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Reliability Theory Applied To Aging And Longevity

Our bodies' backup systems don't prevent aging, they make it more certain. This is one offshoot of a new "reliability theory of aging and longevity" by two researchers at the National Opinion Research Center at the University of Chicago.

The authors write, "Reliability theory is a general theory about systems failure. It allows researchers to predict the age-related failure kinetics for a system of given architecture (reliability structure) and given reliability of its components.

"Reliability theory predicts that even those systems that are entirely composed of non-aging elements (with a constant failure rate) will nevertheless deteriorate (fail more often) with age, if these systems are REDUNDANT in irreplaceable elements. Aging, therefore, is a direct consequence of systems redundancy."

In their paper, "The Reliability Theory of Aging and Longevity" (Journal of Theoretical Biology 213, 527-545), Leonid Gavrilov and Natalia Gavrilova offer a comprehensive new theory to explain why people (and other biological species as well) deteriorate and die more often with age.

Interestingly, the relative differences in mortality rates across nations and gender decrease with age: Although people living in the U.S. have longer life spans on average than people living in countries with poor health and high mortality, those who achieve the oldest-old age in those countries die at rates roughly similar to the oldest-old in the U.S.

The authors explain that humans are built from the ground up, starting off with a few cells that differentiate and multiply to form the systems that keep us operating. But even at birth, the cells that make up our systems are full of faults that would kill primitive organisms lacking the redundancies that we have built in.

"It's as if we were born with our bodies already full of garbage," said Gavrilov. "Then, during our life span, we are assaulted by random destructive hits that accumulate further damage. Thus we age.

"At some point, one of those hits causes a critical system without a back-up redundancy to fail, and we die."

As the abstract puts it, "Reliability theory also predicts the late-life mortality deceleration with subsequent leveling-off, as well as the late-life mortality plateaus, as inevitable consequences of REDUNDANCY EXHAUSTION at extreme old ages."

All those who have achieved the oldest-old age have very few redundancies remaining, therefore they can't accumulate many more defects: They simply die when the next random shock hits a critical system. Hence, the mortality rates tend to level off at extreme old ages, and people all over the world die at relatively similar rates on average. The initial differences in body reserves (redundancy) eventually disappear.

In the authors' words, "The theory explains why relative differences in mortality rates of compared populations (within a given species) vanish with age, and mortality convergence is observed due to the exhaustion of initial differences in redundancy levels."

This fundamental theory of aging and longevity is grounded in a predictive mathematical model that accounts for questions raised by previous models addressing the mechanisms of aging, mortality, survival and longevity.

The authors are research associates at the Center for Aging at the University of Chicago's National Opinion Research Center. Their research was sponsored by the National Institute on Aging.

(Editor's Note: Full text of the paper is available online at this URL.)

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