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GENERAL BIOLOGY

The Ratio between the Frequency of Chromosomal Aberrations in the House Mouse and the Incidence of Malignant Tumors in the Human Population at Different Levels of Radiation Hazard

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Since the principles of organization of genetic material are similar in all animals, the responses of rodents and humans to mutagenic impact are similar. For this reason, the frequency of chromosomal aberrations in the wild-type and synanthropic rodents, which is one of the most adequate tests for mutagenicity and carcinogenicity, is often used as an indicator of the genotoxic potential of the environment [1, 2]. However, the ratio between the level of cytogenetic lesions in the rodents and the genetic hazard to the human population inhabiting the same territory requires special investigation. We studied this ratio in a worker's settlement in Sverdlovskaya oblast (region).

This study was performed in the Dvurechensk settlement, Sysertskii raion (district). As a result of the use of thorium-containing slags (the scraps of a ferroalloy plant) for the construction of private premises and yard buildings, an elevated γ-background (up to 1300 μR/h) has been formed, whereas in the town-type houses (the communal sector), the γ-background was close to normal values [3]. The products of thorium decay comprise, along with β- and γ-radioactive substances, α-radiating gas thoron (Rn^{220}), inhalation of which increases the hazard of lung carcinoma. A similar mode of action, including the clastogenic effect, is characteristic of the natural gas radon (Rn^{222}) [4], the content of which in the air of private premises in Dvurechensk is, on the average, higher than in the town-type houses. We compared the frequencies of chromosomal aberrations in the metaphasic cells of the bone marrow of rodents and the incidence of malignant tumors in humans living in the private and communal sectors of Dvurechensk, which differ in the radiation background.

In this study, we used house mice as indicators of the genetic hazard, because they are similar to humans in their response to mutagenic and carcinogenic impacts, as well as in the ways of mutagen transfer to the organism [2]. The mice were caught in the basements and backyard premises of private houses (where the γ-background, which mainly reflects the pollution with thorium and its decay products, was 70–1000 μR/h, and the average content of radon in the air was 766 Bq/m^3), and in the basements of communal houses (where γ-background was 10–25 μR/h and the average radon content was 453 Bq/m^3). The control group involved mice from a slightly polluted village Shalya (Sverdlovskii raion), where γ-background in the capture places was 8–12 μR/h, and the average radon content was 130 Bq/m^3. The content of Sr-90 and Cs-137 in the osteomuscular tissues of mice from all localities did not exceed the global levels.

As is seen from Table 1, mice from the studied localities significantly differed in the most important cytogenetic parameter measured in this study, namely, the frequency of cells with structural chromosomal aberrations. In the private sector of the factory settlement, this parameter was more than three times higher than in the communal sector and approximately five times higher than in Shalya. Similarly high levels of cytogenetic lesion were also discovered in the rodents inhabiting the area of the Eastern Ural radioactive vestige and 10- and 30-km areas of the Chernobyl nuclear power station after the accident [5, 6].

We discovered that mice from the studied populations did not differ significantly in the frequencies of aneuploid and polyploid cells and those with lacunas, although in animals from the private sector in Dvurechensk, the number of such cells was higher than in those from other localities.

When considering the reasons for an elevated frequency of structural chromosomal aberrations in mice inhabiting private premises of Dvurechensk, it should be noted that, besides thorium, the scraps of ferroalloy plant involve such mutagens as six-valent chrome, sul-

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Table 1. Frequency of chromosomal aberrations in the house mouse from three localities of Sverdlovskii raion

Population	Number of animals	Number of cells	Mean proportion of cells, %		
			with chromosomal aberrations	aneuploid and polyploid	with lacunas
Dvurechensk, private sector	22	1100	4.09	1.18	4.18
Dvurechensk, communal sector	16	800	1.25	0.88	3.88
Shalya	21	1050	0.76	0.48	2.48
χ^2			32.57	3.19	5.11
			$p < 0.0001$	$p = 0.20$	$p = 0.08$

Table 2. Incidence rate of cancer in the population of Dvurechensk in 1986–1995 (per 100000 people)

Type of residence	Age, years						Total
	Below 29	30–39	40–49	50–59	60–69	70 and older	
Private sector	47.8	246.9	561.8	303.0	654.8	1612.9	439.3
Communal sector	16.0	68.2	217.4	277.1	1404.9	1604.9	201.4

fur and nitrogen oxides, fluoride, and toluene. However, they are also present in the communal sector. Therefore, ionizing irradiation (the main contributor of which are radioactive gases) is probably the main clastogenic agent in the private sector. This hypothesis is confirmed by the increased level of chromosomal aberrations in the mice inhabiting this sector (38%) as opposed to 20% in the animals inhabiting the communal houses.

Our data suggest that the mutagenic potential of the environment in the private sector of Dvurechensk was markedly elevated. In view of this, it can be assumed that the dwellers of the private sector are subjected to a higher genetic hazard than those of communal houses. Since there is a considerable correlation between the mutagenic and carcinogenic effects of the environmental factors [7], we verified the above assumption by comparing the incidence of malignant tumors in the inhabitants of the two types of houses. The population was not large; therefore, in order to reveal statistically significant effects, we used the overall data on the morbidity from 1986 to 1995. These data contained the information on 110 patients with malignant tumors from the worker's settlement and the information on the cancer incidence in the entire Sysertskii raion.

The average number of dwellers of the settlement in this period, according to the data obtained from the local authorities, was 4722 people. Thus, the total incidence rate of tumors in the settlement was 233.0 per 100000 population. This is somewhat lower than this value for the same period in the Sysertskii raion on the whole (263.5 per 100000). Thus, at first glance, an elevated mutagenic background of the environment in the private sector of Dvurechensk had a negligible effect on the frequency of tumors. However, a more detailed analysis taking into account the age structure of the population of both types of dwellings (for January 1, 1990) showed that the initial conclusion was wrong (Table 2). Data on male and female patients are pooled, because the ratio between sexes on the whole was the same in both localities (0.46).

As is seen from Table 2, the number of patients with malignant tumors of all locations in the private dwellings was more than two times higher than that in the communal houses ($\chi^2 = 15.99$, $p = 0.0001$). These differences were mainly accounted for by the fact that, in the private sector, the proportion of individuals elder than 50 years was significantly higher ($\chi^2 = 326.56$ and $p < 0.0001$) than in the communal sector (51 and 20%, respectively). The age-related increase in the incidence rate of malignant tumors is well known. However, even irrespective of the age of the patients (in five of six age groups), individuals living in the private sector fall ill more frequently than those in the communal sector (the sign test, $p < 0.05$). The cancer incidence was especially high in the junior age groups living in the private sector. It should be noted that, in both men and women, the differences between the private and communal sectors were accounted for by carcinomas of the lung, skin, lip, oral cavity, and larynx (231.7 per 100000 in the private sector as opposed to 50.7 per 100000 in the communal sector; $\chi^2 = 7.81$; $p = 0.005$), i.e., the organs that are exposed to atmospheric air to the greatest extent. On the average, the dwellers of private and communal houses did not significantly differ in the incidence rate of tumors of other localities (193.1 and 139.4 cases per 100000, respectively; $\chi^2 = 1.29$; $p = 0.26$). This pattern of cancer morbidity was probably associated with an increased content of radioactive gases (first of all, thoron) in the indoor air of private houses. Nevertheless, this conclusion is preliminary, because cancer morbidity depends on many other factors, which were not considered in our study. Further ecological and hygienic investigations are required to draw final conclusions.

Thus, the frequency of chromosomal aberrations in the somatic cells of synanthropic rodents correlates with the carcinogenic hazard for the human population inhabiting the same area, which is characterized by an increased mutagenic environmental potential. In other words, the data obtained corroborate the efficiency of the use of rodents as biological indicators of genetic hazard associated with technogenic pollution of the environment.

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