BOOK REVIEWS

L. A. Gavrilov and N. S. Gavrilova (edited by V. P. Skulachev)
The Biology of Life Span: A Quantitative Approach
Chur, Switzerland: Harwood Academic Publishers, 1991. vii + 385 p. $120.00.

Gerontologists often define lifespan as the verified age of the longest-lived member of a species. What is the lifespan of the human species? Scientists from a variety of disciplines have been asking this question for a long time, with answers ranging anywhere from 60 to 200 years or more. It was therefore surprising to find Gavrilov and Gavrilova scolding scientists who have been studying this question for being too specialized and reductionistic, and for not having resolved the issue some 30 years ago by analyzing readily available life tables. In this 1991 English translation of the 1986 Russian original, the authors weigh evidence from a number of disciplines to support the conclusion that the average species-specific lifespan for humans can easily be identified as 95 ± 2 years (94 ± 3 years for men and 96 ± 4 years for women). The central focus of this book is on the evidence supporting their conclusion.

The first chapter reviews the history of research on the biology of lifespan and describes how each discipline has contributed to this scientific endeavor. Of particular value are sections on the history of lifespan research dating back to the early seventeenth century, the state of the discipline today, and an exhaustive reference list here and in Appendix 1. This is a thorough review of the literature and an impressive reference collection—especially considering the often difficult conditions under which science was (and is) conducted in the former Soviet Union. Perhaps the reason for this thoroughness—aside from the expert knowledge of Gavrilov and Gavrilova—is the rather startling news that the authors have been engaged in a multidisciplinary research program entitled "The Extension of Life." This program is designed to "experimentally develop new approaches to life extension, and to test the ones which are possible on human beings" (quoted on p. 7). Regrettably this is the only mention of the research program in the entire book, for it would be fascinating to learn more about how Russian scientists plan to conduct (or have already conducted) experimental studies on life extension using human subjects.

The driving force behind the life extension program may be Karl Marx himself—who is quoted several times as the "theoretician" supporting the value of human life and who, in *Das Kapital,* is acknowledged to have scorned the utility of reductionistic theory now used in lifespan research to compare the aging of living organisms with the time-dependent loss of functioning of mechanical devices. It is mildly surprising to see reference to Marx in a book on the biology of lifespan. This is either a reflection of scientific etiquette in the former Soviet Union or a hint that scientists who study aging should actually read Marx.

Chapters 2 and 3 dismantle two assumptions that have been common in historical research on the biology of lifespan. The first is the belief in an absolute biological (i.e., genetically determined) limit to life defined by a threshold age beyond which humans are incapable of living. The second is the assumption that there must be a normal distribution of individual lifespans. Most of the evidence used to support the authors' arguments here and elsewhere are published in Russian, and as such are currently unavailable to this reviewer for evaluation or verification. In spite of this, the authors provide evidence across many species for an apparent "law of mortality" that holds for most living organisms and that is closely approximated mathematically by the Gompertz–Makeham formula. The two key elements of this formula are its age-independent component characterized by a total force of mortality that increases exponentially (Gompertz) and a currently immutable background force of mortality that is age-dependent (Makeham). The Makeham component is basically the force of mortality that remains after major diseases are eliminated. It is interesting to note that this law of mortality also applies to the expected failure rate and longevity of mechanical devices and, as such, supports the stochastic nature of aging rather than the notion that aging and death are genetically pre-programmed in individuals.

The authors' conclusion that the debate over estimates of the lifespan could have been resolved over 30 years ago rests on the claim that despite radical changes in social conditions and advances in medicine and health care throughout this century, the age-dependent force of mortality for humans has never changed. The changes in death rates that have occurred in developed countries and some parts of the developing world are a result of declines in mortality from what the authors call "socially regulated parameters." The authors argue that age-dependent mortality risks persist for all species, risks that in the case of humans vary by geographic location and are revealed with increasing frequency as death rates from controllable causes decline. Estimates of the age-dependent component of mortality therefore represent de facto estimates of the biological lifespan of the human species. Manipulating the currently immutable force of mortality is the primary goal of the Soviet program on life extension.

Since the age-dependent component of mortality has historically been stable, once it is approached it becomes difficult to achieve further reductions in death rates and increases in life expectancy. Not surprisingly, therefore, the authors conclude that the presence of competing causes makes less meaningful any focus on individual causes of death and their associated risk factors. The theoretical rationale for this conclusion is rooted in the authors' own concept of an intermediate state of nonspecific vulnerability into which individuals enter as they age—a concept roughly equivalent to competing causes. In other words, as individuals get older their repair mechanisms and recuperative abilities diminish, and death and its eventual underlying cause is determined more by stochastic events than by genetically programmed failure rates. The problem of prolonging life therefore hinges less on the fight against individual causes of death and more on the pursuit of methods of altering the currently immutable and time-dependent biological component of mortality.

Although the concepts of nonspecific vulnerability and the stochastic nature of death are straightforward and logically appealing, it has yet to be determined just how nonspecific individual vulnerability may be. For example, it is possible that individuals carry a genetically determined vulnerability to many diseases—which the authors refer to generically as nonspecific vulnerability—but the emergence of specific diseases may be regulated by a lifetime accumulation of stochastic events that allow for the differential expression of disease-specific vulnerability. This would be more compatible with the now generally accepted view that most diseases have a heritable component that may be influenced by individual lifestyles.

In the fourth chapter the authors scold scientists who have concluded—without any supporting evidence—that the human lifespan is a given age that has remained unchanged since ancient times. Implicit in the assumption of a maximum human lifespan is the presence of an age beyond which humans are biologically incapable of living. The authors effectively argue that there is no evidence to support the presence of a biologically determined maximum lifespan for humans. Instead, the focus should be on estimating average lifespan. To this end the authors present the "compensation effect of mortality," which they developed and unfortunately published only in Russian. This is basically a method of estimating average lifespan by extrapolating the logarithm of the age-dependent component of mortality from life tables for different countries at different time periods. The point of intersection of these extrapolated lines represents an approximation of the invariant age-dependent component of human mortality—from which they derive the average lifespan figure of 95 ± 2 years for humans. The method of extrapolation used here should not be confused with previous efforts by other researchers to arrive at an average lifespan of 85 years by following the apparent point of intersection of the extrapolated trajectories of life expectancy at birth and at age 65.

The remainder of the book is devoted to the question of why there appears to be a consistent and almost universal law of mortality that prevents the average lifespan of humans from exceeding 95 years. The authors dismiss the idea that aging or senescence is "programmed" into the genome. The basis for this conclusion is that natural selection is unlikely to have favored those surviving well past the age of reproduction, because only a small fraction of the population ever survived to those ages. Indeed, why would natural selection favor individuals well past the ages required to ensure the reproductive success of one's offspring? Anthropologists might disagree by noting that during the time in which natural selection was operating on hunter-gatherer societies, the transfer of information between generations (e.g., avoiding predators, locating food, etc.) was a valuable trait likely to have been enhanced by extended survival. Furthermore, the effects of natural selection are observed over very long time periods, thus making it possible that the reproductive success of the offspring of the small fraction of the population surviving to older ages could indeed have been enhanced. Nevertheless, the authors argue persuasively against natural selection operating directly to favor survival well beyond reproductive years.

They then present theories on why there is a biological limit to average lifespan. In a counterintuitive fashion, the authors demonstrate that characteristics of individuals do not offer predictive value for individual longevity. Instead, the characteristics of parents of individuals predict longevity with great accuracy. However, the authors never reveal exactly what characteristics of parents they used to predict the longevity of their offspring. Furthermore, these results so far apply only to mice and appear to be inconsistent with conclusions reached earlier in the book indicating that in humans the longevity of parents is not closely related to the longevity of their children.

After completely dismissing the widely publicized work of Leonard Hayflick, who argued for the existence of a maximum lifespan based on the identification of a finite limit to cell division, the authors elaborate their own theory, called "the limited reliability of organisms." The premise is simple and intuitively appealing. The decline of living biological organisms and of nonliving mechanical devices is remarkably similar. Their comparable rate of breakdown can be proven mathematically. In both cases there is high rate of failure early on, followed successively by relatively low and stable failure rates, exponentially increasing failure rates, and finally a deceleration of that increase near the end of life. The aging of living and nonliving systems is therefore believed to result from " 'a cascade of dependent failures' which occurs when one of the organism's systems randomly fails" (pp. 246–247). Since living organisms and inanimate mechanical devices are saturated with defects from the outset, individual systems fail and death (or nonfunctioning) occurs as a result of stochastic events operating on existing defects. This theory corresponds well with the authors' concept of nonspecific vulnerability, and it is mathematically operationalized by the Gompertz–Makeham formula. I found this section of the book logically appealing and especially well presented.

In spite of those occasional tenuous references to Marx and an overly condescending view of some researchers in the field of aging, this book is a highly valuable contribution to the discipline. It is unfortunate that most of the supporting evidence for the authors' theories and concepts are available only in Russian. Nevertheless, this book should make scientists take notice of research on aging and longevity that was carried out and presumably is still underway in the former Soviet Union.

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R. V. Andelson (ed.)
Commons Without Tragedy: Protecting the Environment from Overpopulation—A New Approach

London: Shepheard-Walwyn; Savage, Md.: Barnes & Noble, 1991. ix + 198 p. $48.00.

Heywood Broun, the noted American commentator, explained how he became a socialist in a witty *New Republic* piece, excerpted some years ago on the back cover of the *Journal of Political Economy*. Referring to his undergraduate days at Harvard, he described a year of economics that carried the unofficial title "radical panaceas and their underlying fallacies," and that consisted of a fall and winter of outside speakers, to be followed by his professor's mainstream rebuttals in the spring. That was the rookie year of Tris Speaker, the famed center fielder with the Boston Red Sox, alas, and so baseball triumphed over balance. *Commons Without Tragedy* shares some of the appeal that the course Broun took back in 1908–09 must have had, but suffers from the same lack of proportion.

The central theme of the seven papers making up the volume under review is that the world may currently be considered overpopulated because of the inequitable distribution of land, and that the policy prescription of the nineteenth-century American Henry George—the imposition of a single tax on the rental value of land—is the cure. The genesis of the book was apparently a discussion between its editor, R. V. Andelson, and Garrett Hardin regarding the meaning of "commons" in Hardin's well-known 1968 article in *Science*, "The tragedy of the commons." Hardin's argument is widely viewed as metaphoric, with the common pasture land representing shared resources. Andelson and most other authors in *Commons Without Tragedy*