THEORY OF RELIABILITY AND AGING: FROM MATHEMATICS TO PRACTICE

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Similarly to technical devices, biological constructs are not perfectly reliable in operation, i.e. – malfunctions happen alternating with normal operation functions. The field of biophysics, in dealing with the problem of reliability, incorporates the theoretical and experimental investigations of quantitative characteristics and mechanisms of failures and renewal processes. It also includes elaboration of methods for testing reliability and predicting failures in biological systems. The regular conferences, which were initiated by the special Committee on Reliability of Biological Systems of Academy of Sciences of the former USSR, to deal with the problems of bio-reliability, have given a strong impetus to research in this direction starting from 1975. It has also spurred the similar studies on reliability ("robustness") on the other side of the former "iron curtain" The problems of bio-reliability are closely related with aging and resistance to deleterious environmental factors including ionizing radiation. The reliability-theory approach to aging developed in our papers [1,2] is based on the simple general principles that (i) biomolecular constructs are designed in keeping with the genetic programs in order to perform the programmed preset functions; (ii) all of them operate with limited reliability; (iii) timely replacement or prophylaxis of functional elements, i.e. metabolic turnover, is the main line of assuring the high systems reliability; (iv) there is a finite number of critical elements which perform supervisory functions over the preventive maintenance; (v) reliability of the "supervisors" decreases with time. On this basis, the universal features of aging, such as the exponential growth of mortality rate with time and the correlation of longevity with the species-specific resting metabolism, are naturally explained. The stochastic malfunctions of the mitochondrial electron transport nanoreactors which produce anion-radicals of oxygen ($O_2^{\bullet -}$) seem to be of first importance. Basing on the reliability-theory approach, one can estimate that longevity of human brain could reach 250 years should the antioxidant defense against the free-radical failures be perfect. Thus, the free radical redox-timer serves as effective stochastic mechanism of realization of the programmed deficiency in reliability of biomolecular constructs. Furthermore, the systems reliability approach serves as heuristic methodology for development of new preventive medicine, including novel radiation protectors based on the stable magnetic isotopes [3].

References.

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