aberrations in needle-base meristematic cells amounted to 11.76% including cells with fragments - 3.26% and cells with bridges – 8.5%. Number of c-mitoses revealed in morphologically abnomal needles of *Pinus sylvestris* were 24.1%. The results obtained suggest that abnomal morphogenesis of conifer trees might to be caused with significant biochemical and genome changes.

THE EFFECT OF BIOLOGICALLY ACTIVE PREPARATIONS ON POSTRADIOATION RECOVERY PROCESS.

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A number of biologically active compounds belonging to different groups were tested in laboratory animals. The preparation characteristics were evaluated by spleen endogenic colony-formation test in mice. The preparation series or doses possessing the highest spleen endogenic colony-formation indices were tested before and after γ-irradiation of animals with doses causing acute or peracute radiation sickness. Examination of some commercial vaccines (e.g., against Newcastle disease, viral haemorrhagic rabbit disease, et al.) properties showed that they stimulated colony formation in spleen (the stimulation index was 3.2 to 4.1). The vaccines allowed 48 to 49% increase in preservation rates for animals irradiated at a dose $LD_{50/30}$ if administered 7 to 30 days before the irradiation. Immunostimulants from other groups (T- and B-activins, prodigiosan, reapheron and mineral-organic substrate) had spleen colony-formation stimulation index of 1.06 to 3.4, with anti-radiation effect being the highest if administered 1-2 days following the radiation injury. Preservation index rose among radiated animals (at $LD_{50/30}$) as compared with irradiated controls, e.g. with T-activin (0.2 mkg) by 58,4%, with reapheron (5.0 thousand IU) by 50.0%, mineral-organic substrate (0,1 ml) by 49.4% and B-activin (10,0 mg/kg) by 41.6%. The preservation index rised by 37.5% with prodigiosan and by 80.0% with reapheron when used for animals radiated at a dose $LD_{80\text{-}100/30}$.

Thus, we determined that the commercial vaccines possess higher endogenic colony-formation indices than the other immunostimulants among the other biologics tested; the above vaccines proved to be the most effective preventive agents, and reapheron, T-activin, prodigiosan, mineral-organic substrate and B-activin were the most effective therapeutic drugs against acute radiation sickness.

ALUMINUM INDUCES CHROMOSOMAL ABERRATIONS IN THE ROOT MERISTEM CELLS OF WHEAT SEED

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In recent years the views on aluminum toxicity have changed, and the interest to evaluation of its biological effect and its behavior in the environment has risen significantly. [1,2] There has been found the capability of aluminum when in a human organism at certain circumstances to cause different aluminoses, including kidney malfunction, Altzhgeimer and Parkinson diseases syndromes [3]. Also phytotoxic effect of aluminum in sour (acid) soils as a result of acid rains has been described. The object of this work has been to find out citogenetic effects of aluminum on wheat cells. The spring wheat seeds have been sprouted in the tested solutions of aluminum nitrate and sulfite in a thermostat at 25 degrees Celsius for 48 hours. The same method was applied to seeds exposed dry to gamma rays of cobalt-60 at 50 Gy or to seeds processed with solutions of potassium nitrate and sulfite with the same concentrations as the above. Samples of 10 roots 5-10 mm long were found also after dying with acetoorcein , the number of cells with aberrations and aberrations spectrum were determined. Processing the seeds with water solution of potassium nitrate and sulfite does not lead to chromosomal aberrations in the meristem cells of the wheat. After processing the wheat sprouts with aluminum salts solutions maximum number of cells with chromosomal aberrations was detected at $5 \cdot 10^{-4} - 1 \cdot 10^{-3}$ mg/ml concentrations calculated for the aluminum (about 23 percent). Chromosomal aberrations spectrum after the action of aluminum nitrate and sulfite or gamma rays action are formed chromatid, genomic and chromosomal mutations in comparable amounts . This allows us to make a conclusion that aluminum ions induce formation of different types of chromosomal aberrations already at very insignificant concentrations in water environment corresponding to 1-2 limited levels for drinking water according to Russian standard.

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BIOLOGICAL EFFECTS OF FAST NEUTRONS OF PULSED REACTOR BARS-6 IN DIPLOID YEAST.

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Diploid cells of yeast of a wild type (M-139B) and radiosensitive mutants (rad52/rad52; rad54/rad54) in a stationary stage of growth irradiated by g-rays ^{60}Co, fast neutrons (0.85 MeV, dose rate 6,3 10^{-2} Gy/s) of the channel B-3 of reactor BR-10 and fast neutrons (1.44 MeV, dose rate up to $6 \cdot 10^{6}$ Gy/s) pulsed reactor BARS-6, which generated impulses by duration ~ 65 mes. During one impulse the set of doses from 8,75 up to 400 Gy was provided. For cells of a wild type the curves a dose - effect had sigmoid shape with a smaller steepness of an initial site on a comparison from a similar curve with an exposure by continuous neutron irradiation; the curves a dose - effect for mutant cells are exponential. The cells of a wild type irradiated by neutrons in different conditions are capable equally to be recovery in an innutritious medium. The value RBE (1,7) with an impulse neutron irradiation is compared to value RBE (2.04) of neutrons at continuous irradiation. The effectiveness of neutrons impulse reactor for cells of mutants rad52/rad52 (RBE-1.52) and rad54/rad54 (RBE-1.4) is little bit lower, than for cells of a wild type, but in view of errors of distinction are uncertain. The lack of these distinctions can mean, that at a high dose rate, when cells ware irradiated with large doses for short time, the singularities of a biological effect of neutrons to explain by recovery processes are impossible. Analyzing datas on value RBE of neutrons with continious and impulse action on cells of a various reparation genotype is found, that a ratio RBE of neutrons reactor BARS-6 to RBE of neutrons of the channel B-3 reactor BR-10 in limits of experimental errors for all types of cells practically is equal 1.

EFFECT OF MAGNETIC FIELD ON L-STRAIN CELLS

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The findings of recent studies conducted show that magnetic field has effects both on cells and organism. In this study, L-strain cells with fibrosarkoma characteristics have been exposed to an average of 23mT magnetic field for 1, 2, 3 and 4 minutes. The death rate of these cells 24 hours after the exposure has been calculated and the effects of the magnetic field on DNA synthesis have been observed.

GAMMA RADIATION EFFECT ON COTTON PLANTS

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Air-dry seeds of cotton plants var.108-F *Gossypium hirsutum (L.)* were irradiated by gamma radiation ^{60}Co: 8, 16, 32, 40, 48, 56, 80, 160, 240, 320 and 560 (Gy) at radiation dose equal to 0,012 Gy/sec.

On plants M_1 & M_2 character of variation of 50 morphological and agronomic characters as well as frequency of beginnings of chlorophyll and other types of mutations have been evaluated.

The main results of our research are the following:

- It was established that 50% (LD_{50}) of survivals in the phase of cotyledonary leaves correspond to dose of 46 Gy, in the phase of budding – 19 Gy, in the phase of flowering-fruit-bearing – 17 Gy.

Hence, cotton plant var. 108-F belongs to the class of medium-sensitive plants.

-Unusual effect of gamma radiation on growth in cotton plant ontogenesis has been found: growth inhibition observed in vegetative phase transforms into "pseudostimulation" when plants enter generative phase of development.

- "Dose-effect" curves based on test data in M_2 chlorophyll and other types of mutations, let us determine the range of dose – 16-32 Gy, within which the maximal output of different types of mutations can be expected, including mutations with agronomic characters.

- On 60 radiomutants of cotton plant it was shown that mutations of single genes had weak effect on the degree of correlative interrelationship between morphological and agronomic characters. When elaborating strategy of improvement of efficiency of methods of mutation selection, this effect should be considered.

- On the basis of combination of methods of radiomutagenesis and hybridization a high-yielding, wilt resistant variety of middle-staple cotton plant "Sogdiana" have been selected. It undergoes field-testing at present.

RADIATION-INDUCED HALOGEN-DERIVATIVE HYDROCARBON RADICALS: MECHANISMS OF FORMATION AND CYTODESTRUCTIVE ACTION

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Determination of mechanisms and potential danger of combined action of ionizing radiation and technogenic contamination on biological systems are actual tasks of modern radiobiology. Great danger represents a substances which modify the primary radical processes in biosystems particularly in cell membranes - one of the main targets of radiation damages of cells. We discovered a sharp increase of radiation-induced destruction of isolated erythrocyte membrane components and hemolysis of cells upon γ-irradiation in presence of some halogenderavative hydrocarbons (HH). On examples of chloroform and carbon tetrachloride it is shown that marked oxidation of membrane protein tryptophanils, lipid peroxidation and cell lysis take place under relatively low (submillimoles) concentrations of HH and radiation doses that induced only insignificant damages of membranes in absence of the modificators (5-10 kDj). Ethanol which catchs $OH^{\bullet}$ radicals and drustically decrease a radiation-induced lipid peroxidation without HH only slightly influenced on lipid peroxidation in presence of HH. But Ni^{+2} ions which effectively intercept the solvated electrons inhibited the effect of HH on peroxidation of membrane lipids though do not exert any effect on the oxidation process without HH. Since HH have a great affinity to solvated electron we propose that formation of radicals of HH one electron redaction takes place under irradiation of samples. The scheme of such reduction for chloroform is: $CHCl_3 + e^-_{eg}$ --> $CHCl^{\bullet}_2 + Cl^-$. This proposal is confirmed by appearance of chlorine ions, which we registered on turbidity of $CHCl_3$ solution irradiated in presence of HH after addition of $AgNO_3$ due to formation of poorly solved salt AgCl. It is known that radicals of HH can easily induce the oxidative damages of protein and lipid molecules. The results received evidence about great danger of join action of γ-radiation and HH on biological membranes and cells because of formation of such radicals.

EFFECTS OF LOW DOSES OF CHRONIC INTERNAL IRRADIATION CAUSED BY INCORPORATED CESIUM-137 ON PURINE METABOLIZING ENZYMES IN RAT BLOOD SERUM

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In spite of 14 years following the Chernobyl accident the most important radionuclide among other dose-forming ones is cesium that is conditioned by its radiotoxicity and peculiarities of behavior in ecosystems. The aim of this study was to examine the influence of incorporated cesium on blood concentration activities of tissue originated enzymes such as 5'-nucleotidase (5'-NT), adenosine deaminase (ADOase), purine nucleoside phosphorylase (PNPase). For two groups of Wistar male rats the cesium-137 chloride salt was daily administered orally in quotas of 100 and 25 kBq on kilogram of body mass during 16 days to cumulate doses of 26 cGy and 8 cGy, respectively. Time course of sequential hydrolysis of [^{14}C]-AMP to hypoxanthine in blood serum samples was analysed by nonlinear regression method for estimation of kinetic parameters (V_{max}, K_m) of these enzymes. It was found that used doses of internal irradiation produce the significant perturbation in enzyme spectrum detected at different postirradiation periods. The content of 5'-NT at dose 26 cGy increased on the 10-90th days, whereas at dose of 8 cGy it slightly decreased on 30th day. The maximum elevation manifested on 10th day was followed by gradual reduction to control values on 180th day. The activity of ADOase at dose 26 cGy was transiently increased in 90 days and PNPase activity was higher than in control at all studied periods up to 360th day. Dose of 8 cGy did not produced any significant changes in V_{max} parameters for ADO- and PNPase activities in contrast to that was observed for K_m parameters. Taken together, these findings demonstrate radiation-induced acceleration in purine blood catabolism. These results stipulate that dose of 26 cGy was sufficient to promote cell membrane damage as opposed to lower dose of irradiation which enhanced the purine metabolism only. It may be concluded that break-down of purine nucleotides may precede the cell damage and that it can occur in early stage of radiation effect.

EFFECTS OF LOW DOSE IRRADIATION ON YEAST CELLS

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The survival and adaptive response were studied after low doses γ-irradiation at different dose rates on yeast cells. The low dose hypersensitivity was not observed in exponential culture and at G_1 stage of cell cycle in contrast to experiments on mammalian cells. We suggest that reaction of yeast differs from the reaction of mammalian cells at low doses due to more efficient repair systems. We suppose that the signal induced the repair system is not a DNA damage. So, we can explain the absence of low dose hypersensitivity of yeast cells. The adaptive response was increased with dose rate of prolong irradiation in studied range: 1.6–7 Gy/h. It was shown that the enhanced radioresistance disappears during some generation after termination of the irradiation and the progeny of irradiated cells are characterized by higher radiosensitivity in compare to intact ones. It proves that the cells are damaged after prolong irradiation in spite of higher radioresistance to acute irradiation. On the basis of previous experiments we concluded that balance between radiation induction and repair of damages was achieved during 2 hours after start of irradiation.

RADIOECOLOGY

ANTHROPOGENIC RADIONUCLIDES IN THE SOIL SOLUTIONS OF SEMI-NATURAL INVIRONMENTS

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One of the processes that governs the vertical migration of radionuclides in soil and radionuclide uptake through plant roots is the transport, as solute, by water passing through the soil and by diffusion within the liquid phase. Consequently, the information on concentrations and chemical forms of anthropogenic radionuclides in the liquid phase of soils is of great importance for forecasting of ecological processes in ecosystems. The paper studies the contents and speciation of main radiopollutants of Chernobyl fallout (^{90}Sr and ^{137}Cs) in the liquid phase of soils of different type (from podzolised chernozem, podzolic and soddy-podzolic soils to peaty soils) in forest and meadow ecosystems. It was shown that parameters under study are functions of physico-chemical properties of primary nuclear deposition, radionuclide nature, soil characteristics, and time elapsed from the radioactive fallout. The results of gel-filtranion study of soil solutions indicate that radiostrontium was present essentially in low molecular mass fraction of organic matter (MMw=350-500) and fraction of inorganic compounds. Radiocaesium was associated chiefly with ftractions of higher molecular masses (MMw≥ 1000). The relative contents of radionuclides in the soil solutions (RC) were extremely low for ^{137}Cs ($n*10^{-4}$ - $n*10^{-2}$ %) and low/or moderate for ^{90}Sr (n - $n*10^{-1}$ %). Long-term dynamics of the parameter involved is characterized by two period. In initial period (over 3-4 years after Chernobyl event) RC-values increased for ^{90}Sr (up to 11 times) and decreased for ^{137}Cs (up to 9 times). The parameter depended chiefly on the ratio between different physico-chemical forms in the deposition. In the following period the radionuclide distribution between solid and liquid phases of the soils was close to the steady state. RC-values changed in time slightly. Substantial distinctions in the RC-values between soils of different type as well variation of the parameter along the soil profiles were related to diversity of soil characteristics, influencing the radionuclide retention by soil solid phase. Organo-mineral layers under the forest litter (subhorizons Oh and OhA) and upper layers of meadow soils (sod cover, humus horizon) served as a long-term, effective barrier preventing radionuclide migration throught the soil profile to the aquifers and transfer from the soils to vegatation.

THE EFFICIENCY OF COUNTERMEASURES IN CROP PRODUCTION ON RADIOACTIVELY CONTAMINATED SOILS IN BELARUS

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After the decay of short-lived radionuclides it is ^{137}Cs and ^{90}Sr that mainly condition the inner dose on the population. A set of countermeasures was developed to decrease the radionuclide concentrations in agricultural food-stuffs.

The crops that are enhanced radionuclide accumulators were precluded from the rotation. In addition, lime treatments of acid soils were performed and enhanced phosphorous and potash fertilizer applications were made.

The action of a great deal of ameliorants (clayey marl, humin preparations, sapropels, etc) on the decrease of the input of ^{137}Cs and ^{90}Sr from soil into crops was studied.

As evident from actual practice, the selection of crops and cultivars that are insignificant radionuclide accumulators is the best way of decreasing the input of radionuclide into crops. To date, it has been recommended that this practice should be applied to the farms located on radioactive-contaminated areas. This practice is particularly effective in olericulture.

A set of countermeasures performed permitted to decrease the input of ^{137}Cs into crops by a factor of four. However, the problem of harvesting clean crops still remains to be solved.

Special-purpose measures are required to be taken to decrease the ^{90}Sr input from soil into plants owing to the excess ^{90}Sr contents in agricultural food-stuffs on contaminated areas.

One of the appropriate ways of solving this problem is a gradual respecialization of farms, for instance, mastering line of seed-growing and cultivation of grain as fodder by the farms involved in crop production. Technological and economic aspects of cultivation of industrial crops such as the rape, the sunflower, the sugar beet and the hop are being studied.

It should be noted that the crop cultivation on radioactive-contaminated areas should necessarily be aimed at conservation and enhancement of soil fertility. This is possible only when applications of organic fertilizers and chemical ameliorants are made with regard to soil properties. This will allow to harvest high crops with minimum radionuclide contents in plants.

THE POSSIBILITIES FOR CULTIVATION OF CEREAL CROPS ON RADIOACTIVELY CONTAMINATED AREAS IN BELARUS

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One of the objectives of agricultural production is to harvest agricultural crops with permissible radionuclide contamination limits.

In 1997-1999 a mass grain control over the ^{90}Sr content was exercised in the Gomel Province. The results obtained show the percentage of grain that could not be processed into food-stuffs was 7 to 40%.

Of the cereals the maximum input of ^{90}Sr from soil into cereals was typical of the oats, next were the barley and the winter rye. The minimum value of the ^{90}Sr input was exhibited by the spring wheat. This trend was observed for three years.

Research was undertaken to estimate the effect of agrochemical properties of soil (pH, humus content, mobile forms of phosphorous, potassium, calcium and magnesium) on the quantity of ^{90}Sr transferred from soil into cereals.

The results of the research corroborated a high correlation relationship between the quantity of ^{90}Sr transferred into crops and the soil acidity level.

The calculations made showed a significant correlation relationship and feedback between the mobile potash content and the ^{90}Sr input into crops. For cereals an average degree of the relationship between the parameters under consideration was established.

Special-purpose measures are required to be taken to decrease the ^{90}Sr input from soil into plants owing to the excess ^{90}Sr contents in agricultural food-stuffs on contaminated areas.

EFFECT OF FERTILIZERS ON ACCUMULATION OF RADIONUCLIDS BY PLANTS.

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Currently, when global soils are polluted more or less by radionuclids, one of parameters of quality of agricultural products is the extent of their contamination by pollutants. A number of works are dedicated to the effect of fertilizers on accumulation of ^{90}Sr and ^{137}Cs by different crops and natural fodder plants in pastures and hay grounds. In their majority it is shown that use of fertilizers decreases the specific contents of ^{90}Sr and ^{137}Cs in plants. On the alpine pastures, the influence of fertilizers is confined indirectly to increase in herb yield in which the "dilution" of radionuclids occurs in large biomass. In NP and NPK variants, a sharp decline in specific content of radiocesium is recorded. On the hay meadows of subalpine zone the effect of fertilizers is weaker. Concerning the rise of yield and decline in specific content of ^{90}Sr in plants of alpine and subalpine the most efficient variant is NP. The studies of perennial fodder plants – legumes (Medicago L., Onobrychis Adans.) and cereals (Arrhenatherum P. B., Festuca L., Dactylis L.) have shown that use of fertilizers has decreased the specific content of ^{90}Sr compared with control. The studies have also shown that for winter wheat, sawn perennials and mountain meadow plants the discrimination coefficients or observed ratio for pair ^{90}Sr - Ca, and coefficients of accumulation of ^{90}Sr generally were above one. Decline of ^{137}Cs concentration in plants with time is caused mainly by its decline in precipitation. The relationship between yield value and accumulation of ^{137}Cs in plants is inverse. The experiments have shown that in fertilized tests the contents of radiocesium in alpine herbs have sharply plummeted. In subalpine belt, effect of fertilizers on accumulation of ^{137}Cs in plants of hay meadows is weaker.

It is evident that introduction of fertilizers to soils triggers complicated processes hich cause a shift in ratio macro- to microelements between the solid phase of soil and soil solution, changes in pH what, in their turn, changed physico-chemical ratios of radionuclids in soils and differences of their inflow to vegetation.

ON ATMOSPHERIC DEPOSITS IN YEREVAN CITY. 1969-1998

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Atmosphere is a sphere of substance transfer on the Earth. The litter surface, soil and vegetation are the main contact zone with pollutants.

As it is known, high levels of pollutant concentration are recorded in urban areas. Yerevan city is not an exception. To obtain data on the amount of deposits, sedimentation method that considers all types of them per 1sq.m was applied. In the table generalized data on atmosperic deposits and their radioactivity are given.

Years	Deposits g/m^2/per annum	Precipitation mm	Bk/m^2/per annum		
			β-activity	^{90}Sr	^{137}Cs
1969-1983	89,6	278	728	34,0	50,0
1989-1998	198,0	264	356	11,3$^{x)}$	23,5$^{x)}$

x) calculation data

Investigations carried out in 1969-1983 showed a close positive correlation between β-activity level and ^{90} Sr and ^{137}Cs concentrations. By regression equation ^{90}Sr and ^{137}Cs concentartions were calculated over the period of 1989-1998. In 1969-1983 samples were taken on the territory of green belts, from 1989 – in the areas adjucent to crossroads with heavy traffic where the amounts of atmospheric deposits have increased by 2.2 times. The level of β-activity and ^{90}Sr and ^{137}Cs concentartions have decreased by 2 and 3 times at the expences of decline of global radionuclids in atmosphere. Within the first period the amounts of macroelements in deposits were on average 19.3%, trace elements – 0.49%, in 1989-1998 – 22.2 and 0.5%, respectively. Macroelements made the row: Ca (8%) > Mg > Fe > K > Na. The trace elements in 1969-1998: Ti > Mn > Sr > Pb > B > Cu > Ni > Li > Rb > Co. In 1992-1994, the row had the same structure except Cu which shifted to 3rd place from 6th.

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RADIONUCLIDE COMPOSITION OF THE YENISEI RIVER AQUATIC PLANTS IN THE AREA AFFECTED BY THE ACTIVITY OF THE MINING-AND-CHEMICAL COMBINE OF RUSSIAN MINATOM

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In 1992, two of the three nuclear reactors of the Mining-and-Chemical Combine (MCC) in Zheleznogorsk (the Krasnoyarsk Territory) were shut down. The MCC officials assert in press that now the remaining reactor does not use the Yenisei water to cool the core and does not produce any adverse effect on the river ecosystem.

In 1997-99, during the expeditions of the Institute of Biophysics SB RAS at the Yenisei River, samples of aquatic plants were taken both near the MCC and far away from it, down the river. The samples are of four species: *Potamogeton lucens*, *Fontinalis antipyretica, Elodea canadensis*, and *Ceratophyllum demersum*. The gamma-spectrometric analysis of the samples of aquatic plants for artificial radionuclides has revealed a wide spectrum of long-half-life and short-half-life radionuclides. The maximal specific activity of the radionuclides ^{60}Co, ^{137}Cs, and ^{152}Eu recorded in the aquatic plants sampled near the MCC is 620, 760, and 120 Bq/kg, respectively. Of the short-half-life radionuclides, the highest specific activity is recorded for ^{51}Cr, ^{54}Mn, and ^{58}Co: 4265, 200 and 290 Bq/kg. Radionuclides of activation origin were found in aquatic plants taken both near the MCC and 180 km down of it. This suggests that cooling water of the operating reactor is still being released into the Yenisei. The radiochemical analysis of aquatic plants revealed ^{90}Sr and plutonium isotopes. Accumulation coefficients have been determined for some radionuclides. Species of aquatic plants with the maximal coefficients of radionuclide accumulation have been revealed.

Since aquatic plants of the Yenisei River grow large biomass and cover vast areas during the growth period, one of the future objectives is to estimate the scale of biological transfer of radionuclides down the river.

RADIOACTIVITY IN THE SOIL OF GOLDEN HORN CATCHMENT AREA-ISTANBUL

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In this study, gamma emitting natural and man made radionuclides in Golden Horn (the estuary of Istanbul) catchment area were investigated. ^{212}Pb, ^{208}Tl, ^{214}Pb, ^{214}Bi, ^{40}K as being natural radionuclides and ^{137}Cs as being a fission product were found. It was seen that the vertical migration of ^{137}Cs depended on the amounts of organic matter and the percentages of clay in the soil. The comparison of ^{137}Cs findings and previous studies showed that ^{137}Cs lost 11.7% of its activity between the years 1988-1996 in the region and ^{137}Cs activity decreased with an increasing depth, although natural radionuclides didn't show significant variations in vertical migration. According to the ^{137}Cs activity there has not been an invasive contamination during and after the Chernobyl reactor disaster in the Golden Horn catchment area which supplies water for the city of Istanbul by Alibey dam.

Key Words: ^{137}Cs, radioactivity, pollution, monitoring

LANDSCAPE APPROACH TO THE REHABILITATION OF THE TERRITORIES CONTAMINATED AFTER THE CHERNOBYL ACCIDENT

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Rehabilitation of the contaminated territories can be defined as activity directed to the restoration the normal, non-accidental regime of the land use.

The possibility of the rehabilitation depends primarily of the contamination of the territory, which forms certain dose rates for the population. Therefore dosage criteria is basic one for the evaluation the territory on the possibility of its rehabilitation.

Because of the permanent character of the rehabilitation measures, in addition to the radiation situation formed, natural conditions, which determine it's further evolution by influence on the processes of the washing-off, infiltration and biogenic accumulation of the radionuclides, are to be considered.

Abandoned lands, apart from heterogeneity of the contamination, are characterized by the landscape diversity, consequently the variety of the relief forms, the soil forming deposits, the soil and the vegetation cover. It brings about sufficient heterogeneity of the landscape-geochemical conditions, so different natural prerequisites of the rehabilitation.

At the base of the maps of the landscapes (relief, lithology, soil, growing conditions) and the actual vegetation cover representative sampling of the soil and phytomass have been made for the territories with good rehabilitation prospects (Narodychi district, Ukraine).

Using data collected, basing at the landscape approach, special algorithms for the maps of the transfer and accumulation coefficients of ^{137}Cs into phytomass have been elaborated, accounting its horizontal redistribution in the natural landscapes during radiologically significant period. By these algorithms, using data of the frequent connected «soil-grass», «soil-potato» and «soil-crops» sampling, the coefficient maps have been created using ARCINFO and MAPINFO software. These maps have been used to quantify the abandoned areas, to determine the priorities of realization the rehabilitation measures and to choice the optimal rehabilitation scenarios for every landscape unit.

THE ASSESMENT OF THE BIOLOGICAL EFFECTS OF RADIATION AND HEAVY METALS AS Pb, Cd WITH MICRONUCLEUS TECHNIQUE

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The number of environmental physical and chemical mutagens increase day by day. The sorts of damage that could be caused by each mutagen at the limit values is almost known but such damages cannot be estimated under low doses of exposure. Researchers are inclined to study with methods that may generate individually spesific and fast obtainable results due to disadvantages that such epidemiological studies do take a very long time and that there is a lot of individual differences in most of case. In the present study, different salts of heavy metals which are widely used in industry and in the presence of such salts, the biological effect of gamma rays as physical mutagens were analysed using micronuclei analysis technique. Lead, mercury and cadmium are known harmful effects on living organism and they tend to accumulate in such organism. Nevertheless, the biological effects of heavy metals on human body when taken into the body in very low concentrations and different chemical compositions and the related dose-response relationship have not been easily determined yet. The aim of the present study is to determine the effects of $Pb(NO_3)_2$, $Pb(CH_3COO)_2$, $CdCl_2$, $Cd(CH_3COO)_2$ on the yield of micronuclei depending on their concentrations were analysed, and dose-response curves were obtained under *in vitro* conditions. Micronuclei frequency were found significantly increased with all metal salts except $Pb(NO_3)_2$. The value of the micronuclei frequencies were evaluated using with their radiation equivalents by comparing with the value obtained in our previous dose-response curves by using Co-60 gamma ray. 0.25 Gy gamma radiation and metal salts' combine effects were also investigated. Metal salts have not shown any sensitive or protective effect on radiation.

RADIOECOLOGICAL CONSEQUENCES OF THE CHERNOBYL ACCIDENT FOR FOREST ECOSYSTEMS IN BELARUS

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The Chernobyl accident inflicted great losses to the economy of Belarus and damaged greatly the environment. The disaster has changed lives of several millions of men.

Every fourth hectare of Belarussian forests is radioactively-contaminated. The ^{137}Cs contamination density of soil exceeding 1 Ci/km^2 is typical for 1.7 million hectares. The Gomel and Mogilev Provinces are noted for the highest percentages of radioactively-contaminated forests (62.3% and 42.8%, respectively).

At present the radiation situation in the contaminated territories is governed by ^{90}Sr, ^{137}Cs and $^{238,239,240}Pu$. In the areas far removed from the reactor a notable contribution is made by ^{137}Cs.

The main problems of contaminated forests are following:

- high radionuclide contents in forest products;
- heavy losses on wood resources;
- very high radiation doses on forest workers. The foresters have more than 2 times higher than those on the rural population;
- a significant contribution of the "forest component" to the internal dose on the population of forested areas. The contribution of the forest component to the internal dose is currently 30 to 70%.

The main objective of our research is modeling and prediction of the radiation situation in forest ecosystems.

As a result of the regular study of forests in Belarus Polesye affected with Chernobyl-derived radionuclides a system of radiological assessment of forest ecosystems following large-scale nuclear accidents was worked out. On the basis of the investigative methodology devised basic features and mechanisms of radionuclide behavior in forest ecosystems were revealed. A set of new mathematical models was proposed.

FORESTLIFE phenomenologiocal model has been developed and is implemented to predict the radiation situation in the forests and dynamics of radiation doses as well as to estimate the efficiency of countermeasures. The model consists of two parts: a FORESTLIFE radioecological model and a FORESTDOSE dose model.

The FORESTDOSE model calculates the external doses from forests and contribution of the "forest component" to the internal doses at the expense of the consumption of forest food products.

These are helpful in predicting dynamics of contamination levels of forest ecosystems and radiation doses in population arising from radioactive contamination of forests and consumption of forest-derived foodstuffs.

The assessment of protective measures was made.

The use of the system of radiological assessment of forest ecosystems following nuclear accidents will make it possible to perform scientifically reasonable forest management in emergency caused by radioactive contamination and to work out a strategy of rehabilitation of affected areas.

ASSESSMENT AND PREDICTION OF POLLUTION OF WATERS AND BIOTA IN THE BLACK SEA WITH ^{90}SR AND ^{137}CS AFTER THE CHERNOBYL NPP ACCIDENT

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The data was obtained during expeditions of oceanographic vessels and as a result of the radioecological monitoring of Sevastopol bays and the Black Sea areas adjacent the Danube and Dnieper river mouth.

It was showed that trends of influxes of ^{90}Sr and ^{137}Cs to the Black Sea with the Danube and Dnieper run-off, as well as the outflow of these radionuclides from the Black Sea through the Bosporus strait may be described by exponential equations. (Egorov, Povinec, Polikarpov et al., 1999). The results of calculation of the ^{90}Sr and ^{137}Cs balance, occurred in the Black Sea in 1995, and the prediction of them, obtained by integration of the exponential functions, are presented in Table.

Table. Balance elements of post – Chernobyl ^{90}Sr and ^{137}Cs in the Black Sea, TBq

Balance component		Entry assessment in 1986-1995		Prognosis of consequent entry		Total	
		^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
	Content before 26.04.86					~1500	1400 +/-300
(+)	Athmospheric fall-out (May, 1986)					100-300	1700-2400
(+)	Entry with the Dnieper River release	90.2	2.0*	59.7	0.06	144.9	2.06
(+)	Entry with the Danube River release	24.5	24.0*	15.8	9.4	40.3	33.4
(-)	Transfer through the Bosporus	94.0	225.0	115.1	73.9	209.1	298.9

*- in1986-1994 years.

The observations in the network of radioecological monitoring have showed that concentration of ^{90}Sr in water, brown algae and mussels of the Sevastopol bays decreased exponentially during 1986-1999 with a time constants of 6.9, 4.0 and 6.7 years, respectively, while the constants for ^{137}Cs were of 5.9, 4.4 and 4.3 years, respectively (Egorov, Polikarpov, Mirzoyeva et al., 2000). A phenomena of the decrease with time of concentration factors of ^{90}Sr and ^{137}Cs in biota was found. By using the mathematical model, it was shown that this is caused by influence of dynamic characteristics of the radionuclide concentrating by marine organisms.

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TECHNOGENIC RADIONUCLIDES IN AN ECOSYSTEM OF NPP'S POND - COOLANT

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The NPP's radionuclides enter in an ecosystem of a pond - coolant on several canals. The main canal - shunt of debalanse waters and offset with service water. Activity of NPP's radionuclides brought in a basin for year of NPP work no more of activity of technogenic radionuclides from other sources and much less of activity of natural radionuclides. NPP's radionuclides are uniformly arranged in enough to body of water of a basin and owing to processes of a self-cleaning are effectively output from water of bottom sediments. A main lobe of technogenic radionuclides (about 95 % and more) concentrate in bottom sediments and are retained in them practically eternally.

On the pond-coolant of any NPP examples is showed as the activity of technogenic radionuclides is arranged. In the pond-coolant ecosystem's compnonents the attempt is done to link this allocation to the performances of a state of ecosystems, and as to place dependence of arguments of transmission of radionuclides in an ecosystem from hydrobiological and hydrochemical modes of a basin.

The radiative consequences of NPP's radioactive inflows in a pond-coolant are estimated. They are insignificant.

STUDY OF THE AMOUNTS OF HEAVY METAL AND RADIOACTIVITY IN DRINKING WATER FROM CERTAIN REGIONS IN THRACE

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This research carried out in November and December in *1995,* deals with the establishment of the amounts of heavy metals and radioactiv,ity in the drinking waters from 10 regions in Thrace.

Mean amounts of iron, lead, cadmium, cobalt, nickel, chrome and zinc in the drinking waters from Catalca city center, Velicesme (Cerkezkoy), Corlu city center, Yulafli (Corlu), Kusbahce (Cerkezkoy), Gokceali (Catalca), Akalin (Catalca), Camurcesme (Silivri), Velikoy (Cerkezkoy) and Celtikli (Silivri), are *0.490±0.352* ppm, *0.087±0.025* ppm, 0.022±0.012 ppm, 0.023±0.039 ppm 0 122+0.072 ppm 0 186+0.130 ppm and 0.018±0.024 ppm respectively.

Total alpha activity in the drinking waters from these regions is 0.077±0.084 Bq/lt, and total beta activity is 0.144±0.128 Bq/lt.

KEY WORDS: Drinking water, heavy metal, radioactivity

RADIONUCLIDE CONTAMINATION OF FRESHWATER ECOSYSTEMS WITHIN THE CHERNOBYL NPP EXCLUSION ZONE

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For the time being, ecosystems of water bodies of the Chernobyl NPP exclusion zone continue to suffer from heavy radioactive contamination, dictating, thus, the need to carry out further research works within the framework of comprehensive regional radioecological monitoring. The results of radionuclides ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}Pu$ and ^{241}Am content in hydrobionts tissues of different trophic levels of water objects within the Chernobyl NPP exclusion zone have been analysed. Initially, separated water bodies and surface water of the river were contaminated due to atmosphere fallout of radioactive substances. Several years after the accident, contamination levels stabilised. River beds were washed out in flood periods and radioactive substances in bottom deposits ceased to play the major role as secondary contamination sources of water streams. Now, radioactive contamination of rivers is due mainly to other secondary processes: washout from water catchment-areas and inflow of radionuclides from more heavily contaminated water bodies. At the same time, closed water bodies, in particular the lakes of the inner exclusion zone, are substantially more heavily contaminated. This is due to limited water exchange and more high levels of radioactive contamination of their bottom deposits (comparatively to washed soils of river beds). Therefore, contemporary levels of radioactive contamination of the majority of closed water bodies are determined by rates of exchange of mobile radionuclide forms between water and bottom deposits, and by inflow of washed out radionuclides from water catchment areas. Our studies were conducted: to identify dynamics of radionuclide distribution in components of freshwater biocenose of water bodies within the Chernobyl NPP exclusion zone; to study dynamic profiles of radioactive contamination levels in fish species of different ecological groups; to assess the major factors, which determine distribution of radionuclides in the freshwater ecosystems; to assess a possibility to use hydrobionts of different trophic levels as biological indicators of radioactive contamination of water objects.

RADIOPROTECTIVE EFFECT OF MICROELEMENTS – SALTS OF HEAVY METALS IN THE AREAS CONTAMINATED WITH RADIONUCLIDES

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As a result of the accident at Chernobyl Nuclear Plant areas around the junction of Ukraine, Belarus, and Russia were exposed to the heaviest radioactive contamination. This area is referred to as "Polesye" (Woodland). In the area the soils are represented by turf-podzolic varieties of light granulometric composition with acidic reaction. The soils are characterized with the deficiency of the majority of nutrition elements, especially microelements. Consequently, deficiency of microelements is observed in plants, animals, and human organisms, which, in turn, results in specific diseases generally referred to as hypomicroelementhoses.

The main radioprotective measure, which decreases the incoming of radionuclides into plants, is spreading of lime on soil. The lime neutralizes acidity, which abates the mobility of radionuclides in soil. Another efficient radioprotective method is the application of phosphoric and potassium fertilizers in relatively large quantities. The fertilizers block the migration of radioactive cesium and strontium from soil into crops. However, it is proved that the above-described methods decrease not only the movement of radionuclides into plants, but also the incoming of microelements, which escalates the deficiency in the following links of the trophic chain.

It is determined that the application of microelements (zinc, manganese, cobalt, copper, and lithium in the form of easily soluble salts) during planting in the soil or in the form of sprays in other plant development periods shows radioprotective effect in decreasing the degree of radiation damage observed. There are essential reasons to believe that the increasing of the amounts of microelements in soil and plants, consequently in the feed for animals, causes radioprotective effect for agricultural animals and leads to certain corrections of microelement content in food products, which provides certain radioprotection on the following levels in the trophic chain.

The mechanisms of radioprotective effects by the salts of metals are being widely discussed nowadays.

RADIOECOLOGICAL EXAMINATION OF PLANKTON FROM RESERVOIR-COOLER OF BELOYARSKAYA NPS

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In the process of radioecological examination the concentration of ^{60}Co, ^{90}Sr and ^{137}Cs in all types of plankton from various regions of Beloyarskoye reservoir was estimated. It was determined, that in the zone of heated water drain the ^{60}Co, ^{90}Sr and ^{137}Cs concentration was cer-tainly higher than in the control region. It is caused by influence of a complex of the factors: boosted temperatures, leakage in heat-exchange equipment etc. It was shown that during the operation period of the second power unit of Beloyarskaya NPS (1985 - 1986), an additional amount of radionuclides, washed away from the cooling system of the NPS, entered the preheating zone through the water-drain channel. Since the unit was withdrawn in 1990 – 1991 no additional entries of radionuclides to the reservoir have been revealed. In the course of summer study of the daily dynamics a 4-5-fold increase in phytoplank-ton number and biomass was displayed between 4 and 6 o'clock p.m. In the same period the drop of ^{60}Co, ^{90}Sr and ^{137}Cs concentration was regis-tered in all types of plankton from this region of the reservoir-cooler. There was found a revertive correlation between the above-mentioned indexes (correlation factors from - 0,6 up to - 0,9). The examination has shown, that the concentration of radionuclides in the plankton from Beloyarskoe reservoir vary within the wide range; the average value is 270 (^{60}Co), 40 (^{90}Sr) and 260 (^{137}Cs) Bk/kg of dry mass. The total amount of radionuclides retained by all plankton from reservoir–cooler in summer was calculated. In the period of examination it made 1788 MBk/kg for ^{60}Co, 265 MBk/kg for ^{90}Sr and 1722 MBk/kg for ^{137}Cs, that many times exceeds the relevant indexes for higher water plants living in the reservoir.

METHODOLOGICAL ASPECTS OF REHABILITATION OF AGRICULTURAL LANDS CONTAMINATED AFTER THE CHERNOBYL NPP ACCIDENT IN UKRAINIAN POLESSJE

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The significant part of Ukrainian Polessje lands has suffered from the Chernobyl catastrophe. More then 50777,3 ha of arable lands have been removed from productive use and referred to alienated zone and zone of unconditional (obligatory) resettlement. Some lands needed countermeasures application. So their return to the productive use is the actual problem till now, as to lands being in use nowadays, as to removed ones.

Directions of rehabilitation should be found on general methodology and principles:

- exclusion of any unreasonable irradiation (principle of the non-exceeding);
- prediction of possible individual and collective doses of irradiation;
- completeness;
- succession of the planning and conducting of protective and economic measures according to their priority;
- interconnection of agricultural development state programs with radioecological and economic problems of contaminated territories;
- taking into account state support opportunities;
- economic and social expediency (benefit of rehabilitation measures implementation should be more then harm for human health without rehabilitation, or principles of expediency and optimisation).

Criteria and rehabilitation order of suffered from the ChNPP accident agricultural lands taking into account mentioned methodological principles have been elaborated.

RADIOECOLOGICAL INVESTIGATION OF FLOOD-PLAIN SOILS FROM TECHA AND ISET RIVERS

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Ecological and geochemical migration of radionuclides in flood-plain soils is rather specific. It is determined by special hydrological conditions, entrance dynamics of geochemical material from riverbeds and from water collecting area, and also by favorable conditions for decomposition of vegetative material. In this connection river Techa's flood-plain, contaminated in 50's as a result of unprecedented discharge of radioactive waste from Production Association "Mayak" are of special interest. This contamination has set up a substantial threat of radionuclide entrance into Ob-Irtysh river system. The present research was conducted on the basis of Institute of Plant&Animal Ecology Biophysical station (Russian Academy of Science, Urals Division), where systematic radioecological inveatigation, ideologically and theoretically grounded by N.V. Timofeev-Resovsky, are realized. The inveatigation were carried out in flood-plain of the Techa and Iset rivers in 1992-1999. The results revealed the extreme non-uniformity in river Techa's flood-plain contamination in the riverbed area (~10 m far from the riverbed), related with hydrological and geochemical dynamics of the landscape. In the upper and medial stream of the Techa river the basic contaminator is ^{137}Cs; down-stream, and also in riverbed area of river Iset it is more active radionuclide of ^{90}Sr. The density of contamination in flood-plain soils with ^{90}Sr changes from 600 up to 60 kBk/m^2, and with ^{137}Cs- from 2000 up to 10 kBk/m^2. Radionuclide content in central flood-plain soils of the Techa river (30-40 m far from the riverbed) also becomes lower further from the discharge poit for 1-3 orders of magnitudes. However and in this river's mouth it exceeds the level of control values, characteristic for the Urals region 4-5 times. In comparison with central flood-plain, soils in the riverbed area are polluted with ^{137}Cs to a greater extent, than with ^{90}Sr, that allows to consider the riverbed area as some kind of geochemical barriers restricting migration of ^{137}Cs. In flood-plain soils of the Iset river the maximal content of ^{90}Sr makes 60 kBk/m^2 and of ^{137}Cs -26 kBk/m^2, that is accordingly 15 and 4 times higher, than at control plots. There is marked the equalization of ^{90}Sr and ^{137}Cs migration ability in over moistened soil profile due to change of physicochemical state of radionuclides and migration processes, binded with transference of organic-mineral fine particles.

RELATIONSHIP BETWEEN THE DEGREE OF RADIOACTIVE POLLUTION AND RESISTANCE OF PLANTS TO DISEASES.

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As is known, ionizing radiation reduces the immunity of an organism, which results in intensive development of various diseases. It is true not only for animals, but also for plants. A number of scientific researches evidence the weakening of crop resistance to diseases on the soils contaminated with radionuclides.

Presently in the area polluted with radionuclides as a result of Chernobyl accident 90 per cent of damage both in animal and plant organisms reported is caused by *incorporated radionuclides*. The objective of our research was the degree of damage in the plants of *winter rye* and *clover*, which substantially differ in the ability to accumulate radioactive cesium. The typical diseases for the above-mentioned crops that were investigated were *Puccinia dispersa, Erysphe graminis, Gloesporium, Uromyces trifolii, Kabatiella caulivora.* The research was performed at In Narodichi, Zhitomir region – one of the most heavily polluted areas, where the degrees of soil contamination with Cs^{137} make up 270 – 2770 kBq/m^2, and external gamma radiation level of 50 – 500 mcR/h. Under these conditions the coefficients of accumulation of Cs^{137} rye varied from 0,11 to 0,23, and for clover – from 0, 98 to 1,67. The estimated dose of internal radiation for rye during the vegetation period of 320 days was 0,03 – 0,8 Gr, and for clover during the vegetation period of 300 days – 0,12 – 2,01 Gr. Damage resulted from the external radiation was estimated to be 5 – 10 times less heavy.

It was found that starting with the degree of contamination of 370 kBq/m^2 there is a relationship between the degrees of soil contamination with Cs^{137} and the development of the above-mentioned diseases. Thus, the spread of *Puccinia dispersa* on winter rye varied from 25 to 80 per cent with the degree of disease development of 20 – 70 per cent, and the spread of *Erysiphe graminis* – from 30 to 75 per cent with the development index of 20 – 60 per cent. On the plants of clover the respective indexes were estimated for *Uromyces trifolii*: spread 12 – 65 per cent, development 5 – 8 per cent; and for *Kabatiella caulivora*: spread 20 – 87 per cent, development 15 – 70 per cent.

Exposure to chronic radiation caused by incorporated radionuclides leads to the above described results because it incessantly hampers the process of metabolism and abates the activity of oxidation ferments taking part in the plant organism reparation.

CONTRIBUTION OF SOIL AND BIOTA TO THE MIGRATION OF ^{137}CS AND ^{90}SR FROM FOREST ECOSYSTEMS TO GROUND WATER

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Forest ecosystems are known to be capable for effective and long-term retention of radioactive fallout. Both soil absorbing complex and biota are principal factors preventing intensive radionuclide migration to the deep soil horizons and ground water. The radionuclide migration down and potentially beyond the soil profile depends on various environmental parameters and landscape type (automorphic or hydromorphic).

Automorphic, sandy soils serve as an effective filter for radiocaesium: even at the deposition more than 20 MBq/m2 ^{137}Cs concentration in the "free" soil liquor (lysimetric water) does not exceed the maximum permissible level (8 Bq/l). Hydromorphic (particularly peat) soils are least effective as a biogeochemical barrier slowing down the radiocaesium migration to deeper soil layers and ground water.

Soil impact on the mobility of ^{90}Sr is less pronounced compared to ^{137}Cs, and higher proportion of the first is expected to reach local water table in less time. High water table (0.7--1.5 m) characteristic for hydromorphic landscapes promotes radionuclide migration to deeper horizons.

Biota may contain of 9 to 65% of total deposition of ^{137}Cs and 9 to 21% of ^{90}Sr depending on landscape. Under conditions of hydromorphic landscapes, biota is the most significant factor of the radionuclide retention in the biota components. Such retention is more manifested for ^{137}Cs and less manifested for ^{90}Sr. In addition, different biota components serve as sinks for different radionuclides. ^{137}Cs is primarily accumulated by fungi complex (up to 47% of total deposition), whereas most proportion of ^{90}Sr (up to 20%) is contained in the arboreal vegetation.

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SOME FEATURES OF SPATIAL DISTRIBUTION OF RADIONUCLIDES AND HEAVY METALS IN FOREST SOILS*

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Global character and present scale of environmental contamination by radionuclides RN and heavy metals (HM) makes of high importance the problem of their combined impact on living organisms. In this connection, the studies of distribution of these elements over landscapes are of interest. Deposition of ^{137}Cs in the zone of Smolensk Nuclear Power Plant (SNPP) is about one кБк/м^2, which is close to background value for the investigated natural zone (southern taiga). This deposition is likely due to both global and "Chernobyl" fallout. Soil contamination by HM reaches sometimes the maximum permissible levels (for Pb and Zn) or exceed permissible level (for Cd). Both forest litter and illuvial soil horizon serve as biogeochemical barriers and prevent RN and HM from intensive downward migration. Spatial distribution of mobile forms of HM in the soils obeys normal (Zn and Cd) and lognormal (Pb) types. The same accumulative zones are characteristic for both Zn and Cd, which is the evidence of the same lithogenic origin of these elements and the same effect of biogenic factors on their fate in the investigated biogeocenoses. The opposite is characteristic for spatial distribution of Pb, which suggests that it is a technogenic element weakly affected by biological cycle. Spatial distribution of ^{137}Cs in the soils of Smolensk bench is quite different from the distribution of stable caesium and HM. This suggests that ^{137}Cs distribution in the soil-plant system is far from steady state with stable Cs. Thus, spatial distribution of chemical elements in the environment may serve as a criteria to trace the element origin and assess the state of technogenic pollutants in the natural environments.

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FORECASTING OF Cs-137 DYNAMICS IN THE FOREST ECOSYSTEMS

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Bank of mathematical models of ^{137}Cs behaviour in the main components (soil, assimilative organs, bark, wood, branches, large and smzll roots) of forest ecosystems is presented. The behaviour of this radionuclide is assumed to obey the same regularities as the behaviour of its stable chemical analogue - potassium. Radionuclide dynamics are considered in parallel with the dynamics of the phytomass. Radionuclides contained in the vegetation are pooled into two basic compartments: external and internal contamination, with separate analysis of each one. The reason for this division is the radionuclide pathway to the plant structures. Internal contamination is due to radionuclide transfer from the soil to plant via root system (root uptake) or radionuclide redistribution within the plant (from more contaminated parts of the plant to the less contaminated ones). The external contamination is fully determined by direct radionuclide fallout onto the aboveground organs of plants exposed. Landscape moistening, age and specific belonging of trees, size of fallout particles are the factors, which are taking into account.

The models were calibrated using the data obtained in the 30-km zone of the Chernobyl NPP in 1986 - 1994 and verified using independent data (global fallout and Chernobyl fallout in other regions). The algorithm described was found to be the most efficient in terms of ^{137}Cs behaviour in the forest environments. Models were realised on BASIC.

The models permit to prognosticate ^{137}Cs behavior under different conditions in the forests of different types (deciduouse, coniferouse and mixed) with the full spectre of moistening. A range of simulative experiments (repeated fallout, continuos fallout, etc.) has been performed using the models. The role of root systems in ^{137}Cs exchange between soil and wood plants was evaluated with the help of models.

THE METHODOLOGY OF ESTIMATION OF CONTAMINATION WITH TRANSURANIUM ELEMENTS OF BELARUS TERRITORY AS A RESULT OF NUCLEAR WEAPON TESTS AND CHERNOBYL NPP ACCIDENT.

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Long-lived transuranium elements having got into the environment can changed the background of ionizing radiation levels that were formed over thousands of year. Calculations of population doses for all the inhabitants show that radiation of the long-lived radionuclides makes the major part, though for individuals it can be insignificant. The levels of radioactive contamination with transuranium elements on territory of Belarus as a result of nuclear weapon tests and Chernobyl NPP accident have been assessed by 12 actinides. The uniform contamination of soil with level of 53±17 Bq/m^2 for $^{239+240}$Pu was formed as a result of global precipitation after the nuclear weapon test. This value increased up to 1.1 × 10^5 Bq/m^2 in South regions of Belarus and gradually decreased to level of global fall out on the North of Republic after Chernobyl NPP accident. The radioactive contamination of territory of Republic of Belarus with transuranium elements due to the nuclear weapon test is distinguished by lower ratio of ^{238}Pu/ Pu$^{239+240}$ activities: 0,034±0,006 and ^{241}Pu/ Pu$^{239+240}$ - 4,3±0,8 as compared with same ratios of activities of plutonium isotopes of Chernobyl origin which constitute 0.41±0.02 and 87.0±11.0 respectively. The real ratio of ^{238}Pu/ Pu$^{239+240}$ activities has an intermediate value. The contribution of fall out to the radioactive contamination of different regions of Belarus was estimated. The levels of soil contamination by transuranium elements and real ratio of ^{238}Pu/ Pu$^{239+240}$ activities were used for this purpose. In our estimation the value of ^{239}Pu of global and "Chernobyl" fall out on Belarus constituted 11TBq and 23 TBq , respectively.

The constants growth of ^{241}Am contents in all components of Belarus ecosystem is observed as a result of radioactive decay of ^{241}Pu . The maximum level of pollution with ^{241}Am will be reached at 2060 and will exceed that of $^{239+240}$Pu 2.7 times, the areas with density of surface pollution of soil with $^{238+239+240}$Pu + ^{241}Am up to 3.7kBq/m2 will be expand out of the limits of alienation zone of Chernobyl NPP in west and north-west direction by 20-30 km.

RECONSTRUCTION OF DOSE FORMATION FOR POPULATION OF BELARUS DURING ACTIVE STAGE OF THE CHERNOBYL NPP ACCIDENT.

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The various approaches were used for reconstruction of a radiating situation during an active stage of the Chernobyl NPP accident. However, all these researches on reconstruction of dozes absorbed by population's thyroid gland in time of "iodine impact" are based on restoring of radioactive contamination of soil and air by ^{131}I. The scientific substantiation and feasibility of retrospective analysis of radiation situation on the territory of Republic of Belarus in April-May 1986 on the basis of results of measurement of ^{129}I in environmental objects is represented. The content of ^{129}I in surface layer of soil from 37 sites of the Republic of Belarus before and after Chernobyl accident on different distance and direction from the place of accident is determined by methods of NAA and AMS measurements.

The levels of "bomb" contamination by ^{129}I was determinate in soil's samples which were collected before Chernobyl accident The levels of "bomb" contamination by ^{129}I is 94±14 μBq/kg. This value is determinate the lower level of reconstructed contamination of iodine-131 at the retrospective analysis.

The measurement of ^{129}I in soil's samples was made during 1995-1998. More than 85% of these radionuclides are in higher layers of soil (0-25 cm). The fraction factor of ^{129}I to ^{137}Cs in separate radioactive spots varied insignificantly. Because of we can use measurements of ^{137}Cs levels for retrospective analysis of levels of radiation contribution of soils contamination by ^{131}I.

More than 20radionuclides on a moment of accident were considered at the calculation. The radiation situation during of the active stage of accident was determinate by iodine isotopes.

The substantiation of possibility of direct measurements of iodine in hystological sections of thyroid gland is given on an example of some Minsk inhabitants (the samples were collected on April-May 1986). On the ground of these data the retrospective analysis of iodine-131 content in thyroid gland after the "iodine impact" is given.

ECOLOGICAL AND GEOCHEMICAL PECULIARITIES OF LONG-LIVING RADIONUCLIDES MIGRATION IN NATURAL-TERRITORIAL COMPLEXES OF THE EASTERN-URALS RADIOACTIVE TRACE

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In the 50s of the XXth century N. V. Timofeev-Resovsky, basing on the ideas of V.V. Dokuchayev, V.I. Vernadsky, V.N. Sukachev, raised the problem of interaction of living organisms and their biotope in the conditions of radioactive contamination. The contamination escalation resulted from the large-scale nuclear weapon tests, imperfection of nuclear technologies and a series of radiation catastrophes. One of them was Kyshtym accident in 1957, which caused the formation of the Eastern-Urals radioactive trace (EURT) with characteristic ^{90}Sr contamination. The wind transposition of silt and sand contaminated mainly with ^{137}Cs from the coast of Karachay lake has made the situation in this region even worse in 1967. In the process of long-term research the level of long-living radionuclides content in soil-vegetable cover in a series of the Urals natural-territorial complexes was estimated.

The variety of landscape geochemical conditions in the inspected zone makes the complex pattern of spatial distribution of radionuclides in soil-vegetative cover. The plots located not far from each other may differ on 1-2 orders of magnitudes concerning the level of contamination.

The modification of ^{90}Sr content in soils within the central axis of the trace submits to the exponential relation $y=e^{(a+bx)}$. The density of soil contamination with ^{90}Sr in the 100 kms distance from Productive Association "Mayak" 6-20 times exceeds the control values (1,5 kBk/m^2). At the same plots the content of ^{137}Cs is less then that of ^{90}Sr by a factor almost 10, varying within the limits of 10 up to 100 kBk/m^2.

The content of ^{90}Sr in soils and plants in peripheral sites of EURT practically does not differ from the background. At the same time the western periphery of the trace is characterized by higher content of ^{137}Cs in comparison with the eastern one. It may depend on its additional entrance with wind transposition form coast of Karachay lake.

On the basis of the obtained data the mathematical model the radionuclides inventory in the soils in the EURT territory with the exception of 30 kms zone of "Mayak" was calculated.

ON THE ROLE OF MASS-LICHEN COVER IN AN INDICATION OF RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT

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Long-term radioecological monitoring presupposes using the plants-indicators of radioactive contamination of the environment. In this respect, the convenient objects are lichens and mosses possessing wide range of distribution and long life cycle. The features of anatomo-morphological structure and physiology peculiar to these plants contribute to their active accumulative function.

The content of long-lived artificial radionuclides ^{90}Sr and ^{137}Cs has been studied in the samples of moss-lichen cover collected from particular plots of the arctic, northern and southern tundras, the forest-tundra zone, and the subzone of northern and middle taiga forests at the territory of the Ural-Siberian region within the limits of geographical coordinates 60-73°N and 60-165°E.

It was ascertained that ^{90}Sr content in moss-lichen cover conserved within 40-170 Bq/kg of dry phytomass and that of ^{137}Cs varied from 70 to 400 Bq/kg. A range of variability of minimum and maximum radionuclide concentrations is influenced by heterogeneity of sampling plots in spesies composition of lichens and mosses as well as by differences in their growing conditions.

Any specific features in accumulative capacity of lichens and mosses from tundra, forest-tundra, and taiga zones from the Polar Urals to North-Eastern Siberia have not been revealed.

Twenty-years dynamics of radionuclide contents in lichens and mosses, their role in radionuclide distribution within the components of soil-vegetational cover had been investigated.

On the whole, the levels of radioactive contamination of lichens and mosses are determined by input of long-lived radionuclides as constituents of global fallout. The data obtained may be used for general assessment of radiational situation in the Ural-Siberian region and for long-term monitoring in the North.

ASSESMENT OF CONTAMINATION WITH RADIONUCLIDES AND MICROBIOLOGICAL ACTIVITY OF BOTTOM SEDIMENTS IN COOLER RESERVOIR AT BELOYARSK ATOMIC POWER STATION

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The goal of the study was to investigate the content of radionuclides ^{60}Co, ^{90}Sr, ^{137}Cs in bottom sediments of Beloyarsk reservoir, and also to assess the number of sulfate-reducing and methanogenic bacteria (one of the major representatives of anaerobic microflora in bottom sediments being involved in the processes of organic substance mineralization), and total number of anaerobic bacteria.

Three stations for sampling of bottom sediments in reservoir were selected: one was regarded as a control (being located 5 km upwards the atomic power station (APS)), the residual two stations were located in sanitary-protection area of APS, and were subjected to the affect of liquid low-radioactive discharges (industrial wasteway channel and reservoir gulf nearby Biophysical station).

The highest concentration of radionuclides, ^{60}Co and ^{137}Cs in particular, was detected for industrial wasteway channel ground through which the supply of low radioactive dumping from APS to reservoir occurred. ^{60}Co and ^{137}Cs content in ground of control area was considerably below their content in reservoir bottom sediments in sanitary-protection area of APS, whereas the ^{90}Sr concentration inconsiderably differed between control and contaminated areas of the reservoir.

It was shown that the number of methanogenic bacteria in bottom sediments of Beloyarsk reservoir comprised 10^2-10^3 cell/sm^3, while the number of sulfate-reducing bacteria, and total number of anaerobic bacteria varied within 10^4-10^6 cell/sm^3. It was determined that the number of bacteria tested in bottom sediments polluted with radionuclides was higher or corresponded to the bacteria content in sediments of relatively pure reservoir area taken as a control.

ECOLOGICAL FUNCTION OF MOSS LAYER IN DISTRIBUTION OF ^{137}CS FLUXES IN CONIFEROUS FORESTS OF AUTHOMORPHOUS AND HYDROMORPHOUS LANDSCAPES

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Mosses are wide spread dominants of understorey vegetation in various forest ecosystems of temperate zone. Projective cover of moss species in forests mount to 90-95%, thus they form specific moss layer of vegetation. Researches noted that all species of mosses are an accumulators of ^{137}Cs. Our research showed that biomass of moss layer consisted of green mosses (mainly *Pleurozium schreberi* and *Dicranum polysetum*) in forests of authomorphous landscapes in the biogeocenosis of pine forest 50 years old belonging to floristic association *Molinio-Pinetum J.Mat. (1973) 1981,* union *Dicrano-Pinion Libb. 1933,* ordo *Vaccinio-Piceetalia Br.-Bl. 1939 em K.Lund 1967,* class *Vaccinio-Piceetea Br.-Bl. 1939* was equiled about 5% of the total aboveground phytomass of cenosis. Moss layer of vegetation in this phytocenosis retained about 12% of the total stock of ^{137}Cs contained in the forest ecosystem as a whole, and 50% of the total ^{137}Cs activity of aboveground phytomass. It was found that on the same experimental plot value of ^{137}Cs ground deposition in the soil of parcels without moss cover was about 25-35% more than with the moss ones. An intensive accumulation of ^{137}Cs during the first post-Chernobyl period was observed as well as the strong retaining of this radionuclide in moss layer during following period. Selfclearing of this layer of vegetation was slowly because of the huge foliar absorption capacity, absence of defoliation, slow (4-8 years) decomposition of moss residuals, forming specific layer of forest litter. This fenomenon essentially reduces the speed of vertical ^{137}Cs migration in forest soils – especially redistribution between forest litter and the mineral part of the soil.

Sphagnum mosses dominate in forests of hydromorphous landscapes especially forest peat (ombotrophic) bogs. In the typical for Ukrainian Polessye floristic association *Ledo-Sphagnetum magellanici Sukopp 1959 em. Neuhausl 1969,* union *Sphagnion magellanici Kastner et Flossner 1933 em. Dierss. 1975,* ordo *Sphagno-Ericetalia Br.-Bl. 1948 em. Moore (1964) 1968,* class *Oxycocco- Sphagnetea Br.-Bl. et R.Tx 1943* biomass of Sphagnum mosses

mount to 0,7-0,9 kg m^{-2} or about 70% of the total aboveground phytomass of ecosystem (tree canopy – 50 years old), this index was about 5 times higher than analogous one of tree canopy from Pinus sylvestris and in 6 times higher than in dwarf-shrub layer. At the same time ^{137}Cs specific activity of Sphagnum layer greatly exceeded analogous indexes of other layers of investigated phytocenosis. ^{137}Cs content in alive part of *Sphagnum fallax* was 16800 Bq kg^{-1}, in the dead part – 11900 Bq kg^{-1}, in spite of ^{137}Cs specific activity of *Pinus sylvestris*: 1260 Bq kg^{-1} in wood and 2700 – in needles; and in dwarf-shrub species: 8600 Bq kg^{-1} – in *Calluna vulgaris*, 8200 – in *Oxycoccus palustris*. Analysis of distribution of the total ^{137}Cs activity in components of aboveground phytomass of forest bog ecosystem showed that in the tree canopy retained about 4% of the total ^{137}Cs stock and in dwarf-shrub layer – about 5%. Thus all fractions of *Sphagnum* layer contained about 90% of the total activity of ^{137}Cs.

It was made a conclusion about prevalence of ascending fluxe of ^{137}Cs in the system "Sphagnum-water-peat" during vegetative period in spite of descending fluxe after finishing the vegetative period. Sphagnum mosses play the leading role in rotation of ^{137}Cs in biogeocenoses of sphagnous peat bogs. In landscapes of all types mosses make up their own subcircles of rotation of ^{137}Cs with relatively strong retaining of radionuclide.

CHEMICAL AMELIORATION OF UKRAINIAN POLESSJE SOILS AS A TOOL REDUCING THE RADIONUCLIDES ACCUMULATION IN AGRICULTURAL CROPS

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Applying of large-scale chemical amelioration as effective measure of radiation safety needs the complete approach of assessment of the ameliorants and fertilizers influence on properties and composition of a soil solution. Intensive amelioration resulting in 2-4 times decrease of radionuclides transfer factors to agricultural crops causes simultaneously significant changes in conditions of mineral nutrition of plants. Soil liming has been shown affects the microelements composition of plants. In lime-susceptible crops (lucerne, meadow clover) manganese content came down to 3 times, lead content – to 2 times, simultaneously ^{137}Cs content reduced 3,5 times. 2,5 times zinc content reduction has been observed in lupine (calcium-phobious). Liming of acidic soils, accompanying with organic fertilizers application especially (manure), leads to microelement immobilization in soil. Their content in potato tubers grown on limed soils in compare with optimal conditions of growing (pH lower 5,5-6,0) decreased 1,5-2,0 times, that is a reason of potato scab affection.

Microelements lack or surplus in a soil is reflected in a soil – plants – animals – human food chain. Ukrainian Polessje soils are characterised by a low content of organic substances, nutritional elements and available species of microelements, by negative hydrological-and-physical properties. Fertility of soils and radionuclides content in plants depend on these characteristics improvement.

Nontraditional organic fertilizers, e.g. sapropel, application as radioactive protective countermeasure improves soil structure and transformation of unavailable nutritional elements forms , including microelements, into available to plants ones. Application of risen doses of sapropel promotes the increase of agricultural crops yield (up to 2-3 times), long-term after action is observed. Microelements content in soil and yield of crops increases significantly.

ASSESMENT OF THE INTERNAL DOSE FORMATION RESULTING FROM RADIONUCLIDES OUTFLUX WITH WATER FLOWING FROM 30-KM ACCIDENTAL ZONE OF CHERNOBYL NPP

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Radioactive contamination of the Chernobyl NPP accidental 30-km zone (alienated zone) territory preconditions radionuclides migration to the Dnieper reservoir cascade system and farther, to irrigated lands of Southern Ukraine, for a long time

Radiation situation in the Dnieper reservoir cascade system became stable now. ^{137}Cs content in water of reservoirs reached the respective one before the accident, ^{90}Sr content is 5-10 times higher and equal to 0,1-0,15 Bq/l.

The alienated zone of Chernobyl NPP plays the leading role in radionuclides entrance into the Dnieper. There are about 110 thousand Ci of ^{137}Cs and 100 thousand Ci of ^{90}Sr in the zone, excluding points of radioactive waste location and the industrial plot of ChNPP.

Average annual flux of ^{90}Sr and ^{137}Cs out the alienated zone to the Dnieper river was 160 and 18 Ci, respectively. During the year 0,15 % of ^{90}Sr activity and 0,018 % of ^{137}Cs activity in average is flown out from the zone. According to accounts $1,45 \times 10^{-3}$ Ci/year of ^{90}Sr and $0,18 \times 10^{-3}$ Ci/year of ^{137}Cs are flown out to the Dnieper from 1 Ci of contaminated territories of the zone.

Calculations of collective effective external doses of irradiation to the population formed due consumption of products obtained in conditions of irrigation from Kiev and Kakhovka water reservoirs are presented. Calculations show, that consumed production obtained in a year from 1 ha of irrigated lands contaminated due to ^{90}Sr и ^{137}Cs migration from 1 Ci of alienated zone formed the collective effective dose of internal irradiation for Kiev region 254×10^{-10} man-Sv, for Kherson region – $9,71 \times 10^{-10}$ man-Sv.

PROVIDING RADIOECOLOGICAL SAFETY IN BIOLOGICAL AND MEDICAL STUDIES WITH USE OF THE RADIOPHARMACEUTICALS.

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One of the actual directions to resolve various problems in nuclear medicine and radiobiology remains the use of radiopharmaceuticals. Long ago such radionuclides as ^{131}I, ^{125}I, ^{3}H, ^{45}Ca, ^{59}Fe and other long-lived isotopes were used and some of them are still being used till now. However there are two serious shortcomings due to long life of these radionuclides: 1.Irradiating healthy tissues of the patients and medical personnel;
2.The danger of pollution of the surroundings during experimental radiobiological studies and treat-diagnostic procedures in hospitals.

To avoid this danger we used such short-lived radionuclide as 99m^Jc(T(half-life) = 6h) for preparing the osteotropic radiopharmaceuticals. The results of our experiments show that 99m^Jc-complexes of biphosphoric acid are effective not only from the point of view of their usefulness for radiodiagnostics but also from that of their radioecological safety.

^{137}CS CONTENT IN THE MUSHROOMS ON THE 30-KM CHERNOBYL ZONE AND "SOUTHERN TRACK"

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The dynamic of the radiocesium content in the fruit bodies of mushrooms of 30-km zone and "Southern track" has the distinctive features. First of all they are connected with the levels of surface contamination of the area, modular state and physicochemical form of soil ^{137}Cs. These parameters cause the depth of penetration of cesium in soil and its availability for biota.

The mushrooms belonging to the definite ecological groups and the depth deposition of mycelium in soil is affected the ^{137}Cs content in their fruit bodies, under the same parameters of radiocontamination and within other equal conditions (soil type, humidity etc.).

The results of the 14 years researches on the training ground testify that reaching of the steady ratio of ^{137}Cs content in the soil and mushrooms needs many years and even decades.

With gradual cleaning of forest litter and high layer of soil in the 30-km zone the decrease of ^{137}Cs content does not happen in the fruit bodies of mushrooms, the mycelium of which is located in these soil profiles. On the "Southern track" territory even the reverse process is observed – the increasing of radiocesium content in many kinds of mushrooms.

BIOGEOCHEMISTRY OF TECHNOGENIC RADIONUCLIDES IN FOREST ECOSYSTEMS *

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Biogeochemical migration of radionuclides (RN) is one of the basic processes determining distribution of radioactive fallout in the biosphere. The level of studies in this field is an indicator of the development of radioecology as a whole. This paper is based on the materials obtained in the course of long-term radioecological studies carried out on the East-Ural Radioactive Trace and territories contaminated due to Chernobyl accident. The following results have been obtained by now. (1) Forest ecosystems under aerial contamination serve as a biogeochemical barrier and long-term sink for the radioactive fallout. Their accumulative capacity depends on climate conditions, phytocenosis, vegetative period, and spatial distribution of stand formations ("clearance effect"). (2) Individual contribution of the ecosystem components as biogeochemical barriers depends on type of landscape. Soil is the most effective barrier in the eluvial landscapes, whereas biota serves as such a barrier in the accumulative landscapes and pine cenoses. Components of biota are different also by their ability to accumulate radionuclides. Fungi complex accumulates a significant proportion of ^{137}Cs (up to 47% of deposition). Arboreal vegetation tends to accumulate more ^{90}Sr (up to 20% of total deposition). Retention functions of the individual ecosystem components exhibit specific dynamics. (3) In forest landscapes, radionuclide redistribution in the "soil-plant" system is characterises by three main periods with increasing duration and alternation of leading processes of radionuclide migration. (4) Dynamics of the contribution of external contamination to total radionuclide inventory in the arboreal vegetation depends primarily on landscape type: it increases with time in eluvial landscapes and decreases in accumulative landscapes. (5) Biological processes play dominant role in the biogeochemical cycles of RN, whereas radionuclide migration with water flow is negligible. (6) In biological cycle of RN their return to the soil with annual litterfall is in 2-5 times higher than their root uptake. (7) The dynamic of biological availability of RN are unequal and depend primarily on soil conditions and physico-chemical forms of fallout.

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THE USE OF PLANT TECHNOLOGIES FOR THE CLEAN-UP OF CONTAMINATED SOILS AND AQUATIC SYSTEMS

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The phenomenon of radionuclides hyperaccumulation by plants, which has been of considerable interest academically may be also used economically in the clean-up of contaminated soils and water. The use of plants for environmental clean-up is an emerging technology, which is called Phytoremediation. The need for radionuclides excluding crop plants is particularly actual in the large areas contaminated after the Chernobyl accident. We have examined during the few last years the efficiency of that plant technologies for the soils' and water clean-up. These are the lessons of our study: i.Phytostabilization may effectively prevent the vertical and horizontal migration of radionuclides in some critical cenozes. ii.Plant technologies (Rhizofiltration) are very effective for the decontamination of water polluted with different radionuclides. iii.The Phytoremediation technologies may be also effectively used for the removal of Sr-90 from the contaminated soils because on high availability of this radionuclides. iv.The method of direct soil Phytoextraction in the case of Cs-137 pollution is not effective because on low bioavailability of the radioceas. v.Addtitional biotechnological treatments especially with selected soils microorganisms may increase significantly the Phytorextraction of 137-Cs from soil complexes.

RADIOECOLOGICAL STUDIES OF THE TECHA AND ISET RIVERS IN THE SOUTH URALS

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The Techa and Iset rivers belong to largest in Western Siberia to a Ob-Irtysh river system. There are several sources of radioactive contamination by this freshwater ecosystem: global fallout from of the nuclear weapons testing in different points of the world, including regional fallout from nuclear explosions on northern polygon " the New Earth ", and also on southern - in Semipalatinsk and in Lop Nor (China); local fallout from accidents at the nuclear enterprises located in zone basin of rivers; direct discharges in an open hydrographic web liquid radioactive waste from the nuclear enterprises located in the South Urals.

The largest contribution to contamination of a Ob-Irtysh river system is made the enterprise "Mayak" per the first years of a realization of the nuclear program (1949-1952), when liquid radioactive waste the enterprise discharge in the Techa river in 6 kms from its source. A basic resource of inflow radionuclides in the river system at present are Assanov swamps in the upper stream Techa river.

In the report the data on modern levels of contamination of water, grounds, hydrocoles of the Techa and Iset rivers, testing the greatest influence enterprise "Mayak" are submitted, the evaluation of a store most biologically significant radionuclides (^{90}Sr, ^{137}Cs, $^{239,240}Pu$) in principal components water ecosystem is given.

The researched radionuclides on a degree their migration ability in water of the river Techa are placed in the following series: $^{90}Sr > ^{239,240}Pu > ^{137}Cs$. Water of the river Techa on a moment of a research contained $2 \cdot 10^{10}$ Bq ^{90}Sr; 10^9 Bq ^{137}Cs and 10^6 Bq $^{239,240}Pu$. It established, that in sediments of the river Techa contained about $3 \cdot 10^{11}$ Bq ^{90}Sr, $6 \cdot 10^{12}$ Bq ^{137}Cs and $8 \cdot 10^9$ Bq $^{239,240}Pu$.

The interpolational evaluation shows, that the total amount ^{137}Cs in water of the Iset river is equal $0,35 \cdot 10^9$ Bq, and the total amount ^{90}Sr has made $69 \cdot 10^9$ Bq. At present the total amount ^{90}Sr in the sediments of the Iset river is $0,62 \cdot 10^{12}$ Bq and ^{137}Cs - $0,12 \cdot 10^{12}$ Bq.

BASIC FEATURES OF THE DYNAMICS OF ^{137}Cs AND ^{90}Sr DISTRIBUTION IN FOREST ECOSYSTEMS

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Knowledge on mechanisms of radionuclide migration and distribution in the components of forest ecosystems is of high priority for radioecology. Numerous studies of various scale have shown that the dynamics of seasonal and long-term migration of radionuclides is very complex and depends on many factors. Seasonal dynamics of ^{137}Cs in assimilating organs of trees is characterized by monotonous decrease from spring to autumn. An opposite, the ^{90}Sr concentration is characterized by monotonous increase during the season. Seasonal variation in the radionuclide content may be as high as the interspecies variation of this index. The long-term radionuclide dynamics in the forest vegetation is even more complex. The long-term dynamics of ^{90}Sr content is characterized by monotonous increase to some maximum level, followed by its stabilization and then decrease because of radioactive decay and irreversible absorption in the soil. In contrast to ^{90}Sr, the long-term dynamics of ^{137}Cs content in arboreal vegetation depends primarily on landscape type. Accumulation of ^{137}Cs by trees is pronounced only in the territories where the intensity of ^{137}Cs root uptake is close to of exceeds the intensity of its irreversible absorption. This may takes place, for example, in hydromorphic and semi-hydromorphic landscapes. Under conditions of automorphic landscapes, ^{137}Cs accumulation is not pronounced, and its long-term dynamics is characterized in general by monotonous decrease in ^{137}Cs content in the tree tissues. This process is most manifested on clayic soils, such as chernozems, which is due to considerable domination of the irreversible absorption of cesium over its root uptake.

ADAPTATIVE STRATEGIES OF NATURAL POPULATIONS OF AQUATIC ORGANISMS UNDER ACTION OF IONISING RADIATION AND CHEMICAL POLLUTION

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Aquatic crustaceous Amphipoda and worms Oligochaeta have different reproductive strategies. We found that peculiarities of the generative structure of Amphipoda populations can create prerequisite for acceleration of microevolution processes. Our investigations showed that embryos of amphipods produced by bigger females of older ages groups are twice as radiosensitive in comparison with embryos born by smaller young females. Change of the age (generative) structure of populations probably stimulate their adaptation to the environmental conditions. Worms Oligochata (fam. Naididae) reproduce in both sexual and asexual ways. Activation of sexual reproduction by radiation exposure was observed. Efficiency of adaptative strategies of amphipods and worms populations at the antropogenic impact areas, including 30-km zone of Chernobyl NPP, is discussed. We have made an attempt to assess separate contributions of radioactive and chemical pollution in the total combined damage of natural aquatic populations according to data on absorbed radiation doses and doses of chemical pollution as well as according to analysis of cytogenetic effects in mutagen equivalent doses based on several criteria: mean number of cells with chromosome aberrations in cells, number of aberrations per an aberrant cell and types of aberrations.

ECOLOGICAL SAFETY ACTING AND PROJECTED NPP OF RUSSIA

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Regeneration and rise of quality of conditions of life of the people, regeneration and preservation of a natural surrounding is one of central problems of mankind in occurred XXI - ohm a blepharon. Our generation of the people, is obliged to use reasonable efforts conditions of life of succeeding generations, the conditions of existence of natural complexes have approximated to "before industrial". To decide this problem it is possible and owes, basing on the concept of ecological safety of human activity. The human activity recognizes ecologically safety, if the consequences is do not change a state of enclosing natural medium more, than it recognized admitted for a place of implementation of activity and for the given activity.

The concept of supply of ecologically safety of activity is to the full diffused to nuclear power engineering. The concept of ecological safety of nuclear power engineering and stick of ecological safety of NPP is designed.

The concrete stuff about a state of a NPP's natural surrounding radiation situation on terrain, contents of radionuclides in objects of NPP's environment is resulted. The items of information on an anticipated state of the environment NPP's projected are resulted. Is draw a conclusioned ecological safety of action and projected nuclear power engineering of Russia.

ACCUMULATION OF RADIONUCLIDES ON THE KANEVSKOE RESERVOUR SHORES AFTER CHERNOBYL ACCIDENT

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At the end of April – and at the begining of May, 1986 the meteorological conditions has stipulated behaviour of radioactive matters in the atmosphere. This event brought to considerable precipitation on a mirror of Kanevskoe reservour and boundaring territories. The left shore in the district of Rzhyshchev appeared to be the most contaminated.

The main reason of the radiation contamination of the Kanevskoe reservour shores is the aerosolic sedimentation of radionuclides on a mirror of the water basin. A conciderable part of radionuclides is located on organic film to the surface of water. Under the effect of wind and stream (partially waves the surface film with holding radionuclides) can be transferred to a large distances and can be concentrated on the bank line.

The cooperative radioactivity of gamma – exposed radionuclides in the biotic objects an the shores on May 3, 1986 reached 20 mBq/ks of dry weight.

So the bank line was intensively contaminated. Gamma - background of the distance of 100 m to the side of land was reduced to 10 - 100 times, and the radioactivity of land vegetation and soils - to 100 - 1000 times. The radioactivity of bottom sediments of the distance of 10 m from the shore was lower in 10 - 1000 times, than ground fractions on the water boundary.

Later the radioactivity of the bank line has considerably decreased, nevertheless, till the present time the shore remains the place of radionuclides concentration.

The shore, contrary to other zones of natural environment, is located of 3 phases demarcation: solid, liquid and gaseous. The total effect of the chemical, physical and biological factors determines the parameters of radionuclides behaviour in the zone of bank line.

DYNAMIC'S PECULIARITIES OF ^{137}CS CONTENT IN FISHES' MUSCLE TISSUE OF THE ChNPP COOLING POND

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The accumulation and release of ^{137}Cs by fishes on different areas of the ChNPP cooling pond have the distinctive features, evidently, connected with effect of the temperature factor. The intensity of the accumulation and release of ^{137}Cs processes by the hydrobionts is enlarged in warmer water.

The predatory kinds of fishes are the most contaminated by ^{137}Cs. Besides the interspecific differences, the intraspecific differences (1.5 - 5 times) in ^{137}Cs accumulation by the fishes are also detected.

Among the different organs and fishes' tissues the highest ^{137}Cs concentration is found in all kinds of muscle tissue, especially in white muscles, and the lowest - in fatty tissues.

The tendency to increase of ^{137}Cs content in muscles with body mass enlargement ("age effect") is observed for the part of some kinds of fishes. For other kinds of fishes this tendency either is absent, or can be consider as a negative.

Since 1992 - 1996 the ratio of ^{137}Cs content in muscles of different kinds of fishes and in some other components of the cooling pond, appeared after the accident, is essentially deranged. As the result of the mentioned above the Silurus glanis L. has gain a leading place on radiocesium content in the muscle tissue. In 1999 ^{137}Cs content in its muscles can exceed those in 2 and more times than in the most contaminated ichthyophagos and corresponds to 16 - 28 (up to 43) kBq/kg of raw the mass.

SELF-ORGANIZATION OF MATTER AND BIOLOGICAL EVOLUTION

STATISTICAL MODEL OF PANMIXIAL CROSSBREEDING

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Suggestive and deductive style in descriptions and experimental manipulations in Silicon Valley manner of Hardy-Weinberg Law (HWL) and its ununiversality in Biology create actuality of Statistical Model of Panmixial Crossbreeding.

There are many ways to build such model (totally analog one may be based on neural nets or theoretical one which formulation may be actual in terms of Dynamic System Theory). We preferred to save objects of HWL formulation and used projective geometry to reorganize theirs connections.

This fully Statistics Model includes three main assumptions: the first is that every individual has own random value of allelic frequency ratio; the second is that gametes frequency ratio is primal to allelic; the third is that we must use the new parameter - inner crossbreeding preference probability (alpha) (this parameter leads to model sensitivity and can be utilized as a control ones in contrast to outer parameters of the assortative crossbreeding).

Main results are: HWL scheme is a case of trivial behavior (stationary process) of model, new parameter creates differential relation between generations and makes clear the problem of synchronizing of process and co-process in phase space of population evolution, model inner structure is enough flexible to study particular cases and to reach new experimental dates. For example we can suggest that "genetic equilibrium in populations" deals with insignificantly small fragments of the whole genotype, the largest fragments consist of no more than 10 genes and their alleles.

GLOBULAR CHROMATIN ORGANIZATION IN THE INTERPHASE CHROMOSOME TERRITORIES

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It was a long standing view that chromatid fibres of different chromosomes in interphase nucleus moved freely over large distances. It was established by chromosome specific painting probes technique (Manuelidis *et al.* 1985) that there is a little or no overlap between nearby chromosomes. This finding gave raise to a question of how chromatin is arranged within nonoverlapped nuclear compartments or chromosomal territories. The model of globular large-scale organization of interphase chromatin proposed previously (Andreev *et al.* 1983, 1986) is reviewed. Basing on results of computer simulation we show that model predictions are in good agreement with recent experimental findings. The globular model is based on two main assumptions. (*) 30 nm chromatin fibre is folded in such a way that multiple chromatin domains of 50-100 kbp of DNA cooperate into discrete compact particles termed as superdomains. (**) There is further folding of superdomain chain in interphase into compact conformations. This is caused by volumetric interactions between chain subunits resulting in formation of thermodynamically favourable condensed state. Volumetric interactions reflect different kinds of DNA-protein and protein-protein interactions, as to tightly bounded protein stickers, points of attachment to the nuclear lamina etc. Scaffold associated regions (SAR) or matrix associated regions (MAR) might represent a specific type of volumetric interactions. A variety of heterogeneous structures are observed in computer simulation experiments. Comparison with recent *in situ* data on human interphase chromosomes allows to verify some parameters of modeled structures. These results further support a model for globular organization of chromatin in the interphase. The model predicts that a mechanism for maintenance of compartmentalized nuclear organization over many cell generations may operate at the level of single chromosome. It might be due to the volumetric interactions resulting in a self-assembly of each individual chromosome. However a problem of *why* interphase chromosomes have structures that they have remains unsolved by this approach. This problem has an inherent relation to the puzzle of cellular differentiation. A dynamic features of chromatin *in vivo* as well as its conformational changes seem to be necessary for establishment of given chromatin organization in the course of differentiation.

THE INDICES OF EVOLUTIONARY TRANSFORMATION OF SEMIPALATINSK TEST SITE MURIFORM RODENTS POPULATIONS

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The problem of ecological adaptation of animal populations to the complex of Semipalatinsk test site (STS) conditions now attracts attention not only of radioecologists but of evolutionists too. The STS territory during forty years were exposed to action of ionizing radiation – one of most powerful evolutionary factor. We have studied the complex of indices of approximately hundredth (from the beginning of STS operation) generation of forest mice (Apodemus sylvaticus) inhabiting two plots of STS and the control territory. The mice in STS plots were numerous and had no essential differences from normal rodents either in mean values or in variation coefficients of most of exterior signs. Nevertheless the mean values of number of interior characters of the same mice exceeded the such of normal animals. The rodents from the former epicentrum of nuclear explosions displayed more expressed changes then the ones from STS boundary plot. The increase of mean values of some interior parameters of STS epicentrum mice was accompanied by essential decrease of indices variability amplitude. This phenomenon may be the sign of genetic heterogenity decrease in this population in the course of evolutionary transformation. In order to verify this supposition the individual correlation index (ICI) reflecting the character of plural correlation of 13 of investigated exterior and interior signs of organism and the group index – exponent correlation variation (ECV) were determined. It was shown that organisms of almost all STS mice had more strong correlation of investigated indices complex than mice of control territory. ECV of mice inhabitants of STS boundary plot remained rather stable and the such of STS epicentrum plot mice was reduced sharply. This is the evidence of correlative relations and genetic heterogenity decrease in this population of STS forest mice under pressure of natural selection.

ON THE SELF-ORGANIZATION OF INFORMATION

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Due to the work of scientists like N.V. Timofeev-Ressovsky, it is a generally accepted thesis today that the recent forms of biological life have to be considered as the result of a Darwinian evolution of plenty of different intermediate species, which lasted for many million years on a global scale. With the pioneering ideas of A.I. Oparin and many followers, the still ongoing search for the origin of life has focussed more and more on details of a small number of scenarios for its physico-chemical self-organization. Some of those identify the beginning of life with the emergence of information processing structures.

Information can be classified into either implicit (or structural or bound) or explicit (or symbolic or free) one. Implicit information is more or less contained in every physical structure and can be measured by entropy. Explicit information is genuine, formal information, it is stored by symbols on a physical carrier, is can be copied and processed. Explicit information always has a purpose, which is a non-physical property it joins with and only with the realm of life, with biological and social systems, including their natural or technical tools.

The transition from implicit to explicit information can be interpreted physically as a kinetic phase transition of second kind, associated with symmetry breaking. It was first observed and described in ethology by K. Lorenz, where it was called "ritualisation", the transition from "use-behavior" to "signal-behavior". Similar phenomena can be found in several social and technical systems, especially also in economy. Its very first and self-organized occurrence, however, possibly happened long ago on the molecular level, namely, at the origin of life.

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SPATIAL-POPULATIONAL DIFFERENTIATION OF POLYMORPHOUS SPECIES

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Polymorphous species of various living organisms are convenient objects for populational-phenetic investigations. Such investigations allow to study the differentiation of species, to define borders of populations and to reveal the direction of microevolutionary processes.

Our research was conducted in south-western Belarus on two groups of invertebrate animals: terrestrial molluscs (Bradybaena fruticum and Helicella candicans) and insects — the Colorado beetle (Leptinotarsa decemlineata Say) and the bedbug-soldier (Pyrrhocoris apterus L.). The variant of polymorphism, which is better studied at the terrestrial molluscs, is that by colour and presence/absence of dark stripes on the last turn of the shell. Singling out of phenes and phenocomplexes, different in scale, and registration of the frequency of their appearance in separate groupings make it possible to reveal the intraspecies structures of different ranks.

While studying insects great attention is paid to the variability of the melanin drawing on the front back and elytrons. Formation of various drawing types at the Colorado beetle is based on the variability of some melanin dots and stripes, and that at the bedbug-soldier — on the variability of melanin spots and dots. The analysis of the variability of melanisied structures allowed to single out stable and rare phenes and phenocomplexes. At the Colorado beetle there have been singled out four pairs of true alternative phenes and has been studied their inheritance character.

In the habitat of the Colorado beetle on the base of the frequency of phenes there annually appear some intraspecies groupings, but it is difficult to define the rank and borders of these differentiated formations. Still, generalized data on the phenetics of the species allowed to single out in the region, which is under the study, two stable groupings, corresponding to the concept of a population.

Phenogeographical investigations of all the species on small territories during approximately ten years showed that frequencies of rare elements and phenocomplexes are more variable than those of true phenes.

MOLECULAR MECHANISMS OF THE MICROEVOLUTION OF MER TRANSPOSONS

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The mercury resistance (mer operons) proved to be a convenient model for studying of gene migrations between various microorganisms, which can be of importance for their adaptation to environmental conditions. Bacteria carrying mer operons are ubiquitous, being present in great numbers in areas with increased mercury concentrations such as mercury mines or contaminated soils and waters. They are also invariably found in small numbers in pristine environments. We demonstrate worldwide horizontal spread of mer operons between various bacterial strains similar to worldwide spread of antibiotic resistance genes in medically important bacteria. The spread was mediated by different transposons and plasmids. Most of the transposons found in environmental bacteria belonged to types not recognized previousely. Some of the transposons were shown to be mosaic, suggesting their origin from different mer operons and transposons via homologous or site-specific recombination. Many transposons were damaged in different ways but the inactivation of the transposons did not prevent further epidemic dissemination of the associated mer operons. In our survey, we recognized independent waves of dissemination of closely related transposons. Our data suggest that the mer operons of environmental bacteria can be considered as a worldwide population composed of relatively small number of distinct recombining clones which form a mer gene pool shared, at least partially, by environmental and clinical bacteria.

EMERGENCE AND EVOLUTION OF LIFE AS PHASES OF GROWTH OF ENTROPY-INFORMATION THAT ARE PART AND PARCEL OF INANIMATE NATURE

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N.V.Timofeeeff-Ressovsky had undertaken to create Theoretical Biology, and outlined its issues [1]. Through the development of L.A. Blumenfeld's ideas [2], those issues have been resolved in [3]. This is the synopsis of the offered solutions.

Information in Nature appears as a result of a hierarchial synthesis. The components of such synthesis are accidents, their constraints and learning. Accidents are represented by the Entropy. Learning is synonymous with stability of processes and objects that are defined in Entropy plane as Functions of Complex Variable. Its true axis is the function from Energy. Imaginary axis is Entropy-Information. The principle of Maximum Generation of Entropy (the concept of maximum transformation capability) explains the transitioning of Systems through the dead ends of Equilibrium (phased hierarchial transition).

The Hierarchial Synthesis of Information is the most common form of the organization of Matter. It is also the principal law of the biological evolution. For instance, the transition from inanimate nature to the animate one is the learnt (or acquired) maximum of hierarchial Entropy to fill atoms' electron shells. It is manifested in Carbon compounds. The formation of species has its roots in static and dynamic DNA equilibriums. Einstein's spontaneous and induced transitions (outlined by the scientist initially to define equilibrium of radiation and matter) is mandatory for such formation. It is eliminated by Darvinist low mutations frequency paradox.

Microevolution is a series of dynamically stable equilibriums emerging from the processes advancing towards the dead end of equilibriums. Macroevolution is breaking through the dead ends of equilibrium with the help of the Maximum Generation of Entropy Principle. Darvin's natural selection reflects learning during the synthesis of information on taxonomical gradations. Macroeveolution always means leaps. Microevolution may be continuous, but its transitional forms are, by definition, unstable and are, therefore, often overlooked. Neutralistic mutations reflect the determinism of the evolution of Life. Electro-chemical thermodynamic

cycles of energy generation forge the redundancy of Life's power mechanisms. In organisms mechanical work is produced by thermodynamic cycles in the media with negative elasticity modulus. Simultaneous action of positive and negative feedbacks allows multiple selective increase of small effects within living organisms.

The Evolution of Life has no objective. Feasibility is not included in Evolution's criteria. Acquisition of biological information warrants change of ambient factors responsible for its synthesis. The value of biological information is in its stability resource during the synthesis of information. Its indispensability is the width of the realm of stability. Progressive evolution is the hierarchy ladder of information synthesis, where the height of steps (phases) decreases exponentially. During progressive evolution the aggregate Entropy-Information is increasing. Exponential decrease of height of Entropy-Information's hierarchial steps is the very reason why the progressive evolution of Life is presumably perceived as decrease of Entropy.

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PRINCIPLE OF INVARIANCE AND INDETERMINACY IN EVOLUTION OF THE LAND SNAILS

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Evolution of biological systems displays uniformity in morphological transformation ways and modes. In the land snails, shells demonstrate definite number of colored spiral bands, which may differ within a population; some specimens may lack them at all. Color phenes reveal genetic determination; 14 examined species of the order *Geophila* show monogenic inheritance in concern to the "banding" trait. In the course of divergent evolution within the closely related species, elementary systems of color traits demonstrate loose "switching" of dominance, i.e. substitution of the dominating morphs. Thereupon goes "encoding" by common phenes of any number of species at the expense of numerous variations within each morph, and channelling of the main variants for phenotypic manifestation of variability. Species of the suprafamily *Helicoidea* had formed during the Cretaceous first half at the territory corresponding to modern North America. Expanding eastwards, ancestors of one american family gave rise to contemporary european representatives of the suprafamily. In Eocene, species of two other american families spread south-westwards, to the territory of the present South-Eastern Asia, where they gave rise to a new pair of families; the latter subsequently gave birth to still another new family (Shileiko, 1979). In North America, 246 autochthonous species of this suprafamily showed the following distribution pattern in regard to the shell coloration types: the unbanded forms number 32.5 %; unbanded and one-banded specimens - 1.2%; those wearing one-many bands – 9.3 %; banded-polymorphic forms – 26.4 %; banded- monomorphic forms – 30.5 %. In the Eurasia, Philippine Isles, and in Australia, 276 species of this suprafamily exhibit the following distribution by the same trait cohorts: 28.4; 4.6; 7.8; 21.6; 37.7. These examples conform to the postulate of the fundamental invariance, standing behind all transformations occurring in nature (Dogel, 1936; Takhtadjan, 1948; Prigozhin and Stenger, 1986). At the verbal level, principle of indeterminacy is also realized here, as only one or another side of a complicated phenomenon can be described in regard to a certain aspect of study (Gumilev, 1990).

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WILL THE POPULATION OF HUMANITY IN THE FUTURE BE STABILIZED?

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The problem of mankind population growth is the one of the global problems concerning the future development of the mankind. Will the demographic explosion of the mankind population stop as already it has stopped in the most developed countries? Will the population of the Earthl be stabilized as it follows from S.Kapitza's theory [1] or will it continue its growth at slower rate? What are the driving parameters that govern the development of mankind (such as presented in non-linear open system)? Are these parameters genetically predetermined or can they be changed and controlled by means of human activity? Stabilization of the mankind population of earth in the future is a sad prospect for mankind, because the absence of the numerical increasing of any biological population almost always leads, early or late, to cessation of any development (the examples are many species of insects, e.g., termites, frozen in development for millions years). Hence, the appearance of more active biological species becomes quite probable. These active form of life will dominate the mankind and may force it out from its present ecological niche. The aim of the report is to introduce new parameter to describe the development of mankind population if it is regard as a large non-linear multifractal system, namely, the fractal dimension (FD) of the whole mankind population in any given time $d(t)$. The introduction of this parameter allows to receive, as a special cases, the results of theories [1-4], and several new scenarios of the mankind's future as well. Alongside with probable increasing of the mankind population, the scenario of ruin of the present civilization (diminution of its number down to zero) is shown to be possible. The value of FD may be determined from statistical data as a box dimension. The analysis of dynamics of multifractal sets of population requires the introduction of the mathematical concept of fractional derivatives, and allow to take into account the memory of system about the past (including genetic memory of mankind about its past development). The equation for number of mankind has form (more detailed see [5], a mathematical questions [6])

$$D_{+,t}^{1+\nu(t)}N(t) = \frac{\partial^{\alpha}}{\partial t^{\alpha}}\int_0^t \frac{N(t')dt'}{\Gamma(\alpha - d(t'))(t-t')^{d(t')-\alpha+1}}, \quad \mathrm{d}(t) = 1 + \quad (t) > 0$$

$$\nu(t) \equiv \nu(X_1(t), X_2(t) \ldots X_i(t) \ldots t), \quad i = 1,2,\ldots\ldots \qquad \alpha = \{d\} + 1, d = 1 + \nu$$

Here (t) is fractional quantity and defines the difference between the derivative of integer order and fractional derivative thus being the driving parameter for the growth of mankind as a whole , $d\}$ is integer part of d(t)>0,$(\alpha - 1 \le d(t) < \alpha), \alpha = 0$ for $d < 0$, and the set {X} are set of driving parameters, determining all external and internal influences. Regulation (adjustable in the parameters X_i) by the growth of mankind population will allow to avoid degeneration of mankind and to keep as much as long time the main ecological niche at Earth occupied by mankind. The last will give time for more realistic forecasting of the future of humanity as one of the biological kinds occupying our world.

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EVOLUTIONARY ROOTS OF ENDOGENOUS PATHOLOGY: ARTERIAL HYPERTENSION

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"Nothing in biology makes sense
except in the light of evolution."
Theodosius Dobzhansky

Traditional medicine searches for the causes of pathology in existing pathophysiological mechanisms, meanwhile the Darwinian medicine tries to clarify the question what is the evolutionary roots which make us susceptible to any disease. Some of the adaptive physiological mechanisms composed during evolutionary process may be considered as genetic predisposition to arterial hypertension. This kind of predisposing mechanisms may be devided into two main physiological systems. The first one is directed to sodium retention, and the second is concerned with neuro-endocrine regulation of the vascular tone. Some of the links of these two systems are triggered by behavioral constitution and social environment. Genetic models of arterial hypertension, the strains of rats and mice intentionally selected for high blood pressure, give a good opportunity to learn on genes saved by evolution because they are responsible not only for hypertension but for some features increasing the fitness as well. Developed in our laboratory the strain of rats with stress-sensitive arterial hypertension (ISIAH strain) demonstrates that increased stress responsiveness is correlated with enhanced behavioral and sympathoadrenal activity providing to hypertensive rats success in situations demanding competition and active exploration.

SELECTION AS A SOURCE OF THE DIRECTED HEREDITARY VARIABILITY

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During 170 generations, the selection on frequency of occurrence of individuals with defect distal part of a wing at heterozygotes on a mutation vestigial (vg) Drosophila melanogaster was carried out. The frequency of occurrence of individuals with defects of a wing, grew from 0.3 % (F1) up to 96 % (F24), remaining hereinafter without essential changes.

The quantitative and qualitative estimation of expressivity of a mutation vg in heterozygous condition in series of generations is carried out. It was shown, that the basic zone of damage in imaginal wing disk is dated for area of formation of the first back cell and boundary to it zones. The penetrance and expressivity of a mutation vg at interlinear hybrids in series of generations is accompanied by change of genotypic medium. The selection during 16 generations on decreasing of frequency of occurrence of individuals with defect of a wing which was carried out in F90, allows to find out the phenomenon « of genetic assimilation ». With frequency 1-2 % individuals occur, the wing damage of which was not stipulated by availability of a mutation vg.

It was fixed that in F120 of selection in an initial line the frequency of occurrence of such individuals was already 20%. During the experiment the epigenetically line of Drosophila as a result of genetic assimilation was revealed, where the frequency of occurrence of individuals with defect of a wing was 74% in F12. The comparative analysis on a complex of morphological and physiological parameters allows to find out the essential differences between an initial line and epigenetically one. The obtained experimental data allows to make a conclusion that the selection by the changing of genotypic of medium not only purposefully influences the display of a recessive mutation vg, but also frames the preconditions for occurrence of attributes, which hereditary display bases on a completely new genetic basis.

EVOLUTION OF MODERN HUMAN BEING

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The great changeability of physical, psychic and other features are characteristic for human being. As an example hereditary aggravation may be described. It constitutes 67,6% at the estimation during 70 years; the multifactors diseases are found to be predominated (podagra, ulcer, diabet et al.). It is known that the pleiotropic effects of some genes determine given features. Among various forms of selection (sexual, embrional etc.) we have studied the gamet selection in detail. It was chosen the feature of different activity of sperms. We expected that the more active sperms will be basis for more viable fish progeny. But this features were connected with row of traits. If eggs of pink salmon, keta, chinook, were fertilized by highly active sperms the progeny was distinguished by strong viablity, higher growth rate, stability of the enviroment factors etc. The balanced metabolism, which forces the viablity and growth rate is controlled by great numbers of genes. Evidently, part of them controls gamets. The spermal selection (SS) was discribed for mammalia and human being. SS prevents appearing deformity, influences gomeostasis of development and individual size (it may be the basis of acceleration). Evidently, it is similar influence to that of intellectual abilities. The hereditary aggravation under the terms of the number growth of Homo sapiens species is the basis for variability but at the same time creating the threat to perish. There are some grounds to consider that biological evolution of the human being has not come to stop. Species evolves to the direction of increase of body size (acceleration), intellectual abilities etc. But there are noted also negative phenomena: such as an increase of disease rate, life duration shortening et al. They appeared due to economic and ecology crises and can influence negatively to genofund through bad nutrition, disturbance of metabolism, decrease of immune sistem activity et al. Due to this, biologycal and social processes of evolution can be interdependent.

ANTAGONISTIC ROLE OF ONCOGENESIS IN MICROEVOLUTIONARY PROCESSES

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In many malignant tumors the oncogenes are functioning , major feature of which is the evolutionary conservatism. The functioning of oncogenes is revealed during the ontogenesis too. However if during the ontogenesis all generations of cells keep their typical shapes and forms, for oncogenesis the atypical structure of cells is characteristic. Therefore one of the problems of biological development is the comprehension of the oncogenesis role and elementary mechanochemical mechanisms, standing behind it, in microevolution.The concept of microevolution stated in the given work is based on the analysis of the role of elementary mechanochemical and mechanoemission processes rendering influence on changes in genetic material. The sense of such approach is based on conception that in cells the mechanochemical processes constantly proceed in a course of enzymatic and free radical reactions. This initiates the excited electron conditions of atoms in macromolecules. The subsequent transitions of the excited electrons to the basic condition are accompanied by electromagnetic mechanoemission in a wide spectrum range, initiating elementary microevolutionary processes including mutations. Were based on the results of experimental researches it is possible to assert, that if during their ontogenesis the mechanochemical processes allow to control shapion, being as though selforganizing,during oncogenesis they bring in disorganization in cellular processes of differentiation. Thus, mechanochemical transformations are accompanied by intensifying chaotization of mechanoemission signal parameters. The absorption of mechanoemission energy occurs faster, than mutation of essential attributes in genes. There is an interrelation between mechanoemission phenomena and mechanochemical reactions. Therefore the absorbed mechanoemission initiates by means of mechanochemical reactions molecular chaos in a mutual locating of DNA nucleotide pairs inducing the formation of malignizated phenotype. The arisen mutations can serve as a source of the appearance of qualitatively new signs leading to the changes of gene pools of appropriate populations and to the formation of new kinds. Thus, there is quite probable the antagonistic role of oncogenesis in relation to ontogenesis in microevolution process, realization of which occurs at participation of mechanochemical reactions and mechanoemission phenomena in cells.

ON EVOLUTIONS OF THE HIGHER NERVOUS ACTIVITY AND "ACCUMULATION" OF TYPOLOGIES

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THE LIMITING FACTORS OF ORGANIZATION OF MOLECULAR GENETIC REGULATORY SYSTEMS, "CORRIDOR" OF EVOLUTION, AND EVOLUTIONARY ACQUISITIONS OF WIDE USAGE

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The different limiting factors of organizations of the Molecular Genetic Regulatory Systems (MGRS) are considered. On different stages of micro- and macro-evolution they resulted in so named "catastrophes of errors and losses": catastrophe of mutational errors (M.Eigen), of selection losses (Haldane's dilemma), of informational, segregational, aberrational, transpositional, inbred losses, errors of regulation, losses by structural instability of macromolecular assembles, deceleration of adaptive evolution by the transition to multicellularity, stochastic evolutionary elimination ("nightmare of degeneration"), etc. In every case the limitation was resulted of interaction of some evolutionary factors with structural characteristics of MGRS, and was expessed in appearance of certain borders of "catastrophes". The cross of such border results in population elimination either directly, or in evolutionary perspective. Thus, the borders of the "catastrophes" of errors and losses became important restrictions of evolutionary potentials of MGRS, excluding some major directions of evolution. In total they form a sort of the "corridor", within the borders of which evolution is permissible. Actually, this "corridor" is determined by the features and parameters of existing organization of MGRS. In many cases the limiting factors of MGRS organization in the course of evolution were overcome by so named "evolutionary acquisitions of wide usage". They eliminated the limitations or shifted the borders to large distances. As a result, the new directions of evolution became possible.

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THE GENETIC THEORY OF ADAPTIVE EVOLUTION

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RADIATION-ECOLOGICAL FACTORS OF THE XXth CENTURY HAVE ACCELERATED THE MICROEVOLUTIONAL PROCESSES IN HUMAN POPULATIONS.

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As N.V. Timofeeff - Ressovsky predicted due to the development of atomic industry the mankind will enter an era of induced mutagenesis and therefore the tempo of microevolutionary proccects will increase. Our long-term genetic monitoring of populations inhabiting regions with radioactive pollutions (the results of the Chernobyl disaster, nuclear explosions at the Semipalatinsk test-ground and waste of the Chelyabinsk and Tomsk atomic enterprises and East-Kazakhstan industrial plants) as well as persons occupationally exposed to synthetic resins on Vladimir plant has revealed that disgenomic effects (gene mutations, structural and numeral chromosome aberrations, reduction of DNA reparation activities) in somatic and germ cells accumulate in consequent (I, II & III) generations. These effects correlate with weakening of compensatory-protective reactions, with disfunctions of organs and systems and lead to development of several syndromes and appearance of congenitaly malformed neonates. Technogenic ionizing radiation, industrial waste and synthetic chemicals, being at present imprescriptible factors of environment, have practically no minimal threshold doses. Their influence on human organism has become constant which causes induced mutagenesis besides the spontaneous one and accelerates the microevolutional process. Genetic balance of human population may be reduced.

A GENERAL PHENOMENOLOGICAL APPROACH TO ANALYSIS OF EVOLUTIONARY DYNAMICS AND CHAOTIC STRUCTURES IN BIOLOGY

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A general phenomenological approach to analysis chaotic series is presented. This approach, which is called the Flicker-Noise spectroscopy (FNS) [1-3], gives a possibility to extract truly physical non-model parameters under processing of time series or "spatial" series, if spatial structures are studied. The basis of the FNS methodology is a postulate about the crucial information which is contained in the sequences of non-regularities (bursts or spikes, jumps with different characteristic values, discontinuities of derivatives) of the measured temporal or spatial dynamic variables. In the frame of the FNS approach the power spectra and the difference moments ("structural functions") of various order are formed by the non-regularities of the different types ("colors"), which are the sequences of the dynamical bursts and the dynamical jumps of measured variables. The corresponding dependences are described by using several parameters ("passport data) which correspond to different introduced "color non-regularities" and may be extracted from a comparison of power spectra and structural functions calculated from the experimental chaotic series as well as the corresponding theoretical equations.

The introducing parameters may be used to characterize and distinguish an evolutionary dynamics of biological systems (f.e., total number of families that went extinct from the Cambrian to the present) as well as the spatial features of biological structures (f.e., "surface roughness" of biological membranes studied by means of AFM, correlation links in DNA sequences).

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EVOLUTION OF ENDOGENIC EGOISTIC ELEMENTS IN EUKARYOTES: CONSEQUENCES FOR CELLS, MULTICELLULAR ORGANISMS, POPULATIONS AND SPECIES

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Genomes of eukaryotic cells are so complicated that spontaneous mutation process leads inevitably to continuous formation of egoistic genetic elements from normal ones. These elements behave as endogenic genetic parasites (EGP) and are able to evoluate (see: Chesin, 1985). The rare of their evolution is very rapid and results inevitably not only in senescence and death of cells and multicellular organisms (Vakhtin, 1985) but also, because of EGP transmission from somatic cells to gametes, in senescence and death of populations and species.

Meiosis, crossingover and random association of gametes put a veto on repetition of genotypes from generation to generation: each genotype originates only once in a lifetime of a population or species, all the genotypes are unique. Populations consist, for this reason, only of sets of unique genotypes in every generation, during species life-time one kinds of pools of unique genotypes change into other kinds of pools of unique genotypes from generation to generation in accordance with the rules which remain so far unknown. ("Genetic equilibrium in populations" deals with insignificantly small fragments of the whole genotype, the largest fragments consist of no more than 10 genes and their alleles).

Formation of unique pools of genotype in each generation puts obstacles in deleterious evolution of EGPs, this is an important adaptation of Eukaryotes.

Products of some mutation of "normal" genes act on EGPs as antibiotics act on bacteria: they inhibit partially or completely reproduction of EGPs and stop their deleterious intracellular evolution.

Many "populations" of EGPs are needed to initiate their evolution de novo, on the basis of egoistic elements which continue to originate from "normal" elements of genome, and this decreases an adoptive level of EGPs and leads to some degree of rejuvenation of an organism. I believe, L.N. Gumilev's "mutations of passionarity" can have such a mechanism of their action (Vakhtin, 1999).

Origination EGPs and their evolution leads to the Death, meiosis, sexual and asexual reprodaction, unique genetic structure of populations and speciation – different forms which needed for saving the Life of Eukariotes.

EVOLUTION OF TRANSLATION TERMINATION FACTORS

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The termination of protein synthesis involves the interaction between different components, among them - ribosomes, mRNA, rRNA, tRNA and release factors. Two groups of release factors have been identified: factors that able to codon recognition (RF1 and RF2 of prokaryotes and eRF1 of eukaryotes) and auxiliary factors (RF3 and RRF of prokaryotes and eRF3 of eukaryotes). Besides similarity between translation termination mechanisms in prokaryotes and eukaryotes the sequence and properties of release factors differ significantly. For example eukaryotic termination factor eRF1 is able to recognize all 3 stop codons whereas bacterial RF1 and RF2 have codon-specificity, although one mutation in bacterial RF2 permits it to terminate translation at all 3 stop codons. It was proposed that the reason for the appearance of RF2 was the necessity of selective UGA codon recognition. RF1 and RF2 proteins possess some sequence similarity but eRF1 differs from them significantly also some conservative elements were identified. Eukaryotic release factor eRF3 has more significant differencies from its prokaryotic analog RF3. All eukaryotic release factors of eRF3 family possess sequence resemblancy in their C-terminal domain with elongation factor eF1A (eukaryotic homologue of bacterial EF-Tu) whereas RF3 has similarity with EF-G. Unlike RF3 in bacteria gene coding eRF3 in yeast is essential for cell growth. The data about catalitic properties of eRF3 in eukaryotes have some discrepancy. It was shown that in S.cerevisiae overexpression of both eRF1 and eRF3 is required for translation termination stimulation. On the contrary, in mammalian cells overexpression of eRF1 alone is sufficient to compete with suppressor tRNA. Recently, the «tRNA-mimicry» model generalized the mechanisms of prokaryotic and eukaryotic translation termination, was proposed that doesn't exclude that prokaryotic and eukaryotic release factors could have independent origin.

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