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Editorial

Mathematical Theory of Reliability and Aging: A Little Bit of History and the State of Art

Vitaly K Koltover*

Institute of Problems of Chemical Physics, Moscow Region, Russia

***Corresponding author:** Vitaly K Koltover, Institute of Problems of Chemical Physics, RAS, Chernogolovka, Moscow Region, Russia, Email: *koltover@icp.ac.ru*

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Editorial

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 mathematical theory of reliability were laid in the 1950s due to the needs of aeronautic machinery, electronics, problems of communication and management, etc. [1-3]. Like in engineering, each and all biological systems are devices constructed to perform the preset functions according to the information planes, i.e. - the genetic programs. Biological constructs 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, biological constructs 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 problem of reliability of biological systems was first put forward by D. Grodzinsky and his collaborators [4]. The regular conferences on reliability of biological systems, starting from the first one in 1975 in Kiev, former USSR, have given a strong impetus to research in this direction [5-17]. Thus, located at the cross-roads of Western Europe and the Orient, Kiev has spurred the studies on reliability ("robustness") of biological systems. It confirms the old saying of the Middle Ages that "Teaching comes from Kiev." Not long ago, a new wave of analogous research has been spurred under the style of "biological robustness", see [18-21] and references therein.

The problem of reliability has direct bonds to the problems of aging. The systems reliability approach, which was developed in our papers, is based on the simple general postulates. First, all biological constructs are designed in keeping with genetic programs in order to perform the preset functions. Second, we believe that all constructs operate with limited reliability, namely, for each and every biological device normal operation acts alternate with accidental malfunctions (recurrent failures). Third, preventive maintenance, i.e., the timely replacement or prophylaxis of unreliable functional elements - metabolic turnover that follows a pattern preset in the genome, is the main line of assuring high systems reliability. Forth, there are a finite number of critical elements of the highest hierarchic level which perform the supervisory functions over the preventive maintenance ("the power structure"). And, five, the "supervisors" also operate with the limited, genetically preset, reliability. On this systems reliability basis, the universal features of aging of living organisms, such as the exponential growth of mortality rate with time and the correlation of longevity with species-specific resting metabolism, are naturally explained. From the reliability point of view, aging occurs as the inevitable consequence of the genetically preset deficiency in reliability of biomolecular constructs while the mitochondrial free-radical redox-timer, located in the specialized cells of central nervous system, serves as the effective stochastic mechanism of realization of the aging program. The longevity of human brain could reach 250 years should the antioxidant enzyme defense against the free-radical failures be perfect [21-23].

Furthermore, the systems reliability approach was successfully applied to revise the problem of antioxidant defense. Some antioxidants, synthetic and natural ones, extend lifespans of animals when added to food or drinking water. However, the rate constants and concentrations of the so-called antioxidants are small to compete with the antioxidant enzymes for reactive oxygen species (ROS). The antioxidants provide a preventive protection against ROS, i.e. - prophylactic maintenance via the organism's neuro-hormonal system and/or microbiota (see refs. in [24]). Thus, the systems reliability approach serves as heuristic methodology in searching realistic mechanisms of aging and anti-aging therapy.

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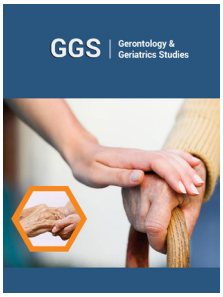

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