



## *The Changing Body*

Humans have become much taller and heavier, and experience healthier and longer lives than ever before in human history. However, it is only recently that historians, economists, human biologists, and demographers have linked the changing size, shape, and capability of the human body to economic and demographic change. This fascinating and groundbreaking book presents an accessible introduction to the field of anthropometric history, surveying the causes and consequences of changes in health and mortality, diet, and the disease environment in Europe and the United States since 1700. It examines how we define and measure health and nutrition as well as key issues such as whether increased longevity contributes to greater productivity or, instead, imposes burdens on society through the higher costs of health care and pensions. The result is a major contribution to economic and social history with important implications for today's developing world and the health trends of the future.

SIR RODERICK FLOUD is Provost of Gresham College, London. He is editor of *The Cambridge Economic History of Modern Britain* (Cambridge 2004) and has published many books on British economic history including *Height, Health and History: Nutritional Status in the United Kingdom, 1750–1980* (with Kenneth Wachter and Annabel Gregory, Cambridge 1990). He is a research associate at the National Bureau of Economic Research, and has received a knighthood for services to higher education.

ROBERT WILLIAM FOGEL is a professor of economics and the Charles R. Walgreen Distinguished Service Professor of American Institutions at the University of Chicago Booth School of Business, where he is Director of the Center for Population Economics. His many published titles include *The Escape from Hunger and Premature Death, 1700–2100: Europe, America, and the Third World* (Cambridge 2004). He is a research associate at the National Bureau of Economic Research, and received the Nobel Prize in Economics in 1993.

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

---

BERNARD HARRIS is Professor of the History of Social Policy at the University of Southampton. His published titles include *The Health of the Schoolchild: A History of the School Medical Service in England and Wales* (1995) and *The Origins of the British Welfare State: Society, State and Social Welfare in England and Wales, 1800–1945* (2004).

SOK CHUL HONG is Assistant Professor of Economics at Sogang University, South Korea. His current research focuses on the innovation of medical and environmental technologies and their impact on human development from a long-term perspective.

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

---

NEW APPROACHES TO ECONOMIC AND SOCIAL HISTORY

SERIES EDITORS

Nigel Goose, *University of Hertfordshire*  
Larry Neal, *University of Illinois, Urbana-Champaign*

*New Approaches to Economic and Social History* is an important new textbook series published in association with the Economic History Society. It provides concise but authoritative surveys of major themes and issues in world economic and social history from the post-Roman recovery to the present day. Books in the series are by recognized authorities operating at the cutting edge of their field with an ability to write clearly and succinctly. The series consists principally of single-author works – academically rigorous and groundbreaking – which offer comprehensive, analytical guides at a length and level accessible to advanced school students and undergraduate historians and economists.

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

*NBER Series on Long-term Factors in Economic  
Development*

A National Bureau of Economic Research Series

*Edited by* CLAUDIA GOLDIN

*Also in the series*

CLAUDIA GOLDIN

*Understanding the Gender Gap: An Economic History of American Women*  
(Oxford University Press 1990)

RODERICK FLOUD, KENNETH WACHTER, AND ANNABEL GREGORY

*Height, Health and History: Nutritional Status in the United Kingdom,  
1750–1980* (Cambridge University Press 1990)

ROBERT A. MARGO

*Race and Schooling in the South, 1880–1950: An Economic History* (University  
of Chicago Press 1990)

SAMUEL H. PRESTON AND MICHAEL R. HAINES

*Fatal Years: Child Mortality in Late Nineteenth-Century America* (Princeton  
University Press 1991)

BARRY EICHENGREEN

*Golden Fetters: The Gold Standard and the Great Depression, 1919–1939*  
(Oxford University Press 1992)

RONALD N. JOHNSON AND GARY D. LIBECAP

*The Federal Civil Service System and the Problem of Bureaucracy: The Economics  
and Politics of Institutional Change* (University of Chicago Press 1994)

NAOMI R. LAMOREAUX

*Insider Lending: Banks, Personal Connections, and Economic Development in  
Industrial New England, 1784–1912* (Cambridge University Press 1994)

LANCE E. DAVIS, ROBERT E. GALLMAN, AND KARIN GLEITER

*In Pursuit of Leviathan: Technology, Institutions, Productivity, and Profits in  
American Whaling, 1816–1906* (University of Chicago Press 1997)

DORA L. COSTA

*The Evolution of Retirement: An American Economic History, 1880–1990*  
(University of Chicago Press 1998)

JOSEPH P. FERRIE

*Yankeys Now: Immigrants in the Antebellum U.S., 1840–1860* (Oxford  
University Press 1999)

ROBERT A. MARGO

*Wages and Labor Markets in the United States, 1820–1860* (University of  
Chicago Press 2000)

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

---

PRICE V. FISHBACK AND SHAWN EVERETT KANTOR

*A Prelude to the Welfare State: The Origins of Workers' Compensation*  
(University of Chicago Press 2000)

GERARDO DELLA PAOLERA AND ALAN M. TAYLOR

*Straining at the Anchor: The Argentine Currency Board and the Search for  
Macroeconomic Stability, 1880–1935* (University of Chicago Press 2001)

WERNER TROESKEN

*Water, Race, and Disease* (MIT Press 2004)

B. ZORINA KHAN

*The Democratization of Invention: Patents and Copyrights in American  
Economic Development, 1790–1920* (Cambridge University Press 2005)

DORA L. COSTA AND MATTHEW E. KAHN

*Heroes and Cowards: The Social Face of War* (Princeton University Press 2008)

Cambridge University Press  
 978-0-521-70561-5 — The Changing Body  
 Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
 Frontmatter  
[More Information](#)

### *NBER Board of Directors*

#### OFFICERS

John S. Clarkeson, *Chairman*  
 Kathleen B. Cooper, *Vice Chairman*  
 James M. Poterba, *President and  
 Chief Executive Officer*  
 Robert Mednick, *Treasurer*  
 Kelly Horak, *Controller and Assistant  
 Corporate Secretary*  
 Alterra Milone, *Corporate Secretary*  
 Gerardine Johnson, *Assistant  
 Corporate Secretary*

#### DIRECTORS AT LARGE

Peter C. Aldrich  
 Elizabeth E. Bailey  
 Richard B. Berner  
 John H. Biggs  
 John S. Clarkeson  
 Don R. Conlan  
 Kathleen B. Cooper  
 Charles H. Dallara  
 George C. Eads  
 Jessica P. Einhorn  
 Mohamed El-Erian  
 Jacob A. Frenkel  
 Judith M. Gueron  
 Robert S. Hamada  
 Peter Blair Henry  
 Karen N. Horn  
 John Lipsky  
 Laurence H. Meyer  
 Michael H. Moskow  
 Alicia H. Munnell  
 Robert T. Parry  
 James M. Poterba  
 John S. Reed  
 Marina v. N. Whitman  
 Martin B. Zimmerman

#### DIRECTORS BY UNIVERSITY

APPOINTMENT  
 George Akerlof, *California, Berkeley*  
 Jagdish Bhagwati, *Columbia*  
 Glen G. Cain, *Wisconsin*  
 Alan V. Deardorff, *Michigan*  
 Ray C. Fair, *Yale*  
 Franklin Fisher, *Massachusetts  
 Institute of Technology*  
 John P. Gould, *Chicago*  
 Mark Grinblatt, *California, Los  
 Angeles*  
 Marjorie B. McElroy, *Duke*  
 Joel Mokyr, *Northwestern*  
 Andrew Postlewaite,  
*Pennsylvania*  
 Uwe E. Reinhardt, *Princeton*  
 Nathan Rosenberg (Director  
 Emeritus), *Stanford*  
 Craig Swan, *Minnesota*  
 David B. Yoffie, *Harvard*

#### DIRECTORS BY APPOINTMENT OF OTHER ORGANIZATIONS

Bart van Ark, *The Conference Board*  
 Jean-Paul Chavas, *Agricultural  
 and Applied Economics  
 Association*  
 Martin Gruber, *American Finance  
 Association*  
 Arthur B. Kennickell,  
*American Statistical  
 Association*  
 Thea Lee, *American Federation of  
 Labor and Congress of Industrial  
 Organizations*  
 William W. Lewis, *Committee for  
 Economic Development*

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

---

Robert Mednick, *American Institute  
of Certified Public Accountants*

Alan L. Olmstead, *Economic History  
Association*

Harvey Rosenblum, *National  
Association for Business  
Economics*

John J. Siegfried, *American Economic  
Association*

Gregor W. Smith, *Canadian  
Economics Association*

DIRECTORS EMERITI

Andrew Brimmer

Carl F. Christ

George Hatsopoulos

Saul H. Hymans

Lawrence R. Klein

Franklin A. Lindsay

Paul W. McCracken

Rudolph A. Oswald

Peter G. Peterson

Nathan Rosenberg

*Relation of the Directors to the Work and Publications  
of the NBER*

1. The object of the NBER is to ascertain and present to the economics profession, and to the public more generally, important economic facts and their interpretation in a scientific manner without policy recommendations. The Board of Directors is charged with the responsibility of ensuring that the work of the NBER is carried on in strict conformity with this object.
2. The President shall establish an internal review process to ensure that book manuscripts proposed for publication DO NOT contain policy recommendations. This shall apply both to the proceedings of conferences and to manuscripts by a single author or by one or more co-authors but shall not apply to authors of comments at NBER conferences who are not NBER affiliates.
3. No book manuscript reporting research shall be published by the NBER until the President has sent to each member of the Board a notice that a manuscript is recommended for publication and that in the President's opinion it is suitable for publication in accordance with the above principles of the NBER. Such notification will include a table of contents and an abstract or summary of the manuscript's content, a list of contributors if applicable, and a response form for use by Directors who desire a copy of the manuscript for review. Each manuscript shall contain a summary drawing attention to the nature and treatment of the problem studied and the main conclusions reached.
4. No volume shall be published until forty-five days have elapsed from the above notification of intention to publish it. During this period a copy shall be sent to any Director requesting it, and if any Director objects to publication on the grounds that the manuscript contains policy recommendations, the objection will be presented to the author(s) or editor(s). In case of dispute, all members of the Board shall be notified, and the President shall appoint an ad hoc committee of the Board to decide the matter; thirty days additional shall be granted for this purpose.
5. The President shall present annually to the Board a report describing the internal manuscript review process, any objections made by Directors before publication or by anyone after publication, any disputes about such matters, and how they were handled.
6. Publications of the NBER issued for informational purposes concerning the work of the Bureau, or issued to inform the public of the activities at the Bureau, including but not limited to the *NBER Digest* and *Reporter*, shall be consistent with the object stated in paragraph 1. They shall contain a specific disclaimer noting that they have not passed through the review procedures required in this resolution. The Executive Committee of the Board is charged with the review of all such publications from time to time.
7. NBER working papers and manuscripts distributed on the Bureau's web site are not deemed to be publications for the purpose of this resolution, but they



- shall be consistent with the object stated in paragraph 1. Working papers shall contain a specific disclaimer noting that they have not passed through the review procedures required in this resolution. The NBER's web site shall contain a similar disclaimer. The President shall establish an internal review process to ensure that the working papers and the web site do not contain policy recommendations, and shall report annually to the Board on this process and any concerns raised in connection with it.
8. Unless otherwise determined by the Board or exempted by the terms of paragraphs 6 and 7, a copy of this resolution shall be printed in each NBER publication as described in paragraph 2 above.

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

# The Changing Body

Health, Nutrition, and Human Development  
in the Western World since 1700

RODERICK FLOUD  
ROBERT W. FOGEL  
BERNARD HARRIS  
SOK CHUL HONG



Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

## CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom  
One Liberty Plaza, 20th Floor, New York, NY 10006, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India  
79 Anson Road, #06-04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9780521705615](http://www.cambridge.org/9780521705615)

© Roderick Floud, Robert W. Fogel, Bernard Harris, and Sok Chul Hong 2011

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2011

Reprinted 2011

*A catalogue record for this publication is available from the British Library*

ISBN 978-0-521-87975-0 Hardback

ISBN 978-0-521-70561-5 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

---

*To the memory of Enid Cassandra Morgan Fogel, who  
dedicated her life to helping others.*

## Contents

|                                                                                                                                                                      |                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <i>List of figures</i>                                                                                                                                               | <i>page</i> xviii |
| <i>List of tables</i>                                                                                                                                                | xxi               |
| <i>Acknowledgements</i>                                                                                                                                              | xxv               |
| 1 Our changing bodies: 300 years of technophysio evolution                                                                                                           | 1                 |
| 1.1 A schema: technophysio evolution                                                                                                                                 | 3                 |
| 1.2 The “standard of living” and “nutritional status”                                                                                                                | 6                 |
| 1.3 Understanding technophysio evolution                                                                                                                             | 15                |
| 2 Investigating the interaction of biological, demographic, and economic variables from fragmentary data                                                             | 41                |
| 2.1 Food consumption (diet) and energy cost accounting                                                                                                               | 41                |
| 2.2 Size distribution of calories                                                                                                                                    | 49                |
| 2.3 Waaler curves and surfaces                                                                                                                                       | 57                |
| 2.4 Scenarios of the possible distribution of the calories available for work in Britain                                                                             | 72                |
| Appendix A A theoretical model of the interaction of biological, demographic, and economic variables                                                                 | 77                |
| Appendix B Lognormal distribution                                                                                                                                    | 85                |
| 3 The analysis of long-term trends in nutritional status, mortality, and economic growth                                                                             | 89                |
| 3.1 Estimating the income distribution of households and identifying the location of the ultrapoor and the average income of households in England for 1759 and 1801 | 89                |
| 3.2 Problems in estimating the income elasticity of demand for food from cross-sectional data rather than longitudinal data                                          | 97                |
| 3.3 Assessing the productivity of food production in France, 1705 and 1785                                                                                           | 105               |
| 3.4 The nature of European famines                                                                                                                                   | 116               |
|                                                                                                                                                                      | xv                |

|            |                                                                                                                                                               |     |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 3.5        | How variations in body size brought the population and the food supply into balance and affected the level of mortality                                       | 119 |
| 3.6        | Contribution of improved nutrition and health to the growth of labor productivity                                                                             | 125 |
| 3.7        | Some implications for the theory and measurement of economic growth                                                                                           | 128 |
| Appendix C | Estimating the effect of changes in stature and weight on the discounted present value of the difference between earnings and maintenance over the life cycle | 131 |
| 4          | Technophysio evolution and human health in England and Wales since 1700                                                                                       | 134 |
| 4.1        | Height, weight, and body mass                                                                                                                                 | 134 |
| 4.2        | Mortality                                                                                                                                                     | 145 |
| 4.3        | Wages, nutrition, and the standard of living                                                                                                                  | 151 |
| 4.4        | Diet, nutrition, and work intensity                                                                                                                           | 164 |
| 4.5        | The contribution of other factors to the decline of mortality                                                                                                 | 170 |
| 4.6        | Morbidity                                                                                                                                                     | 180 |
| 4.7        | Cohort factors and mortality change                                                                                                                           | 186 |
| Appendix D |                                                                                                                                                               | 195 |
| 5          | Height, health, and mortality in continental Europe, 1700–2100                                                                                                | 226 |
| 5.1        | The anthropometric history of continental Europe                                                                                                              | 226 |
| 5.2        | The decline of mortality in continental Europe                                                                                                                | 242 |
| 5.3        | Economic and social change in continental Europe since 1700                                                                                                   | 258 |
| 5.4        | Health and economic development                                                                                                                               | 278 |
| 5.5        | Future prospects                                                                                                                                              | 284 |
| Appendix E |                                                                                                                                                               | 290 |
| 6          | The American experience of technophysio evolution                                                                                                             | 296 |
| 6.1        | Elimination of chronic malnutrition                                                                                                                           | 300 |
| 6.2        | Changing bodies and the escape from premature death, sickness, and poverty                                                                                    | 330 |
| 6.3        | Recent trends and future prospects                                                                                                                            | 350 |
| Appendix F |                                                                                                                                                               | 362 |

Cambridge University Press  
978-0-521-70561-5 — The Changing Body  
Roderick Floud , Robert W. Fogel , Bernard Harris , Sok Chul Hong  
Frontmatter  
[More Information](#)

---

|                                                    |      |
|----------------------------------------------------|------|
| <i>Contents</i>                                    | xvii |
| 7 Conclusion                                       | 364  |
| 7.1 What has been achieved and is now in prospect? | 365  |
| 7.2 Will these improvements continue?              | 368  |
| 7.3 What is still to be achieved?                  | 370  |
| 7.4 Possible constraints                           | 372  |
| 7.5 Conclusion                                     | 374  |
| <i>References</i>                                  | 376  |
| <i>Index</i>                                       | 423  |

## Figures

|      |                                                                                                                                                                                                |                |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 2.1  | Example of distribution                                                                                                                                                                        | <i>page</i> 51 |
| 2.2  | Comparison of the relationship between body height and relative risk in two populations                                                                                                        | 57             |
| 2.3  | Relationship between BMI and prospective risk among Norwegian adults aged 50–64 at risk (1963–1979)                                                                                            | 58             |
| 2.4  | Waalder surface of the relative mortality risk for height and weight among Norwegian males aged 50–63 with a plot of estimated French and English heights and weights since 1700 at ages 25–39 | 60             |
| A.1  | Health improvement predicted by NHS 1985–1988 health surface                                                                                                                                   | 83             |
| A.2  | Flow diagram of the model                                                                                                                                                                      | 86             |
| 3.1  | The income distribution of English households in 1759                                                                                                                                          | 92             |
| 3.2  | Comparison of the Lorenz curves for calories and for income in England during the second half of the nineteenth century                                                                        | 94             |
| 4.1  | Average BMI, by age and birth cohort, 1800–1979                                                                                                                                                | 141            |
| 4.2  | Expectation of life at birth in England and Wales, 1701–1910                                                                                                                                   | 146            |
| 4.3  | Age-specific mortality in England and Wales, 1848/52–1948/52                                                                                                                                   | 147            |
| 4.4  | Average life expectancy at different ages, 1901/10–2000/02                                                                                                                                     | 148            |
| 4.5  | Causes of death in England and Wales, 1911–2001                                                                                                                                                | 149            |
| 4.6  | Real wages (1770/2–1848/52)                                                                                                                                                                    | 153            |
| 4.7  | Food availability and life expectation at birth, 1700–1910                                                                                                                                     | 163            |
| 4.8  | Loans for public health purposes in England and Wales, 1871–1914                                                                                                                               | 174            |
| 4.9  | Percentage of persons reporting acute or chronic illnesses, 1971–2007                                                                                                                          | 184            |
| 4.10 | Percentage of patients consulting an NHS GP over a two-week period and average number of consultations per patient per year, 1971–2007                                                         | 185            |



|                                                                                                                                       |     |
|---------------------------------------------------------------------------------------------------------------------------------------|-----|
| <i>List of figures</i>                                                                                                                | xix |
| 5.1 Adult male heights in Sweden, France, and the Netherlands, 1780–1920                                                              | 229 |
| 5.2 Adult male heights in Germany, Italy, Poland, Russia, and Spain                                                                   | 230 |
| 5.3 Heights of boys in Germany, Sweden, and the Netherlands, 1865–1997                                                                | 236 |
| 5.4 Heights of boys in Greece, Hungary, Norway, and Spain, 1914–1997                                                                  | 236 |
| 5.5 Heights of boys in Italy and Slovenia, 1939–1997                                                                                  | 237 |
| 5.6 Heights of boys in Croatia, the Czech Republic, France, and Poland, 1950–1997                                                     | 237 |
| 5.7 Heights of girls in Germany, Sweden, and the Netherlands, 1865–1997                                                               | 238 |
| 5.8 Heights of girls in Greece, Hungary, and Norway, 1914–1997                                                                        | 238 |
| 5.9 Heights of girls in Italy and Slovenia, 1939–1997                                                                                 | 239 |
| 5.10 Heights of girls in Croatia, the Czech Republic, France, and Poland, 1950–1997                                                   | 239 |
| 5.11 Increases in the average heights of European adults (cm per decade)                                                              | 242 |
| 5.12 Life expectancy in western Europe, 1741–1900                                                                                     | 246 |
| 5.13 Life expectancy in western Europe, 1901–2000                                                                                     | 246 |
| 5.14 Life expectancy in central and eastern Europe, 1951–2000                                                                         | 248 |
| 5.15 Cohort-specific mortality in Denmark, 1870–1949                                                                                  | 253 |
| 5.16 Cohort-specific mortality in Finland, 1890–1949                                                                                  | 253 |
| 5.17 Cohort-specific mortality in Germany (West), 1875–1954                                                                           | 254 |
| 5.18 Cohort-specific mortality in Iceland, 1870–1949                                                                                  | 254 |
| 5.19 Cohort-specific mortality in the Netherlands, 1860–1949                                                                          | 255 |
| 5.20 Cohort-specific mortality in Norway, 1880–1949                                                                                   | 255 |
| 5.21 Cohort-specific mortality in Switzerland, 1880–1949                                                                              | 256 |
| 5.22 Cohort-specific mortality among Danish males, 1870–1949                                                                          | 257 |
| 5.23 Cohort-specific mortality among Danish females, 1870–1949                                                                        | 258 |
| 5.24 Real wages in selected European countries, 1900–1993                                                                             | 263 |
| 5.25 Percentage of the population of selected European countries residing in towns and cities containing more than 10,000 inhabitants | 277 |
| 5.26 Number of person-years in each age group, by birth cohort: Sweden, 1751–1912                                                     | 282 |
| 5.27 Life expectancy at age 65 in selected European countries, 1950–2000                                                              | 285 |

|                                                                                                                                                                                                                               |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 6.1 Trends in adult height, life expectancy, and real GDP per capita since 1700                                                                                                                                               | 299 |
| 6.2 Estimated annual probability of contracting intermittent and remittent fevers by county in the 1850s                                                                                                                      | 323 |
| 6.3 Preliminary findings on trends in disparities in infant death rates of the wards of six large US cities, 1900–1950                                                                                                        | 328 |
| 6.4 The relevance of adult height of native-born males to daily caloric intake per capita and infant mortality rate around birth year, 1800–1980                                                                              | 333 |
| 6.5 The relevance of average BMI of white males at ages 40 to 59 to daily caloric intake per capita, infant mortality rate, and working hours in the examination year, 1870–2000                                              | 337 |
| 6.6 Perinatal mortality by birth weight                                                                                                                                                                                       | 339 |
| 6.7 Trends in average birth weight and proportion of low-birth-weight (< 2,500 g) babies, white population and black population                                                                                               | 340 |
| 6.8 Comparison of relative and absolute mortality risk by height and BMI at ages 40–59, modern American non-Hispanic white males and Union Army veterans                                                                      | 341 |
| 6.9 Shift of BMI distribution and optimal BMI level, modern American non-Hispanic white males and Union Army veterans                                                                                                         | 343 |
| 6.10 Relative morbidity risk by BMI among Union Army veterans at ages 40–59 and relative risk of activity limitation by BMI among modern American non-Hispanic white males at ages 40–59                                      | 346 |
| 6.11 Comparison of relative risk of low economic productivity (non labor force participation and poverty) by BMI and relative wealth and earnings by height, modern non-Hispanic white American males and Union Army veterans | 348 |
| 6.12 US trend of economic inequality                                                                                                                                                                                          | 349 |
| 6.13 US trend in labor force participation rate by age group, 1890–2005                                                                                                                                                       | 351 |
| 6.14 Relative risk of mortality, morbidity, and poverty by BMI among modern Americans at ages 40–59 in 1986–1992, non-Hispanic white, Hispanic, and black                                                                     | 356 |
| 6.15 US trends in national health expenditure and distribution of elderly population                                                                                                                                          | 357 |

## Tables

|                                                                                                                                                                                      |                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 1.1 Mean height of military recruits by birth cohort, 1745–1749 and 1800–1804 (cm)                                                                                                   | <i>page 27</i> |
| 2.1 Examples of physical activity ratio (PAR) for males and females: energy requirements of common activities expressed as a multiple of the basal metabolic rate (BMR)              | 45             |
| 2.2 Example of the procedure for computing the factor to convert caloric consumption per capita to caloric consumption per equivalent adult male: France 1806                        | 46             |
| 2.3 Three alternative French distributions of the daily consumption of 2,413 kcal per consuming unit circa 1785, on the assumption of high, medium, and low levels of egalitarianism | 53             |
| 2.4 Comparison of probable French and English distributions of the daily consumption of kcal per consuming unit near the end of the eighteenth century                               | 56             |
| 2.5 Estimated average final heights (cm) of men who reached maturity between 1750 and 2000 in six European populations, by quarter-centuries                                         | 69             |
| 2.6 The distribution of PAL (physical activity level) among British adult males circa 1800                                                                                           | 73             |
| 2.7 A scenario for the second-lowest decile                                                                                                                                          | 73             |
| 2.8 A scenario for the highest decile                                                                                                                                                | 74             |
| 2.9 Alternative scenarios for Voth's work year                                                                                                                                       | 76             |
| 3.1 Average calories available for daily consumption in England and Wales and annual growth rates of daily caloric consumption and population, 1700–1850                             | 99             |
| 3.2 Income elasticities of the demand for calories in eight nations (computed from time-series data)                                                                                 | 105            |
| 3.3 Three alternative distributions of the daily French consumption of calories per consuming unit circa 1705                                                                        | 109            |

|      |                                                                                                                                                          |     |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 3.4  | The distribution of PAL among French adult males<br>circa 1705                                                                                           | 110 |
| 3.5  | Caloric Productivity Ratio in France c. 1785 and 1705                                                                                                    | 114 |
| 3.6  | Caloric Productivity Ratio in England and Wales in 1700<br>and 1800                                                                                      | 120 |
| 4.1  | Changes in the body mass index of British schoolchildren,<br>1905–2007                                                                                   | 142 |
| 4.2  | Changes in the height, weight, and body mass index of<br>regular army recruits, 1860/4–1970/4                                                            | 144 |
| 4.3  | Infant mortality rates, both sexes, by father’s social class,<br>in England and Wales, 1930/2–2001                                                       | 150 |
| 4.4  | Social class variations in expectation of life at different ages,<br>1972–1991                                                                           | 151 |
| 4.5  | Agricultural output, in millions of bushels, in England and<br>Wales, 1700–1850                                                                          | 155 |
| 4.6  | Average number of calories per head per day derived from<br>domestically produced cereals and pulses in England and<br>Wales, 1700–1850                  | 156 |
| 4.7  | Average number of calories available for consumption per<br>capita per day from domestically produced food sources in<br>England and Wales, 1700–1909/13 | 156 |
| 4.8  | Average number of calories available for consumption per<br>capita per day from imported food sources in England and<br>Wales, 1700–1909/13              | 159 |
| 4.9  | Average number of calories available for consumption per<br>capita per day in England and Wales, 1700–1909/13                                            | 160 |
| 4.10 | Sources of calories, by food group, in England and Wales,<br>1700–1909/13                                                                                | 161 |
| 4.11 | Changes in the composition of working-class diets,<br>1899–2000                                                                                          | 164 |
| 4.12 | Conversion factors for estimating calories per consuming<br>unit in England and Wales, 1700–1909/13                                                      | 166 |
| 4.13 | Calories per consuming unit in England and Wales,<br>1700–1909/13                                                                                        | 167 |
| 4.14 | Calories required for different types of work, 1800–1914                                                                                                 | 169 |
| 4.15 | England and Wales: relative mortalities                                                                                                                  | 178 |
| 4.16 | Percentage of patients who consulted their general<br>practitioners, 1995/6–1991/2                                                                       | 186 |

|                                                                                                                                                 |       |
|-------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| <i>List of tables</i>                                                                                                                           | xxiii |
| D.1 Changes in the average height, weight, and body mass index of British schoolchildren, 1905–2007                                             | 195   |
| D.2 Energy derived from domestically produced cereals and pulses, 1700–1850 (based on crop yields estimated by Chartres, Holderness, and Allen) | 205   |
| D.3 Energy derived from domestically produced cereals and pulses, 1700–1850 (based on crop yields estimated by Turner, Beckett, and Afton)      | 208   |
| D.4 Energy derived from domestically farmed animals                                                                                             | 210   |
| D.5 Energy derived from domestically produced dairy products                                                                                    | 211   |
| D.6 Energy derived from imported cereals and pulses                                                                                             | 212   |
| D.7 Energy derived from imported meat                                                                                                           | 217   |
| D.8 Energy derived from imported dairy products                                                                                                 | 217   |
| D.9 Energy derived from retained sugar imports                                                                                                  | 217   |
| D.10 Wine and spirits                                                                                                                           | 218   |
| D.11 Energy derived from fish                                                                                                                   | 218   |
| D.12 Energy derived from garden vegetables                                                                                                      | 219   |
| D.13 Energy derived from imported fruit and nuts, 1850                                                                                          | 219   |
| D.14 Energy derived from fruit and nuts, 1909–1913                                                                                              | 220   |
| D.15 Energy derived from potatoes                                                                                                               | 221   |
| D.16 Energy derived from domestically produced and imported foods, 1909–1913                                                                    | 222   |
| 5.1 Average life expectancy at birth, for both sexes, in selected European countries, 1741–2000                                                 | 244   |
| 5.2 Differences between life expectancy rates for males and females in selected European countries, 1751–2000                                   | 250   |
| 5.3 Construction workers' welfare ratios, 1701–1913                                                                                             | 260   |
| 5.4 Gross domestic product per capita (1990 international Geary–Khamis dollars)                                                                 | 264   |
| 5.5 Daily calorie consumption per head in western Europe, 1800–1960                                                                             | 267   |
| 5.6 The starchy staples as a percentage of all calories per capita per day                                                                      | 268   |
| 5.7 Housing conditions in Europe, 1900–1975                                                                                                     | 270   |
| 5.8 Number of years lived between the age of 15 and 44 in three Swedish birth cohorts                                                           | 280   |
| 5.9 Number of years lived at each age for both sexes, Sweden, 1751–1912                                                                         | 281   |

|      |                                                                                                                                                                               |     |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 5.10 | The impact of changes in health on changes in GDP per capita                                                                                                                  | 283 |
| 5.11 | Prevalence of disability in three birth cohorts aged 75–79 over twenty years                                                                                                  | 288 |
| E.1  | Height, weight, and BMI of children in selected European countries, 1865–1997                                                                                                 | 290 |
| 6.1  | Average annual allowances of grains and meat for widows in Middlesex County, Massachusetts, 1654–1799                                                                         | 303 |
| 6.2  | American trends of population, migration, and urbanization, 1710–1980                                                                                                         | 305 |
| 6.3  | Annual production and price of major crops in the United States, 1800–1920                                                                                                    | 307 |
| 6.4  | Annual production and price of meat products in the United States, 1800–1920                                                                                                  | 310 |
| 6.5  | Annual production and price of eggs, dairy products, vegetables, and fruits in the United States, 1800–1920                                                                   | 312 |
| 6.6  | Estimated daily caloric intake per capita, 1800–2004                                                                                                                          | 314 |
| 6.7  | Work level and productivity in the United States, 1800–2000                                                                                                                   | 319 |
| 6.8  | Summary of vital statistics, 1850–2000                                                                                                                                        | 322 |
| 6.9  | Disparity in infant mortality rate among wards of selected US large cities, 1890–1930                                                                                         | 329 |
| 6.10 | Height by sex and race, 1760–1980                                                                                                                                             | 331 |
| 6.11 | Comparison of the prevalence of selected chronic conditions among Union Army veterans in 1910, veterans in 1983, veterans in NHIS, 1985–1988, and veterans in NHIS, 1997–2006 | 345 |
| 6.12 | US trends in consumption and daily time use                                                                                                                                   | 352 |
| 6.13 | Recent trends in height, weight, and BMI by sex and age group, 1971–1974 and 1999–2002                                                                                        | 354 |
| 6.14 | Health disparities by sex, race, and income among Americans at ages 20–64 in 1997–2006                                                                                        | 359 |
| F.1  | Computing the factor to convert caloric consumption per capita to caloric consumption per equivalent adult male in the United States, 1830                                    | 362 |
| F.2  | The distribution of PAL among American adult males circa 1800                                                                                                                 | 363 |

## *Acknowledgements*

This book has been long in gestation and we have therefore benefited from the support of a number of institutions and from the comments of many scholars at seminars and conferences in a number of countries. Much of the research which is reported stems from findings from the program project “Early Indicators of Later Work Levels, Disease, and Death,” which is funded by grants from the National Institute on Aging, the National Science Foundation, the National Institutes of Health (grant no. P01 AG010120), the Walgreen Foundation, the National Bureau of Economic Research, and the University of Chicago. Other research has been supported by the Economic and Social Research Council (grant no. G00428325035), by the National Institute of Ageing (grant no. P30 AG-12857-08), London Metropolitan University, the School of Advanced Study of the University of London, the European Science Foundation, Gresham College, the University of Southampton, and Sogang University.

We are particularly indebted to our collaborators, colleagues, friends, and critics who include Brian A’Hearn, Robert Allen, George Alter, Jere Behrman, Tommy Bengtsson, Peter D. Blanck, David Blane, Hoyt Bleakley, Joseph Burton, Louis Cain, Christine K. Cassel, Dora L. Costa, Partha Dasgupta, Paul David, Lance E. Davis, Angus Deaton, Johanna T. Dwyer, Stanley Engerman, Jacob J. Feldman, Joseph P. Ferrie, Cynthia Floud, Enid M. Fogel, Patrick Galloway, Michael Haines, Ben Harris, Deborah Harris, Tim Hatton, Andrew Hinde, Jane Humphries, Matthew E. Kahn, John Kim, Merijn Knibbe, John Komlos, Anton Kunst, Elizabeth Lawler, Chulhee Lee, Kwang-sun Lee, Ronald D. Lee, Mary McNery, Robert Milward, Robert Mittendorf, Aviva S. Must, Louis L. Nguyen, Clayne L. Pope, Samuel H. Preston, Irwin H. Rosenberg, Ira M. Rutkow, Roger Schofield, T. Paul Schultz, T.W. Schultz, Nevin S. Scrimshaw, Samantha Shave, Michael Smith, Chen Song, T. S. Srinivasan, Richard Steckel, James M. Tanner, Peter Temin, Werner Troesken, James

Trussell, Athina Vlachantoni, Kenneth Wachter, Lawrence Weaver, Sven E. Wilson, Larry T. Wimmer, Len Winokur, and Tony Wrigley. Marilyn Coopersmith, Katherine A. Chavigny, and Susan E. Jones prepared and edited early drafts of some chapters. Lewis Meineke assisted with research and with verifying calculations in Chapters 2 and 3. Nathaniel Grotte has given invaluable help in preparation of the final text.

Our co-authors have, perhaps, been our sternest critics and we acknowledge, finally, the pleasure and intellectual profit which we have gained from our collaboration.