Chapter 3: Essay

Extending the Human Life Span

Living isn't easy, especially at the level of the molecules that make us. Our cells and the molecules they contain are constantly exposed to a hostile environment of viruses, bacteria, free radicals, radiation, and random chemical reactions. We live because our bodies are able to repair themselves from perpetual molecular damage. Over time, however, our bodies lose the ability to self-heal. We age. We grow frail and eventually die.

Since the introduction of mod-ern medicine and better health habits, the average life expectancy of humans has increased dramatically—in the United States from about 48 years old in 1900 to about 78 years old in 2000. The maximum attainable human life span of about 120 years, however, appears to have remained fairly constant. Is there truly a limit to how long we can live? Is it possible to change how long we live while still maintaining youthful vigor and resilience? After all, the quality of life matters just as much, if not more, than the quantity of life.

Scientists have long known that a healthier and longer life can be attained by reducing the intake of calories by at least one-third of the number in a normal, healthy diet while maintaining necessary nutrients. Worms fed such a calorie- restricted diet live up to 5 months longer, which for them is a life span increase of about 60 percent. Mice live about 14 months longer (50 percent increase) and dogs also about 14 months longer (10 percent increase). Would calorie restriction also help humans extend their maxi- mum life span? The answer is likely yes, but by how much is questionable. Some scientists are optimistic that it could add 10 to 15 years. Others are more cautious in thinking 2 to 3 years may be more reasonable. Either way, there are potential benefits to be had, and every gain counts.

Scientists are working to unravel the molecular mysteries of why calorie restriction works. This, in turn, should help them to discover compounds that mimic the effects of calorie restriction. Interestingly, one class of compounds that mimics those effects are polyphenols, which are abundant in highly pigmented foods, such as pomegranates, or beverages, such as red wine.

Gerontologists who study the aging process have come to recognize at least six categories of damage sustained by our cells and biomolecules (see Table A). These are likely to be the underlying causes of our becoming frail and more susceptible to death as we grow older. Prevent or reverse these damages, and the result would be a rejuvenated body, which, in turn, would have a greater chance of experiencing an extended life span. The important thing to

TABLE A Six Categories of Cellular Damage

PROBLEM	CURRENT AND POTENTIAL REMEDIES*
Cells die and are not replaced.	Improved health habits; growth factors; gene doping, stem cells; apoptosis active dephosphorylation inhibitors; senescent cell therapy
DNA within the cell nucleus is altered, giving rise to cancer.	Improved health habits; chemotherapy; radiation therapy; surgery; telomere restoration therapy; gene therapy; nano-shells; angiogenesis inhibitors; bivalent monoclonal antibodies; Car-T cell therapy; targeted enzyme inhibitors.
DNA within cellular mitochondria is altered, resulting in cell death.	Gene therapy to produce mitochondrial proteins from nuclear DNA
Unwanted cells, such as fat cells, accumulate.	Improved health habits; calorie restriction diet; surgery; target cell surface differences
Collagen loses elasticity because of cross-linking.	Sunscreen; advanced glycosylation end-product breaker drugs to break crosslinks or inhibit their formation
Unwanted junk, such as atherosclerotic and amyloid plaques, accumulates.	Beta-sheet breaker peptides; inhibition of ABAD beta amyloid complex; genetically modified white blood cells; lysosome replacement therapy

note here is that we're not talking about keeping old people alive in their frailty. Instead, we're talking about strategies that would permit people to both look and feel better despite having lived for so many years. Humans would remain productive and active for much longer periods of time.

Let's take a brief look at senescent cell therapy, which is just one example of longevity research. In the early 1960s, Professor Leonard Hayflick, one of the founders of the biotech revolution, noted that a human cell is only able to replicate about 60 times. Once this limit is reached the cell may self-destruct or it may be attacked by the immune system. Some of these cells, however, remain in a quasi-dormant state, called senescence, where they produce chemicals that are generally not good for the organism. As we grow older, senescent cells in our body accumulate. We are then exposed to greater amounts of the dangerous chemicals these cells produce. This, in turn, gives rise to numerous age-related problems such as the weakening of tissues, arthritis, and cataracts. Recently, scientists found a way to selectively kill senescent cells as they formed in mice. Remarkably, the treated mice remained healthier as they aged compared to mice who received no treatment. If a similar treatment could be applied to humans it would be a huge advance in the treatment of age-related diseases.

Might scientists be interested in finding remedies to the maladies of aging? How about the businesses or organizations that sponsor the scientists? Do you suppose more or less money will be channeled into these efforts as more promising discoveries are made? Will there be a sufficient demand for resulting products that provide for a longer and healthier life? With wrinkle-free skin? Will people of impoverished nations be able to afford this anti-aging technology? Should it be offered freely? Might we have more or fewer remedies available to us by the time you are 40 years older? What if medical science advances faster than you age? Stay tuned. Future advances in biotech are sure to have a profound impact on your quality of living.

CONCEPT **CHECK**
How are people like cars?

CHECK YOUR ANSWER Professor Leonard Hayflick says people are like cars because they age reliably "even though there's nothing in the blueprints that shows a process for doing it." In other words, there is no "death gene," no mechanism that kills us off after a certain time limit; aging is a consequence of living in a corrosive environment. If, however, you want to keep a car like "new," what do you do? Wait until it's ready to fall apart? Or repair as necessary despite the expense of new body parts or skilled labor? Both people and cars need daily maintenance if their life expectancies are to be maximized. If a car can be nurtured to live for many centuries, can people too? Do we have the resources?

Think and Discuss

1. There are millions of people who don't exercise or eat right even though they know such habits will likely extend how long they live in good health. Why?

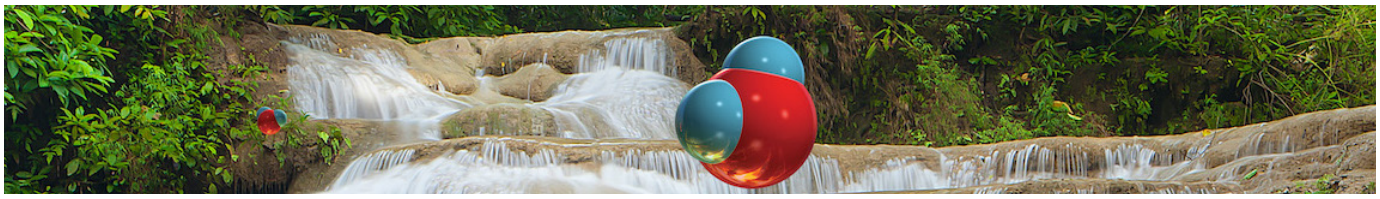
2. In the past 20 years, the aver- age life expectancy within most nations has risen by a couple of years, but so has the "healthy life expectancy," which is a measure of how long people remain in good health. Are the two necessarily related? How so?

3. How might cures for age-related diseases also be a solution to the problem of overpopulation?

4. How would society be able to support so many people living well into their 100s?

5. The Pentagon today owes its soldiers about a trillion in future retirement benefits. What might happen to this cost if the soldiers actually lived some 40 years longer than expected? How about 100 years? 500 years? At what point should the Pentagon no longer "owe" these benefits to the soldiers? What trends do you foresee in company retirement plans?

6. How are younger people going to be able to find work when so many older people are not retiring? And how might a healthier upper age group affect the wealth distribution between generations?



Author Responses to Think and Discuss

1. Time is a funny thing. Millions of people living in modern society are so pressed for time, they put off what they perceive as secondary priorities. "I'll get to it as soon as I finish _____." (fill in the blank). The irony is that if they would exercise, eat right and just relax, they would then have longer lives with even more time to "do what they need to do." Like most animals on Earth, we are adept at focusing on the present moment and our present concerns. Unlike most other animals on Earth, we have the ability to think long term anticipating the future. This is a talent we are wise to practice.

2. Average life expectancies have risen not so much because medicine has been able to keep frail people alive longer. Instead, life expectancies have risen primarily because people are living healthier lives. This trend will likely continue. In other words, as the average life expectancies continue to increase, so will the average healthy life expectancies.

3. There is a direct relationship between infant mortality and birth rate—if half of your babies are dying, it's only natural to have more babies. But babies are expensive and they consume a lot of resources. Once more babies start surviving, then the birth rate goes down, which is exactly what happened soon after Louis Pasteur introduced hygiene to the world in the 1870s. Today we still see the relationship. Countries with the greatest infant mortality, such as developing nations, are countries with the greatest birth rates. Cultural inertia in many of these countries, however, has prevented a proportional drop in birth rates. As a consequence, these countries are experiencing unprecedented hardships. So what happens when the elders start living much longer? Might these elders have grown wise enough to understand the problems of overpopulation? Might they retain their old ways thereby reinforcing the cultural inertia to change? In a world where resources for everyone are growing more scarce, the pressure to keep birth rates down will be great. The crux of the issue, however, is whether or not the elderly will be like the babies in that they are expensive and consume a lot of resources.

4. If people are living well into their 100s then they would likely also have the energy to provide some sort of remunerable contribution back to society on up through to their 90s. With their experience and potential wisdom they would have much to offer. An interesting issue we face today at the beginning of the 21st century is what to do, if anything, with our social security system or various retirement plans. What happens when we expect to live to 80 and thus retire at 65, when in fact we live a healthy life up to 120? Social security and retirement funds won't be sufficient. As our expectations change, so will our plans of action. We don't know what to expect!

5. If in the future people live significantly longer than they live today, then government and corporate retirement plans are destined for bankruptcy. To avoid such bankruptcy, the government and corporations will likely move towards privatized retirement accounts where the impending "lack of sufficient funds" falls squarely onto the retiree, who would thus feel pressure to go back to work. Interestingly, the Pentagon predicts that soldier-replacing robots will be a major fighting force in the American military in less than a decade. Their current robot project is the biggest military contract in American history with a price tag of $127 billion.

6. The older folks have a life's worth of work experience that may be of benefit to society. As they remain in the work force longer, they have more opportunities to help in training younger individuals. The older folks are also hopefully in a position to hire younger folks through companies they may own or manage. Mostly, however, new sorts of jobs and careers will need to be created that younger people would be best suited to fill.