Engineering and Aging: The Best Is Yet to Be

Men grow old, pearls grow yellow; there is no cure for it.—Chinese proverb

The quest for the fountain of youth is as old as humankind. By comparison, the biological study of age-related illnesses began yesterday. After all, until quite recently in our history, most people didn't actually manage to grow old, so there wasn't much point in worrying about it. Genetic malfunction, microbial and virological assault, environmental catastrophe, and our longstanding inclination to kill one another usually swept us from the stage long before we had a chance to sample any of the mixed blessings of growing older: midlife crises, arthritis, enjoying avocational passions built up over decades, seeing grandchildren grow up.

Public hygiene, relatively healthy diets (well, for some of us), and fewer wars, coupled with the discovery of antibiotics and other medical advances, have worked wonders on our average life expectancies. In the United States, for example, it has gone from about 47 years in 1900 to about 77 years in 2000. And as the size of the aging population in developed countries has increased dramatically, so, too, has our interest in understanding exactly how and why we age and what we might possibly do to live a lot longer—and better—than the actuarial tables now say we should.

Not surprisingly, theories and metaphors about how the human body works, falls ill, and ages have often leaned heavily on the prevailing technology of the age in which they are dreamed up. Steam engines, hydraulic systems, switchboards, and computers have all figured prominently in the language used to describe human physiology. More recently, biologists have been applying classic engineering reliability theory to the problem of aging.

What could you, a member in good standing of the species *Homo sapiens*, possibly have in common with the workings and systematic failings of electronic systems? Quite a lot, according to Leonid Gavrilov and Natalia Gavrilova, the chief proponents of the reliability theory of aging [see "Why We Fall Apart" in this issue].

Their theory begins with the provocative idea that we are not born in an optimal condition and that it goes downhill from there. We are born with numerous "faulty" parts and connections that are generated during embryonic development, they say. Then, starting at around age 10, accumulated genetic mutations and environmental damage cause our machinery to start breaking down. Happily enough, our bodies compensate for these defects over our lifetimes by being made up of an enormous number of redundant components, which we call cells. Eventually, our life-saving redundancies are used up, at which point one or more of our developmental flaws gets the better of us and we become vulnerable to disease and die.

The Gavrilovs are enthusiastic supporters of "engineered negligible senescence" and foresee a not-too-distant future in which aging will be controlled and human life spans extended dramatically. In this worldview, the person who lives to be more than 100 years old could be the norm rather than the exception in the next few decades. And while there's still quite a gap between mathematically describing the root causes of aging and finding ways to treat these causes—rather than their ravaging symptoms—the Gavrilovs' work is an important contribution to a young field. ■

Aging and Technology: A Special Series

The article in this issue by the Gavrilovs is the first of a series that *IEEE Spectrum* will run in coming months on biomedical engineering. We'll focus on innovations that will play important roles in keeping human beings healthy, fit, and independent well into their seventh, eighth, or ninth decades. New drug delivery technology, replacement body parts, and wireless medical monitoring technology are among the topics that will be discussed in future articles. What you will notice about all these technologies is that you don't have to be old to appreciate them. And, indeed, engineers should be making products useful to everyone, not just the aged, notes rehabilitation engineering expert and IEEE Fellow Charles J. Robinson. Such so-called universal design means making products that can help individuals throughout their lifetimes. Examples are already all around us, from voice dialing on cellphones to automatic-flush toilets. We can only hope to live to see the day when replacement body parts seem as commonplace.

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