Chapter 26
Health and Immortality

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Abstract Is maintaining good health potentially compatible with a significant or radical life extension? Historically, these phenomena have often been seen as conflicting. Their potential principal incompatibility has often been derived from either health (functional capacity) or lifespan being understood as finite or limited values. The various concepts of limitations to the lifespan or health quantity are surveyed in this work in their historical development, with reference to several dominant theories of aging and mortality. The incompleteness and ambiguities of the limitation theories are demonstrated. Thus, even when proposing limits to the lifespan or healthspan, these limits have often been seen, even by the same authors, as flexible and modifiable. The exact conditions under which lifespan and healthspan "limitations" end and the "possibilities" of their enhancement begin have remained uncertain in the absence of a reliable quantitative formal theory of aging and mortality. An alternative "life-extensionist" view assumes the potential replenishment of any vital resources expended, and thus presumes no inherent natural limitations to either the lifespan or health quantity (functional capacity). The validity of either of those views may be tested in the future with the development of new medical technologies and a better theoretical understanding of health, aging and mortality.

Keywords Health · Lifespan · Healthspan · Functional capacity · Aging · Theory of mortality · Compression of morbidity · Longevity dividend · Rejuvenation · Life-extensionists

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26.1 Is Significant Life Extension Compatible with Good Health?

This essay will consider the principal question of the compatibility of health and immortality. Can good health coexist with immortality? Here "immortality" is understood as a trope implying a significant or radical lifespan extension, or unlimited life extension, insofar as literal "immortality" or the certainty of having lived an infinite amount of time is logically unattainable. In contrast, there is no law of logic or nature that precludes the possibility of a significant, radical or even indefinite life extension, even though it is at present technically unattainable. It is in this latter sense of a theoretical possibility of radical life extension that the term "immortality" is used here. Would this radical life extension be commensurable with good health or functional capacity?

A long philosophical and literary tradition has assumed they would not be compatible (Stambler 2014). Such assumptions were likely based on the common observation that long-lived people are usually unhealthy at the end of their lives and the commonsensical, though somewhat a priori, conclusion has been that if the end-of-life period is extended, the illnesses of that period will also be extended, and thus good health cannot be concomitant with radical life extension.

The archetype for this line of thought has been the ancient Greek story of Tithonus, the lover of Eos the Goddess of the Dawn, who obtained from her the gift of immortality. Yet, in his flawed human nature, he forgot to ask for eternal youth, thus the gift of immortality became a curse of eternal suffering. This story has been persistent and highly influential in the history of ideas about life extension. It first appeared in the *Homeric Hymn to Aphrodite* (c. 7th or 8th century BC), was reintroduced in Ovid's *Metamorphoses* (8 AD) (Ovid 1994) and to the present it has been invoked in almost every philosophical discussion of the consequences of extreme longevity. Another resounding instance of this archetype occurs in Jonathan Swift's *Gulliver's Travels* (1726) that features the immortal Struldbrugs eternally suffering from mental and physical debility (Swift 1892). There are other instances, but the general presumption remains that, insofar as the end-of-life period is commonly associated with disease and suffering, the extension of life will also be associated with disease and suffering, and thus extreme longevity would be incompatible with good health. This view has entailed a principal opposition to the pursuit of extreme longevity.

The incompatibility of health and extreme longevity has been commonly assumed by opponents of life extension. Yet, intriguingly, the idea that health may be at odds with longevity also appears in the works of staunch life extension advocates, though with a more positive perspective for longevity. This can be seen in the writings of the German prolongevity hygienist Christoph Wilhelm Hufeland (1762–1836), the author of the term "macrobiotics" that has survived to the present. In *Macrobiotics or the Art of Prolonging Human Life* (1796), Hufeland thus distinguished the art of life extension from the general medical art, and suggested that longevity and absence of diseases are not necessarily equivalent (Wilson 1867, pp. IX–X):

> This art [of prolonging life], however, must not be confounded with the common art of medicine or medical regimen; its object, means, and boundaries, are different. The object of medical art is health; that of the macrobiotic, long life. The means employed in the medical art are regulated according to the present state of the body and its variations; those of the macrobiotic, by general principles. In the first it is sufficient if one is able to restore that health which has been lost; but no person thinks of inquiring whether, by the means used for that purpose, life, upon the whole, will be lengthened or shortened; and the latter is often the case in many methods employed in medicine. The medical art must consider every disease as an evil, which cannot be too soon expelled; the macrobiotic, on the other hand, shows that many diseases may be the means of prolonging life. The medical art endeavors, by corroborative and other remedies, to elevate mankind to the highest degree of strength and physical perfection; while the macrobiotic proves that here even there is a maximum, and that strengthening, carried too far, may tend to accelerate life, and consequently, to shorten its duration. The practical part of medicine, therefore, in regard to the macrobiotic art, is to be considered only as an auxiliary science which teaches us how to know diseases, the enemies of life, and how to prevent and expel them; but which, however, must itself be subordinate to the highest laws of the latter.

Indeed, the emphasis on the treatment of particular diseases may distinguish general medical practice from the pursuit of life extension. The cure of a disease might be more readily and immediately perceived, while the ascertainment of human life extension may be a more lengthy and confounded process. Moreover, the possibility of "radical life extension" can hardly become subject to empirical confirmation any time soon. These might be some of the reasons that, until quite recently, the terms "life extension" or "lifespan increase" or "longevity extension" have not been regularly considered in biological or medical discourse. And critically for the present discussion, life extension may not be seen as necessarily tantamount to good health.

26.2 The Limits to Life and the Limits to Health

Another well-established intellectual tradition dealing with the relation of health and life extension has presumed a strict limit to the maximum lifespan and/or maximum inherent health quantity necessary to sustain life. In a sense, this is an even more pessimistic position than just presuming the incompatibility of life extension with good health as adversely influencing each other, seen in the former examples (when life extension is perceived to come at the expense of health, and vice versa). When presupposing limits to life or health, health may be conducive to longevity. However, insofar as health is a limited quantity, also longevity cannot be significantly extended, and vice versa. This view essentially presupposes the incompatibility of life extension with the continuation of life itself, due to fundamental health- and life-limiting mechanisms inherent in living beings, as paradoxical as this statement may sound. In this view, insofar as some degree of health (understood here as functional capacity) would be needed to continue life, this capacity simply could not be maintained for an indefinitely prolonged time, due to an inherent limit to life prolongation and/or an inherent limit to the functional capacity.

The latter line of thought arguably has the same conceptual basis as the former one that posited the incompatibility of life extension with maintaining good health, namely both presume health (functional capacity) to be a limited quantity. What differs is the emphasis and the presumed temporal mode of distribution of that limited quantity. In the former view, there would not be enough 'health quantity' to last, hence life could only be extended with a diminished health. In the latter view, health would only suffice for a limited time beyond which life prolongation would be impossible. But in both ramifications, the presumption of inherent limits to health and life is fundamental.

Yet crucially, at the same time, it has also been realized in the history of ideas about health and life extension, even by the very same thinkers who proposed "limits" to the lifespan and/or the life-sustaining health quantity, that these "limits" are rather flexible and the duration of life and quantifies of health are quite modifiable. The exact extent where the health and lifespan's "inherent limitations" would end and healthy life extension "possibilities" begin, has remained uncertain.

Thus, the founder of Gerontology Elie Metchnikoff posited in 1903 the inherent disharmony of human nature that eventually leads to human demise (Metchnikoff 1961). Yet, he also maintained that under proper "orthobiotic" conditions, human life can be extended to 150 years and beyond. Similarly, the American pioneer of aging research Raymond Pearl argued that the dissonance of differentiated body parts is inexorably engraved in human nature, and that the lifespan is an inherited quantity that can only be manipulated to a very limited degree (Pearl 1922). And yet, in Pearl's experiments, the lifespan of Drosophila flies was extended significantly by genetic selection, decreasing the population density, chemical stimulants, or else by lowering the temperature of their environment and reducing their food supply, generally decreasing their "rate of living." The German physiologist Max Rubner famously posited a limited amount of metabolic activity for any species during their lifespan (Rubner 1908). He found that most mammals, during their life course, consume about the same amount of energy per kilogram body weight (approximately 200,000 kcal) and die when the "life-energy" quota is spent. According to Rubner, for man the value is outstandingly high (~725,000 kcal), but is a preordained quantity nonetheless. Intense metabolic activity was, in this view, fatal. Nonetheless, he also believed in the possibility of life prolongation, according to his famous dictum that "the art of prolonging life consists in learning not to shorten it" (Lautenbach 2010, p. 25).

The uncertainties regarding the "limits" to the human lifespan and health have persisted for quite some time, with their discussion intensifying in the late 1970s—early 1980s. Thus, Nathan Keyfitz (1913–2010) of Harvard upheld the so-called "Taeuber Paradox" (named after Conrad Taeuber, 1906–1999, Chief of the Population Division of the US Census Bureau who observed the phenomenon), which suggested that aging organisms become generally frail, and therefore, if an aging person will not die of one age-related disease, he will die of another. Consequently, even the entire elimination of a major age-related disease, such as cancer, will not significantly increase the general life-expectancy, as some new disease will come in its place. As Keyfitz wrote: "A cure for cancer would only have the effect of giving people the opportunity to die of heart disease." This was a major motivation damper for

attempting to find cures against specific age-related diseases, and clearly posited the incompatibility of life extension with absence of diseases (Keyfitz 1977). However, in the same article, Keyfitz stated: "If cancer, heart disease, etc., are merely alternative ways in which the aging of body cells makes itself manifest, then eradicating any one of them may make little difference. The proper entity to attack is the process of aging itself." Elsewhere, Keyfitz further advocated for increasing research into cellular senescence, as an underlying general cause of many age-related diseases, rather than into any specific single disease. Such research would allow us "to break through the barrier that now seems to be set at about 80 years" (Keyfitz 1978).

Further, the Stanford gerontologists James F. Fries and Lawrence M. Crapo, in *Vitality and Aging. Implications of the Rectangular Curve,* posited that "the maximum life span is fixed at about 100 years, and the median life span is fixed at about 85 years" (Fries and Crapo 1981, p. 140). This "natural" lifespan is determined by "a steady decline in homeostasis and organ reserve in many vital systems" (Fries and Crapo 1981, p. 136). This decline in organ reserves results in an exponential increase in the mortality rate with age (Fries and Crapo 1981, p. 37). The authors predicted that a society will increasingly progress toward a "rectangular survival curve" when health care measures will produce a "compression of morbidity." This basically implied that people will remain sufficiently healthy until the age of about 85 and then collapse and die rapidly, saving on national health care expenditures. This scenario has been elaborated and disseminated (Fries 1980, 1983) and has become highly influential for the later concepts of "healthy aging." The authors called such a scenario "optimistic" and "a celebration of life." Still, the authors believed that "if we could understand the aging process at the cellular level and its underlying molecular mechanisms, then we might be able to alter the information units in the cells and thereby alter the life span" (Fries and Crapo 1981, p. 135, 139).

In contrast to Fries and Crapo's ideal of the "compression of morbidity," an "expansion of morbidity" was often observed in conjunction with life extension, as for example in the seminal work by the American psychiatrist and epidemiologist Ernest M. Gruenberg, "The failures of success" (Gruenberg 1977). Despite the differences of emphases, the main conclusions are similar in that limitations are assumed for the extension of life and of health. Moreover, the extension of life by medical technology is observed often to limit the sum total of population health. As Gruenberg noted, "The goal of medical research work is to 'diminish disease and enrich life', but it produced tools which prolong diseased, diminished lives and so increase the proportion of people who have a disabling or chronic disease." The recommendations from the "expansion of morbidity" perception are also similar to those from the "compression of morbidity" vision, namely the ensuing appeal to increase the portion of health research and health care dedicated to prevention of chronic diseases. In this way, it would be possible to achieve the extension of life concomitant with the extension of health.

Further limits on the human lifespan—biological, technological, ethical and economic—were proposed by J. Michael McGinnis, of the US Department of Health and Human Services, in 1985. Yet, McGinnis concluded with "an essentially optimistic perspective." For example, regarding the limits imposed on life extension by

the deficiencies of available technology, the pace of technological change was said to be rapid and "the limits of today will become the opportunities of tomorrow" (McGinnis 1985).

The question of the "limits" to the human life span and life expectancy has remained open to the present. Thus, at the turn of the twenty-first century, the gerontologists Stuart Jay Olshansky of the University of Illinois at Chicago and Bruce Alfred Carnes of the University of Oklahoma, in *The Quest for Immortality. Science at the Frontiers of Aging* (2001) suggested that "given the current state of medical technology, life expectancy at birth will not rise above 85 years." But the qualification regarding "the current state of medical technology" seems to be crucial. "The legitimate science of aging," the authors maintained, "has already led to remarkable extensions of life for many people. We can expect the hard work of researchers and medical practitioners to add to that success in the future." Thus, once again, a limit to the lifespan is posited, but it was understood that it can be quite flexible and modifiable. As the author admit, "The ongoing debate over limits to life expectancy is not likely to be resolved any time soon" (Olshansky and Carnes 2001, p. 142, 149, 211, 219).

Later on, Olshansky and collaborators have developed those ideas and disseminated the notion of the "Longevity Dividend" based on the concept of "healthspan" (healthy lifespan) extension, namely the aspiration to use medical technology to increase the healthy life expectancy in the population, while keeping constant or changing little the general life expectancy. Simply put, in this view, people are hoped, so to paraphrase, 'to die healthy' or 'live healthy until their death' (or almost until their death). The achievement of this visionary scenario is supposed to produce massive savings ("dividends") for the healthcare and welfare systems (Olshansky et al. 2006; Olshansky 2019). The same vision is presupposed by the "Geroscience" school of gerontology who perceive aging as the main "risk factor" for multiple age-related diseases and hope that by intervening into the aging process it may be possible to postpone the emergence of those diseases and increase the population's healthy life expectancy or healthy lifespan, but not necessarily the general life expectancy or lifespan. Or, at the very least, the gains in healthy life expectancy are hoped to exceed the gains in general life expectancy (Sierra and Kohanski 2017). In fact, this view posits a limit to the human lifespan, but not to the healthspan (until it reaches the value of the lifespan). It assumes the ability of biomedical technology to intervene into human biology, but only to modify the "healthspan" up to that lifespan limit. Thus, the uncertainties and ambiguities concerning the limits of life and health extension have remained.

26.3 Theories of Mortality

Despite the ambiguity regarding the actual value of the "limits" of lifespan vs. "possibilities" of life and health extension, the existence of some limits to life extension and/or health extension, and their potential incompatibility, were posited by the

majority of researchers of aging so far. But what is the precise law of this compatibility or incompatibility? Why is it, exactly, that life cannot be extended indefinitely and health improved indefinitely, as assumed by the proponents of the lifespan or health limitations? Or else, why should people "die healthy" as professed by the advocates of the "compression of morbidity" scenario? Why would the "one-hoss shay" metaphor often used in the "compression of morbidity" discussions (Holmes 1858; Fries and Crapo 1981), where the "shay" (carriage) stands intact until it suddenly falls apart in its entirety, be relevant for the human organism? Or why, in principle, can't people continue to live on healthily while their life is being extended, as maintained by the observers of "expansion of morbidity"? These are fundamental theoretical questions that could be answered by formal, mechanistic and mathematical theory-based models of aging and mortality. Such quantitative theoretical models might be able, in principle, also to account for or predict, in a formal and quantitative manner, the actual values for the "limits" or "possibilities" for life and health extension. Yet, there has been a traditional scarcity of such models. Indeed, any theory of aging may be perceived as an explanation of the limit of life or health, or of the incompatibility of life extension with health extension. Yet, formal, mathematical and mechanistic explanations have been few. This may have been partly due to the paucity of relevant data and partly due to the specifics of common training of biologists of aging and gerontologists that placed less emphasis on formal mathematical modeling. Yet some formal theories started to be developed, about 60 years ago, in the 1950s–1960s. Since then, the formal mathematical theories of aging and mortality appear not to have developed very strongly, but mainly reiterated the original premises.

The theories of mortality developed in the 1950s built on much earlier concepts, such as Benjamin Gompertz's law of an exponential increase in mortality rate with age, posited in 1825, or Karl Pearson's population mortality statistics of 1900. Yet, they were more elaborate, quantitatively relating the rate of (molecular and cellular) damage and loss to the rate of mortality. Several theories of mortality were formulated between 1952 and 1960. Thus, according to the theory of Elaine Brody and Gioacchino Failla, the "mortality rate is inversely proportional to the vitality." In the theory proposed by Henry Simms and Hardin Jones, death was attributed to "autocatalytic accumulation of damage and disease," where "the lessening of vitality [is regarded] as the accumulation of damage" and "the rate at which damage is incurred is proportional to the damage that has already been acquired in the past." George Sacher's theory stated that "death occurs when a displacement of the physiologic state extends below a certain limiting value" (Mildvan and Strehler 1960).

Yet, perhaps the most developed and publicized theory of mortality was the theory proposed by Bernard Strehler and Albert Mildvan or "the Strehler-Mildvan theory" (Strehler and Mildvan 1960). It claimed that "the rate of death is assumed to be proportional to the frequency of stresses which surpass the ability of a subsystem to restore initial conditions" (Mildvan and Strehler 1960). The theory was based on the Maxwell–Boltzmann distribution (originally formulated for the kinetic theory of gases in the 1860s), where the linear decline of function of particular organs in time was supposed to eventually lead to an exponential increase of risk for systemic failure of homeostasis of multiple organ systems and hence an exponential increase

of mortality rate. The loss of organ function or "organ functional reserve" was potentially attributable to progressive loss of functioning organ and tissue units, such as cells, or gradual impairment in the functional capacities of individual cells (Mildvan and Strehler 1960; Strehler 1960a; Shock 1960a, b). This model formed the theoretical basis for the "compression of morbidity" concept (Fries and Crapo 1981; Shock 1977). Recently, the Strehler-Mildvan theory was criticized for its presumably uncertain statistical basis, and accordingly its positing of a limit to lifespan extension was questioned (Tarkhov et al. 2017). Yet, to the best of my knowledge, no equally comprehensive formal theory of mortality has yet been proposed.

Though these theories did not appear to refer to any specific goals of life extension, they were designed for a thorough quantitative elucidation of the aging process, deemed a necessary precondition for any actual intervention. Indeed, despite positing a formal theory of lifespan limitation, Strehler was among the most active seekers of life-prolonging means, mainly focusing on enzymatic mechanisms of DNA repair, as he believed that an improved DNA repair system can protect the stability of the human genes against mutations and thus radically increase the human lifespan (Strehler 1960b; Kahn 1985).

In yet another line of theory-building, since the 1950s to the present, there have been ongoing efforts to create theoretical constructs that relate the aging process and mortality with an increase of physical entropy (disorderliness or chaos) of living systems (Hirsch 1955; Quastler 1958; Hershey and Lee 1994; Krut'ko et al. 2018). Considering the second law of thermodynamics that posits the inevitable increase of entropy and the ultimate thermodynamic death of any closed system, an ostensible analogy with the aging process and dying of living organisms intuitively appealed to biologists (Hayflick 2007). Such an analogy suggested the sense of fatality, of inevitable destructibility of living beings, or a limit to their existence. Notably, such entropy-related descriptions of aging and dying have often been qualitative, without concrete quantitative predictions, providing no tangible estimates as to the actual terms of mortality or values of morbidity, and hence the immediate application of such constructs for any practical medical, clinical or demographic purposes has been minimal. Moreover, it has been generally established since the seminal work of Erwin Schrödinger *What is Life?* (first published in 1944) that the notion of a closed system, and accordingly the inevitable increase of physical entropy and thermodynamic equilibrium (death), is not strictly applicable to living systems. Schrödinger explained biological equilibrium in terms of order and organization, as a low entropy (high order) system maintaining its orderliness by increasing the disorder of the environment (Schrödinger 1996). Implicitly, such "entropy parasitism" (in Schrödinger's words, "feeding on negative entropy") seemed to present no inherent physical constraints to its maintenance, and thus, theoretically could be sustained indefinitely. Thus, this class of theoretical constructs, relating entropy with aging and mortality, also presents a strong ambiguity regarding the inevitability of limits vs. possibilities of life and health extension.

Furthermore, a series of limiting models emerged from the "reliability theories" of aging, longevity and mortality (Koltover 2018). For example, one of such theories proposed that "even those systems that are entirely composed of non-aging elements

(with a constant failure rate) will nevertheless deteriorate (fail more often) with age, if these systems are redundant in irreplaceable elements" (Gavrilov and Gavrilova 2001). Despite this premise of inevitability of aging and demise, the theory still had explicit positive propositions for the possibility of practical life extension: "It also follows from this model that even small progress in optimizing the processes of ontogenesis and increasing the numbers of initially functional elements (j) can potentially result in a remarkable fall in mortality and a significant improvement in lifespan" (Gavrilov and Gavrilova 2001).

Another version of biological reliability theory suggested that in a given system there exist tradeoffs between robustness (duration) and performance (function), which might provide another way of conceptualizing and justifying the incompatibility of life extension and healthy function and a proposition of a limit for either (Kitano 2007; Cohen 2016). The tradeoff between robustness and performance has a strong relation to yet another set of explanations for the potential incompatibility of life extension and health extension, namely the incompatibility of constancy and change.

26.4 Life Extension Implies Constancy, Health Implies Change: Are They Compatible?

Another persistent line of arguments against the compatibility of prolongation of life with prolonged maintenance of health has been predicated on the notion of the inherent mutability of healthy life. Health has been associated with the ability to change, to adapt and respond to changing circumstances. In contrast, life extension has entailed the maintenance of certain core components of life unchangeable or with minimal change (Stambler 2017a). Thus, there appears to be an opposition of functions.

On a continuum between the desire for absolute change and the desire for absolute constancy, the proponents of life extension would seem to stand closer to the pole of constancy. Indeed, without some notion of constancy, the concept of life extension, even of survival, would be meaningless. Consider such cases as the atoms of a decomposing human body merging with the Universe, or human life being transformed into the life of grave worms, as for example discussed by Jean Finot in *The Philosophy of Long Life* (Finot 1909). Many boundaries are "transcended" in such "transformations," but one can hardly speak of "life extension." If extinction is determined by "a critical rate of long-term environmental change beyond which extinction is certain" (Burger and Lynch 1995)—notice, *any* change—then proponents of life extension would wish to be as far from this rate of change as possible. Or else, they would wish to design the technological armor that would make us impervious to such changes. Without work invested in maintaining constancy, spontaneous deteriorative change may be expected. Thus, the proponents of life extension might engage the rhetoric of progressive change, but not just any change for change's sake, but only

such change that would serve to perpetuate some existing structure. In the words of the protagonist of Giuseppe Tomasi di Lampedusa's *The Leopard,* "If we want things to stay as they are, things will have to change" (Tomasi di Lampedusa 1960). And in the words of Lewis Carroll, "it takes all the running you can do, to keep in the same place" (Carroll 1871). In this sense, the pursuit of life extension may be a fundamentally "conservative" or "conservationist" enterprise (Stambler 2010).

In contrast, the proponents of maximum health might be more likely to advocate substantial change, as would be required for growth and adaptation. This opposition may have not only psychological or semantic underpinnings, but may have biological or evolutionary roots. In several recent theories of aging, a deficit of species variability has been linked with the possibility of non-aging and/or radical life extension. In these theories, an absence of aging would impair variation and thus reduce the species evolvability and adaptability. For example, an ideal DNA repair mechanism would make mutability impossible (all mutations would be immediately corrected). And without mutability, there would be no diversity and no evolution. Any new threat (e.g. a new infection) could then wipe out the entire stagnant population. (Still, improved immunity and DNA repair may be assumed to provide improved defense against a greater range of pathogens and environmental threats, such as radiation, temperature changes and toxins, including bio-toxins, hence the ambiguity regarding "limits" vs. "possibilities" remain.) A recent evolutionary model argued almost precisely to the effect of incompatibility of change with radical life extension: "when the system is completely stable, no mutation going on and no changing conditions for worse, … it is to be expected that a population that shows senescence will be driven to extinction." However, "When conditions change, a senescent species can drive immortal competitors to extinction." The author concludes: "We age because the world changes" (Martins 2011). Several other contemporary researchers have pondered a return to August Weismann's theory of evolutionary programmed aging, proposing a direct evolutionary selection for senescence. A major suggested reason for such a selection is that an absence of senescence would diminish the species' variability and diversity, hence impair its adaptability and evolvability (Goldsmith 2004; Mitteldorf 2004; Skulachev 1997).

In cognate terms, it was further suggested that complexity and variability (a proxy for adaptation) might be associated with youth and good health, whereas simplicity and homogeneity (a proxy for stability) may be seen as a sign of aging and disease (Lipsitz and Goldberger 1992; Blokh and Stambler 2017b).

Notably, virtually all the researchers of aging under consideration, even those proposing limitations to lifespan or healthspan, seem to be in favor of finding at least some modest aging-ameliorating and life and health-extending means for humans, suggesting that through a better understanding of the mechanisms of aging, including evolutionary mechanisms, tradeoffs and thresholds, factors affecting health and longevity can be identified and manipulated for people's benefit.

26.5 Killing for Health

As seen in the previous examples, the propositions of limits to lifespan and healthspan have been commonly accompanied by various ambiguities and caveats, where the "limitations" would seem not really limiting, and the possibilities of life and health extension emerged quite tangible. This appears to be the prevalent position of many researchers of aging. Yet, in some authors, the supposition of a limit to lifespan and/or healthspan was relentless. In their view, the limits are "written in stone" and any attempts to modify them to any noticeable degree are futile and even in some sense immoral. This view of the truly insurmountable limit to human life and/or health, and of the incompatibility of health maintenance with life extension, has often yielded some rather appalling practical implications and recommendations. A common practical consequence has been the implicit or even explicit suggestion of the desirability of death and abandoning health care for older people, when their "life quality" (health) is below some acceptable limits.

There are quite a few famous examples of this attitude. In 1905, the renowned Canadian physician William Osler (1849–1919) spoke of the "uselessness of men above sixty years of age" (Osler 1905). The essays of the "humanistic" British philosopher and mathematician Bertrand Russell (1872–1970) from the 1930s–1940s provide another stark example. Thus, in his essay "On Euthanasia" (1934), Russell suggested killing people in extremely ill health, such as in cases of "hydrophobia," "pneumonic plague," "congenital idiocy" and other cases which "cannot be useful to society." Also "criminals condemned to long terms ought to have the option of euthanasia" (Russell 1975a). Russell was consistent and logical, hence, according to him, the prolongation of life was undesirable both for the very sick and the very old. Thus, in "The Menace of Old Age" (1931) he was greatly worried by the prospect that "every increase in medical skill is bound to make the world more and more conservative." Hence, he proposed "to prevent all researches calculated to prolong the life of the very old" (Russell 1975b). And in "How to grow old" (1944), he maintained that "in an old man … the fear of death is somewhat abject and ignoble" (Russell 1956). In a less blatant form, the Australian immunologist, the Nobel Laureate in medicine of 1960 and the author of the "intrinsic mutagenesis" theory of aging, Frank Macfarlane Burnet (1899–1985) "doubt[ed] very much whether anything worthwhile would be gained by extending the human life span beyond its present bracket of 70–100 years—and that if we wanted this extension of life, I am deeply sceptical about our chance of ever achieving it." And furthermore, "death in the old should be accepted as something always inevitable and sometimes as positively desirable" (Burnet 1974, p. 63, 66).

These are not just theoretical attitudes. Under certain circumstances, they may well translate into practice, specifically denying care for extremely ill elderly patients, as "useless" and "hopeless." Thus, as early as 1666, the British physician Dr. John Smith urged (Freeman 1938):

> Let none give over their patients when they come overburdened with the infirmities of Age, as though they were altogether incapable of having any good done unto them. Those that

> are negligent toward their Ancient Friends, are very near of kin to those inhuman Barbarians and Americans, who both kill and devour them.

This basic neglect of care may have come true in some of the severe cases of "ageism" or discrimination based on age in healthcare (Ehni 2014; Wyman et al. 2018).

Alternatively, the valorization of "health" (understood as the maximization and optimization of function) over "life extension" (or the "mere" continuation of life) may well take the form of devising medical treatments that may invigorate ("rejuvenate") the person for the short term, with a semblance of "good health," yet in fact shortening the older persons' life, essentially killing them "for health." This possibility was vividly envisioned by Aldous Huxley, in *Brave New World* (1932). In *Brave New World*, biotechnology is used by the society first and foremost for pleasure, and not for the prolongation of life or intellectual growth. The residents of the "New World" undergo "death conditioning" to inculcate the idea that death is a natural, good and pleasant event: "Death conditioning begins at eighteen months. Every tot spends two mornings a week in a Hospital for the Dying. All the best toys are kept there, and they get chocolate cream on death days. They learn to take dying as a matter of course" (Huxley 1965, p. 125). Those who prolong their days and become old are the savages who live at the Reservation. The "civilized" ones are simply not allowed to age and to live long, but die young and healthy at the age of sixty (Huxley 1965, p. 84):

> That's because we don't allow them to be like that [growing old]. We preserve them from diseases. We keep their internal secretions artificially balanced at a youthful equilibrium. We don't permit their magnesium-calcium ratio to fall below what it was at thirty. We give them transfusion of young blood. We keep their metabolism permanently stimulated. So, of course, they don't look like that. Partly, he added, because most of them die long before they reach this old creature's age. Youth almost unimpaired till sixty, and then, crack! the end.

It is unclear from the text why the balancing of the metabolism would lead to a pre-determined early demise, but the passage seems to imply that this is due to an excessive and permanent stimulation. Thus, *Brave New World* appears to reduce to absurdity the common assumption of the incompatibility of life extension and good health and shows its possible "logical" and "practical" conclusion: killing by keeping good health.

Will our "Developed World" follow this "Brave New World" scenario via designing "anti-aging," "rejuvenating" and "bio-hacking" treatments that may momentarily improve function ("health") but disregard possible long-term adverse effects and earlier death?

This is a possibility a founder of prolongevity hygiene, Christoph Wilhelm Hufeland warned against. According to Hufeland's views (to express them in somewhat more modern terms), any treatment of old age should consider the aging organism and the aging process as a whole. Any attempt to artificially strengthen some faculty, at the disregard of the general sensitivity and available resources of the entire aging system, can further advance the disarray and bring about death sooner. The ultimate goal is not "rejuvenation" for the sake of "rejuvenation," but "macrobiotics"—the

prolongation of life. And paradoxically, "rejuvenation" or an immediate improvement of function or health, can become an enemy of life prolongation. In Hufeland's own words, as stated in his *Macrobiotics or the Art of Prolonging Human Life*, Part 3 "Means which prolong life," Chap. 18 "Old Age. Proper Treatment of It" (translated in Wilson 1867, p. 292):

> Old age, though the natural consequence of living, and the commencement of death, can itself, on the other hand, be a means for prolonging our existence. It does not, however, increase the power to live, but it retards its being exhausted; and one may thus affirm, that a man in the last period of life, at the time when his powers are lessened, would, were he not old, finish his career sooner.
>
> This position, which appears to be somewhat paradoxical, is confirmed by the following explanation.
>
> Man, during the period of old age, has a much smaller provision of vital power, and a much less capacity for restoration. If he lived with the same activity and vigor as before, this provision would be much sooner exhausted, and death would soon be the consequence. Now the character of age lessens the natural irritability and sensibility of the body, by which the effects of internal as well as external irritation, and consequently the exertion and wasting of the powers, are also lessened; and, on this account, as consumption is less, he can with such a stock of powers hold out much longer. The decrease in the intensity of the vital processes, as age increases, prolongs therefore vital duration.

This is a lesson by Hufeland that may be well heeded by some contemporary reductionist "anti-aging" attempts who seek immediate health improvement in the elderly without consideration of long-term effects and actual effects on the person's life duration (Le Couteur and Simpson 2011). It should also be well heard by radical advocates of "healthspan" improvement and "healthy longevity dividend" who, in extreme cases, may despise "mere" life extension per se as useless, if it is not accompanied by high functional performance. If taken to extreme, in a "Brave New World" scenario, this attitude may result in some forms of "killing for good health."

26.6 "And Yet It Moves". The Denial of Lifespan and Healthspan Limitations and the Possibility of Radical Life Extension (or Biological Immortality)

Beside the schools of thought that posited relentless and inexorable limitations to the human lifespan and/or healthspan, or limitations that are rather flexible, but still finite, there has existed a school of thought that denied the necessary existence of such limitations altogether. In this school of thought, theoretically no material limits are inherent in the duration of life of organisms, as well as in the possibility of the development of their functional capacities (health).

According to the proponents of this vision, it is theoretically possible to produce changes in the organisms' inner biological structure and/or environmental conditions, thanks to improvements in biomedical technology, which may dramatically modify any existing limitations on life and health imposed by the present conditions. Of

course, it has been realized, even by the most optimistic advocates of human life extension (often termed "life-extensionists"), that there are currently clear practical limits and constraints in our ability to increase the human lifespan with the current medical technological means (Stambler 2014). The life-extensionists simply do not reconcile with those limits; they desire and strive to overcome them by improving biomedical technology.

The assertion of limits on life and health presupposes the existence of some limited life-sustaining material resource or reserve, a sort of nourishing substrate for the "vital force" of a restricted amount that is being exhausted during the life course and cannot be replenished, thus creating the limit. This putative irreplaceable material resource could be the telomere length, the extant stem cell populations, maximum DNA repair capacity, or some mysterious limited "adaptation energy" hypothesized by the founder of stress physiology Hans Selye. Yet, the fundamental characteristic of the life-extensionist worldview is that it strongly asserts the possibility to replenish any material resources necessary for life, and thus modify any restrictive limits. This view is quite ancient. It was, for example, expressed by the renowned Jewish philosopher and physician Maimonides (1135–1204, Rabbi Mosheh ben Maimon) who stated: "For us Jews, there is no predetermined end point of life. The living being exists as long as replenishment is provided [for that amount of] its substantive moisture [i.e. bodily humors] that dissolves" (Rosner 1998). This proactive view has persisted and intensified to our time (Stambler 2014). Hans Selye, even though he believed that "as far as we know, our reserve of adaptation energy is an inherited finite amount," nonetheless admitted the possibility of its replenishment, and thus life and health extension. As he wrote: "If [the adaptation energy] amount is unchangeable, we may learn more about how to conserve it. If it can be transmitted, we may explore means of extracting the carrier of this vital energy—for instance, from the tissues of young animals—and trying to transmit it to the old and aging" (Selye 1956, pp. 276, 303–304). The same proactive principle could be applied for any type of limiting material resources.

Despite the well-recognized current practical limitations, the life-extensionists have strongly asserted that, on the basic theoretical level, there is no law in nature that sets a strict insurmountable limit to the lifespan or functional capacity of the human organism. Regarding the presumed incompatibility of significant life extension with optimal health, or the frequent fear of increasing "life quantity" at the expense of "life quality," the life extensionists denied any natural limitations to those values and asserted the human ability to intervene and enhance them. This position was well stated at the Galileo Symposium in 1964 by the Nobel Prize winning physicist Richard Phillips Feynman (Feynman 1999, p. 100):

> There is nothing in biology yet found that indicates the inevitability of death. This suggests to me that it is not at all inevitable, and that it is only a matter of time before the biologists discover what it is that is causing us the trouble and that that terrible universal disease or temporariness of the human's body will be cured.

Among the sources of hope, the life-extensionists have often cited the existence of non-aging, slowly aging, and even "potentially immortal" life-forms and the constant

evolutionary adaptations of the lifespan even for the humans, according to particular changing environmental and genetic conditions. There may be contingent limitations due to the inner biological structure and external environment, but these are not "limits" in the principal physical sense (like "nothing can travel faster than the speed of light"). The existing practical limits to the human lifespan and functional capacity, due to internal disorder, adverse environment and imperfect medical capabilities, are "rules that can be broken."

Some authors opposed the premises of limitation theories on specific points. An intense debate over the limits to life and health expectancy took place in the 1980s. Thus, the view proposed by Nathan Keyfitz about the intrinsic limit to aging health and life-expectancy was disputed by Arthur Schatzkin of the US National Institute of Cancer. Schatzkin suggested that a single health care measure can improve the outcome for several age-related diseases and the elimination of several risk factors can have a cumulative effect, leading to a significant life extension (Schatzkin 1980). Several authors disputed Fries and Crapo's conclusions about the compression of morbidity and argued that an approximation of a perfect "rectangular survival curve" will not be possible, and health care measures can produce an extension of life expectancy far beyond the 85-year "limit" (Schneider and Brody 1983). Later on, additional evidence was presented about the existence of the "compression of morbidity" and "rectangularization of survival" (temporal concentration of deaths) trends, agreeing with the limitation theories (Faria 2015; Stallard 2016). Yet, these trends were also debated (Crimmins and Beltrán-Sánchez 2011). Moreover, recently a strong critique of the Strehler-Mildvan theory of mortality (lifespan limit) emerged (Tarkhov et al. 2017) explicitly aiming to encourage the search for anti-aging and life-extending therapies.

Yet, many life-extensionists resist the imposition of a limit on life and health not on any specific technical grounds, but on the sheer postulate of the human ability to employ natural processes to achieve benefits for humanity. Their greatest source of hope is the rapid development of therapeutic means for health improvement and life extension. The primary proofs of feasibility are based on the successful cases of health improvement and life extension experimentally achieved in animal models and emerging human studies, and the development of new intervention techniques, based on the ever-better elucidation of the mechanisms of aging (Stambler 2017b). There are now clear proofs of practical technological feasibility of interventions into aging processes and healthspan and lifespan modification. These feasibility proofs for aging modification and health and lifespan intervention are a part of the more general and very encouraging trend of the rapid development of biomedical technologies. The fact of progress in scientific, technological and medical capabilities is difficult to deny. Though, of course, this progress is not a given, and may be brought to naught in the absence of persistent human effort, ingenuity and investment. Yet, the present progress gives encouragement and hope for overcoming the present practical limitations of both the lifespan and healthspan, for extending life concomitantly with the extension of good health, for keeping intellectual, physical and spiritual capabilities without expecting a rigidly set end point. This is the profoundly optimistic vision of health and life promoted by the life-extensionist school of thought.

The truth or error of each school of thought will be shown in time, with fateful impacts on the lives of every one of us, within our yet limited lifespan and healthspan.

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