PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Economic and social structure for an ageing population

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Economic and social structure for an ageing population‡

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SUMMARY

The driving force behind the improvement in the quality of life, the rising standard of living, improving health, and increasing longevity, is a process called '*technophysio evolution*', which began about 300 years ago, accelerated during the twentieth century, and is still in progress. Increased spending on health care and on pensions is an appropriate concomitant of technophysio evolution, and should be welcomed. Only wasteful medical services should be restricted. The resources available now and in the future can provide increasingly long and healthy lives of relative luxury for all. However, methods of financing health care and retirement need to be modernized. In the future, luxury will be defined increasingly in terms of spiritual rather than material resources. The test of well-being in the future for both young and old will be measured increasingly in terms of the quality of health and the opportunity for self-realization.

1. INTRODUCTION

The Organization of Economic Cooperation and Development (OECD) nations generally are faced with crises in their pension and health-care systems not because they are poor but because they are, by historical or Third World standards, exceedingly rich. It is the enormous increase in their per capita incomes over the past century that permitted the average length of retirement to increase by five-fold, the proportion of a cohort that lives to retire to increase by seven-fold, and the amount of leisure time available to those still in the labour force to increase by nearly four-fold (Appendix; Ausubel & Grübler 1995; Costa 1996; Lee 1996).

The current challenge to policy makers is how to maintain and extend these achievements without bankrupting the government. I am optimistic that this goal can be achieved and will outline the reasons for my optimism. Because of the limits of space I will first present my basic findings as a series of theses and then briefly elaborate on these points.

Thesis one: the driving force behind the improvement in the quality of life, the rising standard of living, improving health, and increasing longevity, is a process called '*technophysio evolution*', which began about 300 years ago, accelerated during the twentieth century, and is still in progress.

Thesis two: increased spending on health care and on pensions is an appropriate concomitant of technophysio evolution, and should be welcomed. Only wasteful medical services should be restricted.

Thesis three: the resources available now and in the future can provide increasingly long and healthy lives of relative luxury for all. However, methods of financing health care and retirement need to be modernized.

Thesis four: in the future luxury will be defined increasingly in terms of spiritual rather than material resources. The touchstone of well-being in the future for both young and old will be measured increasingly in terms of the quality of health and the opportunity for self-realization.

2. THESIS ONE: TECHNOPHYSIO EVOLUTION

Study of the causes of the long-term reduction in mortality point to the existence of a synergism between technological and physiological improvements that has produced a form of human evolution that is biological but not genetic, rapid, culturally transmitted, and not necessarily stable. This process is still ongoing in both rich and developing countries. Costa and I call this process 'technophysio evolution'.

Unlike the genetic theory of evolution through natural selection, which applies to the whole history of life on earth, technophysio evolution applies only to the last 300 years of *human* history, and particularly to the last century. Despite its limited scope technophysio evolution appears to be relevant to forecasting likely trends over the next century or so in longevity, the age of onset of chronic diseases, body size, and the efficiency and durability of vital organ systems (Fogel & Costa 1997). It also has a bearing on such pressing issues of public policy as the growth in population, in pension costs, and in health-care costs.

The theory of technophysio evolution rests on the proposition that during the last 300 years, particularly

‡ This paper draws on joint research reported in several earlier studies (Floud *et al*. 1990, Fogel 1992, 1993, 1994, 1997; Fogel *et al*. 1993; Lee 1996; Kim 1996; Fogel & Costa 1997) and in four books in progress (Costa 1996; Fogel 1996, 1998; Fogel *et al*. 1996).

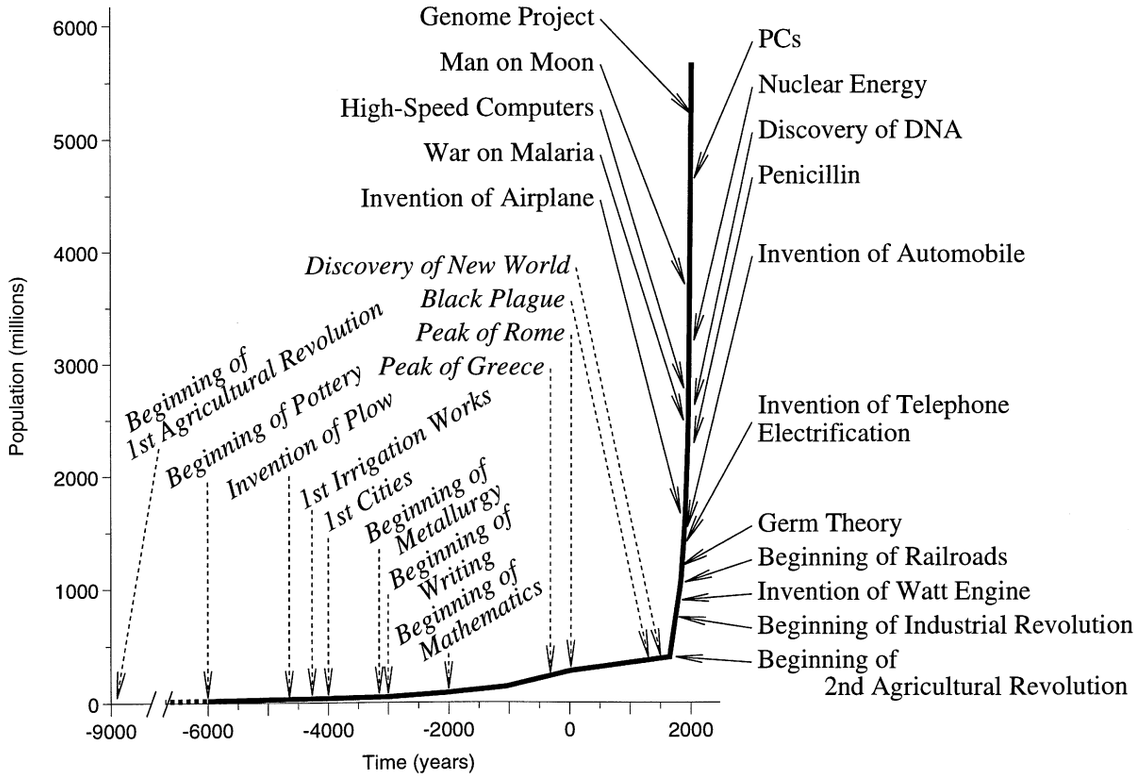

Figure 1. The growth of the world population and some major events in the history of technology. Sources: Cipolla 1974; Clark 1971; Fagan 1977; McNeill 1971; Piggot 1965; Trewartha 1969; see also, Allen 1992, 1994; Slicher von Bath 1963; Wrigley 1987. Note: there is usually a lag between the invention of a process or a machine and its general application to production. 'Beginning' means the earliest stage of this diffusion process.

during the last century, human beings have gained an unprecedented degree of control over their environment—a degree of control so great that it sets them apart not only from all other species, but also from all previous generations of *Homo sapiens*. This new degree of control has enabled *Homo sapiens* to increase its average body size by over 50%, to increase its average longevity by more than 100%, and to improve greatly the robustness and capacity of vital organ systems.

Figure 1 helps to point up how dramatic the change in the control of environment after 1700 has been. During their first 100 000 or so years, *Homo sapiens* increased at an exceedingly slow rate. The discovery of agriculture about 11 000 years ago broke the tight constraint on the food supply imposed by a hunting and gathering technology, making it possible to release between 10 and 20% of the labour force from the direct production of food, and also giving rise to the first cities. The new technology of food production was so superior to the old one that it was possible to support a much higher rate of population increase than had existed prior to *ca*. 9000 BC. Yet, as figure 1 shows, the advances in the technology of food production after the *second* Agricultural Revolution (which began about 1700 AD) were far more dramatic than the earlier breakthrough, since they permitted population to increase at so high a rate that the line of population appears to explode, rising almost vertically. The new technological breakthroughs in manufacturing, transportation, trade, communications, energy production, leisure-time services and medical services were in many respects even more striking than those in agriculture. Figure 1 emphasizes the huge acceleration in both population and technological change during the twentieth century. The increase in world population between 1900 and 1990 was four times as great as the increase during the whole previous history of humankind.

(*a*) *The escape from chronic malnutrition*

The most important aspect of technophysio evolution is the continuing conquest of chronic malnutrition, which was virtually universal three centuries ago. Even the English peerage, with all its wealth, had a diet during the sixteenth and seventeenth centuries that was deleterious to health. Although abundant in calories and proteins, aristocratic diets were deficient in vitamins and included large quantities of toxic substances, especially alcoholic beverages and salt. A diet heavy in salt and alcohol probably increased the incidence of liver, renal, gastrointestinal and cardiovascular diseases among peers who survived to middle age and may have contributed to their high mortality rates at ages 40 and over. But it was *in utero* that dietary habits of the peerage were most deadly since ladies of the realm were apparently consuming well over three ounces (85 g) of absolute alcohol per day on

Table 1. *A comparison of energy available for work daily per consuming unit in France, England and Wales, and the United States, 1700–1980 (in kcal)*

(Source: Fogel & Floud *et al.* (1996).)

year	France (1)	England and Wales (2)	United States (3)
1700[a]		720	2313
1705	439		
1750		812	
1785	600		
1800		858	
1803–12			
1840			1810
1845–54			
1850		1014	
1870	1671		
1880			2709
1944			2282
1975	2136		
1980		1793	1956

[a]Pre-revolutionary Virginia only.

average—more than enough to produce a high incidence of birth defects (Fogel 1986).

Most people in 1700 were chronically malnourished not because their diets abounded in toxic substances or were qualitatively deficient but because of severe deficiencies in dietary energy. Table 1 shows that in rich countries today some 1800 to 2000 kcal of energy are available for work by a typical adult male, aged 20–39. During the eighteenth century, however, France produced less than one-third the current US amount of energy available for work and England was not much better off. Only the US provided potential energy for work equal to or greater than late 20th century levels during the eighteenth and early nineteenth centuries, although some of that energy was wasted due to the prevalence of diarrhea and other conditions that undermined the body's capacity to utilize nutrients.

One implication of these estimates of caloric availability is that mature adults of the eighteenth and much of the nineteenth century must have been very small by current standards and less physically active. Today the typical American male in his early thirties is about 177 cm (70 inches) tall and weighs about 78 kg (162 pounds). Such a male requires daily about 1800 kcal for basal metabolism and a total of 2300 kcal for baseline maintenance. If either the British or the French had been that large during the eighteenth century, virtually all of the energy produced by their food supplies would have been required for personal maintenance, with little available to sustain work. To have the energy necessary to produce the national products of these two countries *ca.* 1700, the typical adult male must have been quite short and very light.

This inference is supported by data on stature and weight that have been collected for European nations. Table 2 provides estimates of final heights of adult males who reached maturity between 1750 and 1987. It shows that during the eighteenth and nineteenth centuries Europeans were severely stunted with mean heights that generally fell below the fifth centile of the Dutch or Norwegian standard (line 6 of table 2). Patchy estimates suggest that the average weights of males in their thirties were in the range of 20–35% below current levels. Amelioration of this retarded development, as we shall see, helps to explain the secular improvement in longevity and in the reduction of chronic diseases.

(*b*) *The connection between body size, chronic disease and premature death*

Recent studies have established the predictive power of height and body mass with respect to morbidity and mortality at later ages. The results of two of these studies are summarized in figures 2 and 3. Figure 2 presents a 'Waaler surface' in mortality. Estimated from Norwegian data, this surface relates the risk of death over an 18-year period to both height and weight simultaneously, for males aged 50–74 in 1963. Transecting the iso-mortality map are lines which give the locus of each Body Mass Index (BMI) between 16 and 34, and a curve giving the weights that minimize risk at each

Table 2. *Estimated average final heights (cm) of men who reached maturity between 1750 and 1875 in six European populations, by quarter centuries*

(Sources: For all countries except France see Fogel (1987, table 7). For France, rows 3–5 were computed from von Meerton (1989) as amended by Weir (1993), with 0.9 cm added to allow for additional growth between age 20 and maturity (Gould 1869, pp. 104–105; cf. Friedman 1982, p. 510 footnote 14). The entry to row 2 is derived from a linear extrapolation of von Meerton's data for 1815–1836 back to 1788, with 0.9 cm added for additional growth between age 20 and maturity. The entry in row 6 was taken from Fogel (1987, table 7).)

(1) date of maturity by century and quarter	(2) Great Britain	(3) Norway	(4) Sweden	(5) France	(6) Denmark	(7) Hungary
1. 18-III	165.9	163.9	168.1			168.7
2. 18-IV	167.9		166.7	163.0	165.7	165.8
3. 19-I	168.0		166.7	164.3	165.4	163.9
4. 19-II	171.6		168.0	165.2	166.8	164.2
5. 19-III	169.3	168.6	169.5	165.6	165.3	
6. 20-III	175.0	178.3	177.6	172.0	176.0	170.9

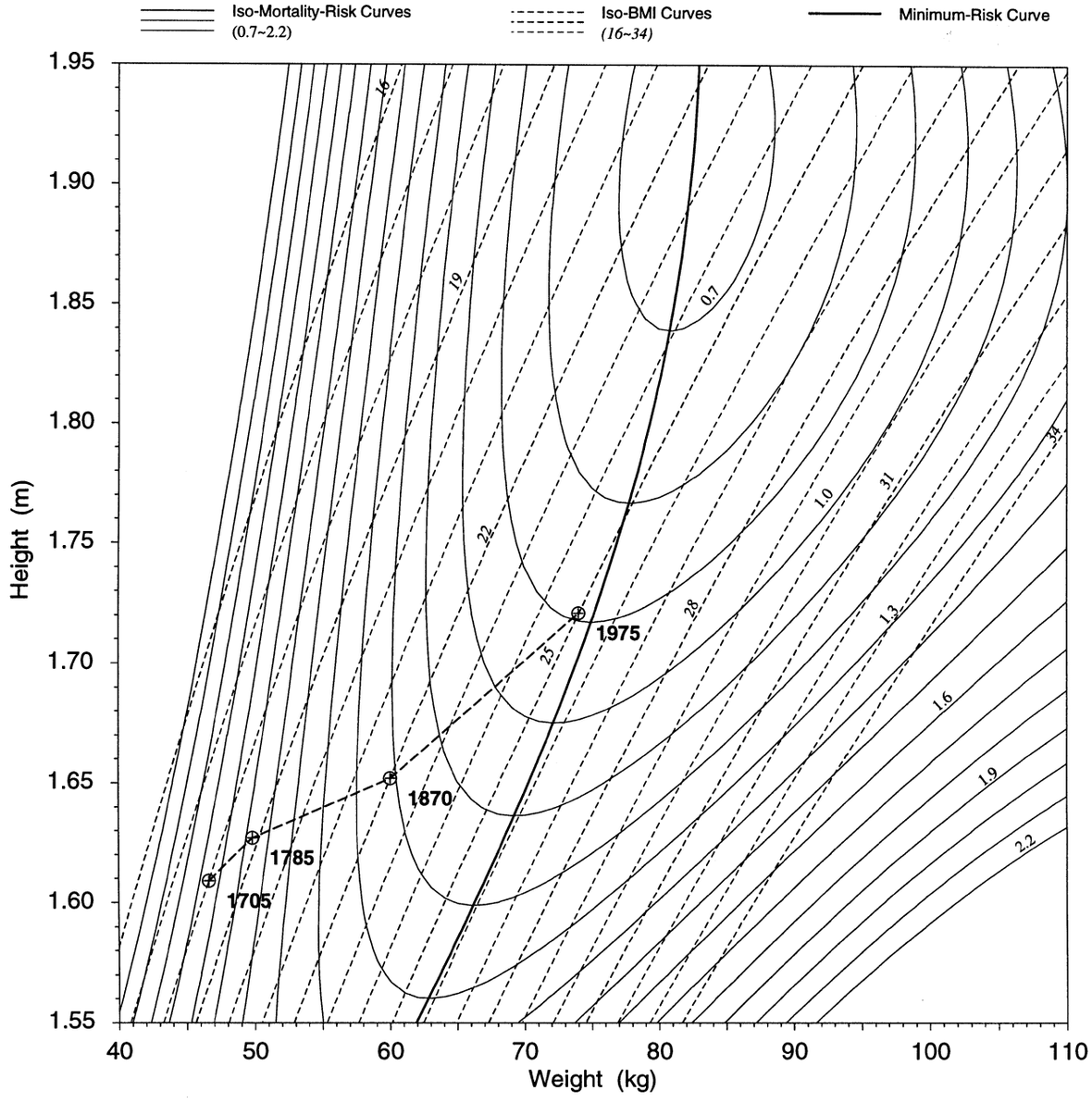

Figure 2. Iso-mortality curves of relative risk for height and weight among Norwegian males ages 50–64, with a plot of the estimated French height and weight at four dates.

height. This figure shows that even when body weight is maintained at recommended levels (BMI in the range 23–25), short men are at substantially greater risk of death than tall men. Also shown in this figure are estimates of heights and weights in France at four dates, indicating the large reductions in risk of death associated with improvement in stature and BMI (Fogel *et al*. 1996).

Poor body builds also increase vulnerability to diseases, not just contagious diseases, but chronic diseases as well. The implication of combined stunting and low BMI for the prevalence of chronic diseases is brought out by figure 3, which presents a Waaler surface for morbidity estimated from US National Health Interview Survey (NHIS) data for 1985–88. The coordinates in height and BMI of Union Army veterans who were 65 or over in 1910 and of veterans (mainly of World War II) who were the same ages during 1985–88 are also shown. These coordinates predict a decline of about 35% in the prevalence of chronic disease among the two cohorts, which is close to what actually occurred.

Table 3 compares the prevalence of chronic diseases among Union Army men aged 65 and over in 1910 with two surveys of veterans of the same ages in the 1980s. That table indicates that among the elderly heart disease was 2.9 times as prevalent, musculoskeletal and respiratory diseases were 1.6 times as prevalent, and digestive diseases were 4.7 times as prevalent among veterans aged 65 or over in 1910 as in 1985–88. Young adults born between 1822 and 1845 who survived the deadly infectious diseases of childhood and adolescence were not freer of degenerative diseases than persons of the same ages today, as some have suggested, but more afflicted.

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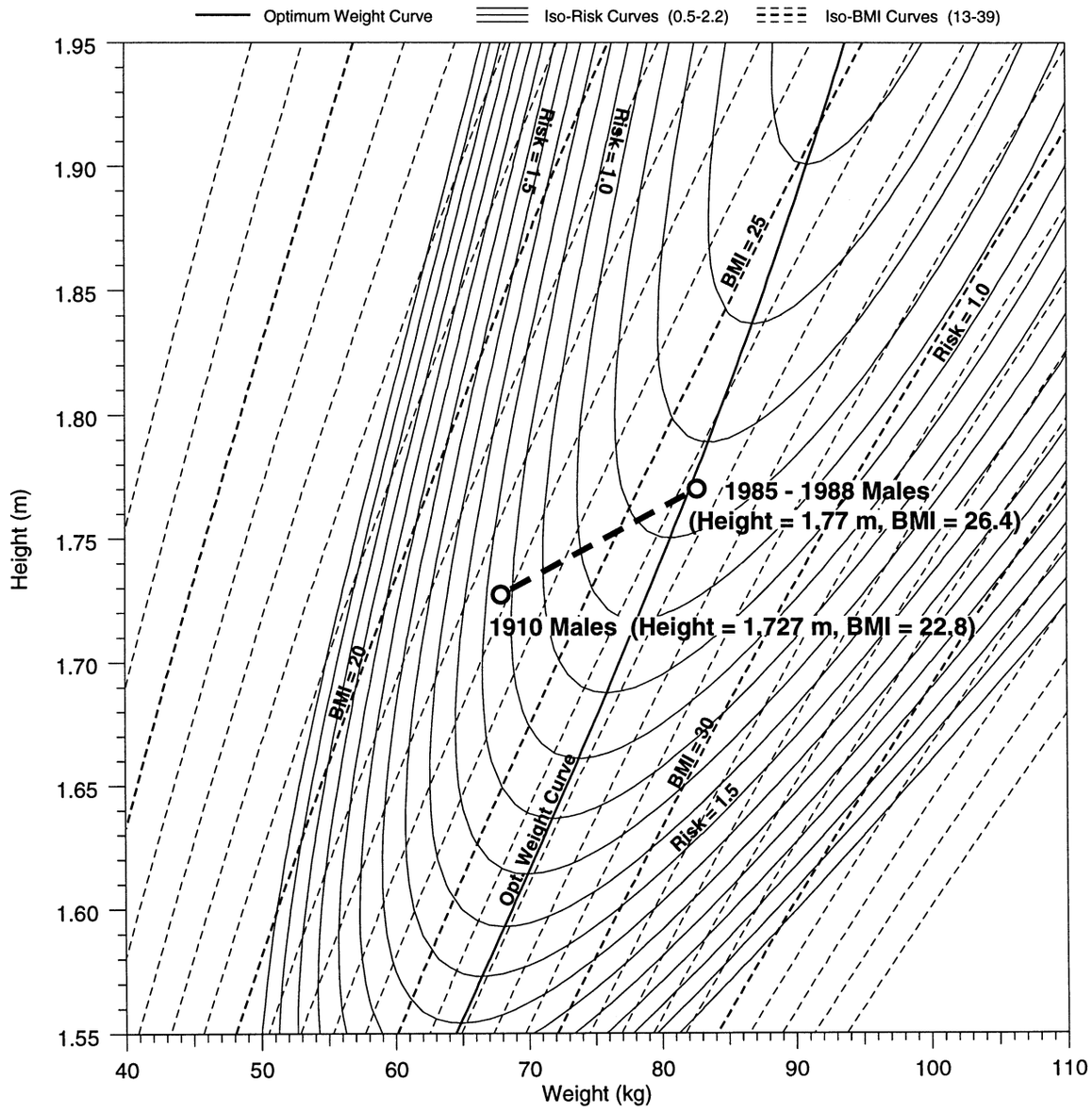

Figure 3. Health improvement predicted by NHIS 1985–1988 health surface. All risks are measured relative to the average risk of morbidity (calculated over all heights and weights) among NHIS 1985–1988 white males aged 45–64. Source: Kim (1993). Note: the point for 1910 refers to veterans of the Union army. The point for 1985–1988 refers to US veterans of World War II.

(*c*) *The physiological foundation for the link between health, longevity and body size*

Variations in height and weight appear to be associated with variations in the chemical composition of the tissues that make up vital organs, in the quality of the electrical transmission across membranes, and in the functioning of the endocrine system and other vital systems. Nutritional status thus appears to be a critical link connecting improvements in technology to improvements in human physiology.

Research on this question is developing rapidly and some of the new findings are yet to be confirmed. The exact mechanisms by which malnutrition and trauma *in utero* or early childhood are transformed into organ dysfunctions are still unclear. What is agreed upon is that the basic structure of most organs is laid down early, and it is reasonable to infer that poorly developed organs may break down earlier than well developed ones. The principal evidence so far is statistical and, despite agreement on certain specific dysfunctions, there is no generally accepted theory of cellular ageing (Tanner 1990, 1993).

With these caveats in mind, recent research bearing on the connection between malnutrition and body size and the later onset of chronic diseases can conveniently be divided into three categories. The first category involves forms of malnutrition (including the ingestion of toxic substances) that cause permanent, promptly visible physiological damage, as is seen in the

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Table 3. *Comparison of the prevalence of chronic conditions among Union Army veterans in 1910, veterans in 1983 (reporting whether they ever had specific chronic conditions), and veterans in NHIS 1985–1988 (reporting whether they had specific chronic conditions during the preceding 12 months), aged 65 and above, percentages*

(Prevailing rate of Union Army veterans are based on examinations by physicians. Those for the 1980s are based on self-reporting. Comparison of the NHIS rates with those obtained from physicians' examinations in National Health and Nutrition Survey (NHANES) II indicates that the use of self-reported health conditions does not introduce a significant bias into the comparison. See Fogel *et al.* (1993) for a more detailed discussion of possible biases and their magnitudes. Source: Fogel *et al.* (1993).)

disorder	1910 Union Army veterans	1983 veterans	age-adjusted 1983 veterans	NHIS 1985–1988 veterans
musculoskeletal	67.7	47.9	47.2	42.5
digestive	84.0	49.0	48.9	18.0
hernia	34.5	27.3	26.7	6.6
diarrhoea	31.9	3.7	4.2	1.4
genito-urinary	27.3	36.3	32.3	8.9
central nervous, endocrine, metabolic, or blood	24.2	29.9	29.1	12.6
circulatory[a]	90.1	42.9	39.9	40.0
heart	76.0	38.5	39.9	26.6
varicose veins	38.5	8.7	8.3	5.3
haemorrhoids[b]	44.4			7.2
respiratory	42.2	29.8	28.1	26.5

[a]Among veterans in 1983, the prevalence of all types of circulatory diseases will be underestimated because of under-reporting of haemorrhoids.
[b]The variable indicating whether the 1983 veteran ever had haemorrhoids is unreliable.

impairment of the nervous systems of foetuses due to excessive smoking or consumption of alcohol by pregnant women. It appears that protein calorie malnutrition (PCM) in infancy and early childhood can lead to a permanent impairment of central nervous system function. Folate and iodine deficiency *in utero* and moderate-to-severe iron deficiency during infancy also appear to cause permanent neurological damage (Scrimshaw & Gordon 1968; Martorell *et al.* 1990; Lozoff *et al.* 1991; Czeizel & Dudás 1992; Rosenberg 1992; Scrimshaw 1993; Chavez *et al.* 1995).

Not all damage due to retarded development *in utero* or infancy caused by malnutrition shows up immediately. In a recent series of studies Barker and his colleagues (1992, 1994) have reported that such conditions as coronary heart disease, hypertension, stroke, non-insulin dependent diabetes and autoimmune thyroiditis begin *in utero* or in infancy, but do not become apparent until mid-adult or later ages. In these cases, individuals appear to be in good health, and function well in the interim. However, early onset of the degenerative diseases of old age appears to be linked to inadequate cellular development early in life.

Certain physiological dysfunctions incurred by persons suffering from malnutrition can, in principle, be reversed by improved dietary intake, but they often persist because the cause of the malnutrition persists. If the malnutrition persists long enough these conditions can become irreversible or fatal. This category of consequences includes the degradation of tissue structure, especially in such vital organs as the lungs, the heart and the gastrointestinal tract. In the case of the gastrointestinal system, atrophy of the mucosal cells and intestinal villi result in decreased absorption of nutrients. Malnutrition also has been related to impairment of immune functions, increased susceptibility to infections, poor wound healing, electrolyte imbalances, endocrine imbalances, and in adults dangerous cardiac arrhythmias and increased chronic rheumatoid disorders (McMahon & Bistrian 1990).

(*d*) *Thermodynamic and physiological factors in economic growth*

So far I have focused on the contribution of technological change to physiological improvement. The process has been synergistic, however, with improvement in nutrition and physiology contributing significantly to the process of economic growth and technological progress. Since I have described this reverse relationship elsewhere, I merely want to point out the main conclusion. Technophysio evolution appears to account for about half of British economic growth over the past two centuries. Much of this gain was due to the improvement in human thermodynamic efficiency. The rate of converting human energy input into work output appears to have increased by about 50% since 1790 (Fogel 1994).

3. THESIS TWO: THE VIRTUE OF INCREASED SPENDING ON HEALTH CARE AND RETIREMENT

Since technophysio evolution is still ongoing, it is likely that improvements in health, in life expectancy and in average income will also continue. One concomitant of these changes has been a change in the structure of consumption. A century ago, the typical household in

Table 4. *Secular trends in time use: the average hourly division of the day of the average male household head (based on a 365 day year), source: Fogel (1998)*

	ca. 1880	*ca.* 1995	*ca.* 2040
sleep	8	8	8
meals and essential hygiene	2	2	2
chores[a]	2	2	2
travel to and from work[b]	1	1	0.5
work[c]	8.5	4.7	3.8
illness[d]	0.7	0.5	0.5
subtotal	22.2	18.2	16.8
residual for leisure activities[e]	1.8	5.8	7.2

[a]Includes chopping firewood, shovelling coal, repairs in homes, fences, etc., maintaining tools, gardening, carting, weaving and sewing, care of children and the aged. Much of what was called 'chores' is now called 'do-it-yourself' and 'sweat equity'.
[b]In the case of farm labourers, travel is the walk from cottages to fields where work was conducted.
[c]In *ca.* 1880: calculated on 3109 annual hours. Assumes a 64 hour work week, seven days of holidays and 18 days of illness. In 1995: calculated on 1730 annual hours. Assumes a 37.5 hour work week, 28 days of holidays and 14 sick days. In 2040: calculated on 1400 annual hours. Assumes a 30 hour work week, 30 days of holidays and 12 sick days.
[d]Sick days in *ca.* 1880 and *ca.* 1995 are based on US data and are applied to the 14 discretionary hours.
[e]Includes travel time to and from leisure-time activities. In *ca.* 1880, seven days of holidays at 14 hours per day discretionary time, provide 0.3 hours of leisure per day on a 365 day basis. The corresponding figures are 1.1 hours per day in 1995 and 1.2 hours per day in 2040.

OECD nations spent 90% of its income on food, clothing and shelter. Today these commodities account for less than half of consumption. Many people are alarmed at this and other recent changes in the structure of consumption, particularly the reduced role of manufactured products, which they fear may presage economic and social decadence and portend a reversal in national fortunes. A similar state of mind was widespread at the end of the nineteenth century. But then it was the decline of agriculture and the rise of industry that was the focus of concern. Those who identified the good life with agriculture were fearful of life in an urban and industrial age. Now it is life in a service society that promotes anxiety (Fogel 1998).

(*a*) *Changes in hours of work and use of time*

The decline in hours of work, the rise in unemployment and the threatened 'end of the job' also create anxiety, although there is another way of looking at these phenomena (Rifkin 1995; Aronwitz & DiFazio 1994). Table 4 shows the remarkable reduction in average daily work that has occurred for males in the US labour force over the past century (Fogel 1998). It also forecasts the future division of the average day, indicating that by 2040 more than half of the discretionary day will be devoted to leisure activities. The forecast is for a reduction of the work year from the current average of about 1730 hours to just 1400 hours, with the average work week down to 30 hours, paid holidays up to 30 days, and sick days at 14.

The work day of women in 1880 was somewhat longer, and in some respects may have been more arduous, than that of men. There is evidence suggesting a female workday in 1880 that may have run about 15 minutes longer than that of males, amounting to perhaps nine hours per day, on the basis of a 365 day year, or about 3200 hours annually.

As a result of the mechanization of the household, smaller families per household, and the marketing of prepared foods, the typical non-employed married woman today spends about 3.4 hours per day engaged in housework; and if she is employed the figure for housework drops to 2.1 hours. However, women in the labour force average about 4.6 hours per day as employees. Hence combining 'work' with 'chores', men and women work roughly equal amounts per day, and both enjoy much more leisure than they used to. The principal difference is that the gains of women have come exclusively from the reduction in hours of housework, while the gains of men have come from the reduction in the hours of employed work (Robinson 1988; Moffit 1968–1992).

I have so far retained the common distinction between work and leisure, although these terms are already inaccurate and may soon be obsolete. This distinction was invented when most people were engaged in manual labour for 60 or 70 hours per week and was intended to contrast with the elevated activities of the gentry or their American equivalent, Thorstein Veblen's 'leisure class' (Veblen 1934). However, it should not be assumed that members of the leisure class were indolent. In their youth they were students and athletes. In young adult years they were warriors. In middle and later ages they were judges, ministers of state, parliamentarians, bishops, landlords, planters, merchant princes, other high office holders and patrons of the arts. Whatever they did was for the pleasure it gave them since they were so rich that earning money was not their concern.

Hence, leisure is not a synonym for indolence, but a reference to desirable forms of effort or work ('work' is to be understood here in the physiological rather than the economic sense). As George Bernard Shaw put it, 'labor is doing what we must; leisure is doing what we like; and rest is doing nothing whilst our bodies and our minds are recovering from their fatigue' (Shaw 1931). To some extent presently, and more so in the future as the average work week declines toward 28 hours and retirement normally begins at age 55, these terms will lose their pejorative connotation. *Work* will increasingly mean activity under compulsion of earning income regardless of whether the effort is manual or mental. And *leisure* will mean purely voluntary activity, as was characteristic of the English gentry or Veblen's American leisure class, although it may incidentally produce income. In order to avoid confusion, I reserve the word 'work' for use in its physiological sense, an activity that requires energy above basal metabolic rate and maintenance. Activity aimed primarily at earning a living I will call *'earnwork'*.

Table 5. *Estimated trend in the lifetime distribution of discretionary time, source: Fogel (1998)*

(Discretionary time excludes time required for sleep, eating and vital hygiene, which is taken to require an average of ten hours per day. The availability of discretionary time is taken to commence with the average age of entry into the labour force and includes chores, travel to and from earnwork, and earnwork. Expected years of life after entering labour forces is 41.9 in 1880, 53.0 in 1995 and 62 in 2040. Expected years in the labour force at time of entry is 40.1 in 1880, 40.3 years in 1995 and 33 years in 2040.)

	1880	1995	2040
lifetime discretionary hours	214 100	270 800	316 800
lifetime earnwork hours	178 600	120 600	81 900
lifetime volwork hours	35 500	150 200	234 900

Purely voluntary activity, even if it incidentally carries some payment with it, I will call '*volwork*.'

It is not only daily and weekly hours of earnwork that have declined. The share of lifetime discretionary hours spent in earnwork has declined even more rapidly. Table 4 did not reflect the fact that the average age of entering the labour force is about three years later today than it was in 1880, or that the average period of retirement for those who live to age 65 is about 15 years longer today than it was in 1880 (Lee 1996).

Overall the lifetime discretionary hours spent at earning a living have declined by about one third over the past century (see table 5) despite the large increase in the total of lifetime discretionary time. In 1880 four-fifths of discretionary time was spent at earning a living. Today, the lion's share (55%) is spent doing what we like. Moreover, it appears probable that by 2040, close to 75% of discretionary time will be spent doing what we like, despite a further substantial increase in discretionary time due to the continuing extension of the life span.

Why do so many people want to forego earnwork which would allow them to buy more food, clothing, housing and other goods? The answer turns partly on the extraordinary technological change of the past century, which has not only greatly reduced the number of hours of labour the average individual needs to obtain his or her food supply, but has also made housing, clothing and a vast array of consumer durables so cheap in real terms that the totality of material of consumption requires much fewer hours of labour today than was required over a lifetime for food alone in 1880.

Indeed, we have become so rich that we are approaching saturation in the consumption, not only of necessities, but of goods recently thought to be luxuries, or which existed only as dreams of the future during the first third of the twentieth century. Today there are an average of nearly two cars per household in the US. Virtually everyone who is old enough and well enough to drive a car has one. In the case of television there are 0.8 sets per person (2.2 per household). On some items such as radios, we seem to have reached super saturation, since there is now more than one radio per ear (5.6 per household). The level of saturation on many consumer durables is so high that even the poorest fifth of households are well endowed with them (US Department of Labor, Bureau of Labor Statistics 1994; US Bureau of the Census 1996, pp. 623, 723).

Consequently, the era of the household accumulation of consumer durables which sparked the growth of many manufacturing industries during the decades following World War II is largely over in the US. Most of the future purchases of consumer durables in the US will be for replacement and for newly established households (US Department of Labor, Bureau of Labor Statistics 1994; Edmondson 1996; US Bureau of the Census 1994, 1996, p. 623).

The point is not merely that we are reaching saturation in commodities that once defined the standard of living and quality of life but also that the hours of labour required to obtain them has drastically declined. All in all, the commodities which used to account for over 80% of household consumption can now be obtained in greater abundance than previously, with less than half of either the market or the household labor once required (US Department of Labor Statistics 1959; US Department of Labor, Bureau of Labor Statistics 1994).

(*b*) *Dismantling standard working hours*

The entry of married women into the labour force on a wide scale after World War II was a major step toward dismantling fixed daily and weekly working hours (Goldin 1990). Married women often sought jobs that could be pursued at home. There was also often a preference for part-time over full-time jobs. And many preferred jobs that would permit them to work in blocks of time lasting several months, after which they could take several months off without losing the opportunity to return.

These new flexible arrangements are desired by an increasing number of workers, both men and women, who want a life that is not overwhelmed by earnwork. Although money and social status matter to these workers, they are content with a lifestyle that places greater emphasis on such values as family life, shared time, spiritual values and good health. A poll conducted in late 1995 reported that 48% of US adult earnworkers had either cut back on hours of work, declined a promotion, reduced their commitments, lowered material expectations, or moved to a place with a quieter life during the preceding five years (Marks 1995). What is at issue to such employees is time—time to enjoy the things they have, time to spend with their families, time to figure out what life is all about and time to discover the spiritual side of life (Shellenbarger 1997; Graham & Crossen 1996).

In the mid-1980s most corporations looked on non-traditional work arrangements with a jaundiced eye. Today a wide array of US corporations view these alternative working arrangements as part of an inventory of personnel policies that increase corporate productivity and reduce absenteeism, labour turnover and the cost of office space. In a recent survey more than 86% of establishments reported that they had to address

family and diversity issues to remain competitive in the current marketplace (Bohl 1996; Capowski 1996; Peak 1996; Scott 1996).

Although the average annual hours of earnwork undertaken by household heads has continued to decline over the past quarter century, the combined hours of earnwork undertaken by *households* with husbands and wives present has increased by 24% since 1969 (Moffitt 1968–1992; US Bureau of the Census 1994*b*; Robinson & Godbey 1997; cf. Schor 1991; Hochschild 1997). These extra hours are concentrated in prime working ages, and they are one of the main ways that couples are financing early retirement.

What then is the virtue of increasing spending on retirement and health rather than on goods? It is the virtue of providing consumers in rich countries with what they want most. It is the virtue of not insisting that individuals must increase earnwork an extra ten hours a week or an extra 40 000 hours per lifetime in order to produce more food or durables than they want, just because such consumption will keep factories humming. The point is that leisure time activities (including lifelong learning)—volwork—and health care are the growth industries of the late twentieth and the early twenty-first centuries. They will spark economic expansion during our age, just as agriculture did in the eighteenth and early nineteenth centuries, and as manufacturing, transportation and utilities did in the late nineteenth and much of the twentieth centuries.

The growing demand for health-care services is not due primarily to a distortion of the price system but to the increasing effectiveness of medical intervention. That increase since 1910 is strikingly demonstrated by comparing the second and last columns of the line on hernias in table 3. Prior to World War II, hernias once they occurred, were generally permanent, and often exceedingly painful conditions. However, by the 1980s about three-quarters of all veterans who ever had hernias were cured of them. Similar progress over the seven decades is indicated by the line on genito-urinary conditions, which shows that three-quarters of those who ever had such conditions were cured of them. Other areas where medical intervention has been highly effective include control of hypertension and reduction in the incidence of stroke, surgical removal of osteoarthritis, replacement of knee and hip joints, curing of cataracts and chemotherapies that reduce the incidence of osteoporosis and heart disease (Manton 1993; Manton *et al.* 1997). It is the success in medical interventions combined with rising incomes that has led to a huge increase in the demand for medical services.

4. THESES THREE AND FOUR: OPPORTUNITY FOR SELF-REALIZATION

Today, ordinary people have time to enjoy those amenities of life that only the rich could afford in abundance a century ago. These amenities broaden the mind, enrich the soul and relieve the monotony of much of earnwork. They include travel, athletics, enjoyment of the performing arts, education and shared time with the family.

Today, people are increasingly concerned with the meaning of their lives. Earthly realization was not an issue for the ordinary individual in 1880, when nearly the whole day was devoted to earning food, clothing and shelter, and whose reward was promised in heaven. A half century from now, perhaps even sooner, when increases in productivity make it possible to provide goods in abundance with half the labour required today, the issue of life's meaning and other matters of self-realization may take up the bulk of discretionary time.

The forecasts embodied in tables 4 and 5 imply that by 2040 those still in the labour force, as conventionally defined, would have over 50 hours per week of leisure (volwork), that the average age of retirement (the beginning of the full-time volwork or the end of regular earnwork) would begin about age 55, and that the average duration of full-time volwork would be about 35 years. Will OECD nations have the resources to afford amounts of leisure that would once have been considered luxurious and also provide high quality health care for an additional seven or eight years of life?

Assuming that the per capita income of OECD nations will continue to grow at a rate of 1.5% per annum, the resources to finance such expanded demands will be abundant. This is a modest growth rate, well below the long-term experience since World War II, and also well below the experience of the past decade and a half (Maddison 1991). Consider a typical new American household established in 1995 with the head aged 20 and with the spouse earning 36% of the income of the head (i.e. the spouse works part time) (Fogel 1998, chapter 5). Such a household could accumulate the savings necessary to retire at age 55, with a pension paying 60% of its peak life-cycle earnings, by putting aside 14.7% of annual earning from the year that the head and spouse enter the labour force. That pension would permit retirees at age 55 to maintain their preretirement standard of living, with a real income that would rank them among the richest fifth of householders today.

By putting aside an additional 9.4% of income the household can buy high-quality medical insurance that will cover the entire family until the children (two) enter the labour force, and also cover the parents' medical needs between the time they retire and age 83 (assumed to be the average age of death in their cohort). Saving an additional 7.8% of income will permit parents to finance the education of their children for 16 years, through the bachelor's degree at a good university.

What I have described is a provident fund of the type recently introduced or under consideration in some of the high-performing Asian economies (Iyer 1993; Poortvliet & Laine 1995). I have assumed that the savings would be invested in conservatively run funds, such as Teachers' Insurance and Annuity Association (TIAA)/College Retirement Equities Fund (CREF) which is subscribed to by most American universities for their faculties. These pension funds could be managed by the government, by private firms, or as joint ventures. The only requirement is that the funds invest in a balanced portfolio of government and

private securities that yield a respectable rate of return and are kept insulated from irrelevant political pressures. As in TIAA/CREF, individuals may be permitted modest latitude in choosing among investment opportunities.

The point of the example is that prospective real resources are adequate to finance early retirement, expanded high-quality education, and an increasing level of high-quality medical care (I assume that medical expenditures will increase to about 20% of Gross Domestic Product (GDP) by 2040). The typical working household will still have 68% of a substantially larger income than is typical today to spend on other forms of consumption. Since current levels of food, clothing and shelter will require a decreasing number of hours of work during the family's life cycle, dropping to about 20% of earnwork hours just before retirement, families will be able to increase their rate of accumulation in consumer durables and housing, or increase expenditure on such consumables as travel, entertainment and education, or reduce hours of earnwork, or retire before 55.

Embedded in my simulation is a suggestion for modernizing current government systems of taxation and expenditure. Close to half of what are called taxes are actually deferred income or forced savings. In these cases the government does not collect money for its own benefit but merely acts as an intermediary in order to insure that money needed for later use (such as retirement) by individuals is set aside for the stated purpose and then delivered to households when needed. The particular form of intermediation exercised by the US government, however, is quite peculiar. Instead of setting up an account in the name of the individual doing the savings, the government transfers the funds to a person who had earlier deferred consumption. At the same time it promises the current taxpayer that when he or she is ready to retire, the government will find new taxpayers to provide the promised funds. Under normal circumstances OECD governments provide this form of intermediation quite efficiently. The costs of administering the US social security system, for example, is less than three-fifths of 1% of expenditures (US Social Security Administration 1997).

The problem with the current system, aside from the fact that it gives the impression that personal savings are actually taxes, is that its operation is subject to heavy political buffeting. As a consequence, rates of return on the savings for deferred income are highly variable and often far lower than they would have been had they been invested in a fund similar to TIAA/CREF. Moreover, the current system is affected by variations in the fertility and mortality rates that have created financial crises and thrown into doubt the governments' promises that they will be able to provide the money supposedly set aside for later retirement income, health care, or education.

The crisis then is not in a nation's resources for providing extended retirement, improved health care, and extended education, but in the exceedingly clumsy system for financing these services. The crisis is to a large extent due to accidents of history. When the original social security systems were established prior to World War I they were intended to be class transfers. The levels of transfers were modest, supplying the elderly with barely enough food to keep them from starving. Such payments were not generally expected to cover the cost of housing or other necessities of life. Moreover, only a small percentage of a cohort was expected to live long enough to become eligible for the benefits and the average duration of support was expected to last only a few years. Under these circumstances a tax of one or two per cent on the income of the richest five per cent of the population was adequate to fund the program. The rich of Prussia and Great Britain were prepared to bear this cost for the sake of political stability.

Over the course of the twentieth century, however, the enormous increase in life expectancy and the rising standard of living led to much longer periods of retirement and much higher levels of support after retirement. Such programmes could no longer be financed through a highly concentrated class tax. To support more expensive pension systems, taxes had to be extended to the entire working population. In so doing social security programmes were transformed from redistribution schemes into systems of forced savings, although the transformation in the nature of these systems was obscure to most participants.

Modernization of the essentially self-financed programmes for retirement, health care and education from their current unsustainable systems of financing to a more transparent system of forced savings in provident funds is not easy. If provident funds were being established anew, as in the case of Malaysia, no special problem would confront OECD nations. All individuals currently in the labour force would be required to set aside 25 or 30% of their income in a TIAA/CREF type of account to use later for the specified purposes. Although that can also be done in rich countries that currently have social insurance systems, they are confronted with the burden of meeting trillions of dollars of debt to savers under the old system. It is immoral and politically impossible to default on this obligation. Nevertheless, because of demographic factors and the unstoppable movement toward early retirement some adjustment in the old system will have to be made.

The problem is one of intergenerational equity. It has been estimated that provident funds could be established today in the US, and the obligations could be met to individuals under the old system, by installing a national sales tax of 10%, which would continue until the last of the individuals who had paid into the old social security and medicare funds had died (Kotlikoff 1996). In other words, this new tax would be greatest today and gradually diminish over the next century. A difficulty with this approach is that it places the greatest burden on the current generation. It would probably be desirable to spread this debt out over several generations in order to minimize the cost of the change imposed on a particular generation. One way of spreading the burden of changing to a new system would be to borrow the funds as needed, using government securities. These securities would then be retired with taxes spread over several generations.

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The problems preventing individuals from making use of the abundant resources that they have created are purely administrative. They can be solved in a manner that does not force individuals to forego increased leisure while still in the labour force, extended retirement, expanded education for themselves and for their children, and the full benefits of modern medicine.

I have focused this analysis on the typical (median or average income) household in order to demonstrate that the economies of OECD nations have the prospective resources to permit early retirement, expanded education and expanded medical care. Unfortunately, the income of some households is so low that saving 32% of earnings would not provide a provident fund large enough to permit decent retirement, health care and education for these households. This is not a problem of inadequate national resources but of inequity. Such inequities can continue to be addressed by redistributing income from high-income to poor households by taxes and subsidies. Correcting these inequities does not require restricting retirement or health care.

Self-realization requires good health and extensive leisure. The process of technophysio evolution is satisfying these conditions. Self-realization also requires, however, an answer to the question that persons with leisure have contemplated for more than 2000 years. How do individuals realize their fullest potential? Technophysio evolution is making it possible to extend this quest from a minute fraction of the population to almost the whole of it. Although those who are retired will have more time to pursue this issue, even those still in the labour force will have sufficient leisure to seek self-realization either within their professional occupations or outside of them (Laslett 1991; Lenk 1994).

One implication of this analysis is that decision-makers both in government and in the private sector now need to review existing policies for their bearing on the timely growth of institutions that will satisfy an expanding demand for volwork. Some may consider it premature to speculate on the new forms of human activity that will come into being in order to provide solutions to the quest for self-realization. Nevertheless, I believe that one of the solutions will be lifelong education—education not to train for an occupation but to provide a better understanding of ourselves and our world. What is required is more than an expansion of existing universities and other forms of adult education. Entirely new educational forms are needed that aim at satisfying not only curiosity, but also a longing for spiritual insights that enhance the meaning of life, and that combine entertainment with edification and sociality. I believe that the desire to understand ourselves and our environment is one of the fundamental driving forces of humanity, on a par with the most basic material needs. We are lucky to be living in an age that provides vast amounts of time, much longer lives and better health to satisfy this urge.

APPENDIX 1

The figures in this sentence are computed from data on labour force participation rates by age obtained from the US Census of 1880 and from a period life table for 1880 developed by Lee (1996), from data in Pope (1992) and Haines (1992). Before age 50 the share of a cohort that is retired is estimated to be zero because death preceded retirement before that age. After age 50 retirement preceded death for an increasing proportion of a cohort. However, in 1880, the percentage of survivors who remained in the labour force did not drop to 50% until age 85. Consequently in 1880 the expected years of retirement at age 50 was only about 2.6 years, while life expectancy for males at age 50 was 20.54 years (Lee 1996). If follows that at age 50 expected length of retirement in that year was only about 13% of life expectancy ($2.6/20.54 \approx 0.127$).

The calculation is symmetrical for 1990, with retirement again presumed to begin at age 50. In 1990, however, 50% of the survivors are retired by age 63 and 90% by age 77. Consequently the expected period of retirement at age 50, which is 13.80 years, is now more than half as large as life expectancy ($13.80/26.08 \approx 0.53$). It follows that the expected length of retirement in 1990 is more than five times as large as the corresponding figure in 1880 ($13.80/2.60 \approx 5.3$).

The data already described make it possible to compute the proportion of a cohort that live to retire, which was 10% in 1880 and 71% in 1990.

Persons too malnourished for work are excluded from the calculations with respect to requirement and leisure, since, as discussed in the text, leisure requires the resources needed to do what one desires to do. Nutritionally dictated indolence is not leisure.

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