Some Possible Implications of Life-extension

(*and a subtle weakness in* Demographic Transition *theory*)

More than two decades ago, researchers in the fields of aging and molecular genetics began to unlock clues to the genes, mechanisms, and processes of aging. And by 1993, Cynthia Kenyon and her colleagues succeeded in doubling the lifespan of an experimental laboratory organism, *Caenorhabditis elegans* (from 20 days to 40 days). And by 2005, Kenyon was able to report further work that had allowed researchers to multiply the lifespan of individuals within this same species SIX-FOLD (from 20 days to 120 days).

An equivalent six-fold increase in humans
would equal approximately **500** *years*

(a) Simultaneously, of course, other researchers have been investigating life extension by other means such as calorie restriction, resveratrol, and other approaches

(b) Secondly, other research has found that many of the same or similar mechanisms have worked in other laboratory organisms such as flies, mice, and yeast

(c) In addition, continuing research in health and medicine promises to prevent and/or cure disease and may also reward us with dramatic increases in longevity

So where might all of this be heading? At what pace? And what far-reaching implications may await?

First, let us consider our track-record over the past 100 years as scientists and scholars have pursued one new field and technology after another. Again and again, we have proceeded from an initial breakthrough to rapid advances and proliferation with breathtaking speed. Think, for example, of the advances and trajectories seen in computers, communications, medicine, DNA technologies, and genomics.

For now, however, think of the Wright brothers, who in 1903 flew, for the first time, a heavier-than-air vehicle *for twelve seconds and 120 feet.*

Consider next that just sixty-six years later,
the astronauts of Apollo 11

traveled to the moon and back in a little over one week

Which brings us back to 1993 and the initial doubling of lifespan in individual members of the species *C. elegans.* If we envision, beginning in 1993, a life-extension progression *similar to that seen in aeronautics*

then 1993, when extended sixty-six years
into the future, would bring us to 2059.

Even if a real possibility of a six-fold/500 year life-extension for humans were to (or might actually) exist, the exact details and the exact amount of lengthening are of less importance than the fact that

(a) Such research is occurring, and

(b) That some degrees of dramatic success
may not just be possible,
but may well be probable

Thus, if even a *fraction* of that 500 year human equivalent were to emerge in the decades ahead

(imagine, perhaps, a forty or fifty year extension)

then today's optimistic U.N. population projections that envision a stabilization of world population or that envision a total world population of *nine billion* around 2050 *could go right out the window*.

Note that the propositions and examples below are
offered as stimulants to thought, implications, insights,
and caution - not as advocacy

For those who think that China's one-child policy is strict, should a 500-year human life-time ever actually emerge, then replacement-level fertility may have to drop to just

4/10^{ths} of a child
per woman
per century

Suppose, for example, that a woman were to live for 500 years: If she were to restrict herself to just 4/10^{ths} of a child **per century** this would result in a total of two children over the course of her five-hundred year lifetime (one child to replace her upon her death, and a second child to replace the father upon his death).

It is all somewhat astounding. Advances in this research
could be very interesting in the decades ahead.

Faster than Ever

We have seen that experiments involving flies, worms, mice, and yeast have already succeeded in lengthening the life-spans of individual organisms six-fold and other researchers are exploring still other ways of lengthening life-spans such as calorie restriction, resveratrol, and sirtuins.

To these we must add still other experiments in the fields of medicine and health that work toward extending life by preventing and/or curing disease. One glimpse of the latter can be seen in studies underway in the synthetic biology department at the Lawrence Berkeley National Laboratory, where, Jay Keasling and his team have engineered "a large network of wormwood and yeast genes into *E. coli*," enabling the bacterium to synthesize a chemical precursor to

artemisinin – an “anti-malarial drug that is currently too expensive for… parts of the developing world that need it most” (Gibbs, 2004)

In just three years, Keasling’s lab “increased yields by a factor of one million,” and by amplifying the yields another 25-to-50 times, Keasling anticipates that artemisinin-based medicines might be supplied to the Third World “for about one-tenth the current price.”(ibid) In a similar way, bio-engineered bacteria may be used to produce the cancer drug taxol and other medicines (ibid).

As our Sri Lanka discussion (below) will show, falling mortality has repeatedly caused demographers to *repeatedly underestimate* future populations in the past,

and current research suggests that the same
thing may be about to happen once again -

this time on a worldwide basis

SRI LANKA

Forty-five years of data from the island of Sri Lanka may have something to tell us about the decades just ahead. Consider, for example, the data set below which reflects birth rates and death rates between 1939 and 1984:

Year	Births per 1000	Deaths per 1000	Extra per 1000
1939	35	21	14
1940	34	20	14
1945	38	20	18
1947	36	19	17
1950	39	11	28
1955	35	9	26
1960	32	8	24
1965	33	9	24
1970	30	8	22
1975	28	6	22
1980	25	6	19
1984	27	6	21

If we look at birth rates alone (Births per 1000; left-hand column) we see that, as a general trend, the number of births per thousand fell from 35/1000 in 1939 to 27/1000 in 1984.

Thus, to a policymaker or a planner, the trend-line in birth rates might suggest (erroneously) that population growth in Sri Lanka need not be a priority factor in their planning for agriculture, schools, utilities, and jobs.

If, however, we also examine death rates
(deaths per thousand; middle column)

we see that death rates also trended downward.

From 21 deaths per thousand in 1939
to just six deaths per thousand in 1984

The reduction in death rates was also good news because advances in agriculture and medicine (and in the war against malaria) meant that lives were being saved and people were living longer.

It might be that the data column that is most provocative, however, is the right-hand column which shows the number of "extra" persons/1000 added to the island's population.

Notice that in **1939**, for example, there were FOURTEEN extra births/1000
(35 births/1000 minus 21 deaths/1000 = 14 extra/1000)

Yet, in **1984**, by comparison, there were TWENTY-ONE extra births / 1000
(27 births/1000 minus just 6 deaths/1000 = 21 extra/1000)

As the last column shows, then, by 1984, despite
almost half a century of declining birth rates,

(a) *not only was Sri Lanka's population 45 years larger,*

but, in addition,

(b) its *rate* of population growth had *actually increased by fifty percent*

This, then, is the lesson
that Sri Lanka's data holds
for the world today:

Even if we succeed in lowering birth rates around the world, progress in medical research and biotechnologies may end up lowering our death rates even more. Thus, while both trends, examined individually, each constitute one sort of good news, at the end of the day, when taken together, our populations could end up growing faster instead of more slowly.

Delays and Lag-times

Over and over again, demographers underestimate the impacts of dramatic and unexpected medical and technical advances and the rapid implementation that characterize modern science, research, and genomics.

Today's advances in medicine, molecular genetics, and biotechnologies (including early work like that seen with *Caenorhabditis*), for example, may have far-reaching impacts on death rates and demographics in the half-century just ahead.

And similar patterns have also characterized the development of computers, DNA technologies, communications, and molecular biology – each beginning with technical advances, followed by quick proliferation and progression to today's capabilities with breathtaking speed.

The *benefits* of each such advance tend to be realized relatively quickly by immediately saving lives and reducing mortality (imagine vaccines and anti-malarial medications, for example).

At the same time, however, lengthy ***delays*** and ***lag-times***

occur when traditions, social customs, and fertility
adjustments do not occur for decades, if at all

If our early steps in understanding longevity, lifespan, and aging develop and proliferate in a way analogous to the advances we have seen in biotechnology, aeronautics, DNA, computers, and communications,

precipitous declines in mortality could be on the horizon.

If so, then today's demographic projections *may constitute serious underestimates* of earth's future populations and may lull us into an exceedingly dangerous state of complacency and inaction.

Our recent past reveals repeated underestimates which have happened again and again exactly as we saw in our data from Sri Lanka. We should appreciate, therefore, that unexpected declines in mortality may offset and cancel-out anticipated gains that we currently expect based on declining fertility.

Suppose that unexpected medical advances bring about a sudden reduction in mortality. In this circumstance, demographic theory envisions a period of **demographic transition** during which *there is a time-delay before reductions in fertility occur to reflect the reduced mortality*

and during this lag-time,
populations skyrocket
as births greatly exceed
the lowered death rates

It is currently imagined that, however (perhaps after one or more generations), fertility rates slowly decline (theoretically) to levels commensurate with mortality rates, and a population stabilizes.

Thus, demographers commonly envision our time of soaring populations as a transition period during which fertility rates have not yet caught up to our falling mortality rates. And they hope, imagine, and expect that the transition will complete itself any decade now. One worrisome problem is, however, that such hopes and expectations *may well be subverted* by a nuanced and unexpected limitation within the theory.

How? Why?

Because science, medicine, and technology lower mortality rates not just once, but repeatedly, over and over and over again *so that we live in a perpetual state of transition*

In other words, we repeatedly extend and perpetuate the period of demographic transition (with its skyrocketing populations) *so that its completion never occurs* or is repeatedly postponed

In effect, each of our breakthroughs in medicine and longevity RE-INITIATE the transition period, delaying its completion and extending its duration more and more so that our *falling fertility rates are never allowed to catch up*

As fertility rates slowly and gradually adjust to an initial mortality reduction, today's genetics, technologies, and medical advances institute a *second*, *third*, *fourth*, and *fifth* mortality reduction in increasingly quick succession. As a result, falling fertility never catches up to the multiple new

reductions in mortality *and the interim stage of the transition* (with its period of soaring population) *is never completed*.

(It will be completed eventually, of course, but with each delay in the transition, the completion is increasingly likely to occur as a collapse.)

What the current theory does not fully articulate, therefore, is the role of science, technology, and medicine that are currently making reductions in death rates so quickly and repeatedly that off-setting fertility reductions do not (or cannot) occur in the short times available.

In effect, falling fertility is never able to completely catch-up and conclude the transition, because science and medicine keep perpetually extending the transition over and over again.

In the meantime, of course, our already exploding populations continue to rise dangerously higher

And finally, the coup de grace of all this is that the emerging advances in longevity as seen in *Caenorhabditis* (and in compounds, perhaps, like resveratrol) seem set to perhaps amplify and worsen our current overshoot and carry us calamitously past natural thresholds and tipping points that should not be transgressed.

Most strikingly, our ingenious advances in genetics, genomics, molecular biology, and medicine are repeatedly and systematically reducing mortality rates

(which we should pursue, of course, and for which their discoverers should be honored and greatly rewarded)

The transition, however, becomes perpetual and never ends because constant advances keep ex-tending it before it can proceed to completion. Each such advance, therefore, acts to cancel out or neutralize a key expectation of the demographic transition theory and repeatedly postpones completion of the expected transition *so that it never occurs* or it never ends until our degree of overshoot is so great that complete collapse can no longer be avoided.

A continuation of today's demographic tidal wave *may constitute the greatest single risk that our species has ever undertaken*.

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Literature and Links

An introductory sampling; search engines
will generate scores of others

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Given our current demographic trajectories, a
Franklin Roosevelt / Winston Churchill
level of mobilization should have begun two decades ago

Expanded implications of this excerpt are also
addressed in additional PDFs in this collection:

- Razor-Thin Films: Earth's Atmosphere and Seas
- Numerics, Demographics, and a Billion Homework Questions
- Conservation planning - Why Brazil's 10% is Not Enough
- Eight Assumptions that Invite Calamity
- Climate - No Other Animals Do This
- Critique of Beyond Six Billion
- Delayed feedbacks, Limits, and Overshoot
- Thresholds, Tipping points, and Unintended Consequences
- Problematic Aspects of Geoengineering
- Carrying Capacity and Limiting Factors
- Humanity's Demographic Journey
- Ecosystem services and Ecological release
- J-curves and Exponential progressions
- One hundred key Biospheric understandings

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