## MAX-PLANCK-INSTITUT MAX PLANCK INSTITUTE

 FÜR DEMOGRAFISCHE FOR DEMOGRAPHIC FORSCHUNG RESEARCH
## The Biodemography of Human Longevity:

by James W. Vaupel

The Future of Science IX: Secrets of Longevity,
Venice, 21 September 2013

## The Frontier of Survival: Three Views

View 1: The Fixed Frontier of Survival
Limited lifespans
Aristotle 350 BC, James Fries NEJM 1980
View 2: Breaking through the Frontier of Survival $\Rightarrow$ Secrets of longevity

Luigi Cornaro The Art of Living Long 1558
View 3: The Advancing Frontier of Survival:
$\Rightarrow$ Unrecognized progress
Vaupel, Manton, Stallard Demography 1979

## Discovery of Postponement of Senescence

Vaupel and Lundstroem 1994


## The decline in chances of death in Japan at ages 80, 85, 90 and 95

$q(x)$, Japan, Women

$q(x)$, Japan, Men


## The explosion of centenarians



## Mechanisms of Human Longevity

The major discovery - The advancing frontier of survival.

## Supplemental discoveries

1. The frontier of survival is advancing because senescence (the increase of mortality with age) is being postponed.

## The Postponement of Senescence:

 Evidence from Sweden

## Mechanisms of Human Longevity

$\rightarrow$ The major discovery- The advancing frontier of survival.

## Supplemental discoveries

1. The frontier of survival is advancing because senescence is being postponed.
2. The advancing frontier of survival is part of the larger, long-term Life Expectancy Revolution.

## The Revolution in Human Life Expectancy

Oeppen \& Vaupel, Science 2002


## The Linear Rise of Best-Practice Life Expectancy



## The rise in remaining life expectancy at age 65



## Age-Specific Contributions to the Increase of Life Expectancy among Women 1850 to 2007

| Age <br> group | $1850-$ | 1900 | $1900-$ | $1925-$ | $1950-$ | $1975-$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1950 | 1975 | 1990 | 2007 |  |  |  |
| $0-14$ | 62 | 55 | 31 | 30 | 11 | 6 |
| $15-49$ | 29 | 32 | 38 | 18 | 6 | 5 |
| $50-64$ | 5 | 9 | 19 | 16 | 24 | 11 |
| $65-79$ | 3 | 4 | 13 | 28 | 41 | 37 |
| $80+$ | 0 | 0 | 0 | 8 | 18 | 42 |
| Total | $100 \%$ | $100 \%$ | $100 \%$ | $100 \%$ | $100 \%$ | $100 \%$ |

## Life Expectancy and Life Disparity

Vaupel, Zhang, van Raalte BMJ Open 2011

|  |  |  |  | Probability of death <br> before age 65 <br> (in percent) |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Country | Life Expectancy | Life Disparity | Female | Male |  |  |
|  | Female | Male | Female | Male | Fer |  |
| Switzerland | 84.1 | 79.3 | 9.1 | 10.2 | 7 | 13 |
| Italy | 83.7 | 78.2 | 9.0 | 10.3 | 7 | 14 |
| Germany | 82.2 | 77.0 | 9.1 | 10.7 | 9 | 17 |
| Eng\&Wales | 81.7 | 77.5 | 9.9 | 10.9 | 10 | 14 |
| USA | 80.4 | 75.2 | 11.3 | 12.7 | 13 | 21 |
| Hungary | 77.2 | 68.7 | 10.8 | 12.9 | 16 | 36 |
| Russia | 73.2 | 60.4 | 12.2 | 15.4 | 23 | 55 |

Life Expectancy vs. Life Disparity


## Determinants of Longevity

- Average lifespan in a population
- Biomedical knowledge, health care system, standard of living, education, healthy behavior, environment
- Variation in lifespans among individuals
- Healthy behavior: listen to your mother
- $25 \%$ genetics, $10 \%$ childhood, $65 \%$ adult life McGue, Vaupel, Holm \& Harvald, J. Gerontology A 1993

The Life Expectancy Revolution: Why?


## Money?



Medicine?


It's never too late
Vaupel, Carey, Christensen, Science 2003


## Three states of health



## Life expectancy without and with long-term disability at age 75 in Denmark


with long-term disability
without long-term disability

## Life expectancy without and with long-term disability at age 75 in Denmark


with long-term disability
without long-term disability

## How many of us work? How much do we work?

Vaupel \& Loichinger, Science 2006

| Country | R, nonworkers per worker |  |  | H, hours worked per week per capita |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2009 | 2025 | Change | 2009 | 2025 | Change |
| Germany | 1.13 | 1.47 | 30\% | 12.55 | 11.16 | -11\% |
| Denmark | 1.01 | 1.12 | 11\% | 14.96 | 14.13 | -6\% |
| France | 1.40 | 1.69 | 21\% | 12.45 | 11.35 | -9\% |
| Italy | 1.60 | 1.86 | 16\% | 13.14 | 12.05 | -8\% |
| Netherlands | 0.91 | 1.20 | 32\% | 13.84 | 11.97 | -14\% |
| UK | 1.11 | 1.19 | 7\% | 14.97 | 14.67 | -2\% |
| USA | 1.17 | 0.99 | -15\% | 15.64 | 16.36 | 5\% |

## Forecasting Life Expectancy

- Rely on extrapolation using time-series methods
- Be very cautious about using expert judgments about the future


## The Sorry Saga of Looming Limits to Life Expectancy

Oeppen and Vaupel Science 2002


## Directly Forecasting Record Life Expectancy



Forecasting female record life expectancy (up to 2100) using a random walk with drift

## The Future Will Be Different from the Past

- In next decade or two, progress against cancer and dementia and in developing genotype-specific therapies
- Then progress in regenerating and eventually rejuvenating tissues and organs
- Accompanied by progress in replacing deleterious genes
- Aided by nanotechnologies (nanobots)
- Perhaps in a decade or two, probably later, progress in slowing the rate of aging (as opposed to further postponing aging).

Oldest Age at which at least $50 \%$ of a Birth Cohort is Still Alive
Christensen, Doblhammer, Rau \& Vaupel Lancet 2009, Updated by Rau 2013

| Year of Birth: | 2000 | 2005 | 2010 |
| :--- | ---: | :---: | :---: |
| France | 101 | 103 | 104 |
| Germany | 99 | 100 | 102 |
| Great Britain | 101 | 102 | 104 |
| Japan | 104 | 106 | 107 |
| Italy | 101 | 103 | 104 |
| USA | 100 | 101 | 103 |

Data are ages in years. Baseline data were obtained from the Human Mortality Database and refer to the total population of the respective countries.

## Summary: Prospects for the $21^{\text {st }}$ Century

$\Rightarrow$ Live longer and longer
Live healthier at any specific age


Postpone disability to later ages
$\Rightarrow$ Geriatic medicine

Work more years but fewer hours per year

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