

the random factors (stochastics), should be taken into account. Hence, the theory of reliability naturally suggests methodology and mathematical apparatus for building a unified theory of aging of living systems that can encompass both programmed and stochastic events.

The important line of supporting the systems reliability is redundancy, when redundant components of the same type are introduced to fulfill one and the same function in the device. Indeed, all essential biomolecular constructions in cells are present in superfluous amounts. The redundant amounts of mitochondria and other organelles represent the examples of structural reservation. The elimination of hydrogen peroxide ( $H_2O_2$ ) and organic peroxides from cells by two different enzyme systems, catalase and glutathione peroxidase, is an example of functional reservation.

The main line of creating reliable devices from unreliable functional components is, however, in the timely supplying of repair and replacement of unreliable functional elements. Repair and renewal processes proceed in all complex biological systems starting from the level of cells. In order to provide a failure rate as low as possible, components are to be replaced for novel ones before the phase of their wear-out begins. The failure rate of the system may become intolerably high if components are replaced only as they have been damaged or worn-out. Hence, the preventive replacement of functional elements that follows the pattern preset in the cell genome, the so-called metabolic turnover, seems to be the main line of providing the high reliability of biological systems.

### 8.2.2 Preset Reliability Prescribes Lifespan

It is generally known that any organism is a hierarchical structure in which a relatively small number of key elements that manage a large number of executive elements can be distinguished. The template principle of organization of living systems implies that information DNA structures are of the first operation importance in the cell hierarchy. A multi-cellular organism is governed by the genes of a special anatomically isolated group of cells. In animals, for instance, these are the specialized neurons of the hypothalamus. Furthermore, from the mathematical theory of reliability, it is known that the effectiveness of the operation of a complex system is determined mainly by the reliability of its governing elements, "the power structure".<sup>19</sup>

Following this line, the systems reliability approach to the problems of aging was developed in our papers.<sup>10-19</sup> This approach is based on simple general principles. The first one is the template principle of organization of living systems implying that information structures rank first in cell hierarchy. An organism works like a system of biomolecular constructions designed in accordance with the genetic program (*information plan*) in order to perform the preset programmed functions (*purpose*). The second one is that all biomolecular constructions operate with limited reliability, namely, for each and every biological device or bionanoreactor, starting from enzymes, normal operation acts alternate with accidental malfunctions. The