**From "Why We Age: What Science Is Discovering about the Body's Journey through Life" by Steven N. Austad**



## 2—
## Age Inflation and the Limits of Life

*In the matter of prolonging human life, science has played no part whatever. Take the case history of one Bessie Singletree. At the early age of five, Bessie suddenly became six and entered school. On trolley cars her age remained at six until she was nine. When she was 11 years old, she was 12, and for the benefit of movies and railroads, she was 12 until she was 15. . . . On her 27th birthday Miss Singletree became 24. . . . At 40 she was 39 and she remained so until she was close to 50. At 50 Bessie was 40; at 60, 55. . . . [O]n her 70th birthday everyone said Grandmother Singletree was pretty chipper for an octogenarian. At 75 she had her picture in the paper as the oldest woman in the county, aged 93. Ten years later she passed away at the ripe old age of 109.*
NORMAN INGERSOLL (1936)



Trying to understand aging requires, not suprisingly, knowledge about how old people actually live to be. Yet as the epigraph illustrates, people will lie about their age for a variety of reasons. Youngsters want to be older, the middle-aged would like to appear younger, and the very elderly would like to be believed to be even more elderly. Even when people don't lie, the very elderly often don't know how old they are because of lost birth records or a memory devastated by senility. So there was nothing out of the ordinary in Old Parr's exaggeration of his age. It is a particularly universal form of vanity among aged humans—one that is apparently more common in men than women for reasons that I'll leave to the psychologists. However, it is easy to understand the fundamental motivation. An 85-year-old man is just another codger, but a 130-year-old man such as, say, Charlie Smith, is a celebrity, a guru of longevity whose advice on successful living is broadcast far and wide. But systematic age exaggeration of the very oldest people means that for eras and geographic areas lacking accurate written birth and death records, evaluating individual longevity is an uncertain task. It isn't just self-reported ages that may be erroneous. Lies and erroneous ages can as easily be hammered into tombstones or entered into official documents as proffered over cocktails.

For the very oldest of old people—those older than 90 or 100—there are few places in the world where reliable information on death rates exists, even today. Accurate death rates of centenarians (people 100 years old or older) are available for some European countries, such as France and Denmark, that had compulsory birth registration by the late nineteenth century. Sweden is the platinum standard: it has had good records since 1750 and impeccable ones since 1850. Universal birth registration did not exist in the United States, however, until 1940 and still doesn't exist in much of the world. Therefore, although we may speak confidently of the number of centenarians currently alive in a few countries, similar information in the United States and most of the rest of the world is more speculative. Demographers who study the very elderly actually consider questionable any ages higher than about 80 in the United States. [8] The U.S. Census Bureau is aware of this problem and



dismissed as fabrications more than 94 percent of the 106,000 cases in which people claimed to be older than 100 in the 1970 census. And as we shall see shortly, they may not have been skeptical enough. Age exaggeration is particularly unfortunate because determining whether the *maximum length of life* (presumably a measure of how long our bodies will last under the best circumstances) differs geographically or historically or with certain dietary or exercise habits or overall lifestyle could conceivably provide a wealth of information about how and why we age.

Given all this uncertainty, how could I have been so sure when I claimed that Old Parr's stated age of 152 was a fraud? The fact that Parr had no birth records whatsoever is suspect, but I'm most convinced by the fact that we now have many millions of unquestionably valid ages at death from around the world. Because there are now more people alive than ever before, and because precise birth records are available in an increasing number of countries, we have probably learned more about the limits of human longevity in the past 20 years than in all previous historical eras combined. And with all these millions upon millions of reliable records, there were until recently no verified records of any human living to even 120 years of age. However, on February 22, 1995, Jeanne Louise Calment, a woman born in Arles in southern France 13 years *before* Vincent van Gogh moved there from Paris, became the first verified 120-year-old person in human history. (As of this writing, in November 1996, she is still going strong.) There have been plenty of previous claimants to that age or greater, but they never have had documentation as extensive and valid as Madame Calment's. It is difficult to credit more extravagant but undocumented claims than Madame Calment's when you realize that even with all of today's improved health care, a person is more likely to be struck by lightning than to live to be even 110 years old, much less 120 or beyond.

If there is a secret to achieving a life of 100 years or longer, we have now discovered what it is. You simply need the good fortune to be born into a nonliterate culture, or one with sloopy record keeping, or one such as ours of exceptional gullibility.



Near the turn of the twentieth century, T.E. Young, the skeptical former president of the English Institute of Actuaries, published several editions of a monograph reexamining the authenticity of extreme longevity claims. In the first edition of his book, published in the 1870s, he found no verified claim of anyone living longer than 105. But by his last edition, in 1905, when he had accumulated thousands more death records, he would admit that the four oldest people known to that time were truly 108, 109, 110, and 113 years old. Not until 1995 did we have our first well-authenticated case of a 120-year-old. But a seven-year increase since the beginning of the century, given medical and public-health advances—not to mention the many millions of additional reliable records available since 1905—seems surprisingly small. If the maximum length of human life is increasing, it is doing so at a glacial pace.

Despite little evidence that maximum longevity has changed with modern medical progress, three areas of the world—isolated regions of the Caucasus, the Karakoram Mountains, and the northern Andes—have received special attention as putative Shangri-las, where living a healthy 100 years is commonplace. Each of these regions is characterized by Spartan farming, hard physical labor, a supportive social network, and, of course, poor birth records. All the areas have been visited at one time or another by scientists interested in factors leading to extremely long life. We need to bear in mind, though, that these scientific visits do not necessarily validate the longevity claims themselves. Scientists can be as gullible as anyone else. Martin Gardner, an amateur magician and professional debunker of pseudoscientific assertions of paranormal powers, says that it is a commonplace among magicians that scientists make the easiest dupes, because they believe that they are especially acute, trained observers. But take a scientist out of the laboratory, drop him in an alien milieu, and he's just another rube waiting to be fleeced by the locals.

As a scientist who has worked for a number of years in remote villages of Papua New Guinea, I speak from firsthand experience. I can't usually get reliable answers to questions such as, "Who owns this land?" and "How many days' walk is it to the next village?" The



inevitable answer to the first question is, "I do," and the tacit answer to the second is, "As many days as you will continue to pay us for carrying your gear." It took me a while to discover this. I initially thought that walking three to four hours per day was all the locals ever did. I found out otherwise when some of my carriers forgot some personal items they wanted to have along. We had walked a bit more than two days when these fellows turned around, walked home and back, and caught up with us on the same day.

Dr. Alexander Leaf, a distinguished physician at Harvard Medical School and Massachusetts General Hospital who visited all three of these localities in the early 1970s, pointed out that in addition to being areas of Spartan farming, each of these locales was also characterized by "poor sanitation, infectious diseases, high infant mortality, illiteracy, and a lack of modern medical care," [9] making the inhabitants' extreme longevity even more extraordinary. Clearly, if people do live exceptionally long lives under such harsh conditions, detailed studies of their genetics or way of life might provide clues about how human life might be extended elsewhere. Another reason for examining these claims more closely is that reports of similarly isolated long-lived groups continue to appear, and we want to understand how much credence we should give them.

The region about which we know the least is the small, extremely isolated Hunza region in Pakistan's Karakoram Mountains, near the western end of the Himalayas and Pakistan's borders with India and China. The Hunza are tall and fair compared with their neighbors and claim to be directly descended from Persian "wives" of Alexander the Great. Outsiders have typically employed Hunzas as load carriers on mountaineering expeditions and invariably mention their remarkable vigor, endurance, and good humor. The organic-farming evangelist J. I. Rodale, who widely publicized their longevity claims, called them the "happy Hunza." I became less convinced of their intrinsic charm after learning that one of their *mirs*, or chieftains, came to power during Victorian times by poisoning his father and having his two brothers pitched off a cliff. Maybe he did it with good humor, though.

In any case, initial reports were that many Hunza *men* lived to be



120 to 140 years old. More recent claims are less extreme, 110 years or so, but the mention of only men of this extreme age is suspicious, given that women greatly outnumber men by the age of 100 in all cultures with a history of reliable records.

Nonetheless, claims of Hunza longevity have been publicized in a series of books since the 1920s. [10] The explorer Lowell Thomas visited them in 1957 to report on their unusual longevity, and the television personality Art Linkletter financed an expedition to Hunza territory in the early 1970s to study their living habits. Their longevity has been attributed to vigorous exercise, farming with optimally cured manure, a largely vegetarian diet, breast feeding of their young, and even the rock dust that floats down onto

their crops of wheat and barley from the mountains above. One physician claimed that rats fed a Hunza diet suffered far less from disease and were more cheerful than rats fed white bread, sweet tea, and tinned meat—a so-called English diet.[11]

The only problem with these accounts is that the Hunza, like Old Parr, have no age documentation whatsoever. They have no written language. Everything we know about their longevity comes from the world of their *mir*. Further, old men are venerated to the degree that a Council of Elders routinely advises the *mir* on all important decisions. Therefore, although there is no evidence supporting or refuting their claims of longevity, the Hunza have means, motive, and opportunity for rampant age inflation.

A second region, one that has reported the most extreme ages yet, is in the remote Caucasus Mountains, formerly in the Soviet Union but now consisting of the independent states of Georgia, Armenia, and Azerbaijan. People in the Caucasus have been visited more frequently by scientists than the Hunza. Here a number of people claim to be more than 150 years old: The oldest among them was the previously mentioned Shirali Muslimov, who died at the declared age of 168 years, seven years after his picture appeared in *Life* magazine. The television show *60 Minutes* followed up more than a decade after *Life*'s story with a segment on the same village, and somewhat ironically, given the institutional skepticism of *60 Minutes*, seemed to swallow these stories whole. An especially healthy lifestyle,



at least as we currently understand it, could not be responsible for the longevity reported there. The local diet contains plenty of meat, dairy products, wine, and sweets. The oldest woman Dr. Leaf interviewed on his visit to the region, supposedly 130 to 140 years old, said she had smoked a pack of cigarettes a day for more than 60 years and started each morning with a shot of vodka before breakfast.

There is no reliable documentation of these longevity claims, either. The region has been repeatedly ravaged by wars and social dislocation, especially during the late nineteenth century, when the putative centenarians would have been born. Even the normally rudimentary church records typical of this period rarely exist, and no Soviet identification documents were required before 1932. Birth dates for identification cards of people born before 1932 were determined from oral interviews.

Of course, the official statistics of the Soviet period are not widely believed in any area. What can one make, for instance, of the Soviet Union's claim from its 1959 census that it had the lowest death rate in the world? [12] Regarding the special claims of the people of the Caucasus, and of Georgia in particular, Zhores Medvedev, an emigré Russian geneticist, tells us that because Stalin was a Georgian, he enjoyed hearing stories about extremely old Georgians. Not surprisingly, local authorities were eager to satisfy his desire for these stories. Thus, in the 1959 census, Georgia provided 97 percent of all Soviet centenarians, even though it had less than 2% of the Soviet population.

At least one fraudulent centenarian from the Caucasus was exposed when he had the misfortune to have his photograph appear in the government newspaper *Izvestiya* on the occasion of his alleged 128th birthday. Soon afterward, *Izvestiya* received a letter from the man's fellow villagers revealing that he was a World War I deserter who had been using his father's papers to avoid detection. He was actually 78. Medvedev claims that similar deceptions were common throughout the former Soviet Union. Also, because most people in this area are Muslims, there is ample room for confusion in translating the 10-month Islamic calendar into our 12-month one. Ulti-



mately, then, we must take claims about longevity in this area on trust, too, and there is little reason to suspect that our trust would be well placed.

The third region—one that has received the most thorough attention from scientists, including repeated visits over almost a decade—is the Andean village of Vilcabamba in southern Ecuador and its environs. There is a tradition of people in this region claiming to be more than 120 years old, and many more claiming to be in their 90s and early 100s. Dr. Leaf was tentatively convinced that the claims were valid when he first visited Vilcabamba. Dr. Donald Davies, a gerontologist from the Medical College of London who visited Vilcabamba in the early 1970s, was so thoroughly gullible not only about Vilcabamba but also the Caucasus and Hunza region, that one wonders whether he may have been on some unusual medication at the time. He simply reported as fact everything he was told—150 years, 160 years, no problem. His book (*The Centenarians of the Andes*) attributes the longevity of the Andeans largely to a positive attitude among the elderly and an abundance of trace minerals, such as gold, magnesium, and cadmium, in the soil. [13]

Superficially, there is little in life in the Ecuadoran Andes that might lead one to expect the people to be particularly long-lived. If anything, one might expect the reverse. Although they eat relatively little and work very hard, the Andeans also smoke and drink alcohol extravagantly. In one of the unintentionally funniest lines in his book, Dr. Davies reports, "At times of stress the males drink themselves into a stupor; they also do this regularly on weekends. The women show more signs of stress, looking much older for their years and they don't live so long."

So why did this information initially appear so convincing? For once, there were actual baptismal records in the local church and Civil Registry records as far back as 1860 which could be checked for verification. Records, any records, were more than had been available elsewhere. In addition, Ecuadoran physicians always accompanied the visiting scientists, and the physicians claimed to have checked the records personally.

And yet, when Dr. Leaf returned to Vilcabamba a second time



four years later, he found that Miguel Carpio, who had previously been the oldest man in the valley at 121 years of age, had miraculously become 11 years older. When he demanded to see Carpio's baptismal certificate, it seemed to have disappeared in a church fire. The earliest book of existing records had also had its first seven pages torn out.

The confusion about birth records was ultimately explained when it came to light that the people of Vilcabamba intermarry almost exclusively within the same mountain valley, and the same few names are used over and over. There is also a local tradition of reusing the same name within a family, so that a child born after an older sibling dies is likely to be given exactly the same name. Thus Micaela Quezada claimed to be 106, and her baptismal record, underlined emphatically by local officials, made her 104, which is not too far off. However, the names of the parents on her baptismal certificate were very different from those of her actual parents. When questioned about the names on the baptismal certificate, she said, "Oh, yes, of course: That's my cousin [*actually her aunt*]. . . . She was older than me and died 30 or 40 years ago." [14]

Several years after the initial spate of scientific visits, Richard Mazess, a radiologist, and Sylvia Forman, an anthropologist, visited Vilcabamba determined to get to the bottom of this story once and for all.[15] They thoroughly reviewed the skeletal condition of the people, looking for arthritis and osteoporosis. They performed a house-by-house census; checked all birth, death, and marriage records that they could find; and cross-checked the various documents against one another. The people whose ages they could reliably determine from records showed no differences in the degree of skeletal deterioration from similarly aged people in the United States. As they worked their way through a bewildering maze of documentation, Mazess and Forman found a consistent pattern of age inflation and a consistent pattern of inconsistency in the records. For instance, the Miguel Carpio who had magically transformed from 121 to 132 in only four years was officially recorded as having died at 112 years. In actuality, he died at 93. Like the fictional Bessie Singletree of this chapter's epigraph, when he was 61, he reported that he was 70; five years



later, he was 80; and when he was really 87, he said he was 121. His mother was, in fact, born five years after his own stated birthdate, something that even the heroic modern advances in reproductive technology have not been able to duplicate.

Mazess and Forman ultimately found that none of the 23 self-proclaimed centenarians had actually reached 100 (their average age was 86), and none of the 15 "nonagenarians" had reached 90 (their average age was 81.5).

In his later evaluation of Vilcabamba's inhabitants, Dr. Leaf felt he had at least found the motive for their continually increasing age inflation. On his second visit, traveling over a newly paved road that had been rough gravel on the first go-round, he was met by the governor and a local band and hailed as the economic savior of the region. His articles in *National Geographic*, *Scientific American*, and *Nutrition Today* had brought much-appreciated attention to the area. The governor was calling the village's old people "our oil wells." Even in 1978, when the myth of Vilcabamba was being debunked thoughout the scientific community, Japanese investors were negotiating with local authorities to build a high-rise hotel, and an American entrepreneur was planning to market bottled water from Vilcabamba's stream.

It would be a mistake to assume that these occasional high-profile frauds define unique moments of age inflation. It is systematic throughout the world, appearing wherever the deficiency of records allows. Consider, for instance, the geography of your chance of living to be a centenarian. No matter where or when you were alive, you were much more likely to live to be 100 years old if you or your relatives were illiterate, or if you lived in a place frequently ravaged by infectious disease and far removed from modern medical care.

Currently, Sweden has among the longest life expectancies in the world (the third longest for men, at just over 75 years, and the fifth longest for women, at nearly 81 years) and an excellent history of record keeping for better than 150 years. In fact, comparison with Swedish data is one method used to assess the validity of mortality records from other countries. The proportion of centenarians in Sweden is about 5 per 100,000 people. Japan, with the greatest life

expectancy in the world, has about the same proportion of centenarians as Sweden. But remarkably, according to "official records," you were more than twice as likely to live to 100 if you resided in turn-of-the-century Argentina, Bolivia, Brazil, Bulgaria, the Philippines, Russia, or Ireland than if you resided in present-day Sweden or Japan!

Also, in the United States as elsewhere, the number of centenarians has decreased as literacy rates have increased. For instance, in 1850, the centenarian rate among Americans was 11 people per 100,000. By 1910, it had fallen to 4 per 100,000. There was also a puzzling difference between death rates in extremely elderly African Americans versus Caucasian Americans. In 1910, African Americans reached 100 years of age at more than 20 times the rate of white Americans. This rate has been steadily falling since then (only four times as high by 1960) as literacy among blacks has risen.

This consistent relationship between literacy and long life is not necessarily due to conscious fraud. It's just that, in the absence of knowledge, people exaggerate. And such a habit is apparently responsible for another common demographic anomaly—the mortality-rate crossover, in which one group of people dies at higher rates than another group early in life, but dies at lower rates later on. For instance, perusing vital statistics compiled by the United Nations in 1990, you will find that in the small southern African country of Malawi, whose early-life death rates are so high that the country's current life expectancy is only about 40 years, older people have a *lower* risk of dying at any particular age than people of similar age in the United States and Japan. Japan is currently the country with the greatest life expectancy in the world for both men (over 76 years) and women (almost 83 years).

There are two possible explanations for this rather apparent paradox. One interesting idea is what we might call "survival of the hardiest." That is, the mortality crossover may represent selective weeding out of weaker individuals. The harsh conditions of life in Malawi could conceivably kill off all but the physically hardiest early in life, leaving only exceptionally disease- and death-resistant people surviving to greater ages.



A similar explanation has been advanced for a similarly puzzling observation in the United States. Throughout this century, life expectancy has been lower—considerably lower—for African Americans than for Caucasians. It's not surprising, then, that from birth until their late seventies, blacks have higher annual death rates than whites. What *is* surprising is that when Americans reach their late seventies, these death rates traditionally "cross over"—as do the U.S. and Malawian death rates—and at all subsequent ages, black Americans die at lower rates than whites. The traditional explanation for this pattern has been survival of the hardiest. That is, because of the acknowledged harsher social and economic conditions in which blacks live on average, only the most healthy and fit are likely to make it to their late seventies in the first place. Those who do survive are so hardy that they thrive even in their difficult living conditions.

A second, more likely explanation is that the death rates for older people in Malawi or among very elderly American blacks are simply false, due to a lack of birth records combined with age inflation. Even when old people *do* know their true age, they *still* exaggerate. Appreciating the validity, or lack of it, of longevity claims is crucial to determining whether or not aging rates have changed historically or are lower in some parts of the world.

Most demographers now agree that this "crossover" between blacks and whites in the United States has resulted from a lack of accurate birth records. A good clue that this is so is that the age of the crossover has steadily risen from 76 in 1960 to 85 in 1980 to 90 in 1987. [16] Recently, the demographer Samuel Preston appeared finally to have killed the myth of "survival of the hardiest." He pointed out that people exposed to bad health conditions generally die at higher rates throughout life—even in the very latest years. Cross-checking census and Social Security records from early in the century with ages on death certificates of several thousand black people who died in 1985 at ages greater than 65 years, he and a colleague, Irma Elo, indeed found inconsistencies in more than half of these records.



Because of rampant age inflation, professional demographers have developed a number of clever tricks for assessing the reliability of the official records for the extremely elderly. One thing they look for is "age-heaping"; that is, a trend for an unexpectedly high number of people with ages that are "round numbers," such as five or 10. In some censuses, 10 times the number of people are recorded as age 70 than as 69 or 71. This is a sure sign of shaky information.

Another sign that information is unreliable is a suspiciously low death rate at older ages. In countries with good records and low overall death rates, such as Sweden and Japan, the odds of dying after age 100 are about 50 percent per year. Calculating this figure over five years, there should only be about 3 percent as many people who are 105 years old or older as there are people who are 100 years old or older. So finding that there are 40 percent or 50 percent as many 105-year-olds as there are 100-year-olds is a sure sign of age inflation. By this criterion, very few countries have reliable statistics on their very oldest people.

An interesting and instructive exception to the general rule about the reliability of age claims and literacy is among the Han, the ethnic majority in China, representing about 95 percent of its people. Even illiterate people can usually supply their precise date of birth in this culture, because Han birth dates have astrological importance. Also, the Han calendar consists of an easily remembered cycle of "animal" years (each year will be associated with one of five different qualities of one of 12 different animals) that repeats every 60 years. By examining age-heaping and several other criteria to expose age inflation, the demographers Ansley Coale and Shaomin Li determined that in contrast to Han Chinese, other ethnic groups in China *were* prone to systematically inflating their ages. For instance, Xinjiang Province, in which the Wei minority make up almost half of the population, shows extensive age-heaping: Although the province contains only about 1 percent of the Chinese population, it accounts for 84 percent of all males claiming to be more than 110 years old.

Most of China's other "supercentenarians" are spread among other provinces with high proportions of ethnic minorities. One should



bear this in mind when one comes across news items such as the front-page story in the March 19, 1990, *Wall Street Journal* reporting that an area of Guangxi Province in China had been newly discovered to abound with centenarians—a place where 90-year-olds were unexceptional, and octogenarians were comparative whippersnappers. Later in the article, one finds that most of the old people are Yaos, a polytheistic ethnic minority inhabiting mountainous parts of relatively inaccessible southern China, Thailand, and Vietnam. Sound familiar?



## 3—
## Has Aging Changed over Time?

*If they [the Houyhnhnms] can avoid casualties, they die only of old age. . . . [T]hey live generally to seventy or seventy-five years. . . . [S]ome weeks before their death they feel a gradual decay, but without pain.*
SWIFT, *GULLIVER'S TRAVELS*

Bearing in mind that it is unwise to credit any extreme ages without firm documentation, let's now look at the history and geography of human aging and longevity. If people living uneventful bourgeois lives in modern industrialized countries and harshly treated prisoners-of-war both double their risk of death every eight years or so as they grow older, how universally does this represent human aging? Did the Greeks of Socrates' day, the sun-worshiping Egyptians of 5,000 years ago, and our Ice Age ancestors huddling against the night in smoky caves also age at the same rate? Might the 20-year



life expectancy of Neanderthal humans living 60,000 years ago and the 27- and 48-year life expectancies of the ancient Romans [17] and turn-of-the-century Americans, respectively, reflect only progressively less hostile environments as deaths from famine, warfare, and disease became less common? Or has the manner in which we age changed throughout history? Might the details of aging differ in different parts of the world today?

### A Brief Biological History of Humanity

Modern humans appear to have migrated out of Africa about 120,000 years ago. As they spread through the rest of the world over the next 100,000 or so years, they replaced by force, guile, or interbreeding their last remaining relatives, the Neanderthals. During this Paleolithic period, people survived by hunting wild game and gathering fruits, nuts, and vegetables. When they had depleted the local food supply, these small bands—maybe no more than a few dozen people—moved on, perhaps returning later when the fruits, roots, and game had replenished themselves.

The amount of food required by a human group limited its number. Groups could not be so large as to need more food than could be hunted down or gathered within a reasonable walking distance from their temporary encampments. If groups became larger, even an area they had never previously visited would not have enough food for everyone within a reasonable hunting distance. Then tension would have arisen over who got how much of the limited food available, and the resulting quarrels and disagreements would ultimately have led to group division, with breakaway bands going their separate ways.

This pattern began to dissolve 5,000 to 10,000 years ago, when the development of agriculture and the domestication of wild animals made settling in one place for long periods possible. Nearby food was suddenly reliably abundant. It could also be stored (in bins or on the hoof) for use over the winter or during droughts. Group size was no longer limited by "natural" food abundance, and permanently occupied villages and towns began to develop. Clustered, permanent

populations of hundreds or thousands were now possible, and with the increasing sophistication of agriculture, animal production, and transportation over the next few millennia, we ultimately arrived at the crowded megalopolises of today.

In terms of health (and perhaps longevity), the development of agriculture was not an unalloyed benefit. Farming decreased dietary diversity, for one thing, as people were no longer forced to scrounge for every available food resource. Because no single food provides a full complement of vitamins and nutrients, reducing the diversity of foods eaten may have led to certain nutritional deficiencies. One reason to suspect that this was the case is that with the coming of agriculture, people's stature dropped dramatically—by as much as six inches—as we know happens when people suffer nutritional deficiencies during childhood and adolescent growth. [18] In fact, adult human stature has once again begun to approach that of late Paleolithic times only during this century in well-fed countries.

The development of agriculture also resulted in new opportunities for infectious diseases (as contrasted with genetic diseases such as cystic fibrosis and Down syndrome, or degenerative diseases, such as cancer, atherosclerosis, and Alzheimer's disease—that is, the diseases of aging). So far as we can tell, diseases such as smallpox, measles, cholera, and tuberculosis—responsible for so much death and misery in historical times—troubled humans consistently only after the advent of agriculture, which brought about the development of sizable towns and cities.[19] Such diseases require sizable populations to persist. Infectious diseases, like wildfire, require fresh fuel to stay alive. From the viewpoint of an infectious disease, fresh fuel is someone who has never had the disease. If someone catches a disease, he or she ultimately dies or recovers, and after recovery is then generally immune to a recurrence of that disease. This is our so-called acquired immunity, the part of the immune system destroyed by AIDS.

Even diseases we seem to get repeatedly, such as colds and flus, behave this way. When we get subsequent infections, they are due to different viruses—that is, viruses of a different origin or those that have mutated beyond recognition by the immune system. Thus, to an infectious disease, any population is composed of people who are



either sick (already infected and contagious), recovered (noncontagious and immune to further infection), or as yet unexposed (susceptible).

If the rate of new infections is higher than the rate of disappearing infections, a disease will live on. If there are too few newly available susceptibles (such as new babies), the disease will rip through a population, killing a certain initial number, and disappear. All survivors will be immune, and the disease will have no place to live. With no new susceptibles to attack, it will die out.

Depending on the particular traits of any disease—how deadly, how contagious, how long infections typically last, and so on—there will be a critical minimum number of people required to sustain it. For instance, the measles require a population of about 300,000 people. This means that in cities smaller than 300,000 people, the measles are constantly going extinct, only reappearing when infected outsiders bring it back into the community.

A major, somewhat fortunate consequence of a disease's requirement for fresh fuel is that immunization can entirely eradicate diseases even when some people are not immunized. Immunization needs to decrease the susceptible number of people only below the critical number. Therefore, smallpox was eradicated worldwide by a 12-year intensive vaccination campaign that began in the late 1960s. When the campaign started, 10 million to 15 million people per year worldwide caught smallpox, and about 2 million of them died. By 1979, the smallpox virus survived only in a few high-security medical laboratories. As it turned out, vaccinating 70 to 80 percent of susceptible children—which was possible even in nonindustrialized countries—was sufficient to wipe out the disease.

In medically sophisticated parts of the world today, with *most* serious infectious diseases under control, we tend to forget about the impact of such diseases in the past. But until antibiotics became generally available in the 1940s, infectious diseases were by far the most common cause of death. In the United States in 1900, for instance, more than twice as many people died of pneumonia, flu, and tuberculosis than died of today's "Big Three"—heart disease, cancer, and stroke. Today, pneumonia, flu, and tuberculosis combined kill at least 10 times *fewer* people than the Big Three.



So as human populations grew and clustered in increasingly larger villages and towns, the population threshold for more and more diseases was reached. Simultaneously, new ways appeared for serious diseases to arise. People began living in close contact with domesticated animals—cows, horses, sheep, pigs—and some diseases (viruses, in particular), are prone to jump from one species to another, given sufficient time and contact. Thus, human smallpox probably jumped from cattle, the most virulent form of malaria from birds, and a number of flus from pigs. Cities and towns supported by local agriculture, therefore, were fertile grounds for the birth and spread of human diseases.

As the millennia passed, a few subtle inroads were made against infectious diseases. Some awareness of public health developed, and as people linked conditions such as fouled water with outbreaks of disease, attempts were made to get rid of waste without fouling drinking water. But these measures were limited in scope and not sufficiently emphasized until the late nineteenth century, when Louis Pasteur proved that small organisms such as bacteria and viruses—not bad air, wretched smells or tastes, or an imbalance of internal fluids—caused infectious diseases. Shortly thereafter, antibiotics were discovered, and by the middle third of this century were generally available in most of the industrialized world. Infectious disease would never again be the chief killer of humans. The expectation of life soared.

**Are We Aging More Slowly Now?**

How does this biological history of humanity relate to the history of aging and longevity? If life expectancy is now greater than ever before, does that mean we are aging more slowly than ever before? Have our bodies materially changed in some way in the past few thousand years? Does our lifestyle today accelerate or retard aging as it occurred in our distant past?

One bit of evidence that suggests we are not aging differently these days is that the age at which a person is considered "elderly" hasn't seemed to change over time. We find no historical accounts



of 40-year-old men who were considered elderly, even though in, say, ancient Greece (and all other known cultures until the eighteenth century) life expectancy was no greater than about 30 years. Being considered elderly at 40 seems a fate reserved for professional athletes and models, even in ancient times. The only difference is that now the psychic pain of being old at 40 is often eased a bit by the attendant economic rewards. So Alexander the Great, for instance, was considered to have died young, although at 33 he was older than the life expectancy for his time. On the other hand, Plato and Sophocles were considered to be old when they died at about age 80 and 90, respectively, and it was considered noteworthy and amazing in the second century B.C. that the Roman statesman Cato, the Elder, would begin to learn Greek at the age of 80. (How well he spoke it at 85, when he died, is a different issue.)

The reason for the discrepancy between ages considered "old" and these ancient life expectancies is that life expectancy is just the average of everyone's age at death. If there are a lot of infant deaths, the large number of very low ages will reduce the average regardless of how long adults typically live.

I can't imagine a more vivid testament to the impact of modern standards of hygiene and medicine than to note that in industrialized countries today only about 1 percent of babies die before their fifth birthday. Compare this with medically undeveloped cultures such as the primitively agricultural Yanomamö of the Brazilian rain forest, or even Africa as a whole in the 1960s, where as many as half—half!—of all children died before they turned five. [20] I wonder that in such cultures people are not too depressed to continue having children.

As a consequence of all these infant and childhood deaths, historical life expectancies can be very misleading. For instance, if in a hypothetical population half of all babies die before their fifth birthday but everyone else lives to age 90, life expectancy would be the late forties. And in that case, life expectancy would severely misrepresent the length of a typical adult life and could therefore give us no idea of how aging may have changed over time.

The rate of infant and childhood mortality in medically naive cultures of the past has usually been underestimated, falsely increas-



ing estimates of life expectancy at those times. The reason for those distortions is that what we know about longevity in the distant past is generally inferred from reading tombstones or estimating the age at death of skeletons excavated by archeologists. In many cultures, however, the death of young infants is not recorded, and normal burial and burial rites are not observed. Moreover, the composition of infant bones makes them less likely to survive millennia of burial in a recognizable form. By failing to compensate sufficiently for this factor, the ecologist Edward Deevey presented a number of erroneously high life expectancies (in the thirties for classical Greece and Rome; nearly 50 for medieval Europe) for ancient times in a famous paper in *Scientific American*. [21] Everyone who has seriously studied the matter since then agrees that Deevey's estimates of life span are too high, although they seem to be the ones most often repeated in textbooks and the popular press.

The major pattern in the rate of aging that emerges from our best estimates of life expectancy is that from very ancient times until the eighteenth century, when some appreciation of hygiene and public health developed, little changed and life expectancy remained lower than 30 years. Somewhat surprisingly, there is no evidence of a decline in longevity as infectious diseases became more common with the development of cities and towns. This might be explained by the fact that the growth of cities brought more reliable food sources, which compensated to some extent for the rise of infectious disease. And once public-health measures began to be taken with sufficient seriousness (around the turn of the century), followed by the development of antibiotics,

childhood mortality plunged, and life expectancy increased in proportion.

Also clear is the fact that because of massive early mortality in premodern cultures, changes over time in the life expectancy itself fail to reveal much, if anything, about the typical longevity of adults, much less the timing of growing old. After all, despite these 20-something life expectancies, famous people such as Plato and Sophocles lived lives that would be considered lengthy even by modern standards. But in general, the evidence suggests that for most of human history, most adults have lived only to be 30 to 40 years of age. Life



was short—remarkably short. A few lucky individuals may have lived to be what we would consider elderly today, but they were clearly exceptional. Was a 50-year-old truly a codger in ancient times?

One of the best sources we have for understanding aging in preliterate times comes from a remarkable archeological excavation near the shores of Lake Erie in northern Ohio in the United States—the so-called Libben Site. In 1967–1968, more than 1,300 skeletons were exhumed from ancient cemeteries there. Between 800 and 1100 A.D., these people hunted and gathered on the edge of a great swamp bordering the lake. Perhaps toward the end of this period, they also cultivated a little corn. The skeletons were exceptionally well preserved and were excavated with exceptional care. Estimates put the ages of death from prenatal babies to more than 70 years.

Assuming these estimates are roughly accurate for the Libben people, life was apparently nasty, brutish, and short. The life expectancy of an average adult was only about 34 years. Although a few people did reach respectably old ages by today's standards, they were very few indeed. In the Libben community, even 15-year-olds had only about a 5 percent chance of reaching age 50, much less 70. A 50-year-old was indeed a rarity; a 70-year-old may have been the Jeanne Calment of that time.

But all evidence suggests that these short lives were due to the harshness of the environment, not a biological difference in the rate that people deteriorated over time. The rare 50-year-old codger would not have been as decrepit as a modern 80-year-old—just exceptionally lucky for his time. We suspect this because some of the oldest written records of human history—much older than the Libben Site—present aging pretty much as it is today. The nearly 5,000-year-old figure of a bent osteoporotic man leaning on his staff, for instance, means "old age" or "to grow old" in Egyptian hieroglyphics. Ancient Egyptian texts indeed describe most of the medical conditions associated with aging today—heart pain and palpitations, tumors, deafness, cataracts, incontinence, and constipation. The Egyptians also considered the practical limit of human life to be 110 years [22]—an age that is reached even today in the countries with the greatest life expectancies by only about one person in 10 million. The Egyptian Pharaoh Pepi II is claimed to have reigned for at least 90 years more



than 4,000 years ago, though his age at assuming the throne is unknown. Although documentation on the length of Pepi's reign is weak, the Cambridge Egyptologist John Baines assures me that Ramses II, a Pharaoh who reigned more than 3,000 years ago, had a well-documented reign of 67 years and was clearly not young when he came to the throne following the death of his elder brother. Ramses was likely at least 90 and perhaps as old as 100 when he died.

Of course, nearly all we know about the very old in the past comes from accounts of the lives of famous people—royalty or famous artists. The longevity of kings and emperors is particularly well documented because succession from one monarch to another was considered a particularly noteworthy event, and because genealogical records of royal families were meticulously maintained. Naturally, there is no reason to think that the longevity of royalty was representative of the rest of society. Princes and potentates were not likely to be malnourished or to die from overwork, and perhaps for this reason they lived to surprisingly modern ages for as far back in time as we have good records. In addition to the longevity of pharaohs, we know that among the rare Roman emperors who outwitted their enemies long enough to die nonviolently, several lived into their late seventies. The first six kings of England to die natural deaths (ruling between 1066 and 1400 A.D.) all lived to ages between 56 and 68. So for at least as long as we have written records, it was possible for people to live to ages that we still consider elderly today.

If there was a time in which people never lived to modern ages, it may have been in the very distant past—tens of thousands of years ago—when modern humans coexisted with Neanderthals. Of course, no written records from the late Ice Ages exist, but it is possible to estimate the age of death of skeletal remains using a wide variety of skull and bone characteristics (closing of growth plates, condition of long bone ends, extent of tooth wear, etc.). Since the first Neanderthal skeletons were discovered in 1856, more than 150 skeletons of Neanderthal adults (plus about 100 children) have been unearthed in the Middle East and Europe. According to skeletal estimates, none of the adults appears to have lived beyond the early forties. [23]

We can be certain that Neanderthal life was no picnic. One particularly well-preserved skeleton is of a man who apparently died

in his late thirties. Healed injuries show that, at that age, he was blind in one eye, had a withered right arm, and walked with difficulty due to foot and leg injuries. On the other hand, if he survived as long as he did with those injuries, he would have had to rely on the care and kindness of others. Such attributes do not normally spring to mind when thinking of Neanderthals. One hundred fifty skeletons is not really a big enough number to conclude with any certainty that living to 60 or 70 was impossible 50,000 years ago, but it may have been.

So does this mean that the aging rate, or the speed of physical deterioration, is the same today as it has been at least since Neanderthal times, and that we are longer-lived simply because of a safer environment and better sanitation and health care? If there is a gold standard of measuring aging, something that doesn't depend so much on environmental harshness, it is mortality-doubling time, not life expectancy or maximum longevity. Remember my earlier generalization about humans aging versus that of fruit flies and mice: Humans age more slowly because the amount of time it takes for their probability of death to double is much greater. This doubling time is about eight years for modern humans versus 10 days for fruit flies and three months for mice living in climate-controlled laboratories. One way to think of these differences is to imagine that fruit flies age about 300 times as fast as humans (eight years is roughly 300 times as long as 10 days) and mice 30 times as fast. So, how has the mortality-doubling time changed over the millennia, and how variable is it today?

Humans, unlike mice and fruit flies, are not frequently found living in climate-controlled laboratories. We live in a complex world with various unpredictable dangers, such as wars, viruses, and in-laws. Yet for all this environmental complexity, our mortality-doubling time is pretty constant, varying throughout the world and throughout history less than threefold, from about seven years to about 26 years. The larger numbers, which seem to suggest slower aging, suggest something quite different. They all come from countries with low life expectancy and, in actuality, represent special situations in which young people die at unusually high rates rather than the elderly dying



at low rates. If we consider death rates only from age 40 on, mortality doubling is much more constant, or if we eliminate deaths due to accidents and violence, as the demographer Jay Olshansky of the University of Chicago has done, mortality doubling stabilizes nicely in the seven- to ten-year range.

The historical perspective is similar. As overall death rates have dipped during this century and life has lengthened, the mortality-rate doubling time has decreased, because we have made more progress combating causes of death in early life than in later life. Today's longevity champions, the Japanese, averaged only 43 years of life at the turn of the century, and their mortality doubled every 16 years. Now they average nearly 80 years of life, but their mortality rate doubles in only eight years. The same general pattern is repeated in all countries in which such information has been collected.

Even in preliterate, protoagricultural cultures such as that of the fierce Yanomamö in the Brazilian Amazon forest, with a 15-year life expectancy at birth and a 40-year life expectancy in adulthood, there is a 19-year mortality-doubling period similar to that of modern Afghanistan. For the primitive Americans hunting and gathering 1,000 years ago at the Libben Site, who could expect to live to only about 34 years if they made it to adulthood at all, the risk of death doubled in a reasonably modern 11 years, about the same as in modern Colombia and Bangladesh. We can't ignore, however, that life in ancient America was dramatically harsher than that in any modern country. The odds of dying at any particular age were some 100 times higher at the Libben Site than in modern Bangladesh, which is worth remembering when we fantasize about a simple, carefree life in an imaginary Edenic past.

So although we have succeeded remarkably well over the millennia in making our environment safer, we seem to have been unable to affect the rate at which our bodies deteriorate.