1 *Our changing bodies: 300 years of technophysio evolution*

This book is based on the belief that changes in the size, shape, and capability of the human body since the beginning of the eighteenth century both reflect and illuminate economic and demographic change over those three centuries. Such change has been immense. To take the United Kingdom as an example, its population has risen from under 5.5 million in 1700 to over 61 million today; life expectation at birth has risen from about 38 years to 75 years for males and 80 years for women; and gross domestic product per capita has risen in real terms from £1,643 to £20,790 (Wrigley 2004). Despite the setback in the world economy at the time of writing, similar changes have occurred in every other country of the developed world and are now occurring in almost every country in the world as a whole. At the same time, humans have become much taller and heavier and now experience lives which are much healthier, as well as longer, than ever before in human history.

It is only recently that the full potential of linking these apparently disparate aspects of the human experience has been realized by historians, economists, human biologists, and demographers. It was a matter of common observation during the eighteenth and nineteenth centuries that men and women from the richer groups within a given society – be it France, Britain, Belgium, or the United States – tended to be taller and heavier than those from poorer backgrounds, to suffer less from chronic and debilitating diseases, to live as long or longer and to be capable of harder and more sustained work. But the elucidation of the exact mechanisms which led to these observations – and their generalization to wider changes within economies and societies – has been a task of the late twentieth and early twenty-first centuries which is not yet complete. This book surveys the current state of knowledge of these matters, discusses some of the evidential and statistical problems which have been encountered, and suggests further lines of enquiry.

In one sense, the thesis of this book is very simple. It is, in brief, that the health and nutrition of one generation contributes, through mothers

and through infant and childhood experience, to the strength, health, and longevity of the next generation; at the same time, increased health and longevity enable the members of that next generation to work harder and longer and to create the resources which can then, in their turn, be used to assist the next, and succeeding, generations to prosper. But this relatively simple statement conceals great complexity and also requires simultaneous attention to many different aspects of human experience which have normally been considered separately by different groups of human, social, and natural scientists. Even the terms used in the simple statement above are problematic. How do we define and measure "health" or "nutrition?" What is "one generation?" Does increased longevity contribute to greater productivity or does it, as is sometimes argued, impose great costs on society through higher costs of healthcare and pensions for an ageing population?

It will be particularly surprising to many people that this book chooses to place at the center of its enquiries into these matters the size and shape of the human body. How tall or heavy, pretty or ugly, each person grows up to be is often a matter of intense interest to them and to their friends and families, but it is not widely known how much can be gleaned, from statistics arising from the measurements of groups of people, about the societies and economies from which they came, even if they lived in periods before the existence of written documents (Steckel and Rose 2002). Nor is it generally known that historians and economists are able, by linking together the many apparently disparate documents which exist from more recent periods about the bodies of men and women, to describe and analyze social and economic change, often in great detail and not only over time but over space.

There is a further feature of this book which needs to be emphasized. Like much interdisciplinary or multi-disciplinary enquiry, it seeks to link phenomena and findings of previous studies which are simultaneously obvious or taken for granted by some and a revelation to others. It is, for example, a commonplace among human biologists that improved nutrition will lead rapidly to taller, stronger and heavier children; but it comes as a surprise to some historians that humans have grown significantly taller and heavier over recent decades and that this is more likely to have been the result of improved nutrition than of evolution or of the effects of migration in changing the composition of populations. It is equally surprising to many economists that the mean height of a group within a population can be used to measure changes to

the standard of living, since they conceive of that term as being exclusively about monetary income and expenditure. Finally, it comes as a surprise to many human biologists, used to the concept of the "secular trend" in height, that historical studies show that growth in average height has been uneven and sometimes actually reversed.

There is, however, one matter that is common to all disciplines and, indeed, to all living beings: the conversion of energy into work. Human beings, from conception to death, take in energy in the form of food and warmth and expend it in body maintenance, growth, exercise, and work – both physical and intellectual. Greater inputs of energy allow men and women to work longer but also more intensively. In addition, for much of human history, intellectual work has resulted in the invention and innovation of tools which enable men and women to convert their energy more efficiently into outputs, both physical and intellectual. These tools have enabled men and women to transcend the limitations of their own individual physical capacity for work and thus, over centuries, have expanded their productivity – their lifetime output – to an enormous degree. Much of that expanded productivity has occurred during the past three centuries and the subjects of this study – centered around the size and shape of the human body – are the linkages and interactions which have made it possible. Much of the evidence for this – growth in childhood, mortality, adult living standards, labor productivity, food, or manufacturing output – has hitherto been studied as discrete topics; the ambition of this book is to link them.

1.1 A schema: technophysio evolution

There are dangers, but also benefits, in simplification and the use of analogy. Put very simply, this book will – on the basis of studies within many different disciplines – attempt to justify the use of the following schema:

1. The nutritional status of a generation – shown by the size and shape of their bodies – determines how long that generation will live and how much work its members will be able to do.
2. The work of a generation, measured both in hours, days, and weeks of work and in work intensity, when combined with the available technology, determines the output of that generation in terms of goods and services.

3. The output of a generation is partly determined by its inheritance from past generations; it also determines its standard of living and its distribution of income and wealth, together with the investment it makes in technology.
4. The standard of living of a generation determines, through its fertility and the distribution of income and wealth, the nutritional status of the next generation.
5. And so on *ad infinitum*.

It might perhaps be prudent to replace the word "determines" in each of these statements by the word "influences" or "partially determines." The former word is probably too strong, the latter two probably too weak. An alternative form of caution, beloved by economists, is to append the words *ceteris paribus* – others things being equal. The schema is certainly not put forward as a deterministic model; there are, in its workings, many historical contingencies and also many uncertainties. This book seeks to make use of the voluminous literature on these topics to assign some magnitudes, at the least, to the effects of one variable on another.

Economists will recognize this schema as a simplified form of endogenous growth theory, in which technology develops partly through investment in human capital in the form of health and education (see, for example, Mankiw, Romer, and Weil 1992; López-Casasnovas, Rivera, and Currais 2005).[1] Like such models, the schema focuses attention on the central or salient features which need to be measured and related one to the other – nutritional status, morbidity, mortality, technology, output, productivity, standard of living, investment, fertility, distribution of income and wealth. It differs from contemporary growth theory, appropriately for a work which has its genesis in economic history, in emphasizing long period change and, in particular, in its focus on the concept of "generation," which has defied attempts at precise definition but still remains useful as an heuristic device; there is no such thing as a single generation of a society, since generations overlap in very confusing ways, but it remains useful to think of the

[1] Such models have not yet fully integrated changes in health. As Morand (2005, p. 251) puts it: "additional theoretical work is needed to incorporate other mechanisms into a unified model of the long-term interaction between economic growth, population health and longevity, and that further empirical work is also needed to test the hypothesis generated by these models."

transmission of health and wealth within society in a way analogous to similar transmission within a family, where the term "generation" can more easily, though still with some difficulty, be defined.

Whatever the problems of definition, there is no doubt that from 1700 to 2000, over the course of some 12–15 human generations, all the features of this schema have been transformed in ways never seen before in human history. In the process, humankind has gained equally unprecedented control over its environment – even if it has sometimes misused that control – through the invention and application of new forms of technology. One sign of that control is that, in most if not quite all parts of the world, the size, shape, and longevity of the human body have changed more substantially, and much more rapidly, during the past three centuries than over many previous millennia. There were, of course, evolutionary changes to our bodies during those past millennia, but the change that has occurred in recent times is of a different character. It has come about, within a timescale which is minutely short by the standards of Darwinian evolution, through the application of technology, in particular to food production and distribution and to the development of means of combating disease. Fogel and Costa have named this process "technophysio evolution," linking technological with physiological change and using the word evolution – by analogy with Darwinian evolution – to emphasize the magnitude and speed of the changes that have occurred (Fogel and Costa 1997; Fogel 2004b).

As Jones has explained in his best-selling attempt to "update" Darwin's *Origin of Species*, modern evolutionary theory rests on the two fundamental principles of variation and selection. Variation in sexual populations occurs because of recombination and mutation, while evolution occurs because some of these variations will prove more or less beneficial in the environments within which they find themselves. However, although the incidence of such variations may be quite high, the pace of evolutionary change is nevertheless slow. This is because most variations are, in themselves, of limited value and need to be maintained for several generations before acquiring a "fixed character" (Jones 2000; Ridley 2004, pp. 87–89, 590–611).

The theory of "technophysio evolution" differs from conventional theories of biological evolution because it emphasizes the extent to which human beings have a unique capacity to shape their own environments; it differs also because of the rapidity of the changes which it describes. As Fogel and Costa explained in 1997: "the theory of

technophysio evolution rests on the proposition that, during the last three hundred years, particularly during the last century, humans 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*" (Fogel and Costa 1997, p. 49). This "unprecedented degree of control" has led to dramatic improvements in the "physiological capital" of human beings and in their life expectancy.

The theory of technophysio evolution also draws on recent research into the relationships between early-life health and health at older ages. Although the ideas which lie behind this research are not new, they have become increasingly influential in recent work as a result of the work of Barker and others, who have drawn attention to the fetal origins of adult disease (Barker 1992; Barker 1998). This has encouraged a large number of researchers to adopt a "life-course" approach to the study of human longevity (e.g., Ben-Shlomo and Kuh 2002).

Some of the concepts used in discussion of technophysio evolution and in the schema which will be elucidated below – such as mortality, fertility, income, or wealth – are familiar, if not always free from problems. Two, however, are less familiar or less well defined but nevertheless so important in summing up the changes that have occurred that they demand special attention at this stage: the standard of living and nutritional status.

1.2 The "standard of living" and "nutritional status"

In 1848 Thomas Babington Macaulay (later Lord Macaulay) devoted the third chapter of *The History of England* to a description of the state of England in 1685 (Macaulay 1848, pp. 209–320). Although this chapter is described by the author of the *Oxford Companion to English Literature* as "superficial and discredited" (Drabble 1985, p. 599), Macaulay displays in it a clear sense of the change in living conditions of the population which had occurred, and would occur, the difficulty of measuring such changes in human welfare, and the need to take account in any historical narrative of many different aspects of those conditions and of the distribution of the rewards of economic growth. As he concluded (Macaulay 1848, pp. 320–321):

> It is now the fashion to place the golden age of England in times when noblemen were destitute of comforts the want of which would be intolerable

to a modern footman, when farmers and shopkeepers breakfasted on loaves the very sight of which would raise a riot in a modern workhouse, when men died faster in the purest country air than they now die in the most pestilential lanes of our towns, and when men died faster in the lanes of our towns than they now die on the coast of Guiana. We too shall, in our turn, be outstripped, and in our turn be envied. It may well be, in the twentieth century, that the peasant of Dorsetshire may think himself miserably paid with fifteen shillings a week; that the carpenter at Greenwich may receive ten shillings a day; that labouring men may be as little used to dine without meat as they now are to eat rye bread; that sanitary police and medical discoveries may have added several more years to the average length of human life; that numerous comforts and luxuries which are now unknown, or confined to a few, may be within the reach of every diligent and thrifty working man. And yet it may then be the mode to assert that the increase of wealth and the progress of science have benefited the few at the expense of the many, and to talk of the reign of Queen Victoria as the time when England was truly merry England, when all classes were bound together by brotherly sympathy, when the rich did not grind the faces of the poor, and when the poor did not envy the splendour of the rich.

Macaulay encapsulates, in this passage, the difficulty of measuring what was later to be called the "standard of living" of a population. He was writing at a time when many observers were concerned at the "condition of England" under the impact of industrialization and urbanization and when Marx and Engels had just begun to mount their challenge to emergent industrial capitalism. In the process, they were to challenge also Macaulay's presupposition, which became known as the Whig interpretation of history, one of continual progress toward a better society.

During the twentieth century, historians and economists focused their discussion of living standards on the measurement of wages, adjusted for changes in the cost of living. The wages of different groups of workers were aggregated and compared with movements in the prices of "baskets of goods" representing their consumption expenditure. This had the merit of simplicity and reasonable precision, particularly if the nature of the occupations whose wages were being measured had not changed significantly. The principal drawbacks of the method were that – being based entirely on monetary income – it could not incorporate such issues as changes to the length of human life, that it did not adequately reflect the advent of new "comforts and luxuries," that it was difficult to incorporate new occupations, and that it was always

difficult to ensure that the whole, or even a majority, of the population was considered.

These deficiencies did not prevent the resultant measures of real wages being used as evidence in what has rightly been called "the most sustained single controversy in British economic history" (Mathias 1975, p. vii).[2] The controversy was essentially begun by Engels in *The Condition of the Working Class in England*, first published in Germany in 1845. During the course of the next hundred years, British economic historians became divided between the "optimists," who believed that economic growth during and after the Industrial Revolution had benefited the working classes at the time, and the "pessimists," who believed by contrast that industrialization had led to declining living standards or, worse, to the "immiseration" of the English proletariat. The controversy was so long lasting – it is, indeed, still in progress – for two main reasons. First, there was no general agreement on a definition of the "standard of living" and, second, measures of changes to real wages were ambiguous. As Von Tunzelmann put it at one stage of the debate, after examining several series of wages and prices, "the patterns of real wages ... range anywhere from an increase of 150 percent between 1750 and 1850 down to no increase at all" (1979, p. 48). While the later work of Feinstein (1998) has achieved general acceptance as to the course of changes to real wages, argument still remains on the scope of measures of living standards and the quality of life. This topic is discussed in more detail in Chapter 4 below, where account is also taken of recent contributions to the debate from Clark (2007) and Allen (2009).

In the middle of the twentieth century, living standards came to be defined by economists, even more narrowly than before, in terms of income per capita, in other words the total annual measured income of an economy divided by the number in the population. The measurement of national income, primarily due to the work of Simon Kuznets, represented an enormous step forward in the ability of economists to describe and analyze economic growth and to compare that growth over time and space. It also provided, in the shape of the calculation of real income or real gross domestic product per capita, a means of comparing the average living standards of the population of a particular

[2] Oddly, as Engerman (1997) points out, a similar controversy did not take place in Germany, France, or the United States.

country either with those of another country or with those of the past. It did not, however, remove the drawbacks of the previous calculations of real wages, in particular their exclusive concentration on monetary income. Thus, as has often been pointed out, it ignored the contribution of unpaid employment such as housework or gardening, did not value leisure time, could not incorporate improvements in the quality of goods and services unless they were reflected in prices, could not take account of changes in health and mortality, and, in general, did not measure changes to the "quality of life."[3] Nor could it reflect, without the addition of other statistics, changes in the distribution of income (both within and between households) in order to test, as Macaulay put it, whether increasing national income had "benefited the few at the expense of the many."[4]

In recent years, these problems with the use of national income analysis in the description of changes in the standard of living have been addressed in two entirely separate ways. First, a number of economists have followed Nordhaus and Tobin (1972) and Usher (1980) in seeking to make adjustments to measured income per capita so as to reflect elements of life which are not included within conventional measures of income per capita. The major such adjustments have been for non-paid work such as housework and gardening and for leisure. In similar vein, Williamson (1981; 1982) attempted to value changes to the quality of life, including morbidity and mortality, with particular reference to the growing cities of the United Kingdom in the nineteenth century. These adjustments, each dependent on a series of debatable assumptions, share the characteristic that – when put into practice – they are quite large, thus throwing further doubt on the value of the underlying calculation of income per head when making temporal and spatial comparisons.[5] The second approach has relied on the insights of Sen (see, for example, 1999) and in particular on his stress

[3] Economists such as Kuznets and Abramowitz, who devised and refined the methods of measuring the national accounts, were of course fully aware of these omissions and deficiencies and discussed them in a number of papers and books. The problem lies, however, in the use to which simple measures of GDP and other variables have been put in cross-national and temporal comparisons.

[4] In recent years, economists have paid increasing attention to the question of whether economic growth increases happiness and of how happiness can be best measured; see, for example, Layard 2006 and Bok 2010.

[5] For a very thoughtful and comprehensive account of the relationship between national income analysis and economic welfare, see Offer 2003.

on "capabilities" as the true definition of living standards. Rather than using a measure which stresses income and the command over resources which it gives at one point of time, he regards a greater standard of living as being given by an improved capability to live a rewarding and fulfilling life. Part of this is, of course, "freedom from want," and therefore in measures based on these insights, such as the Human Development Index (HDI) developed by the United Nations, income per head forms one input into the index, the others being the average expectation of life and the average literacy of the population or country being measured. This concept has been further developed by the addition, in some formulations, of measures of political and civil freedom, again because they are seen as conferring a capacity or capability (Dasgupta and Weale 1992). It is natural that the HDI, and these other formulations based upon it, produce somewhat different rankings of nations in terms of living standards from the simpler criterion of income per capita. This has the virtue of drawing attention to particular features of societies, such as the expectation of life in the United States, which is low compared to other nations with similar, or even smaller, incomes per capita.[6]

Income per capita – whether adjusted or not – reflects the output of an economy, and the command over resources which this gives to its citizens, at one point in time. The HDI, or any measure based on the concept of capability, is intended to reflect the capacity or potential of the economy and society and thus in a sense its future as well as its present.[7] The difference is not as large as it might seem, since income per capita also reflects the potential for using resources in the future, but the emphasis of the HDI is on the long term, of income per capita on the short term. Both, of course, reflect the past in the sense that income and capabilities today are both determined and constrained by their development over past decades or centuries.

For these and other reasons, it seems unnecessary or misleading to express a generalized preference for one type of measure over another. Each is designed to measure a particular feature, or set of features, of

[6] For an application of the Human Development Index to historical data for Europe, see Crafts (1997). The Human Development Index and similar indices are, of course, sensitive to the chosen, and inevitably arbitrary, weighting of the different components of the index.

[7] For a slightly different formulation, see Harris, Gálvez, and Machado 2009.