LIFE EXTENSION

PROPONENTS, OPPONENTS, AND THE SOCIAL IMPACT OF THE DEFEAT OF DEATH

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Introduction

I don't want to achieve immortality through my works.
I want to achieve immortality by not dying.
— Woody Allen

The finitude of human life is a blessing for every individual, whether he knows it or not.
— Leon Kass

It is always a shock to get we ask for. In the unreflective rush of modern post-modern science, dreams are achieved with unsettling ease. One candidate dream is the quest for immortality.

That phrase itself, "the quest for immortality," its embarrassing pretension a kind of throwback to Victorian natural-philosopher hubris, underscores how close we've come to the impossible. Science once gloried in stolid, methodical methodology, progress made one deliberate step at a time. The grand "Eureka!" was more legend and romance than real science; everyday labwork is the quiet clarification of small problems in small fields. But the shocking power of contemporary science has awakened dormant dreams and birthed futures quite old-fashioned in their grandeur. The entire human genome in a memory bank, "the theory of everything," babies conceived hither and gestated thither: science is dreaming big again.

As medical power increases, it seems possible not merely to mitigate the most threatening diseases but to eliminate, or at least stave off, disease itself, and with it the debilitation that once seemed the inevitable burden of advanced age. Scientists are now talking seriously of extending the human life span – that is, of finding, and possibly eradicating, the inherent limit to human longevity, which, they claim, we have so far failed to reach only because of the unnatural intervention of natural death.

Whether this hope will be borne out remains to be seen. That the attempt would be made, however, that we must now seriously contemplate how to, and whether to, and whether we really want to, sentence ourselves to more of the future than any human yet has faced, forces us to raise questions that have hitherto enjoyed the luxury of irrelevance.

The Dream of Life, The Fear of Death

Death, be not proud . . .
Death, thou shalt die.
— John Donne

Many cultures expected life after earthly death – whether by rebirth, transcendence to an eternal realm, or as reward or punishment at the hands of the gods. That this should be such a common theme underscores the severity of the problem of death – not that we *can* die, but that death was seen as *insurmountable*. To beat death, to cheat death, required not *not-dying* but *dying and living on*. For pre-scientific cultures, afterlife was the only path to eternity. Physical immortality was a concept unknown, or applicable only outside the human sphere (gods were immortal; ordinary humans, by contrast, stood so far bereft of this status they were *referred to as* . . . "mortals").

The hope of an afterlife may thus be seen as a surrender to the inevitability of death, a last best hope when a more immediate, and possibly more enjoyable, physical immortality eludes. (No need of an *after*life if one does not intend one's life to end.) If an eternal future is what is sought, it would seem preferable on probabilistic grounds alone to continue a life in the mundane, physical realm, rather than gamble on the unknowns of the unseen.[1] Immortality in the fleshly realm offers the promise of a familiar (and presumably desirable – else why fear death?) mode of living, in familiar surroundings; the afterlife carries the attendant risk that one will wind up in an eternity not to one's liking. All things considered, then, the best way to live forever is not to die. The catch, of course, is that to achieve immortality one must find a way to beat some very long odds. Few achieve this. In fact, every person known to have attempted it is known to have failed. The ubiquity of death makes dreams of the afterlife a highly popular insurance policy.

That may be changing. An eternity of life *in this life* has come to seem more possible than before – having stepped, perhaps, from the level of fantasy to that of science fiction, one notch closer to fact. The thought of extending physical life to the point that it promises the benefits of the eternal afterlife has shed its trappings of lunacy and quackery. Serious scientists now speak of immortality, and serious moralists now cluck at imaginings that would have been ravings scant years ago. The denial of death has emerged from its embarrassing status as plot or symptom. It is now a goal, a plan, a research program, a *project*.

Curing Death

The factual observation that death is a natural process – resulting either from physiological malfunction or the body's inherent mechanisms of senescence – gives rise to the perfectly logical suspicion that if those processes could be slowed or mitigated, death itself could be "treated" just as any other bodily ailment. Denial of death, in this way of thinking, is a denial that death is an inevitable and implacable finality – not a mere failure of the life process, but a distinct and final "stage" of life, an unavoidable stage that punctuates, and terminates, all other stages. Instead, death, denied, is a *disease*, a *treatable condition*. Death is perhaps a serious disease – no need to minimize it – but no different in principle, to the scientifically ambitious thinker, from any other

severe derangement of organ function.

As a disease, death can be – and, one might think, surely should be – *cured*. Denial of death has thus moved from a dream to a practical goal – a goal that, in its simplest form, envisions death as a kind of medical specialty, not the endpoint of a failed treatment but the disease being treated, perhaps someday eliminated, itself. For if presenescent morbidity can be eliminated, why not senescence, too? If medicine gives us control of our bodies' responses to the degradations of disease and injury, why can it not give us control of the internal mechanisms of wear and decline? Why should our bodies *ever* wear out? [2]

Death denied in this way would be a denial of the idea that every life reaches an endpoint as a natural result of the processes of living. It would remove the inevitability of that endpoint, and remove the terminal implications of the concept of a "natural" human lifespan. There are many people dedicated to doing this. Denial of death is no longer a mindset. It is a program, a goal, a science, and an industry.

Sowing the Wind

The field is not new - anti-oxidation strategies for preventing cell aging have been proposed since at least the late 1950s. It is growing rapidly, however. There is now an "International Association of Biomedical Gerontology" (IABG) which has been holding annual conferences on life-extension technology for 15 years. A remarkably broad, profit-minded life-extension industry has also quietly grown up, involving academic scientists and cutting-edge commercial-science firms. None is yet ready to market anti-aging therapies or life-extension treatments, but the range of serious players is testimony to the perceived possibilities the field offers. They include DARPA, the military advanced-research program, ACT, (in)famous for producing the first cloned human embryo for stem cell research, Geron Corporation, a high-profile biotech firm specializing in anti-cancer treatments based on stem cells and telomerase, Human Genome Sciences, another biotech firm pursuing genetically-engineered pharmaceuticals based on human proteins, and researchers at numerous academic facilities, including at UC Irvine, UC Berkeley, Stanford, Cambridge University, and elsewhere.[3]

The term "engineered negligible senescence" – meaning a state in which medical treatments and biotechnology had reduced age-related disease to the point that there would be no statistically detectable change in a population's death rate with the increasing age of the population – was coined almost twenty years ago by Caleb E. Finch of the University of Southern California.[4] A landmark paper in 2002, co-authored by a team of scientists from across the US and England, proposed "SENS" ("Strategies for Engineered Negligible Senescence") as a practical program for which they held the expectation "within about a decade, of substantive progress toward that goal."

> In each case [of necessary avenues of research] we anticipate that adequately funded efforts to develop such technology have a good chance of success in mice within ten years . . .; moreover, we argue . . . that translation of it to humans may occur rapidly thereafter.[5]

They go further, suggesting it is possible not merely to prevent aging for healthy adults, but that

"*reversing mammalian aging is not necessarily any harder than dramatically postponing it.*" [6] Thus today's oldsters, if they are lucky enough to make it past the point that aging is finally subdued, may be able to look forward to an essentially endless life of rejuvenated health and youth as well!

The figurehead of the scientific longevity movement – active in research but more active in cheerleading his fellow researchers – is Aubrey de Grey of Cambridge University and the IABG. De Grey, the architect of the "SENS" movement, thinks the technical challenges it presents will be met faster than critics expect. He points out that only a relatively minor, but consistent, incremental decrease in age-specific mortality rates would produce "actuarial escape velocity" – a situation in which the average person's probability of death in a given year falls faster from cumulative scientific progress in anti-aging than it rises from that person's own biological aging. De Grey calculates that this point would be reached if science manages to reduce the risk of death by 10% per year on a continuous basis. Even a total reduction of only 30% altogether would give the average person an extra 20 years of life, during which science is likely to achieve a second 30% reduction, and so on.[7]

An even more sanguine opinion, however, holds that merely making old age more likely could, by itself, open the door to potentially limitless continuation from there onward. Applying engineering principles, Leonid Gavrilov & Natalia Gavrilova point out that the graph of increasing human mortality with age closely models the curve of increasing failures of technological systems, which is well-known to engineers. Both graphs exhibit a characteristic "late-life mortality leveling off" – a plateau in the death rate in old age, beyond which increasing age does not increase one's chances of dying (though of course the absolute death rate in a given year is still high).[8] This suggests that, if the direct causes of death in old age – disease, accidents, strokes, etc. – could be controlled, just getting older would not, itself, result in death for biological organisms any more than it does for well-maintained machines:

> There is no fixed upper limit to human longevity—there is no special number that separates possible from impossible values of a life span. This conclusion flies in the face of the common belief that humans have a fixed maximal life span and that there exists a biological limit to longevity.[9]

They argue also that the mathematics of engineering failure processes suggest that low rates of "manufacturing error" in biological systems (i.e., improving health in the early years of life, in preparation for the periods of increasing damage with aging) will have a dramatic increase in late-life mortality irrespective of major changes in basic human biology:

> Even small improvements to the processes of early human development—ones that increase the numbers of initially functional elements—could result in a remarkable fall in mortality and a significant extension of human life.[10]

Taking a longer view, technology visionary Ray Kurzweil and longevity specialist Terry Grossman see a multi-stage procession from current, groping efforts to full control of aging and

debility – what they describe as three "bridges" to an immortal future. The first "bridge" is life extension using the best available knowledge, to allow the current generation to last long enough to be on hand when true control of aging is finally achieved. The second bridge takes those alive at that time through the process of aging control and the revision of all life-threatening disease or degenerative processes. This would represent "immortality" in a limited sense. But Kurzweil and Grossman are ambitious even for a field grounded on expansive visions of the future. Immortality is not enough for them. Its main significance is merely that it will serve to keep all those who benefit from it alive indefinitely, until technology progresses to the point that the third bridge – "the nanotechnology-Artificial Intelligence revolution" – is crossed to "enable us to rebuild our bodies and brains at the molecular level."[11]

Reaping the Whirlwind

In among the cautious engineers, sober biologists, and technologically-savvy visionaries, however, the life-extension field is rife with dreamers who range from outright cranks and opportunists to more influential figures whose intentions, and apparently sincere expectations, can give pause to the most sanguine futurist.

The "Extropy Institute" is a life-extension-promotion outfit that sponsors an annual conference attended by mainstream researchers. At a 1999 conference,

> Extropy Institute's founder, a chiseled, ponytailed philosophy PhD named Max More, confidently declare[d], "This is the fourth revolution in our history - the ultrahuman revolution." . . . More's wife, an artist and bodybuilder named Natasha Vita-More, sketch[ed] out a future in which people will enjoy multiple sex organs, polymer skin that changes color like a mood ring, and virtual reality eyeball implants. . . .
>
> "Maybe I can look like a Renaissance painting for a while, or maybe a pointillist image, or maybe Cubist, like a Picasso," she [said]. . . . "Our future bodies will have streamlined muscles in all sorts of interesting shapes - new types of limbs, new types of carved skeletal structures." [12]

The industry also suffers from its unwelcome association with quack medicine peddlers and scam artists who prey on the gullibility of a scientifically ignorant public, raising false hopes while touting worthless products. Fad therapies and snake-oil have flooded the "alternative medicine" market, embarrassing researchers who do not want serious science associated with such schemes and who are afraid that funding and public acceptance for their work will be hampered by the sideshow excesses that accompany it. In 2002, a statement, signed by 52 aging researchers, was published in a scientific journal declaring that "the [anti-aging] products being sold have no scientifically demonstrated efficacy, in some cases they may be harmful, and those selling them often misrepresent the science upon which they are based." [13]

The scientific community is equally wary of its own members who show an awkward degree of enthusiasm for immortality. It is often remarked that proposals to the NIH Office of Aging

Research have to carefully avoid using the word “longevity,” and instead claim to be aimed only at reducing disease-related mortality. A group of leading researchers also noted, “any positive remark about the feasibility of [successful longevity treatments] risks two undesirable reactions: in the public the engendering of unwarranted optimism, and in the research community the pigeon-holing of oneself with snake oil-peddling charlatans.”[14]

Aubrey De Grey has argued to his colleagues that scientists working on life extension or immortality should come out of the closet (so to speak), and encourage the public to take an interest in this work by offering tentative timescales on which practical extension of life and retardation of aging can be expected to become available, in part to enable the public to plan their own health strategies to survive until that time, and to pressure governments for necessary funding and programs to achieve it.[15, 16] He also notes that a majority of his IABG colleagues disagree.[17]

Life Extension

Immortality is not a gift,
Immortality is an achievement;
And only those who strive mightily
Shall possess it.
— Edgar Lee Masters

It is clear enough, then, that something is underway – something significant, possibly life-changing (in the most broadly literal sense), and which already carries with it snares and pitfalls of human perfidy or technological mishap. Just what that is, and what it portends for individuals – perhaps the species – requires serious consideration.

Terminology

We must pause here to review the practical grounding of these dramatically big dreams. There are various avenues by which death is being given the scientific bum's rush, and various means by which its denial may be obtained. Some clarifying terminology, and a review of the currently-promising avenues of research, is needed.

It is as well to admit at the outset that "immortality" – though that word is used – is not truly on offer. What is conceivable in practical terms is, at best, effective control of the natural processes – disease and inherent debility – that commonly lead to death. Control of morbidity in this sense could conceivably eliminate those processes, thus eliminate both the inevitability of senile debility and the statistical certainty of fatal diseases – it could, that is, remove any natural inevitability of mortality. But no such program can encompass all possibilities; death by violence or accident would always be a danger, and even death by untreated disease or unique genetic defect would remain possible. Thus everyone would face some possibility of death even if no "natural" source of death were to be feared – and, probability being what it is, everyone would eventually roll the mortal snake-eyes in life's mandatory crapshoot. 18

We must therefore distinguish between the attempt to extend the average human lifespan by reducing debilitating disease, the attempt to extend the maximum human lifespan by preventing or delaying natural senescence, and the attempt to actually remove the possibility of natural death entirely through as-yet-unknown technologies. In the literature of the field, both increasing average life expectancy and increasing maximum human lifespan are often referred to as "life extension," while the elimination of all natural sources of death is sometimes referred to as "immortality." The attempt to extend lifespan by the specific means of slowing, but not eliminating, the natural process of aging is known as "age retardation"; there are other proposed methods of life extension, however, that aim to eliminate aging entirely. Finally, the increase in total healthy years of life, without increasing the total overall lifespan – the use of technology, that is, to maintain health as long as possible, and restrict morbidity to the later years of a life of otherwise normal length – is often referred to as "morbidity compression."

The Second Half of Life

The most likely and most direct program of life extension focuses on simply increasing the average lifespan of the normal human being. Remarkable results in this line are available from relatively modest technological investments. The average life expectancy of a resident of the United States increased from 46.3 years to 74.0 years, for males, and from 48.3 years to 79.7 years, for females, between 1900 and 2000 – a gain of about 3 years of life expectancy per decade, in other words.[19] The American Academy of Anti-Aging Medicine notes that "this advance can be generally attributed to improvements in sanitation, the discovery of antibiotics, and medical care. Now, as scientists make headway against chronic diseases like cancer and heart disease, some think it can be extended even further."[20] The Centers for Disease Control – traditionally a cautious organization – declares:

> "The United States is on the brink of a longevity revolution. . . . Although the risk of disease and disability clearly increases with advancing age, poor health is not an inevitable consequence of aging. Much of the illness, disability, and death associated with chronic disease is avoidable through known prevention measures."[21]

In other words, the 30 years of extra life granted the average American over the last 100 years are the product of medical and social improvements we now think of as fairly ordinary, and, more significantly, *which were not developed for the purpose of extending lifespan*. That death is a disease is shown most clearly by the convenient, but remarkable, fact that, *in curing disease*, *medicine put death off by 30 years* for the average person, while also extending the range of healthy, productive life – and this in only the first decades of truly effective scientific medicine and antibiotics.

This "easy" way to life extension – by reduction of natural morbidity – serves only to reveal the natural maximum human lifespan, currently thought to be about 120—125 years.[22] With disease elimination and morbidity compression, this would make available 40—50 years of good health in the "second half" of life that most people today never see.

Who has not said "If I could only go back and start over . . ."? If the dreams of the "mainstream" anti-aging researchers bear fruit, it may finally be possible to "live your life over again," or at least to live another life when your threescore-and-ten are done with, and manage to do some of the things you wished you had done the first time around. Under that scenario, one would cheat death entirely in one's first life. Seventy years of age would not be the beginning of the end, but merely early middle age; decline, debility, and the fading of one's capacities would be as far off for a 70-year-old as they are for a 20-year-old today. And, if 50 years of healthy adulthood seems today like a full life, then to live out that 50 years and have 50 more still to come, with no likelihood of immediate death or decline, would be essentially *to live through an entire life, and move on to the next one, without dying*!

The Means to the End of the End

On closer inspection, it is apparent that this dramatic 30-year gain is largely the result of eliminating common causes of infant and childhood mortality, which have a large statistical impact on the population-wide ”average age at death.” There are limits to how much can be gained from disease-reduction alone, however. Morbid disease has a lesser impact on the life expectancy of adults; extending maximum life expectancy for those of adult years through reductions in disease-related morbidity alone would require unrealistic advances. S. Jay Olshansky, who has been tracking changes in average age at death in the US for over 15 years, notes:

> “[T]he vast majority of this increase in life expectancy from 47 to about 77 through 80 [years] now for females in the United States, is a result of declines in infant, child and maternal mortality. That can only be achieved once for a population. Once it is then achieved, the only way to achieve another increase in life expectancy like that is to influence the elderly. . . .
>
> If, indeed, we were to find a cure for cancer, for example, life expectancy at birth would rise by about three and a half years. Life expectancy at birth would also rise by about the same amount, three to three and a half years if systemic heart disease was hypothetically eliminated. And if we eliminated all cardiovascular diseases, diabetes and all forms of cancer combined, life expectancy at birth in humans would rise up to about 90. So you have to believe that we will be experiencing rather dramatic reductions in mortality in order to yield these very high life expectancies. A life expectancy of 100 required about 85 percent reductions in all causes of death at every age . . . .”[23]

Thus, it is evident that, while mainstream medicine and related improvements in health across the population have had a dramatic impact on *average* life expectancy at birth, they have had little impact on *maximum* life expectancy or life expectancy for those who survive to reach their 70s. These advances have not addressed the inbred limits (if any) to human lifespan, but rather the phenomena that most commonly prevent those limits even being reached.

Other approaches to life extension are in the offing, however. Steven Austad, a leading researcher in longevity, confidently proclaims limited life extension currently doable, and more dramatic alterations in the mortal course possible with future developments:

> In the near term using traditional medicine, I think . . . that we will get a few additional years, whether it's going to be five, whether it's going to be ten, whether it's going to be three, I think we'll find out. Longer term as the sorts of therapies that I've been talking about that work in animals actually get extended to humans . . . I think it's easily possible that we'll get a few additional decades of

> human life expectancy. . . .
>
> The last question, are there hard physiological barriers on the maximum human life span? I will say we don't know, but I [have] some animal data that I think suggests that there are not . . . .[24]

Sherwin Nuland, on the other hand, argues that longevity is less desirable than simple compression of morbidity, and that we should focus our resources on the latter.

> [Biotechnological revisions of the human condition] are not the problems American medicine should be struggling with. Its proper task is not the prolongation of life beyond the naturally decreed maximum span of our species . . . but its betterment. And if anyone's life needs betterment it is surely the elderly man or woman still living well beyond the years of vigor and productivity because the benisons of public health and biomedicine have made it possible.[25]

Needless to say, each of these scenarios is far-fetched, but each is the focus of an active research program. The practical control of bodily functions that science commands increases almost by the day. Advances on each of these fronts are all but inevitable – as are the consequences of those advances.

Nuts and Bolts

How is all this to come about?

Morbidity compression, as previously noted, is the logical result of control of ordinary pathology. True life extension, however, requires as-yet-speculative, but surprisingly promising, research into a number of common pathways to cellular-level mortality and organ-system degradation – the processes by which the body runs down even if it is not killed by outright pathology.

Current Research

Aubrey de Grey's group identifies seven biological mechanisms which, if adequately controlled, are all he thinks necessary for retardation of aging. He points out that each of these was first identified at least 20 years ago, and no other major degradation pathways have been identified since then, suggesting that no others are likely to be found. The list includes:

- Cell mass loss;
- Cellular senescence;
- Chromosomal mutations and cancer;
- Mitochondrial plasmid mutations;

- Lysosomal "junk"';
- Amyloid plaques in neural tissue;
- Extracellular structural protein cross-linking.[26]

For each of these problems, de Grey blithely proposes a technological fix – sometimes radically esoteric (hiding a redundant copy of the mitochondrial genome in the chromosomes in the cell's nucleus; genetically engineering the telomerase gene entirely out of the human species to eliminate all cancers, and then rejuvenating the body with periodic injections of telomerase-enabled stem cells for tissue growth), sometimes merely optimistic (new drugs to dissolve amyloid buildups). The handwaving quality of these solutions, and de Grey's breathless indifference to their enormity (permanently restructure an entire, distinct part of the human genome?) tends to undermine his assurances that "all of [these techniques] are likely to be feasible in mice within a decade (presuming adequate funding), and may be translatable to humans within a decade or two thereafter."[27] Nonetheless, none of them is absurd, and all are the subject of active research programs. The "ten years in mice" prediction is taken seriously by others in the field.

The President's Council on Bioethics, in surveying the range of necessary and possible treatments for aging for their symposium on the ethics of such treatments, comes up with a similar list of prerequisite techniques for life extension:

- Muscle enhancement;
- Memory enhancement;
- Anti-senescence through caloric restriction;
- Genetic engineering to combat mutations;
- Cell-loss prevention through anti-oxidation (anti-free-radical) therapy;
- Anti-senescence through hormone treatment;
- Anti-senescence through telomere manipulation.[28]

The similarity to de Grey's list is obvious, although the treatments recommended in some cases are different.

It appears, then, that the scientifically-informed community has converged on a practical and manageable research project on aging retardation. Nothing guarantees success, but the field is well-defined, long active, and takes itself seriously enough to be now engaged in a debate over *when* its own success can be expected.

Wishful Thinking

Other technological bids for immortality involve rather grander flights of fancy. In the time-honored way of wishful futurists, seekers of immortality seize upon each new scientific advance, or fad, as the solution they have been waiting for. Some visionaries see "science" – the grand

enterprise itself, not just some particular piece of knowledge or technology – as guaranteeing its own eventual triumph over the mundane physicality of an imperfect world:

> According to models that Ray [Kurzweil] has created, our paradigm-shift rate – the rate of technical progress – is doubling every decade, and the capability (price performance, capacity, and speed) of specific information technologies is doubling every year. So the answer to our question ["Do we have the knowledge and the tools today to live forever?"] is actually a definitive yes – the knowledge exists, if aggressively applied, for you to slow aging and disease processes to such a degree that you can be in good health and good spirits when the more radical life-extending and life-enhancing technologies become available over the next couple of decades.[29]

In a similarly hopeful vein, much of today's headline-setting science has been confidently cited as the breakthrough that – "any day now" – will make life extension and the final defeat of death a reality:

- Anti-senescence through hormone treatment; "Nanotechnology"[30] will provide intracellular robots that systematically clean up tissue damage and repair malfunctioning biomolecules – what the body can't do for itself will be done by an invisible corps of indwelling majordomos and repair techs. . . . or something.
- The Human Genome Project will unlock the secrets of our inherited bioprocesses – including the mechanisms of senescence and of many diseases. Once we have that knowledge in hand, the next step will surely be obvious.[31]
- Stem cell research, not surprisingly, is the latest great hope for the evermore. There is perhaps a symbolic suggestion of eternal youth lurking in cells taken from embryos or umbilical cord blood, not to mention their notable property of immortality (in the technical sense – they can be maintained permanently in tissue culture flasks). At any rate, the oft-made promise that stem cells will provide a source of rejuvenated tissue for debilitative conditions such as Alzheimer's disease is reason enough to hope that further such applications would stave off any form of tissue damage, perhaps forever.
- And, for those of us unlucky enough to be born on the cusp of glory – late enough to see the promised land of immortality, but too soon to get there ourselves – "cryogenics"[32] will preserve our corpses until highly advanced and highly altruistic citizens of the future perfect techniques for reconstructing personalities and memories from the slush of an old, frozen brain – and then choose to invest the money and effort needed to do so.

Though far more speculative than the others, these radical technologies are also the subjects of active research programs. Thus, maximum-age life extension technologies run across a spectrum from the merely far-fetched to the entirely fictional, but it is difficult to say what is too amazing – or too crazy – for so grand an enterprise.

The World of Tomorrow

With this much technological progress in the pipeline, clearly we are living in the end times. Immortality is but an R&D cycle away. Given any luck at all, we will be the last generation to face death, the first to face deathlessness. For all their eager adherents, however, and all the promise they – perhaps legitimately – show, there is no guarantee that any of these nascent technologies will bear fruit for the current generation of immortality-seekers. How bitter to be a member of the *next-to-last* generation to face death!

What these exercises in hope and hype have in common is the expectation that . . . *somehow*, in some unknown, but almost-visible way . . . technology will prevail over the most insurmountable barrier known. For the technological main-chancers of the life-extension community, it is a given that some breakthrough – "just around the corner" – will solve the last remaining problems and open the future to whoever wants to take it.

This roll-the-dice approach to life extension requires more than just a drive to deny death; it requires a complementary positive expectation regarding the development and benefits of technology. Mainstream life extension – mortality reduction and morbidity compression – focuses on existing technology, with its too-obvious gaps, limitations, and side effects. Anyone counting on familiar technology – improved antibiotics, say, or new hormone pills – to give them the future has to be aware of the practical limitations on what is likely to be achieved by such means. The full-gone futurist, though, has the luxury of boundless optimism, unburdened by any inconvenient contrary facts, or any facts at all.

The Denial of Death

To venerate the simple days
Which lead the seasons by,
Needs but to remember
That from you or me
They may take the trifle
Termed mortality!
— Emily Dickinson

Why, then, all this chasing after more years and more science to bring more years?

Denial and Affirmation

We speak of "denial of death," but medico-technological life extension takes that concept rather literally. Fear of death, and its denial, are cultural characteristics that manifest in many ways, often behavioral: irrational risk-taking, harrowing medical treatments in hopeless cases, an imbalance of medical resources expended in the final months of life, a cultural emphasis (in the West, at least) on an absurdly impossible ideal of youth. In all these cases, though, death is *denied* essentially by pretending that it will not happen, or will happen only to other people. Death itself – death as a phenomenon – is left untouched; its denial is an act of wishing-away, of the closing of one's eyes. The seemingly obvious, direct approach to the denial of death – that of *refusing to die* – is actually one of the less common ones. Like the weather, everyone talks about death but few do anything about it.

It requires not merely a tremendous aversion to death, but a complex of attitudes and expectations – about technology, medicine, the "natural" course of life, and much else – to see death as *optional*, as a problem to be *solved* rather than delayed or denied. Denial of death in the traditional guise – denial of death as a refusal to *acknowledge* death – seems to be an essentially conservative impulse: what is desired is the continuation of the here and now, the avoidance of a disruptive finality. One wants not to be much, much older, but rather young forever; not to undergo more and better medical treatments, but never to need medical care. Denial of death by way of technological life extension, by contrast, is a more expansive undertaking: *more of* more of the same; this life, yes, but ever-so-much-more-so.

Continuing that thought, a paradox appears in distinguishing these two modes of denial of death. The conservative mode – pretending death is irrelevant – often causes death through risky behavior or a refusal to respond appropriately to danger. The expansive mode – overcoming death with technology – requires explicitly acknowledging that death is a reality in order to achieve the technological change that constitutes its denial. Each mode incorporates its own contradiction: the denial of death that leads to death, the acceptance of death that overcomes it.

The technological denial of death, then, is not in the nature of a running-away or a fearful wish for immunity; it is a kind of acceptance of a challenge, a task imposed by humanity's most implacable enemy and offering (as such technological challenges do) the reward of continued opportunities to meet further challenges. This is not to suggest that those who seek life extension through medical technology are engaged in mere game-playing; presumably they are motivated

to defeat death because, in fact, they really don't want to die. But that desire manifests, for the technologically-inclined immortalist, as an active project to change the terms on which life is lived, to fix the bug in the system that otherwise inevitably causes it to crash.

It would be much too glib to posit specific psychological motivations underlying one or another mode of response to death. The point is merely that there is a distinct difference – if not of motivation, then of intention in action – between wishing one did not have to die and undertaking an actual practical program to make death obsolete. The latter is a peculiarly aggressive form of denial (and one that, *Frankenstein* notwithstanding, became a plausible dream only in the late 20th century).

The Fear of Death and The Love of Life

This analysis is not universally received, however. The President's Council on Bioethics traces the desire to prolong life to the fear of death:

> The fear of death, that ultimate and universal fear, surely has a hand (even if only implicitly) in motivating the search for ways to slow the clock. Death is nature's deepest and greatest barrier to total human self-mastery. . . . Our subjection to death – and our awareness of this fact – is central to what makes us human ("mortals") rather than divine, and it makes us fearful and weak and constrained.[33]

There is certainly an intuitive appeal to this perspective: what could motivate us to go to such lengths (remaking our genes?, nano-robots?, cryogenic hibernation?) to gain more time on Earth *other than* a fear of the alternative? What but desperation could justify such desperate measures?

But the language of life extension advocates does not betray fear so much as excitement and anticipation; death, to many in the field, appears not to be an awesome transition as much as a regrettable waste. Since almost no one *wants* to die (including opponents of life extension, who value death but are content to wait for it), the thinking seems to be that no one should *have to* die – and anyone who does die, whether through lack of technological alternatives or the refusal to use them, has forfeited the one thing that makes all other things worthwhile.

A telling point in the Council's statement, above, is the pejorative use of the phrase "total human self-mastery." For visionaries like de Grey, who intends to physically reconfigure the human genome, for technocratic futurists like Kurzweil and Grossman, who want nothing less than a new form of computer-enhanced human intelligence, for gushing bio-*artistes* like Vita More who foresee a carnival of colored and sculpted human bodies, total human self-mastery is both a goal and a tool. And that distinction – that difference in perspective, between seeing the audacious control of human bodies and human nature as an act of impiety or hubris, and seeing it as the next step forward on the continuing drive toward human betterment – may explain why the flight from death need not be driven by the fear of death. For many of its most vocal proponents, it seems motivated more by an almost irrepressible enthusiasm for all that may be possible once the limitations and frustrations imposed by our lack of total human self-mastery are overcome.

Certainly these deniers of death show no signs of being "fearful and weak and constrained" in the face of death. This suggests, too, that the fear of death is *not* an "ultimate and universal fear" – its place is taken by other, richer and more welcoming emotions among those who, when they gaze upon immortality, take *life* and not *death* as the object of that gaze.

For the life-extensionists, then, denial of death is their stock in trade, but that denial springs from a vision that looks beyond death to the possibilities inherent in a world from which death has been removed. Traditionally, transcending death meant achieving an afterlife of whatever sort – it meant, that is, *dying*. But for today's technological transcendentalists, going beyond death means removing death as an obstacle so that time and energy – much more time, much more energy – can be focused on more important things.

Life as a Consumer Commodity

What of the public who may make use of this technology if it is perfected? In choosing the means to deny death to themselves, what are they seeking and what are they hoping to avoid? It is impossible to speculate on the motives of hypothetical people in choosing to use technologies that do not even exist yet, but still we may ask whether the decision to extend one's life, or remove natural death entirely from the course of life, is the same mental process as that which valorizes eternal youthfulness or oblivious risk-taking. Intuitively, it seems not to be. We struggle so hard to maintain life when we know we cannot – in illness, in old age – that it seems unlikely we would choose death when the realistic prospect of banishing it is offered. At first glance, at least, we may imagine that the average person would choose treatments to achieve immortality for the same reason that the average person chooses treatments to prolong dying during a terminal illness: *they don't want to die*.

We do not need to posit psychopathologies of fear or denial to explain such a choice; the thing virtually explains itself. Whatever good there is is found in life; to cling to that good – and why not? – means to cling to life, and reject its termination. And so we seek what means we can to live when death looms. This is not to say that the fear of death is not a real phenomenon, nor a common one; surely it is the former and likely it is the latter. Nor even is it to say that fear of death does not serve a protective purpose under many circumstances; no doubt it does. But one may choose life without being especially fearful of death; one does not need to fear it not to *prefer* it when a choice is available. For consumers of life-extension technology, then, immortality may hold the positive allure that it seems to for its researchers and professional proponents; immortality is a denial of death by way of an affirmation of its alternative, a positive evaluation of what will continue without death, rather than a negative statement about what will end with it.

So, denial of death is certainly a prominent aspect of the search for immortality – how could it not be? But that denial seems to play out in ways and forms different from the stereotype of fear and pathological obliviousness. The act of denial by way of technological life extension requires an aggressive and open-eyed *engagement with* death, a literally scientific scrutiny of death's ways and mysteries until no more mystery remains and its ways are mastered and overcome. The individual motivations of the seekers, dreamers, main-chancers and visionaries who pursue this project are unknown and, no doubt, various – but they seem to have little to do with "ultimate fear" and, certainly, recognize no irony and no fault in the attainment of "total human self-mastery."

The Future of Denial

Has the prospect of immortality emptied the *concept* of "denial of death" of its own meaning, then? When death's pale horse has been put out to pasture, and life in abundance is for the taking, what is there still to deny?

Death looms throughout mortal life. Death is the motivation for life-extension, obviously, and, given that it can never be truly eliminated, it will be as real to our "immortal" descendants as it was to us or our short-lived forebears. What will change, if significant life-extension is achieved, is its immediacy. Generation will succeed generation as before, but with centuries, perhaps, between them; one's acquaintances will pass away as their allotted time closes, but once a decade, maybe, or once a century. Death as a near and present danger will recede; future generations may view today's epidemic of fear and denial of death as we, today, view our ancestors' panic over smallpox and whooping cough: a nearly-incomprehensible hysteria over a mortal danger that, in retrospect, proved amenable to medico-technological control. Death may be seen as significant but not likely; a serious matter but not a priority.

In that environment, denial of death *as a practice* would be unremarkable; future generations will have denied death in the way in which our own denied smallpox – by defeating it and then mostly forgetting about it. In that environment also, denial of death *as a psychological state*, still less a *pathology*, would be unknown – like denial of childbed fever or denial of gout – a needless worry over a real but somewhat quaint and old-fashioned condition.

This technology, if it succeeds, bids fair not just to remake our lives but to re-contextualize, and thus re-define, death as a phenomenon and as a biological/sociological constraint upon our species. What we understand death to be, what impact the mere thought of death has on us, must be different, and likely much less profound, when death looms no more in the landscapes of our lives and every prospect pleases.

[End of excerpted section. Please see published volume for full text.]

NOTES

1 Pascal's Wager intrudes here: if you assume the afterlife is eternal perfection, then of course the gamble is more attractive; Pascal apparently never considered the possibility of embracing the afterlife and still winding up in "the bad place."

2 The question of "senescence" – the natural decline of a biological organism over time, through inbred mechanisms of aging and death – is itself controversial. Non-mammalian species are known to exhibit senescence – they simply will not live beyond a specified period, even in a nurturing environment. For single-celled organisms, this results from "telomere shortening" – the step-by-step reduction in the end-segments of chromosomal DNA during successive cell divisions; after a certain number of such divisions (called the "Hayflick limit," after the scientist who described this mechanism), the telomeres are too short to permit DNA replication, and the cell dies. In mammals, however, the question seems more complicated. Telomere shortening was confidently predicted to pose a barrier to mammalian cloning, but it has not done so. Also, some species, notably mice, can be forced into extremely long lifespans far in excess of what appears to be their natural age limit, in particular by imposing a drastic reduced-calorie diet. In the end, senescence in humans is still poorly understood. Though many scientists – notably Hayflick – expect there is an upper limit on human age, some aging researchers predict that no absolute maximum for human aging will be found; others predict that such a limit exists but will be overcome with more-radical future technologies.

3 Brian Alexander, "Don't Die, Stay Pretty: Introducing the Ultrahuman Makeover," *Wired* 8.01 (January 2000)

4 Caleb E. Finch, *Longevity, Senescence and the Genome* (Chicago: University of Chicago Press, 1990)

5 Aubrey D. N. J. de Grey, et al., "Time to Talk SENS: Critiquing the Immutability of Human Aging," *Ann. N.Y. Acad. Sci*. 959: 452—462 (2002)

6 Aubrey D. N. J. de Grey, et al., "Time to Talk SENS: Critiquing the Immutability of Human Aging," *Ann. N.Y. Acad. Sci.* 959: 452—462 (2002), emphasis original

7 Aubrey D. N. J. de Grey "Escape Velocity: Why the Prospect of Extreme Human Life Extension Matters Now," *PLoS Biol* 2 (6): e187 (2004)

8 Older people, even if healthy, are more likely to die in a given year than younger people due to the natural mechanisms of aging and the older body's more-limited resources for recovery from illness or injury. Even if all overt diseases, but not the process of aging itself, were eliminated, individuals would still die from the contingencies of aging and the unavoidable risks of living in imperfect and fallible bodies, and older individuals would be at the greatest risk. So, incrementally reducing the risk of mortality from disease, even at a rate faster than the increasing risk of mortality from aging, would not eliminate older people's relatively higher risk of death even if that risk were lower than otherwise. It's better to be young and healthy in a world free of cancer and heart disease than it is to be old and frail in a world free of cancer and heart disease – even though both age cohorts benefit from the elimination of those diseases. Thus, the elderly are not guaranteed a lifespan long enough to see the day that true anti-aging and functional immortality are reached, even if the major causes of adult pathology are eliminated. (But see below for a contrasting opinion.)

9 Gavrilov, Leonid and Gavrilova, Natalia, "Why We Fall Apart: Engineering's reliability theory explains human aging", *IEEE Spectrum* (NA), September 2004

10 Gavrilov, Leonid and Gavrilova, Natalia, "Why We Fall Apart: Engineering's reliability theory explains human aging", *IEEE Spectrum* (NA), September 2004

11 Ray Kurzweil and Terry Grossman, *Fantastic Voyage: Live Long Enough to Live Forever* (Emmaus, PA: Rodale, 2004) 15

12 Brian Alexander, "Don't Die, Stay Pretty: Introducing the Ultrahuman Makeover," *Wired* 8.01 (January 2000)

13 S. J. Olshansky, L. Hayflick, B. A. Carnes, "Position Statement on Human Aging," *J Gerontol A Biol Sci Med Sci.* 57 (8): B292-97 (August 2002)

14 Aubrey D. N. J. de Grey, John W. Baynes, David Berd, Christopher B. Heward, Graham Pawelec, and Gregory Stock, "Is Human Aging Still Mysterious Enough to Be Left Only to Scientists?," *BioEssays* 2002 24 (7):667-676

15 Aubrey D. N. J. de Grey, et al., "Time to Talk SENS: Critiquing the Immutability of Human Aging," *Ann. N.Y. Acad. Sci.* 959: 452—462 (2002)

16 Aubrey D. N. J. de Grey, "Biogerontologists' Duty to Discuss Timescales Publicly," *Ann. N. Y. Acad. Sci.* 1019: 542—545 (2004)

17 Aubrey D. N. J. de Grey, "Report on the Open Discussion on the Future of Life Extension Research," *Ann. N. Y. Acad. Sci.* 1019: 552—553 (2004)

18 The 2002 age-adjusted death rate from accidental causes was 35.5 per 100,000. (Centers for Disease Control, "Deaths: Preliminary Data for 2002," *National Vital Statistics Reports* 52 (13), Table B, http://www.cdc.gov/nchs.data/nvsr/nvsr52/nvsr52_13.pdf, accessed 1/12/2005)

Assuming only accidental deaths would occur with effective life-extension technology, this rate, if it persisted, would give an average age at death of only 1,963 years; if suicides and homicides also continued at present rates, long-lived future citizens would die, on average, after only 1,333 years. Hardly "immortality."

19 http://www.cdc.gov/nchs/data/hus/tables/2003/03/hus027.pdf accessed 7/4/2004

20 http://www.worldhealth.net/p/90,4862.html accessed 7/4/2004

21 http://www.cdc.gov/aging/ accessed 7/4/2004

(NB: By "longevity," the CDC seems to mean merely that the average age of the US population is increasing due to the "Baby Boom" moving out of its middle age. The CDC does not appear to expect or advocate an extension in the maximum human life span. However, a significant reduction in the death rate due to chronic illness would increase the average age at death, even if it did not increase the maximum age.)

22 The idea of a 120-year human age limit arises from the fact that the examples of extreme longevity in humans seem to end around that age: that is, there are a few rare cases of humans living beyond 120 years, but none beyond 125 or 130. Although the age/frequency curve is extremely low at that point, it does not tail out forever as a truly random curve would do. This suggests that there is a "hard cutoff" at that age. However, the number of cases of death near or above 120 years is so low (with reliably confirmed cases nearly non-existent) that any such conclusions are speculative at best. Humans may be encountering senescence above 100 years, or they may simply be falling prey to increasingly lengthy odds of remaining fit and disease-free at that age. It is hard to tell.

23 S. Jay Olshansky, testimony of 12 December, 2002, to President's Council on Bioethics hearings on "Adding Years to Life: Current Knowledge and Future Prospects," Session 2, http://bioethicsprint.bioethics.gov/transcripts/dec02/session2.html, accessed 12/30/2004

24 Steven N. Austad, testimony of 12 December, 2002, to President's Council on Bioethics hearings on "Adding Years to Life: Current Knowledge and Future Prospects," Session 1, http://bioethicsprint.bioethics.gov/transcripts/dec02/session2.html, accessed 12/30/2004

25 Sherwin B. Nuland, "How to Grow Old," in *The Best American Science Writing 2004*, ed. Dava Sobel (ecco, 2004)

26 Aubrey de Grey, "SENS (Strategies for Engineered Negligible Senescence)," http://www.gen.cam.ac.uk/sens/ accessed 1/13/2005

27 Aubrey de Grey, "SENS (Strategies for Engineered Negligible Senescence)," http://www.gen.cam.ac.uk/sens/ accessed 1/13/2005

28 President's Council on Bioethics, *Beyond Therapy: Biotechnology and the Pursuit of Happiness*, (New York: Dana Press, 2003) 189—203

29 Kurzweil, Ray, and Grossman, Terry, *Fantastic Voyage: Live Long Enough to Live Forever*, (Emmaus, PA: Rodale, 2004) 3

30 Nanotechnology: the science of designing artificial mechanisms on the scale of individual molecules, which could then be used to perform tasks inside the body or even inside individual cells, such as repairing molecular damage or enhancing biological functions.

31 It is known that remarkably small genetic changes can produce dramatic life extension in animal models. Once it was assumed that genetic control of aging would be an extremely complex process – like genetic control of intelligence or physical appearance or such. In fact, multiple single-gene changes have been identified, any one of which significantly increases longevity in their respective species with retained robust physical ability. Over 50 such genes have been identified in nematodes (a standard life-extension experimental subject) and at least half a dozen in mice; more are expected. These genes are not necessarily identical to human genes, but it is likely that similar mechanisms exist.

Cf. Austad, Steven N., testimony of 12 December, 2002, to President's Council on Bioethics hearings on "Adding Years to Life: Current Knowledge and Future Prospects", Session 1, http://bioethicsprint.bioethics.gov/transcripts/dec02/session2.html, accessed 12/30/2004

32 Cryogenics: the practice of infusing a newly-dead body with a solution to replace most of the water in the tissues, and then storing the corpse indefinitely at the temperature of liquid nitrogen. The embalming solution reduces cell damage from the formation of ice crystals, but, inasmuch as the body is already dead when the process is performed, and there is no known way to return the tissues to their natural state or undo the damage that does occur, the technique offers no hope that the dead person will be any better off when they are warmed than they were at the time of cooling. The entire process is premised on the hope that some future technology will be invented that will allow for the reanimation of super-cooled dead bodies. Naturally, cryogenics organizations offer no guarantees that anyone in the future will undertake that part of the project.

33 *President's Council on Bioethics, Beyond Therapy: Biotechnology and the Pursuit of Happiness*, (New York: Dana Press, 2003) 182