Biotopology and the Extension of Longevity

Stanley Shostak

ABSTRACT: **We are blighted by biology.** If we continue as we are, increasing numbers of human beings will live to become fragile and vulnerable nonagenarians, centenarians, and supercentenarians, or we can employ biotopology to extend youthful life into adulthood. The choice is between the haphazard process of "squaring the curves" of life expectancy or untangling the tails of old age and promoting the evolution of youthfulness through biotopology and niche construction. Gins and Arakawa's visionary architectural projects seem well on their way toward promoting human enhancement and the evolution of youthful life.

Introduction

Fig. 1

Thank you Slought Foundation and Arakawa and Gins for throwing this intellectual party. As a biologist, I am especially pleased to speak under the image of the double helix rendered into architectural perfection.

I'm Stanley Shostak and I'm here to describe the forces impinging on reversible destiny—At present, we have access to two ways of extending human life in our lifetime and beyond. One way is already in play. This is the “way things are.” The other way is through biotopology. It is new and only beginning to be tapped. Biotopology is the study of “rearrangements and transformation … [of] waxing and waning … in all scales of action that contribute to the formation of an architectural body.”[1]

I’ll begin by describing “the way things are,” where they have taken us, and where they’ll take us in the future.

“The way things are” is the consequence of biological evolution, the way human life has turned out through the natural selection of variants appearing spontaneously among our human populations, without planning, by chance.

Fig. 2. [2]

This slide shows roughly where the duration of human lifetime is today, or, more precisely, in 1988 for people in the US and Europe. Plotted here are hypothetical percentages of “survivors” as a function of years after birth. Overall two slightly curved arms meet at a bend. This is the “life expectancy curve” for the 1988 cohort. It begins at 100% when all the members in the cohort are alive, and ends some time in the future at 0% when no member of the cohort is alive—all members are dead. The shape of the overall curve shows that life expectancy declines with age. Although life expectancy

hardly descends until adolescence;

it descends rapidly during adulthood;

and dampens off for nonagenarians, people in their nineties, centenarians, from hundred to one hundred and nine years old, and supercentenarians, one hundred and ten years and older.

The curve subtends a median ***life expectancy***—the point where the curve crosses 50%—also known as the ***life expectancy at birth,*** the age when only half the members of a cohort are alive.

For the 1988 cohort, representing the US and Europe, ***life expectancy at birth*** [***le@b***] was roughly 75 years. Life expectancy was higher elsewhere (e.g., Iceland and Japan) and lower elsewhere (conspicuously Africa and Russia), but I'll confine myself to life expectancy curves for the US and Europe.

How then has the duration of a lifetime changed over centuries? The answer is found by comparing life expectancy curves for different cohorts.

Here are some ***life expectancy curves*** for past cohorts. Looking back over 250 years, you see that ***life expectancy at birth*** increased from 24 years in 1754 to 42 years in 1850 and from 47 years in 1900 to 75 years in 1988.

These increased ***life expectancies at birth*** are accompanied by changes in the shape of the life expectancy curves. The curves have squared—a process known familiarly as **"squaring the curve."** The upper arm has become more nearly horizontal; the lower arm has become more nearly vertical; and the bend sharper.

What then has squared our life expectancy curve and changed the duration of the human life time?

Fig. 3.

In order to answer this question I must dissect the curves into portions with fundamentally different dynamics. In fact, the life expectancy curves are three dynamically different curves sutured together in time.

the lag portion with linear dynamics begins at birth and runs through adolescence;

a log portion has exponential dynamics;

and a tail portion trails off linearly to approach zero asymptotically.

Beginning with the lag portions of the life-expectancy curves, one sees that over the past 250 years, the left arm of the curves has been pushed upward dramatically into its present more nearly horizontal position. What has happened is that more young people, juveniles and preadolescents at the left end of the curve—individuals who would have died in past centuries—are now surviving and advancing into adulthood.

Fig. 4. [1 click]

Increased rates of survival in youth are even detectable in recent data on mortality in infants, in this case, data from Singapore. These data show the decline in infant mortality over the decade of 1991 to 2000.

The increased survival of young people is in large measure a consequence of the vast improvements in maternal health, prenatal care, neonatal care, vaccination, and treatment of infectious diseases in the young. Regrettably, not everyone is doing as well. In fact, 25% of global deaths are still due to infectious diseases striking disproportionately at the young. Even in the United States, the young may not have access to adequate health care.

Fig. 5.

The log portion of the curve is also swollen by the increased numbers of young people surviving the lag portion of the curve. Their survival has pushed the diagonal arm of the curves outward and toward the vertical.

The outward thrust of the log portion is also due in part to middle-aged people surviving longer because, nowadays they are exposed to fewer hazards especially on the job, including pollution and cigarette smoke, and have more time to rest and allow their bodies to recuperate from the daily assaults we call normal life, especially those insults suffered at work. In addition, survival is promoted by improved treatment of chronic disease—the kind of diseases that make you miss work—although the raging epidemics of obesity and type II diabetes suggest we are not doing everything we should be doing to combat chronic disease.

Fig. 6.

In theory, if we continue "the way things are," doing much the same as we're doing now while the curve "squares," the log portions of the curve will continue moving outward and toward verticality. For the cohorts born in 2000, for women and men identifying themselves as white or black, ***life expectancies at birth*** are 80, 75, 75, and 68, respectively.

Were the present rate of increasing ***life expectancy at birth*** to continue, the ***le@b*** for white women born in 2100 would be 102, 97 for black women and white men to, and 90 for black men.

In addition, if the conquest of diseases were complete by 2200, ***life expectancy at birth*** would be 117 years for white women, 112 for black women and white men, and 105 for black men. [3]

Fig. 8.

Indeed, the geriatrician, Thomas Perls, principal investigator of the New England Centenarian Study wrote in a 1995 article:

> The centenarian population grew by 160 percent in the U.S. during the 1980s.

Here, he's not talking about "baby boomers"!

> [And many] demographers predict that … 500,000 to four million [people] will be centenarians in 2050.[4]

Their ranks will be swollen by "baby boomers."

According to Perls, the quality of life need not be bad for many of these future centenarians if we start paying social security and medicare what it will need!

But I disagree. My guess is that ***le@b*** will reach an equilibrium in the early nineties and **life** be like for these super senior citizens of the future will be grim?

In order to explain, I turn to the **tail portion** of the life expectancy curve?

Fig. 8.

You see that over 250 years, the tail portion has ***thickened*** as it accommodates adults becoming nonagenarians, centenarians, and supercentenarians surviving beyond their life expectancy at birth.

But, unlike the other portions of the curve, the ***thickened*** tail portions do not separate. Indeed, the tails are ***entangled*. The tails converge,** roughly at 92 years.[5]

Thus, life comes together for nonagenarians!

The entangled tails remain, more or less on the same track. The rate of aging approaches an equilibrium that continues for **centenarians, and supercentenarians.**

The death rate for supercentenarians settles in at about 50% per year, which is to say, one has about the same chance of living another year as one has of correctly calling a fair coin toss—survival for the supercentenarian is a game of chance—subject to random contingency.

Thus, given "the way things are," as the life expectancy curve squares, we hit a biological wall—a genetic barrier—in the thickened, entangled tail portion of the life expectancy curve. The life of nonagenarians, centenarians, and supercentenarians is not necessarily one of **decrepitude,** but **it is** a life of **chance**, of **fragility** and **vulnerability**: the chance of someone sneezing near and your catching the cold, flu, or pneumonia that will kill you; fragility to environmental hazards that you would have walked away from earlier in life but now trip you up; and vulnerability to conditions, like smog, that earlier might have caused annoyance but now threatens to lay you out.

Were we to accept "the way things are" we would be committing an increasing proportion of the population to death as fragile, vulnerable nonagenarians, centenarians, and supercentenarians subject to the rules of chance—the gambling table.

Fig. 9.

The increasing number of individuals dying in older age is seen in this histogram showing data, once again, from Singapore.

As already mentioned, infant to juvenile mortality declines,

while the elderly (over 75) represent an increasing proportion of the dead.

Fig. 10.

Thus,[6] continuing "the way things are," by "squaring the curve" further, we will only push our ***life expectancy at birth*** outward into a period of fragility and vulnerability ruled by chance and death in extreme old age.

That's what "squaring the curve" promises to do for our future. "Squaring the curve," will not break the confinement of youth or the stranglehold of aging. It will not expand the youthful part of our life expectancy curve or untangle the tails of aging. Dying will continue as the inevitable consequence of extreme old age, because of the biological imperative.

Death in old age as the inevitable consequence of prolonged biological aging **is the challenge of reversible destiny.**

How then, can we **stop** squaring the curve? How can we **start** "making death illegal"?

How do we ***untangle the tails*** of our life expectancy curve so we are no longer ensnared by old age? How do we expand the youthful phase of life into adulthood so adult life continues with youthful vigor?

How do we take control of our life expectancy curve instead of leaving it to the biological imperative—to normal evolution and "squaring the curve"?

I cannot say if years can be added or when, but unless we take human **life enhancement** into our own hands, reversible destiny won't happen.

We must take charge of human evolution—of our destiny!

Fig. 11. [1 click]

Here is where biotopology comes into play.

We **can use biotopology for reversible destiny** and turn human evolution away from the biologically-limited process of "squaring the curve." **We can bring lifetime extension under our control instead of biological control, and determine the evolution of our species instead of surrendering it to chance.**

As surprising as it may sound, it won't be all that difficult to take control of our destiny and human evolution! Indeed, it is all but certain that enhancing human life is within reach.

Arakawa and Gins have already shown how biotopology can transform our biological niche and through our niche transform our evolution!

Fig. 12. [1 click]

In biology, it is called "niche construction": how "the activities of organisms bring about changes in their environments" and, consequently, in their own evolution—how a species' activity feeds back on the species' environment and hence on its evolution.

That is how we can extend life and "make death illegal"!

Fig. 13.

What the biotopologists are showing us is how we can live longer by living younger!

Then we will be taking the evolution of life in hand and taking control of human destiny—bringing about the kind of biotopological transformation that promotes life by promoting living younger. Michel Foucault's biopolitics may have anticipated biotopology, but he didn't appreciate the range of creative possibilities.

Let me illustrate some of these possibilities with a couple of examples of topological transformation drawn from Gins and Arakawa's visionary architectural projects.

Fig. 14.

Some topological transformations are familiar, for example, transforming a sphere into a cube by pushing and shoving.

Fig. 15.

Other topological transformations are less familiar,

Fig. 16.

for example, transforming a doughnut into a teacup by pushing in one surface and drawing out the doughnut's hole into a handle—turning the doughnuts of our lives into the tea cups of "reversible destiny."

Fig 17.

And how will these transformations affect longevity?

Fig. 18.

By returning us to the sand box of youthful life, of challenge and discover, of tentativeness, surprise, and learning: where life is play; where sex is fun; where commodities do no harm; where creativity expands without leaving waste; and where poetry thrives without breeding despair! That is where niche construction will create our future in the here-and-now; where genes will be reshuffled over generations; and where selection will favor a new, youthful, long-lived *Homo sapiens.* That is where we will evolve.

My hope is that scientists, poets, artists, architects—biotopologists—can now plunge ahead and take control of human life and evolution: enhance human life, appropriate niche construction for reversible destiny, and promote the evolution of youthful longevity for a lifetime!

Fig. 19.

Thank you for your attention.

---

[1] Arakawa and Madeline Gins, Architecture Against Death: Original to the 21st Century: Making Dying Illegal. New York; 2006, pg. 71.

[2] This slide is adapted from the logo of the Los Angles Gerontology Research Group.

[3] Olshansky, S.J., B.A. Carnes, C. Cassel, 1990, In search of Methuselah: estimating the upper limits to human longevity. *Science,* 250:634–40.

[4] Perls, Thomas T., 1995, The oldest old: People in their late nineties or older are often healthier and more robust than those 20 years younger. Traditional views of aging may need rethinking. *Scientific American,* January 1995:70-5.

[5] Gavrilov, L.A. and N.S. Gavrilova, *The Biology of Life San: A Quantitative Approach.* Revised and updated English Edition. Edited by Academician V.P. Skulachev. Translated from the Russian by John and Liliya Payne. Originally published in Russian in 1986 by Nauka, Moscow. Chur: Harwood Academic Publishers; 1991.

[6] **if** we do not cook ourselves out of existence in a steamy stew of global warming; and **if** we can avoid other forms of global conflagration brought on by war; and **if** we manage to avoid horrendous new diseases, such as a flu pandemics while eradicating already rampant diseases; and **if** we continue to improve nutrition, health care, sanitation, hygiene, etc.