



What Happens When We All Live to 100?

If life-expectancy trends continue, that future may be near, transforming society in surprising and far-reaching ways.

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FOR MILLENNIA, if not for eons—anthropology continuously pushes backward the time of human origin—life expectancy was short.

The few people who grew old were assumed, because of their years, to have won the favor of the gods. The typical person was fortunate to reach 40.





Comments

Beginning in the 19th century, that slowly changed. Since 1840, life expectancy at birth has risen about three months with each passing year. In 1840, life expectancy at birth in Sweden, a much-studied nation owing to its record-keeping, was 45 years for women; today it's 83 years. The United States displays roughly the same trend. When the 20th century began, life expectancy at birth in America was 47 years; now newborns are expected to live 79 years. If about three months continue to be added with each passing year, by the middle of this century, American life expectancy at birth will be 88 years. By the end of the century, it will be 100 years.

Viewed globally, the lengthening of life spans seems independent of any single, specific event. It didn't accelerate much as antibiotics and vaccines became common. Nor did it retreat much during wars or disease outbreaks. A graph of global life expectancy over time looks like an escalator rising smoothly. The trend holds, in most years, in individual nations rich and poor; the whole world is riding the escalator.

Projections of ever-longer life spans assume no incredible medical discoveries—rather, that the escalator ride simply continues. If anti-aging drugs or genetic therapies are found, the climb could accelerate. Centenarians may become the norm, rather than rarities who generate a headline in the local newspaper.

Pie in the sky? On a verdant hillside in Marin County, California—home to hipsters and towering redwoods, the place to which the Golden Gate Bridge leads—sits the Buck Institute, the first private, independent research facility dedicated to extending the human life span. Since 1999, scientists and postdocs there have studied ways to make organisms live much longer, and with better health, than they naturally would. Already, the institute's researchers have quintupled the life span of laboratory worms. Most Americans have never heard of the Buck Institute, but someday this place may be very well known.

Buck is not alone in its pursuit. The University of Michigan, the University of Texas, and the University of California at San Francisco are studying ways to slow aging, as is the Mayo Clinic. Late in 2013, Google brought its trove of cash into the game, founding a spin-off called the California Life Company (known as Calico) to specialize in longevity research. Six months after Calico's charter was announced, Craig Venter, the biotech entrepreneur who in the 1990s conducted a dramatic race against government laboratories to sequence the human genome, also founded a start-up that seeks ways to slow aging.

Should research find a life-span breakthrough, the proportion of the U.S. population that is elderly—fated to rise anyway, considering declining fertility rates, the retirement of the Baby Boomers, and the continuing uplift of the escalator—may climb even more. Longer life has obvious appeal, but it entails societal risks. Politics may come to be dominated by the old, who might vote themselves ever more generous benefits for which the young must pay. Social Security and private pensions could be burdened well beyond what current actuarial tables suggest. If longer life expectancy simply leads to more years in which pensioners are disabled and demand expensive services, health-care costs may balloon as never before, while other social needs go unmet.

With each passing year, the newly born live about three months longer than those born the prior year.

But the story might have a happy ending. If medical interventions to slow aging result in added years of reasonable fitness, life might extend in a

sanguine manner, with most men and women living longer in good vigor, and also working longer, keeping pension and health-care subsidies under control. Indeed, the most-exciting work being done in longevity science concerns making the later years vibrant, as opposed to simply adding time at the end.

Postwar medical research has focused on specific conditions: there are heart-disease laboratories, cancer institutes, and so on. Traditional research assumes the chronic later-life diseases that are among the nation's leading killers—cardiovascular blockage, stroke, Alzheimer's—arise individually and should be treated individually. What if, instead, aging is the root cause of many chronic diseases, and aging can be slowed? Not just life span but “health span” might increase.

Drugs that lengthen health span are becoming to medical researchers what vaccines and antibiotics were to previous generations in the lab: their grail. If health-span research is successful, pharmaceuticals as remarkable as those earlier generations of drugs may result. In the process, society might learn the answer to an ancient mystery: Given that every cell in a mammal's body contains the DNA blueprint of a healthy young version of itself, why do we age at all?

Counting yeast

“Here in our freezers we have 100 or so compounds that extend life in invertebrates,” says Gordon Lithgow, a geneticist at the Buck Institute. He walks with me through labs situated on a campus of modernistic buildings that command a dreamlike view of San Pablo Bay, and encourage dreamlike thoughts. The 100 compounds in the freezer? “What we don’t know is if they work in people.”

The Buck Institute bustles with young researchers. Jeans and San

Francisco 49ers caps are common sights—this could be a Silicon Valley software start-up were not microscopes, cages, and biological-isolation chambers ubiquitous. The institute is named for Leonard and Beryl Buck, a Marin County couple who left oil stocks to a foundation charged with studying why people age, among other issues. When the institute opened, medical research aimed at slowing aging was viewed as quixotic—the sort of thing washed-up hippies talk about while sipping wine and watching the sunset. A mere 15 years into its existence, the Buck Institute is at the bow wave of biology.

In one lab, researchers laboriously tamper with yeast chromosomes. Yeast is expedient as a research subject because it lives out a lifetime before an analyst's eyes, and because a third of yeast genes are similar to human genes. Deleting some genes kills yeast; deleting others causes yeast to live longer. Why deleting some genes extends life isn't known—Buck researchers are trying to figure this out, in the hope that they might then carry the effect over to mammals. The work is painstaking, with four microscopes in use at least 50 hours a week.

Buck employs Lilliputian electrocardiogram machines and toy-size CT scanners to examine the internal organs of mice, since the goal is not just to make them live longer but to keep them healthy longer, with less cancer or heart disease. Researchers curious about aging mainly work with mice, worms, flies, and yeast, because they are small and easily housed, and because they don't live long, so improvements to life expectancy are quickly observable. "Twenty years ago it was a really big deal to extend the life span of worms. Now any postdoc can do that," says Simon Melov, a Buck geneticist. Experiments funded by the National Institute on Aging have shown that drugs can extend a mouse's life span by about a quarter, and Buck researchers have been able to reverse age-related heart dysfunction in the same animal. Think how the world would be upended if human longevity quickly jumped another 25 percent.

The rubber will meet the road with human trials. “We hope to find five to 10 small molecules that extend healthy life span in mice, then stage a human trial,” says Brian Kennedy, the Buck Institute’s CEO. A drug called rapamycin—being tested at the institute and elsewhere—seems closest to trial stage and has revolutionary potential. But in addition to being ethically fraught, human trials of a life-extension substance will be costly, and might take decades. The entry of Google’s billions into the field makes human trials more likely. Calico is tight-lipped about its plans—the company agreed to let me visit, then backed out.

Anti-aging research is not without antecedents, some of which offer notes of caution. A generation ago, Linus Pauling, a winner of the Nobel Prize in chemistry, proposed that megadoses of vitamin C would retard aging. It turned out that at megadoses, vitamins can become toxic. If you take vitamins, swallow the amounts recommended by the Food and Drug Administration.

A decade ago, a biotech start-up called Sirtris sought to devise drugs that mimic the supposed health-giving properties of red wine. GlaxoSmithKline bought Sirtris for \$790 million in today's dollars, money the company may wish it had back: Sirtris experiments have yet to lead to any practical product.

About 15 years ago, Bruce Ames, an accomplished scientist at the University of California at Berkeley, proposed that acetylcarnitine, which regulates the mitochondria of cells, combined with an antioxidant, might retard aging while treating mild Alzheimer's. *Antioxidant* has become a buzzword of supplement marketing and Dr. Oz-style quackery. Too much antioxidant would be unhealthy, since oxidation is essential to the body's respiration. Ames thought he had found a compound that safely moderates the pace at which cells use themselves up. He began dosing himself with acetylcarnitine, and continues to work at Berkeley, at age 85; whether he would have enjoyed such longevity anyway is unknowable. Pharmaceutical companies have shown little interest in Ames's idea—because it occurs naturally, acetylcarnitine cannot be patented, and, worse from Big Pharma's standpoint, the substance is inexpensive.

Today, lab results show a clear relationship between a restricted-calorie diet and longevity in mice. That eating less extends the life spans of small mammals is the strongest finding of anti-aging research to this point. A restrictive diet seems to put mouse cells into a state vaguely similar to hibernation; whether caloric restriction would work in people isn't known. A campaign against calories might seem to possess broad practical appeal,

since what's recommended—eating less—costs nothing. But if the mice are any indication, one would need to eat a *lot* less, dropping caloric intake to the level at which a person feels hunger pangs throughout the day. “Caloric restriction is a fad diet in Northern California,” Melov told me. “We had a caloric-restriction group come in to visit the institute. They did not look at all healthy.”

Most research assumes that chronic diseases arise and should be treated individually. What if, instead, aging is the root cause of many chronic diseases, and aging can be slowed?

Recently, separate teams at Harvard, Stanford, and UC San Francisco reported that transferring the blood of adolescent mice into old, declining mice had a rejuvenating effect on the latter. The thought of the old rich purchasing blood from the young poor is ghoulish on numerous levels. The research goal is to determine what chemical aspect of youthful blood benefits mature tissue. Perhaps compounds in adolescent blood excite dormant stem cells, and a drug could be developed that triggers the effect without transfusion.

The Buck Institute and other labs have been looking for health-span DNA that may exist in other mammals. Whales are a lot less likely than people are to get cancer. Polar bears consume an extremely high-fat diet yet don't develop arterial plaque. If the biological pathways for such qualities were understood, a drug might be designed to trigger the effect in people.

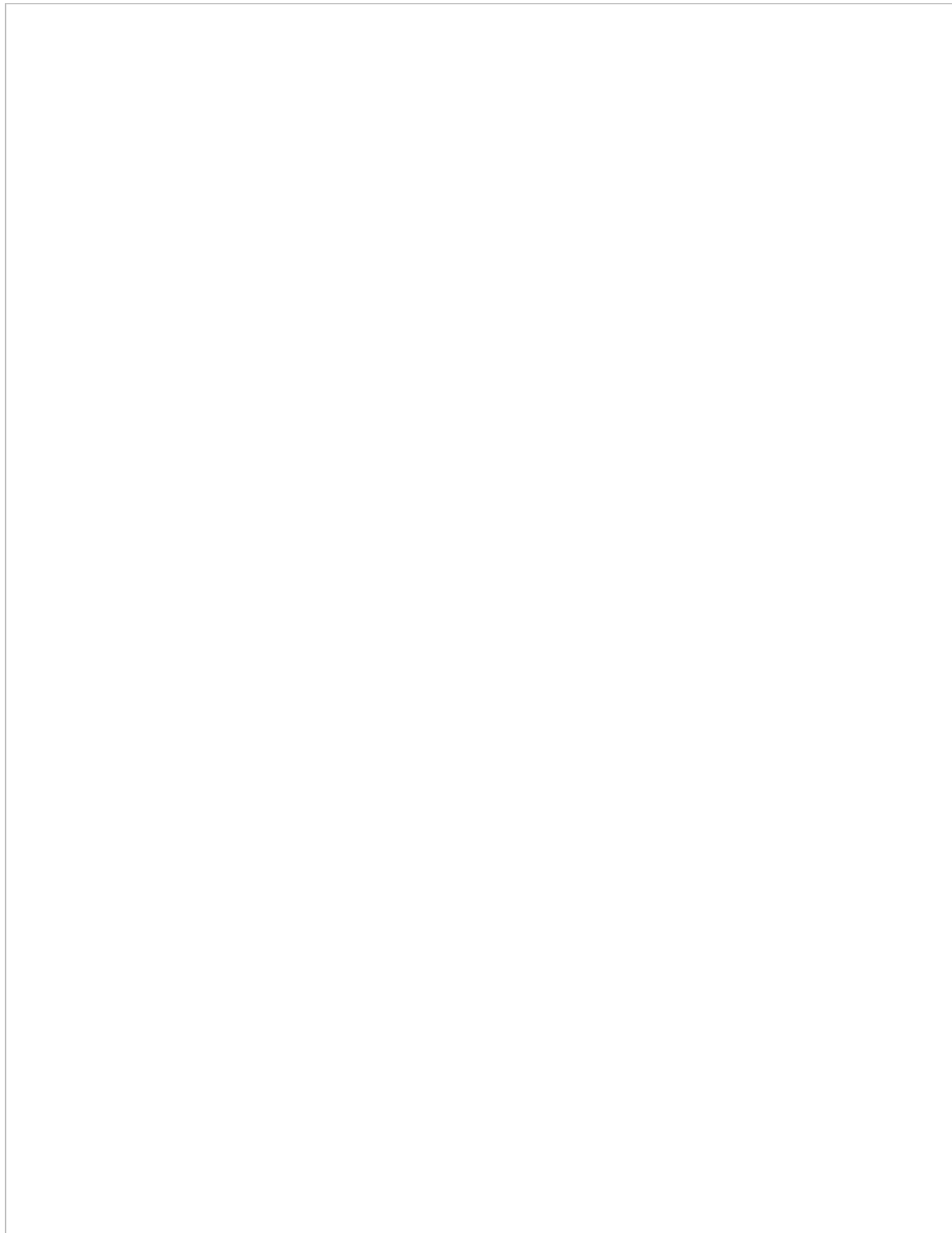
Mimicking what nature has already developed seems more promising than

trying to devise novel DNA.

In worms, genes called *daf-2* and *daf-16* can change in a way that causes the invertebrates to live twice as long as is natural, and in good vigor. A molecular biologist named Cynthia Kenyon, among the first hires at Calico, made that discovery more than two decades ago, when she was a researcher at UC San Francisco. By manipulating the same genes in mice, Kenyon has been able to cause them to live longer, with less cancer than mice in a control group: that is, with a better health span. The *daf-16* gene is similar to a human gene called *foxo3*, a variant of which is linked to exceptional longevity. A drug that mimics this *foxo3* variant is rumored to be among Calico's initial projects.

A long time has passed since Kenyon's eureka moment about worm genes, and she's still far from proving that this insight can help people. But the tempo of the kind of work she does is accelerating. Twenty years ago, genetic sequencing and similar forms of DNA research were excruciatingly time-consuming. New techniques and equipment have altered that: for instance, one Silicon Valley lab-services firm, Sequetech, advertises, "Go from [cell] colony to sequence" in a day. The accelerating pace of genetic-information gathering may come in handy for health-span research.

The Buck Institute became cautiously optimistic about rapamycin when its life-extension properties were noticed in yeast. Lab mice dosed with rapamycin are dying off more slowly than they would naturally, and many of the old mice appear energetic and youthful. Devised to prevent rejection of transplanted organs, rapamycin seems to alter some chemistry associated with cellular senescence. (More on that later.) If the drug turns out to delay aging in people, it would be the greatest off-label pharmaceutical use ever. But don't ask your doctor for a prescription—health-span therapy based on rapamycin is years away, if it ever happens. Kennedy, the Buck Institute CEO, does not dose himself with rapamycin, whose side effects are not understood.



Smoke, eat red meat, live to 100

Researchers at the Buck Institute are lean: society's obesity problems are not in evidence there. Everyone takes the stairs; elevators are viewed as strictly for visitors. If there is a candy machine on the 488-acre grounds, it

is well hidden. I met some researchers for lunch in a glass-and-chrome conference room (Buck's buildings were designed by I. M. Pei and fairly shout "Give me an architecture award!"). Lunch was an ascetic affair: water and a small sandwich with greens; no sides, soda, or cookies. Kennedy says he seldom eats lunch, and runs up to 20 miles weekly. Yet, even doing everything right by the lights of current assumptions about how to stave off aging, at age 47, Kennedy has wrinkle lines around his eyes.

Except with regard to infectious diseases, medical cause and effect is notoriously hard to pin down. Coffee, salt, butter: good, bad, or neither? Studies are inconclusive. Why do some people develop heart disease while others with the same habits don't? The Framingham Heart Study, in its 66th year and following a third generation of subjects, still struggles with such questions. You should watch your weight, eat more greens and less sugar, exercise regularly, and get ample sleep. But you should do these things because they are common sense—not because there is any definitive proof that they will help you live longer.

The uncertainty inherent in the practice of medicine is amplified when the subject is longevity, because decades might pass before anyone knows whether a particular drug or lifestyle modification does any good. Scrutinizing the very old has not been the gold mine some researchers hoped it would be. "Lifestyle studies of centenarians can be really puzzling," Kennedy says. "They smoke more and drink less than we might guess. Few are vegetarians. Nothing jumps out as a definitive cause of their long lives."

Among the first wide-scale efforts to understand gerontology was the Baltimore Longitudinal Study of Aging, begun by federal researchers in 1958 and ongoing. Its current director, Luigi Ferrucci, says, "The study has determined that disabilities among the elderly often have warning signs that can be detected in youth, and this insight might lead to early-life interventions that decrease late-life chronic disease. But on some of the big

questions, such as whether longevity is caused mainly by genes or mainly by lifestyle and environment, we just have no idea at all.”

Studies of twins suggest that about 30 percent of longevity is inherited.

This is one of the factors that make researchers optimistic—if 30 percent of longevity is inherited, perhaps laboratories can design a compound that causes anyone’s blood chemistry to mimic what happens in the bodies of those who were born with the DNA for long life. “But when we sequence the genome, only 1 percent seems linked to longevity,” Ferrucci told me. “The other 99 percent of the presumed genetic effect is unexplained.”

At medical conferences, Ferrucci likes to show physicians and researchers an elaborate medical profile of an anonymous patient, then ask them to guess her age. “Guesses are off by as much as 20 years too high or low,” he says. “This is because medically, we do not know what ‘age’ is. The sole means to determine age is by asking for date of birth. That’s what a basic level this research still is at.”

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Aging brings with it, of course, senescence. Cellular senescence, a subset of the overall phenomenon, is a subject of fascination in longevity research.

The tissues and organs that make up our bodies are prone to injury, and the cells are prone to malfunctions, cancer being the most prominent. When an injury must be healed, or cancerous tissue that is dividing must be

stopped, nearby cells transmit chemical signals that trigger the repair of injured cells or the death of malignant ones. (Obviously this is a simplification.) In the young, the system works pretty well. But as cells turn senescent, they begin to send out false positives. The body's healing ability falters as excess production of the repair signal leads to persistent inflammation, which is the foundation of heart disease, Alzheimer's, arthritis, and other chronic maladies associated with the passage of time. Cars wear out because they cannot repair themselves; our bodies wear out because they lose the ability to repair themselves. If the loss of our ability to self-repair were slowed down, health during our later years would improve: a longer warranty, in the auto analogy.

“If we can figure out how to eliminate senescent cells or switch off their secretions,” says Judith Campisi, who runs the Buck Institute's research on this topic, “then we could prevent or lessen the impact of many chronic diseases of aging. It's not a coincidence that incidence of these chronic diseases increases sharply after the age of 50, a time when senescent cells also increase in number. If you believe, as many scientists do, that aging is a prime cause of many chronic diseases, it is essential that we understand the accumulation of senescent cells.” Rapamycin excites longevity researchers because it seems to switch off the repair signal mistakenly sent by senescent cells. Mayo Clinic researchers are studying other substances that dampen the effects of cellular senescence; some have proved to keep mice fit longer than normal, extending their health span. Many elderly people decline into years of progressive disability, then become invalids. If instead most people enjoyed reasonable vigor right up to the end, that would be just as exciting for society as adding years to life expectancy.

Big medical efforts tend to be structured as assaults on specific conditions—the “war on cancer” and so on. One reason is psychological: a wealthy person who survived a heart attack, or lost a parent to one, endows a foundation to study the problem. Another reason is symbolic: we tend to view diseases as challenges thrown at us by nature, to be overcome one by

one. If the passage of time itself turns out to be the challenge, interdisciplinary study of aging might overtake the disease-by-disease approach. As recently as a generation ago, it would have seemed totally crazy to suppose that aging could be “cured.” Now curing aging seems, well, only somewhat crazy.

The escalator debate

The life-expectancy escalator has for nearly two centuries risen about three months a year, despite two world wars, the 1918 influenza pandemic, the AIDS epidemic, and the global population’s growing sevenfold—the latter deceptively important, because crowded conditions are assumed to more readily communicate disease. Will life-span increases continue regardless of what may happen in biotech? The yea position is represented by James Vaupel, the founder of Germany’s Max Planck Institute for Demographic Research; the nay by Jay Olshansky, a professor of public health at the University of Illinois at Chicago.

In 2002, Vaupel published an influential article in *Science* documenting the eerily linear rise in life expectancy since 1840. Controversially, Vaupel concluded that “reductions in mortality should not be seen as a disconnected sequence of unrepeatable revolutions but rather as a regular stream of continuing progress.” No specific development or discovery has caused the rise: improvements in nutrition, public health, sanitation, and medical knowledge all have helped, but the operative impetus has been the “stream of continuing progress.”

Vaupel called it a “reasonable scenario” that increases will continue at least until life expectancy at birth surpasses 100. His views haven’t changed. “The data still support the conclusions of the 2002 paper. Linear rise in life expectancy has continued,” Vaupel told me earlier this year. In a recent report, the Centers for Disease Control and Prevention found that the age-adjusted U.S. death rate declined to a record low in 2011. Today the first

four causes of death in the United States are chronic, age-related conditions: heart disease, cancer, chronic lower-respiratory diseases, and stroke. As long as living standards continue to improve, Vaupel thinks, life expectancy will continue to increase.

On the opposite side of this coin, Olshansky told me the rise in life expectancy will “hit a wall soon, if it hasn’t already.” He noted, “Most of the 20th-century gains in longevity came from reduced infant mortality, and those were onetime gains.” Infant mortality in the United States trails some other nations’, but has dropped so much—down to one in 170—that little room for improvement remains. “There’s tremendous statistical impact on life expectancy when the young are saved,” Olshansky says. “A reduction in infant mortality saves the entire span of a person’s life. Avoiding mortality in a young person—say, by vaccine—saves most of the person’s life. Changes in medicine or lifestyle that extend the lives of the old don’t add much to the numbers.” Olshansky calculates that if cancer were eliminated, American life expectancy would rise by only three years, because a host of other chronic fatal diseases are waiting to take its place. He thinks the 21st century will see the average life span extend “another 10 years or so,” with a bonus of more health span. Then the increase will slow noticeably, or stop.

“Avoiding mortality in a young person—say, by vaccine—saves most of the person’s life. Changes in medicine or lifestyle that extend the lives of the old don’t add much to the numbers.”

Whether human age may have a biological limit does not factor into this debate. A French woman who lived from 1875 to 1997, Jeanne Calment, had the longest confirmed life span, at 122. She's obviously an outlier, and while outliers don't tell us much, they do hint at what's possible. Her age at death was well beyond the average life span that either Vaupel or Olshansky are contemplating in their analyses. And in any case, various experts, at various times across the past century, have argued that life span was nearing a ceiling, only to be proved wrong.

Diminishing smoking and drunk driving have obviously contributed to declining mortality. Homicide has fallen so much—shootings aren't necessarily down, but improved trauma response saves more victims—that murder is no longer among the top 15 causes of death in the United States. Other health indicators seem positive as well. All forms of harmful air and water emissions except greenhouse gases are in long-term decline. Less smog, acid rain, and airborne soot foster longevity—the old are sensitive to respiratory disease—while declining levels of industrial toxins may contribute to declining cancer rates. Life expectancy can be as much as 18 years shorter in low-income U.S. counties than in high-income counties, but Obamacare should correct some of that imbalance: Romneycare, enacted in 2006 and in many ways Obamacare's precursor, reduced mortality in low-income Massachusetts counties. These and many other elements of Vaupel's "stream of continuing progress" seem to favor longevity. So does climate change: people live longer in warm climates than cold, and the world is warming.

Popular attention tends to focus on whether what we gulp down determines how long we live: Should people take fish oil and shop for organic probiotic kefir? The way our homes, families, and friendships are organized may matter just as much. Thomas Perls, a professor at Boston Medical Center who analyzes the genomes of centenarians, notes that Seventh-Day Adventists enjoy about a decade more life expectancy than peers of their

birth years: “They don’t drink or smoke, most are vegetarians, they exercise regularly even when old, and take a true weekly day of rest.” But what really strikes Perls about Seventh-Day Adventists is that they maintain large social groups. “Constant interaction with other people can be annoying, but overall seems to keep us engaged with life.”

For years, the American social trend has been away from “constant interaction with other people”—fewer two-parent homes, fewer children per home, declining participation in religious and community activities, grandparents living on their own, electronic interaction replacing the face-to-face in everything from work to dating. Prosperity is associated with smaller households, yet the large multigeneration home may be best for long life. There are some indications that the Great Recession increased multigeneration living. This may turn out to boost longevity, at least for a time.

The single best yardstick for measuring a person’s likely life span is education. John Rowe, a health-policy professor at Columbia University and a former CEO of Aetna, says, “If someone walked into my office and asked me to predict how long he would live, I would ask two things: What is your age, and how many years of education did you receive?”

Jay Olshansky’s latest research suggests that American women with no high-school diploma have experienced relatively small life-span increases since the 1950s, while the life expectancy of highly educated women has soared since then. Today the best-educated Americans live 10 to 14 years longer than the least educated, on average. “Nothing pops out of the data like the link between education and life expectancy,” Olshansky says. “The good news is that the share of the American population that is less educated is in gradual decline. The bad news is that lack of education seems even more lethal than it was in the past.”

Education does not sync with life expectancy because reading Dostoyevsky

lowers blood pressure; college is a proxy for other aspects of a person's life. Compared with the less educated, people with a bachelor's degree have a higher income, smoke less, are less likely to be overweight, and are more likely to follow doctors' instructions. College graduates are more likely to marry and stay married, and marriage is good for your health: the wedded suffer fewer heart attacks and strokes than the single or divorced.

Many of the social developments that improve longevity—better sanitation, less pollution, improved emergency rooms—are provided to all on an egalitarian basis. But today's public high schools are dreadful in many inner-city areas, and broadly across states including California.

Legislatures are cutting support for public universities, while the cost of higher education rises faster than inflation. These issues are discussed in terms of fairness; perhaps health should be added as a concern in the debate. If education is the trump card of longevity, the top quintile may pull away from the rest.

Aging and politics

Society is dominated by the old—old political leaders, old judges. With each passing year, as longevity increases, the intergenerational imbalance worsens. The old demand benefits for which the young must pay, while people in their 20s become disenchanted, feeling that the deck is stacked against them. National debt increases at an alarming rate. Innovation and fresh thinking disappear as energies are devoted to defending current pie-slicing arrangements.

This isn't a prediction about the future of the United States, but rather a description of Japan right now. The Land of the Rising Sun is the world's grayest nation. Already the median age is 45 (in the U.S., by comparison, it is 37), and it will jump to 55 by 2040. As Nicholas Eberstadt, a demographer at the American Enterprise Institute, has noted, median age in the retirement haven of Palm Springs, California, is currently 52 years.

Japan is on its way to becoming an entire nation of Palm Springs residents.

The number of Americans 65 or older could reach 108 million in 2050. That's like adding three more Floridas, inhabited entirely by seniors.

Japan's grayness stems from a very low fertility rate—not enough babies to bring down the average age—and strict barriers against immigration. The United States remains a nation of immigrants, and because of the continual inflow of young people, the U.S. median age won't go haywire even as life expectancy rises: the United Nations' "World Population Prospects" estimates that the U.S. median age will rise to 41 by mid-century.

Nonetheless, that Japan is the first major nation to turn gray, and is also the deepest in debt, is not encouraging. Once, Japan was feared as the Godzilla of global trade, but as it grayed, its economy entered a long cycle of soft growth. In 2012 the centrist Democratic Party of Japan, then holding the Diet, backed a tax whose goal was not to pay down what the country owes but merely to slow the rate of borrowing. The party promptly got the heave-ho from voters. Last year Japan's public debt hit \$10 trillion, twice the nation's GDP.

Sheila Smith, a Japan specialist at the Council on Foreign Relations, told me, "Young people in Japan have some of the world's worst voter-participation rates. They think the old have the system so rigged in their favor, there's no point in political activity. The young don't seem excited by

the future.” News accounts of young Japanese becoming so apathetic that they’ve lost interest in having sex sound hard to believe, but may bear some truth.

Young urban Japanese surely are aware that their elders are ringing up bills to be handed to them, but they’re also aware that if funding for the retired is cut, Grandma may want to move into their very small apartment. As life expectancy rises, a Japanese person entering the happy-go-lucky phase of early adulthood may find that parents and grandparents both expect to be looked after. Because the only child is common in Japan’s newest generation, a big cast of aging people may turn to one young person for financial support or caregiving or both. Acceding to public borrowing may have become, to young Japanese, a way to keep older generations out of the apartment—even if it means crushing national debt down the road.

That America may become more like Japan—steadily older, with rising debt and declining economic growth—is unsettling. From the second half of the George W. Bush administration until 2013, U.S. national debt more than doubled. The federal government borrowed like there was no tomorrow. The debt binge, for which leaders of both political parties bear blame, was a *prelude* to the retirement of the Baby Boomers. Tomorrow has a way of coming.

Suppose the escalator slows, and conservative assumptions about life expectancy prevail. In a 2009 study, Olshansky projected future demographics under the “hit a wall” scenario. The number of Americans 65 or older, 43 million today, could reach 108 million in 2050—that would be like adding three more Floridas, inhabited entirely by seniors. The “oldest old” cohort, those 85 and older, may increase at least fivefold, to more than 6 percent of the U.S. citizenry. Olshansky projected that by 2050, life expectancy will extend three to eight years past the age used by the Social Security Administration to assess the solvency of its system, while forecasting that by 2050, Medicare and Social Security will rack up

between \$3.2 trillion and \$8.3 trillion in unfunded obligations. (State and local governments have at least another \$1 trillion in unfunded pension liabilities.) These disconcerting numbers flow from the leading analyst who thinks that the life-span increase is slowing down.

When President Obama took office, Social Security's trustees said the current benefits structure was funded until 2037. Now the Congressional Budget Office says the year of reckoning may come as soon as 2031. States may be "funding" their pension obligations using fuzzy math: New York issues promissory notes; Illinois and New Jersey sell debt instruments distressingly similar to junk bonds. Many private pension plans are underfunded, and the Pension Benefit Guaranty Corporation, which on paper appears to insure them, is an accident looking for a place to happen. Twice in the past three years, Congress has voted to allow corporations to delay contributions to pension plans. This causes them to pay more taxes in the present year, giving Congress more to spend, while amplifying problems down the road. Social Security's disability fund may fail as soon as late 2016. Medicare spending is rising faster than Social Security spending, and is harder to predict. Projections show the main component of Medicare, its hospital fund, failing by 2030.

If chronic ailments related to aging can be prevented or significantly delayed, big-ticket line items in Medicare might not go off the rails.

The Congressional Budget Office estimates that over the next decade, *all* federal spending growth will come from entitlements—mainly Social

Security and Medicare—and from interest on the national debt. The nonpartisan think tank Third Way has calculated that at the beginning of the Kennedy presidency, the federal government spent \$2.50 on public investments—infrastructure, education, and research—for every \$1 it spent on entitlements. By 2022, Third Way predicts, the government will spend \$5 on entitlements for every \$1 on public investments. Infrastructure, education, and research lead to economic growth; entitlement subsidies merely allow the nation to tread water.

If health span can be improved, the costs of aging-related disability may be manageable. Not that long ago, vast sums were spent on iron lungs and sanitariums for treatment of polio: preventing the disease has proved much less expensive than treating it. If chronic ailments related to aging can be prevented or significantly delayed, big-ticket line items in Medicare might not go off the rails.

But if health span does not improve, longer life could make disability in aging an economic crisis. Today, Medicare and Medicaid spend about \$150 billion annually on Alzheimer's patients. Absent progress against aging, the number of people with Alzheimer's could treble by 2050, with society paying as much for Alzheimer's care as for the current defense budget.

Many disabilities associated with advanced years cannot be addressed with pharmaceuticals or high-tech procedures; caregivers are required. Providing personal care for an aged invalid is a task few wish to undertake. Already many lists of careers with the most job openings are headed by “caregiver” or “nurse's aide,” professions in which turnover is high.

As longevity increases, so too does the number of living grandparents. Families that once might have had one “oldest old” relative find themselves with three or four, all expecting care or money. At the same time, traditional family trees are being replaced with diagrams that resemble maps of the London Underground. Will children of blended families feel the same obligation to care for aging stepparents as they feel for biological

parents? Just the entry of the phrase *birth parent* into the national lexicon suggests the magnitude of the change.

With Japan at the leading edge of lengthening life expectancy, its interest in robotics can be eerie. Foxconn, the Asian electronics giant, is manufacturing for the Japanese market a creepy mechanized thing named Pepper that is intended to provide company for the elderly. More-sophisticated devices may be in store. A future in which large numbers of very old, incapacitated people stare into the distance as robot attendants click and hum would be a bad science-fiction movie if it didn't stand a serious chance of happening.

The problem of aging leadership

As the population ages, so do the political powers that be—and they're aging in place. Computerized block-by-block voting analysis and shameless gerrymandering—Maryland's new sixth congressional district is such a strange shape, it would have embarrassed Elbridge Gerry—lock incumbents into power as never before. Campaign-finance laws appear to promote reform, but in fact have been rigged to discourage challengers. Between rising life expectancy and the mounting power of incumbency, both houses of Congress are the oldest they've ever been: the average senator is 62 years old; the average representative, 57.

A graying Congress would be expected to be concerned foremost with protection of the status quo. Government may grow sclerotic at the very time the aging of the populace demands new ideas. "There's already a tremendous advantage to incumbency," one experienced political operative told me. "As people live longer, incumbents will become more entrenched. Strom Thurmond might not be unusual anymore. Many from both parties could cling to power too long, freezing out fresh thinking. It won't be good for democracy." The speaker was no starry-eyed radical: he was Karl Rove.

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Now think of the Supreme Court as life expectancy increases. The nine justices on the first Court sat an average of nine years; the last nine to depart, an average of 27 years. John Paul Stevens, the most recent to retire, was a justice for 35 years. If Clarence Thomas lives to the actuarial life expectancy of a male his current age, he could be a Supreme Court justice for 40 years.

The Framers would be aghast at the idea of a small cadre of unelected potentates lording it over the body politic for decades. When the Constitution was written, no one could have anticipated how much life span would increase, nor how much power the Supreme Court would accrue. If democracy is to remain vibrant as society ages, campaign laws must change to help challengers stand a chance versus incumbents, and the Constitution must be amended to impose a term limit on the Supreme Court, so confirmation as a justice stops being a lifetime appointment to royalty.

A new view of retirement

In 1940, the typical American who reached age 65 would ultimately spend about 17 percent of his or her life retired. Now the figure is 22 percent, and still rising. Yet Social Security remains structured as if longevity were stuck in a previous century. The early-retirement option, added by Congress in

1961—start drawing at age 62, though with lower benefits—is appealing if life is short, but backfires as life span extends. People who opt for early Social Security may reach their 80s having burned through savings, and face years of living on a small amount rather than the full benefit they might have received. Polls show that Americans consistently underestimate how long they will live—a convenient assumption that justifies retiring early and spending now, while causing dependency over the long run.

James Vaupel has warned that refusing to acknowledge longevity's steady march “distorts people’s decisions about how much to save and when to retire” and gives “license to politicians to postpone painful adjustments to Social Security.” Ronald Reagan was the last president to push through legislation to account for life-span changes. His administration increased the future eligible age of full Social Security benefits from 65 to 66 or 67, depending on one’s birth year. Perhaps 99 percent of members of Congress would agree in private that retirement economics must change; none will touch this third rail. Generating more Social Security revenue by lifting the payroll-tax cap, currently \$117,000, is the sole politically attractive option, because only the well-to-do would be impacted. But the Congressional Budget Office recently concluded that even this soak-the-rich option is insufficient to prevent insolvency for Social Security. At least one other change, such as later retirement or revised cost-of-living formulas, is required. A fair guess is that the government will do nothing about Social Security reform until a crisis strikes—and then make panicked, ill-considered moves that foresight might have avoided.

Americans may decry government gridlock, but they can’t blame anyone else for their own decisions. People’s retirement savings simply must increase, though this means financial self-discipline, which Americans are not known for. Beyond that, most individuals will likely need to take a new view of what retirement should be: not a toggle switch—no work at all, after years of full-time labor—but a continuum on which a person

gradually downshifts to half-time, then to working now and then. Let's call it the "retirement track" rather than retirement: a phase of continuing to earn and save as full-time work winds down.

Widespread adoption of a retirement track would necessitate changes in public policy and in employers' attitudes. Banks don't think in terms of smallish loans to help a person in the second half of life start a home-based business, but such lending might be vital to a graying population. Many employers are required to continue offering health insurance to those who stay on the job past 65, even though they are eligible for Medicare. Employers' premiums for these workers are much higher than for young workers, which means employers may have a logical reason to want anyone past 65 off the payroll. Ending this requirement would make seniors more attractive to employers.

Many people may find continuing to work but under the lower-stress circumstances of part-time employment to be preferable to a gold watch, then idleness. Gradual downshifting could help ease aging people into volunteer service roles, where there's never any end of things to do. The retirement track could be more appealing than traditional retirement. A longer health span will be essential to making it possible.

Longer life as directed evolution

Understanding the evolutionary biology of aging might help the quest for improved health span. Each cell of the body contains DNA code for a fresh, healthy cell, yet that blueprint is not called on as we grow old.

Evolutionists including Alfred Russel Wallace have toyed with the idea of programmed death—the notion that natural selection "wants" old animals to die in order to free up resources for younger animals, which may carry evolved genetic structures. Current thinking tends to hold that rather than trying to make older animals die, natural selection simply has no mechanism to reward longevity.

Felipe Sierra, a researcher at the National Institute on Aging, says, “Evolution doesn’t care about you past your reproductive age. It doesn’t want you either to live longer or to die, it just doesn’t care. From the standpoint of natural selection, an animal that has finished reproducing and performed the initial stage of raising young might as well be eaten by something, since any favorable genetic quality that expresses later in life cannot be passed along.” Because a mutation that favors long life cannot make an animal more likely to succeed at reproducing, selection pressure works only on the young.

A generation ago, theorists suspected that menopause was an evolutionary adaptation exclusive to the *Homo* genus—women stop expending energy to bear children so they can care longer for those already born, as mothers and grandmothers. This, the theory goes, increases children’s chances of survival, allowing them to pass along family genes. Yet recent research has shown that animals including lions and baboons also go through menopause, which increasingly looks more like a malfunction of aging cells than a quality brought about by selection pressure. As for the idea that grandparents help their grandchildren prosper, favoring longevity—the “grandmother effect”—this notion, too, has fared poorly in research.

“Evolution doesn’t care about you past your reproductive age. It doesn’t want you either to live longer or to die, it just doesn’t care.”

The key point is: if nothing that happens after a person reproduces bears on which genes flourish, then nature has never selected for qualities that

extend longevity. Evolution favors strength, intelligence, reflexes, sexual appeal; it does not favor keeping an organism running a long time. For example, a growing body needs calcium, so nature selected for the ability to metabolize this element. In later life, calcium causes stiffening of the arteries, a problem that evolution has no mechanism to correct, since hardened arteries do not occur until it's too late for natural selection to side with any beneficial mutation. Testosterone is essential to a youthful man; in an aging man, it can be a factor in prostate cancer. Evolution never selected for a defense against that.

Similar examples abound; the most important may be senescent cells. Natural selection probably favors traits that reduce the risk of cancer, because cancer can strike the young before reproductive age is reached. Senescence doesn't occur until evolution is no longer in play, so natural selection has left all mammal bodies with a defect that leads to aging and death.

If senescence could be slowed, men and women hardly would become immortal. Violence, accidents, and contagious disease still would kill. Even if freed of chronic conditions, eventually our bodies would fail.

But it is not credulous futurism to suppose that drugs or even genetic therapy may alter the human body in ways that extend longevity. Brian Kennedy, of the Buck Institute, notes, "Because natural selection did not improve us for aging, there's a chance for rapid gains. The latest BMWs are close to perfect. How can an engineer improve on them? But the Model T would be easy to improve on now. When young, genetically we are BMWs. In aging, we become Model Ts. The evolutionary improvements haven't started yet."

A grayer, quieter, better future

In the wild, young animals outnumber the old; humanity is moving toward

a society where the elderly outnumber the recently arrived. Such a world will differ from today's in many outward aspects. Warm-weather locations are likely to grow even more popular, though with climate change, warm-weather locations may come to include Buffalo, New York. Ratings for football, which is loud and aggressive, may wane, while baseball and theatergoing enjoy a renaissance. The shift back toward cities, initiated by the educated young, may give way to another car-centric suburban and exurban growth phase.

The university, a significant aspect of the contemporary economy, centuries ago was a place where the fresh-faced would be prepared for a short life; today the university is a place where adults watch children and grandchildren walk to *Pomp and Circumstance*. The university of the future may be one that serves all ages. Colleges will reposition themselves economically as offering just as much to the aging as to the adolescent: courses priced individually for later-life knowledge seekers; lots of campus events of interest to students, parents, and the community as a whole; a pleasant college-town atmosphere to retire near. In decades to come, college professors may address students ranging from age 18 to 80.

Products marketed to senior citizens are already a major presence on television, especially during newscasts and weathercasts. Advertising pitched to the elderly may come to dominate the airwaves, assuming there still is television. But consumerism might decline. Neurological studies of healthy aging people show that the parts of the brain associated with reward-seeking light up less as time goes on. Whether it's hot new fashions or hot-fudge sundaes, older people on the whole don't desire acquisitions as much as the young and middle-aged do. Denounced for generations by writers and clergy, wretched excess has repelled all assaults. Longer life spans may at last be the counterweight to materialism.

If health span extends, the nuclear family might be seen as less central. Bearing and raising children would no longer be the all-consuming life event.

Deeper changes may be in store as well. People in their late teens to late 20s are far more likely to commit crimes than people of other ages; as society grays, the decline of crime should continue. Violence in all guises should continue downward, too. Horrible headlines from Afghanistan or Syria are exceptions to an overall trend toward less warfare and less low-intensity conflict. As Steven Pinker showed in the 2011 book *Better Angels of Our Nature*, total casualties of combat, including indirect casualties from the economic harm associated with fighting, have been declining, even as the global population has risen. In 1950, one person in 5,000 worldwide died owing to combat; by 2010, this measure was down to one person in 300,000. In recent years, far more people have been killed by car crashes than by battle. Simultaneously, per capita military expenditure has shrunk. My favorite statistic about the world: the Stockholm International Peace Research Institute reports that, adjusting to today's dollars, global per capita military spending has declined by one-third in the past quarter century.

The end of the Cold War, and the proxy conflicts it spawned, is an obvious influence on the subsiding of warfare, as is economic interconnectedness. But aging may also be a factor. Counterculture optics notwithstanding, polls showed that the young were more likely to support the Vietnam War than the old were; the young were more likely to support the 2003 invasion of Iraq, too. Research by John Mueller, a political scientist at Ohio State University, suggests that as people age, they become less enthusiastic about war. Perhaps this is because older people tend to be

wiser than the young—and couldn't the world use more wisdom?

Older people also report, to pollsters and psychologists, a greater sense of well-being than the young and middle-aged do. By the latter phases of life, material and romantic desires have been attained or given up on; passions have cooled; and for most, a rich store of memories has been compiled. Among the core contentions of the well-being research of the Princeton University psychologist Daniel Kahneman is that “in the end, memories are all you keep”—what's in the mind matters more than what you own. Regardless of net worth, the old are well off in this sense.

Should large numbers of people enjoy longer lives in decent health, the overall well-being of the human family may rise substantially. In *As You Like It*, Jaques declares, “Man in his time plays many parts, his acts being seven ages.” The first five embody promise and power—infant, schoolboy, lover, soldier, and success. The late phases are entirely negative—pantaloon, a period as the butt of jokes for looking old and becoming impotent; then second childishness, a descent into senile dependency. As life expectancy and health span increase, the seven ages may demand revision, with the late phases of life seen as a positive experience of culmination and contentment.

Further along may be a rethinking of life as better structured around friendship than around family, the basic unit of human society since the mists of prehistory. In the brief life of previous centuries, all a man or woman could hope to accomplish was to bear and raise children; enervation followed. Today, life is longer, but an education-based economy requires greater investments in children—contemporary parents are still assisting offspring well into a child's 20s. As before, when the child-rearing finally is done, decline commences.

But if health span extends, the nuclear family might be seen as less central. For most people, bearing and raising children would no longer be the all-consuming life event. After child-rearing, a phase of decades of friendships

could await—potentially more fulfilling than the emotionally charged but fast-burning bonds of youth. A change such as this might have greater ramifications for society than changes in work schedules or health-care economics.

Regardless of where increasing life expectancy leads, the direction will be into the unknown—for society and for the natural world. Felipe Sierra, the researcher at the National Institute on Aging, puts it this way: “The human ethical belief that death should be postponed as long as possible does not exist in nature—from which we are now, in any case, diverging.”



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