MATHEMATICAL THEORY OF RELIABILITY AND BIOLOGICAL ROBUSTNESS: A LITTLE BIT OF HISTORY AND THE STATE OF ART

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In engineering, reliability is defined as the ability of a device to perform the preset function for the given time under the given conditions. The foundations of the mathematical theory of reliability were laid in the 1950s due to the needs of aeronautic machinery and problems of communication, management, etc. Biological systems perform their functions in the presence of a great number of random factors which disturb all functional strata starting from the molecular level of organization and to ecosystems inclusive. Therefore, similarly to technical devices, they are not perfectly reliable in operation, i.e. – for each and every device normal acts of operations alternate with stochastic (random) malfunctions or failures. The field of systems biology, in dealing with the problem of reliability, incorporates the theoretical and experimental investigations of: classification and systematization of failures in biological systems; mechanisms of failures of biomolecular nanoreactors and mechanisms of realization of the failures in functional breaks; investigations of renewal processes; elaboration of methods for testing the reliability and predicting failures in biological systems. The regular conferences on reliability of biological systems, starting from the first one in 1975 in Kiev, former USSR, have given the strong impetus to research in this direction. The special Committee on Reliability of Biological Systems at the Scientific Council on Biological Physics of the USSR Academy of Sciences, to deal with the problems of reliability of biological systems, was organized in 1978 and many prominent biophysicists were the members of this Committee. A quarter of a century after, it has spurred the similar studies behind the former iron curtain under the style of "robustness" (Kitano, 2004). The problem of reliability has direct bonds to the problems of aging and resistance of biological systems to deleterious environmental factors, including ionizing radiation. Aging occurs as inevitable consequence of the genetically preset deficiency in reliability of the biomolecular constructions while the free-radical redox-timer, located in specialized neurons of central nervous system, serves as effective stochastic mechanism of realization of the program. Furthermore, the systems theory of reliability provides the heuristic methodology for applications in biomedicine, including anti-aging medicine and radiation ecology.

References

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