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6 Stature and Living Standards in the United States

Richard H. Steckel

The conceptual foundations and measurement of living standards have been enduring concerns for economists, human biologists, anthropologists, and other social scientists. Attempts to define and measure national income, for example, originated in the seventeenth century, while stature was used in the early nineteenth century to monitor health conditions. These and subsequent efforts to assess living conditions were sustained by several motives, including intellectual curiosity, nationalism, and desires to implement social and economic policies. The twentieth century has witnessed considerable progress in designing and implementing various measures of living standards, but scholars continue to research and debate the alternatives.

This paper briefly reviews the literature on the evolution of approaches to living standards and then applies the methodology discussed for stature to the United States from the late eighteenth through the early twentieth century. Section 6.1 of the paper emphasizes two major strands of the subject: national-income accounting and related measures, developed by economists and government policymakers, and anthropometric measures (particularly stature), developed by human biologists, anthropologists, and the medical profession. Until recently the practitioners of these seemingly diverse approaches apparently had little in common and certainly had little interaction. I compare and contrast these alternative approaches to measuring living standards and place anthropometric measures within the context of the ongoing debate over the system of national accounts.

Section 6.2 examines the relationship of stature to living standards, begin-

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ning with a discussion of sources of evidence and the growth process. A statistical analysis explores the relationship of stature to per capita income and the distribution of income using twentieth-century data.

Section 6.3 presents evidence on time trends, regional patterns, and class differences in height. The major phenomena discovered to date are the early achievement of near-modern stature, the downward cycle in stature for cohorts born around 1830 to near the end of the century, the height advantages of the West and the South, and the remarkably small stature of slave children. The secular decline in height is puzzling for economic historians because it clashes with firm beliefs that the mid-nineteenth century was an era of economic prosperity. I establish a framework for reconciling these conflicting views on the course of living standards and discuss possible explanations for the height patterns noted in the paper. The concluding section suggests directions for future research.

6.1 Intellectual History

6.1.1 National Income Accounting

The history of attempts to measure national income before the early twentieth century consists of sporadic efforts by individuals who used several different conceptual foundations and data that were often fragmentary.[1] The earliest attempts can be traced to England and France in the late seventeenth century. In 1665 Sir William Petty sought to measure a country's annual income as the sum of the annual value of labor and the annual proceeds of property. This approach anticipated the current distinction between labor income and capital income, the latter consisting of rent, interest, and profits. Shortly thereafter in France, Pierre Boisguillebert formulated a similar approach, defining national income in terms of a flow of goods and services and in terms of a flow of money incomes. In his view national income consisted of two nearly equal parts, income from labor, which was derived from peasants, artisans, factory workers, petty tradesmen, and professionals, and income from property, which consisted of land, houses, mills, toll houses, revenue-producing public offices, and money capital. Eighteenth-century scholars in England and France, who followed these pioneering efforts, tended to employ narrower concepts of national income. The French physiocrats, led by François Quesnay, defined national income in terms of consumable commodities alone and treated agriculture as the only productive occupation, while Adam Smith took a broader view, including agriculture, manufacturing, and trade but excluding services as productive. Comprehensive production and income

1. This section draws heavily on Studenski (1958), Kendrick (1970), Kendrick and Carson (1972), and United Nations Statistical Office (1980).

concepts were not firmly reestablished in this literature until Alfred Marshall set forth his ideas in the late nineteenth century.

By the beginning of the twentieth century attempts to estimate national income had filtered through much of the industrial or industrializing world. The time pattern of first attempts, presented in table 6.1, shows that the pace of diffusion was slow until the mid-nineteenth century. Although estimates were made for Russia in the late eighteenth century, these endeavors were uninfluential and largely unknown until they were rediscovered in the mid-twentieth century. In the United States the process began with George Tucker (1843), who based his estimate on the new categories of economic data first collected by the census of 1840, and continued with improvements by Ezra Seaman (1852, 1870), who made estimates for 1839, 1849, and 1859, and Edmund Burke (1848, 1849), who made estimates for 1847 and 1848.[2] In 1855 Tucker extended this work to data assembled by the 1850 census, but after the mid-nineteenth century attempts in the United States languished until the 1890s, despite the growing richness of census data collected under the direction of Francis A. Walker. By the end of the century first attempts to estimate national income extended to Austria, Germany, Australia, and Norway and by the end of World War I had reached Japan, Switzerland, the Netherlands, Italy, Bulgaria, and Spain. The Australian case in 1886 is notable as the first example of an estimate that was officially prepared and published by a government agency.

During the course of the twentieth century, national income accounting changed from the casual and sporadic activities of individual researchers to become a nearly universal, systematic endeavor sponsored by governments. The economic restructuring that followed World War I prompted interest in the subject during the 1920s. In the United States the National Bureau of Economic Research, founded in 1920, contributed substantially to the development of methodology. Desires to understand and to cope with the Great Depression stimulated progress in the 1930s. In 1932 the Senate instructed the Department of Commerce to prepare national income estimates, which were delivered in 1934 under the guidance of Simon Kuznets, who was leading the National Bureau's work in the area. Thereafter estimates were produced on an annual basis, and by the end of the decade these were supplemented by monthly and by state-level figures. By 1939 nine countries were preparing official estimates on a continuing basis. Government involvement accelerated during the 1940s with needs for fiscal and economic planning brought on by World War II. Soon after the conclusion of the war, international organizations such as the United Nations played an important role in standardizing concepts, in promoting the diffusion of government involvement in national income accounting, and in facilitating international compar-

2. For a discussion of these early estimates see Gallman (1961).

Table 6.1 First Attempts to Estimate National Income

Country	Estimator	Date or Preparation or Publication	Approach
England	Petty	1665	Value of labor and proceeds of wealth; expense of the people
France	Boisguillebert	1697	Details unavailable
Russia	Hermann (Austrian)	1790	Based on per capita consumption
United States	Tucker	1843	Net value of material production
Austria	Czoernig	1861	Net value of the principal branches of production
Germany	Rumelin	1863	Income tax statistics
Australia	Coghlan	1886	Net output
Norway	Unknown	1893	Unknown
Japan	Nakamura	1902	Net output
Switzerland	Geering and Holtz	1902	Income distributed
Netherlands	Bonger	1910	Income distributed
Italy	Santoro	1911	Net output
Bulgaria	Popoff	1915	Net output
Spain	Barthe	1917	Net output

Source: Compiled from Studenski (1958, pt. 1, "History").

isons.[3] The number of countries that systematically prepared estimates grew from 39 in 1945 to more than 130 in 1969.

During the 1920s and 1930s accounting methodology emerged as an important subject in university economics departments, and scholars debated alternative ways of conceptualizing the accounts. Controversies centered on the types of economic activity that should be included, the extent to which imputation should be used, distinctions between consumption and investment expenditures, the definitions of intermediate versus final products, the organization of subaccounts, and the classification and evaluation of government activities. One school of thought, represented by Simon Kuznets (1941, 1946, 1953), Joseph Davis (1945), and M. K. Bennett (1937), urged the development of welfare-oriented measures that would reflect the satisfaction of consumers. Kuznets argued that a welfare measure might begin with national income but that numerous refinements were necessary to incorporate items such as nonmarket activities, occupational costs, leisure, costs of urban civilization, and the distribution of the product among various groups in society. Ultimately many practical considerations were involved, and given pressures to implement a system useful for coping with the depression and wartime emergencies, the Commerce Department followed a narrower approach, defining national product as "the market value of the output of final goods and

3. On the last point see the methodology and results in Kravis, Heston, and Summers (1978), who develop an alternative to using exchange rates for converting GDPs of different countries into a common currency.

services produced by the nation's economy." This definition is useful for investigating macroeconomic matters such as savings, investment, productivity, and growth, but nonetheless is tangential to a welfare measure. Though it had recognized shortcomings, per capita gross national product soon emerged as a widely used measure of living standards.

With the major conventions of national income accounting more or less established by the 1940s, economic historians began to extend these concepts to the past.[4] By combining census data, market prices, and other sources with methods of imputation and interpolation, data series on national product and related components were constructed from the mid-nineteenth century onward for many countries. While important for understanding the extent and possible ingredients of long-run economic growth, these series typically began too late for analysis of the crucial early phase of the industrialization process. By the 1950s many economists believed that the major accounting questions had been resolved to the extent practical, and the emphasis in the emerging field of macroeconomics shifted to using the new results on national product and its components to study determinants of income, employment, and the price level. Organizations such as the Conference on Research in Income and Wealth and the United Nations continued to refine methods and to work on developing a comprehensive system of national accounts, but national income accounting lost its place as the preeminent field of research, and new cohorts of graduate students in the discipline were exposed less and less to the methodological debates and issues of earlier decades.

The 1970s witnessed a revival of interest in the methodology of social accounting. Moderation of business cycles and high rates of economic growth and accompanying disamenities in the form of urban sprawl, pollution, congestion, and crime stimulated interest in broad welfare measures. In an influential article of the early 1970s William D. Nordhaus and James Tobin (1973) asked whether growth was obsolete.[5] Taking issue with gross national product as a measure of production as opposed to welfare or consumption, they proposed a measure of economic welfare constructed by incorporating adjustments to GNP for capital services, leisure, nonmarket work, and disamenities. In a similar vein Edward Denison (1971) discussed possible components of a welfare measure and its relationship to GNP, while Richard Easterlin (1974) used surveys of human happiness to investigate whether economic growth improves the human lot.

International organizations and economists concerned with the lagging progress of the poor in Third World countries also expressed dissatisfaction in the 1970s with the focus on economic growth, urging a greater role for welfare considerations in the form of distribution and equity. The United Nations, the

4. See, for example, Conference on Research in Income and Wealth (1960).

5. This paper and others were presented in 1971 at the Conference on the Measurement of Economic and Social Performance. Moss (1973).

World Bank, and economists such as Irma Adelman and Cynthia Taft Morris (1973) have proposed what are called growth-with-equity or basic human needs approaches to living standards.[6] While there is some disagreement over the essential elements of basic needs, they may be interpreted in terms of minimum amounts of food, clothing, shelter, water, and sanitation that are necessary to prevent ill health and undernourishment (Streeten 1981). Morris (1979) took up the task of quantifying these concerns in the form of a Physical Quality of Life Index based on the infant mortality rate, the literacy rate, and life expectation at age one. In 1990 the World Bank hosted an International Society for Ecological Economics conference, "The Ecological Economics of Sustainability," which included discussion of accounting frameworks that would incorporate environmental losses.[7]

The concept of measuring results in terms of health rather than using only inputs to health has the advantage of incorporating the supply of inputs to health as well as demands on those inputs, a consideration high on the agenda of Amartya Sen's (1987) approach to the standard of living. Sen rejects the notion that the standard of living can be portrayed in terms of opulence or commodities alone, though it is influenced by them, in favor of the idea that one must consider the balance between functionings (the various living conditions that one can or cannot achieve) and capabilities (the ability to achieve various living conditions). Using the example of nutrition he observes that "to reach the same level of nutrition as another, one needs a larger command over food if one has a higher metabolic rate (or a larger body frame), or if one is pregnant (or breast-feeding), or if one has a disease that makes absorption more difficult, or if one lives in a colder climate, or if one has to toil a lot, or if food has other uses (such as for entertainment, ceremonies, or festivals)" (1987, 16). Sen (17) extends the concept of the standard of living in terms of functionings and capabilities by noting the views of Adam Smith, who discussed functionings such as not being "ashamed to appear in public." The commodities needed for this achievement vary with social customs.

While research on living standards by economists in the past two decades has moved toward welfare matters, historians have traditionally dealt with the complexity and diversity of the subject. Those who study the past, particularly the period before governments became heavily involved in data gathering, have been forced by the lack of systematic evidence into foraging among the remains of diverse sources. European historians and scholars of the colonial period in America, for example, have used sources such as probate inventories, yield-to-seed ratios, tax lists, grain reserves per family, and measures of real wages as proxies for a component of the standard of living (see, for example, Deane and Cole 1967; Jones 1980; Cipolla 1980; Lindert and Williamson 1983; and McCusker and Menard 1985).

6. See Johnston (1977) for a discussion of issues.

7. See Constanza et al. (1990) for a discussion of issues, a list of papers, and abstracts of work in the area.

6.1.2 The Evolution of Thought and Use of Stature

The history of national income accounting and that of auxology (the study of human growth) have two things in common: the first substantial efforts occurred in the seventeenth and eighteenth centuries and the early studies were sporadic, imprecise attempts made by individuals. Unlike national income, however, useful measurements of height and related attributes could be made on a small scale. Systematic national income data awaited government involvement and support in the twentieth century, while important progress in auxology had been made before the end of the nineteenth century.

Although desires to monitor social conditions or to engage in the therapeutic treatment of children have sponsored many growth studies in the past, interest in anthropometry, or measurement of the human body, did not originate with science or medicine but with the arts; painters and sculptors needed human measurements to create lifelike images.[8] Artists in this tradition were interested primarily in relative proportions rather than in absolute size, however, and the data they gathered during the Renaissance had little value for understanding processes of human growth.

Table 6.2 charts milestones in anthropometry from the perspective of human biology. The table shows that initial steps were taken in the seventeenth and eighteenth centuries, but progress was slow until the second quarter of the nineteenth century. The first person to use measurements for medical purposes may have been Sigismund Elsholtz, who tried to relate body proportions to health in the mid-seventeenth century. In the next century early attempts at systematic anthropometry appeared in the form of Jampert's measurements of orphans of various ages, Roederer's study of newborns, and the growth table of Montbeillard's son from birth to maturity.

Substantial impetus to growth studies appeared in the 1820s and 1830s when scholars realized that environmental conditions systematically influenced growth. The rise of auxological epidemiology can be traced to France, where Villerme studied the stature of soldiers; to Belgium, where Quetelet measured children and formulated mathematical representations of the human growth curve; and especially to England, where Edwin Chadwick inquired into the health of factory children. After examining the heights of soldiers in France and Holland and studying the economic conditions in their places of origin, Villerme concluded in 1829 that poverty was much more important than climate in influencing growth. The idea that human growth reflected health was put into action in reports on the stature of factory children that were submitted to Parliament in 1833. Legislation in that year incorporated stature as a criterion in evaluating minimum standards of health for child employment.

The greatest strides in the modern study of human growth occurred in the late 1800s and early 1900s with the work of Charles Roberts, Henry Bow-

8. This section draws heavily on material in Tanner (1981).

Table 6.2 Milestones in Auxology

Country	Investigator	Year	Events or Developments
Germany	Elsholtz	1654	Graduation thesis on anthropometria
Germany	Jampert	1754	Cross-section measurements of stature by age
Germany	Roederer	1754	Measured and weighed newborns
France	Montbeillard	1777	First longitudinal study from birth to adult
France	Villerme	1829	Studied environmental influences on growth
England	Chadwick	1833	First survey of factory children
Belgium	Quetelet	1842	First mathematical formulation of growth
England	Roberts	1876	Used frequency distributions to assess fitness; studied growth by social class
United States	Bowditch	1877	School surveys; analyzed velocity of growth
Italy	Pagliani	1879	Longitudinal studies; school surveys
England	Galton	1889	Studied inheritance of height; introduced regression coefficient
France	Budin	1892	First infant welfare clinic established
United States	Boas	1892–1932	Tempo of growth; concept of developmental age; growth studies in anthropology; standards for height and weight
France	Godin	1903	Detailed growth surveillance
United States	Baldwin	1921	Supervised the first large longitudinal study
England	Douglas	1946	First national survey of health and development
England	Tanner	1952	Models underlying clinical standards

Source: Compiled from Tanner (1981).

ditch, and especially, Franz Boas. Roberts's work in the 1870s increased the sophistication of judging fitness for factory employment with the use of frequency distributions of stature and other measurements, such as weight-for-height and chest circumference. Bowditch assembled longitudinal data on stature to establish the prominent gender differences in growth. In 1875 he supervised the collection and analysis of heights from Boston school children, a data set on which he later used Galton's method of percentiles to create growth standards. In a career that spanned several decades, Boas identified salient relationships between the tempo of growth and height distributions and in 1891 coordinated a national growth study, which he used to develop national standards for height and weight. His later work pioneered the use of statistical methods in analyzing anthropometric measurements and investigated the effects of environment and heredity on growth.

From the late nineteenth century onward there has been a substantial increase in the volume and quality of evidence on human growth. The school surveys of the 1870s and 1880s, noted earlier, were merely the first in a series of large-scale collection efforts. In the United States these endeavors continued with Bird T. Baldwin at the Iowa Child Welfare Research Station beginning in 1917, W. F. Dearborn and the Harvard Growth Study that began in 1922, and the studies initiated in the 1930s in response to the Great Depression, such as the Longitudinal Studies of Child Health and Development of the Harvard School of Public Health, the Child Research Council studies at the University of Colorado, and the Brush Foundation longitudinal study at Western Reserve University. The largest and longest North American longitudinal study was sponsored by the Fels Foundation and investigated Ohio families beginning in 1929. The first in a series of national studies of growth and development was begun in 1946 by England's Royal Commission of Population. The results of an explosion of growth studies throughout the world beginning in the 1950s are contained in the volume by Phyllis Eveleth and J. M. Tanner, *Worldwide Variation in Human Growth* (1976).

6.2 Stature and Living Standards

These movements devoted to assessing human welfare—national income accounting and anthropometric measures—have long, distinguished intellectual traditions that emanated to an important extent from humanitarian considerations, yet until recently there has been virtually no overlap of personnel or cross-fertilization of ideas.[9] Casual inspection of tables 6.1 and 6.2 shows that none of the major players in either field was involved in an important way in the other field.[10] Why these movements unfolded in isolation remains to be explained. Perhaps the demands of understanding and making important contributions to economics and national income accounting (or to auxology) precluded forays into other, seemingly distant areas. Perhaps the greatest flurries of activity occurred at times when these fields were particularly remote; national income accounting advanced rapidly in the 1930s and 1940s, a time when the data gathering and analysis in auxology were centered in medical enterprises and in institutions devoted to the study of child welfare, which were removed from the economics profession. Perhaps the national income accountants of the 1930s and 1940s were repelled by the perversion of human measurements and study of human form that occurred in Hitler's Germany. Whatever the explanation, I will argue the case for collaboration.

Figure 6.1 is a useful organizing device for exploring the relationship of average height to living standards. The top portion of the figure shows a circular chain of causation or influence. One portion of the chain goes from left to right: stature is a function of proximate determinants such as diet, which in turn are functions of socioeconomic variables such as income. In addition, human growth may have functional consequences for health, mental development, and personality, which in turn may influence socioeconomic conditions.

9. It may be interesting to speculate on developments that might have occurred if Franz Boas and Simon Kuznets had been collaborators.

10. It is possible, but unlikely, that an extensive study of lesser contributors in these fields would alter this conclusion that collaboration or interchange was rare, if not entirely lacking, in the past.

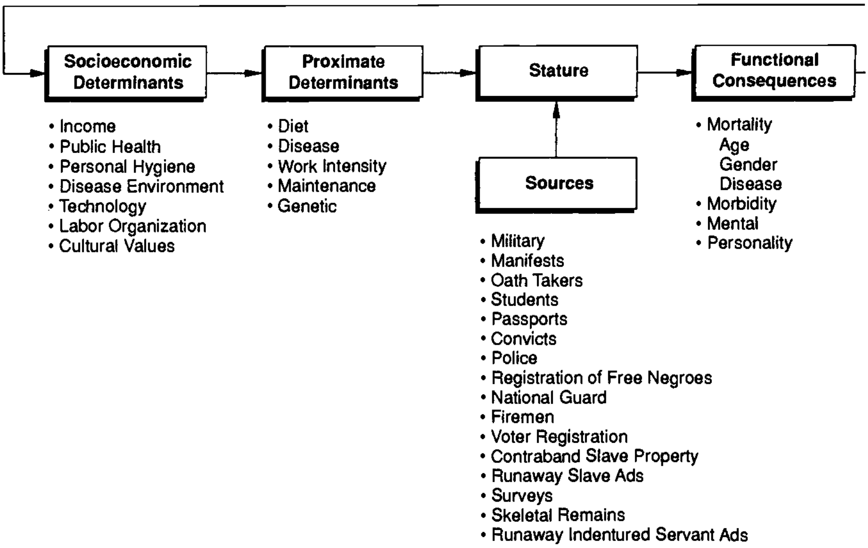

Fig. 6.1 Relationships involving stature

6.2.1 Sources of Evidence on Stature

Height can be used as a measure of living standards because measurements were widely collected from the mid 1700s onward, often as part of an identification or registration scheme for soldiers, students, slave cargoes, oath takers, or travellers. In the absence or high cost of photography, identification procedures before the present century usually relied on personal characteristics such as age, height, hair color, and complexion. Military organizations recorded stature as part of the physical exam of the mustering process, and the results were used to track deserters, to assure that compensation went to the proper individuals, and to assess the fighting capability of regiments. Heights were also useful for the manufacture of uniforms and the estimation of standard food rations. Authorities extended the physical exam and related procedures to students enrolled in military preparatory schools such as West Point. In an effort to prevent smuggling from Africa after 1807, Congress required ship captains to record slave heights on cargo manifests of the coastwise trade in the United States. Comparison of slaves in the cargo at the port of destination with the characteristics enumerated on the manifest confirmed that the slaves originated within the country. Since most black people were slaves in the antebellum American South, many localities required free blacks to register or to carry identification papers that proved their status as free persons of color. During the Civil War the Union Army collected identifying information, such as age, height, and value, on contraband slaves. Beginning in 1863 the president and Congress established an amnesty program for residents of states that were in rebellion; by confirming allegiance to the government of the United States the oath-takers regained rights as citizens. In addition, skeletal remains have proven useful for documenting stature and the nature of work, nutrition, and disease in the past.

Minimum height standards, age and height heaping, ethnic differences in growth potential, and selectivity of those measured complicates the interpretation of stature, but techniques have been devised to address these problems. Military organizations often applied minimum height standards that led to an undersampling of short individuals. The standards varied with manpower needs, and because they were flexibly enforced, the lower tail of the height distribution was eroded rather than truncated. Based on the assumption that the underlying distribution was normal or Gaussian, techniques such as the quantile bend estimator and the reduced-sample maximum likelihood estimator have been devised to identify the height below which standards were applied and to compensate for those who were omitted (Wachter and Trussell 1982).

Heaping, or concentrations of measurements at whole feet or meters, at even-numbered ages or units, and at ages or units ending in zero, plagues many data sources, including some modern studies (Fogel et al. 1983). But simulations of several cases suggest that these adverse aspects were relatively minor for estimates of sample means, primarily because their effects are largely self-cancelling. Rounding error may have affected calculated means depending on tendencies to round upward or downward to whole units of height. Rounding by the military during World War II probably biased average heights by approximately 0.5 centimeters below the actual mean. In any event, rounding practices that were uniform over time and across space would not distort comparisons of relative height averages. In addition, smoothing techniques such as the Preece-Baines models help to overcome heaping irregularities that contaminate the picture of the growth profile (Preece and Baines 1978).

It was seldom the case that the individuals measured represented the entire population about which investigators would like to draw inferences. Army volunteers, for example, typically included more unskilled and more foreign-born relative to the adult male population, and it has been alleged that slaves who were transported in the coastwise trade were rejects in poor health. Questions of sample selectivity can be addressed in three ways. One is to compare different samples from the same population. For example, the average heights of U.S. Colored Troops and slaves shipped in the coastwise trade were nearly identical, a finding that reinforces the credibility of both samples (Margo and Steckel 1982). Second, it may be possible to assign population weights to components of the sample. If laborers made up a disproportionate share of army volunteers, for example, the population mean could be calculated by appropriately reducing the weight given to their average stature. Third, in a few cases, such as Sweden beginning in 1840 and the United States during the

Civil War, all (or nearly all) men of a particular age were measured, which makes possible study of the labor market for volunteers and the characteristics of rejects. Results of this type of study may provide insights into the recruiting process elsewhere.

6.2.2 The Growth Process

The growth process following birth is organized into two periods of intense activity (Tanner 1978). The change in height, or velocity, is greatest during infancy, falls sharply, and then declines irregularly into the preadolescent years. During adolescence velocity rises sharply to a peak that equals approximately one-half of the velocity during infancy, then declines rapidly and reaches zero at maturity. In girls the adolescent growth spurt begins about two years earlier than for boys, but the magnitude of the spurt is smaller. Girls and boys are about the same height at a given age prior to adolescence in girls, but during their spurt girls temporarily overtake boys in average height. Males eventually emerge taller than females primarily because they have approximately two additional years of growth prior to their adolescent growth spurt.

The height of an individual reflects the interaction of genetic and environmental influences during the period of growth. According to Eveleth and Tanner (1976, 222),

> Such interaction may be complex. Two genotypes which produce the same adult height under optimal environmental circumstances may produce different heights under circumstances of privation. Thus two children who would be the same height in a well-off community may not only be smaller under poor economic conditions, but one may be significantly smaller than the other. . . . If a particular environmental stimulus is lacking at a time when it is essential for the child (times known as "sensitive periods") then the child's development may be shunted as it were, from one line to another.

Although genes are important determinants of individual height, studies of genetically similar and dissimilar populations under various environmental conditions suggest that differences in average height across most populations are largely attributable to environmental factors. In a review of studies covering populations in Europe, New Guinea, and Mexico, Malcolm (1974) concludes that differences in average height between populations are almost entirely the product of the environment. Using data from well-nourished populations in several developed and developing countries, Martorell and Habicht (1986) report that children from Europe or European descent, Africa or African descent, and India or the Middle East have similar growth profiles. Comparisons involving European and Far Eastern children or adults are an exception that may have a substantial genetic basis; well-off Japanese, for example, reach on average the fifteenth height percentile of the well-off in Britain (Tanner et al. 1982). Important for interpreting stature in the United States during the eighteenth and nineteenth centuries is that Europeans and people of European descent and Africans and people of African descent who grew under good nutritional circumstances have nearly identical stature (Eveleth and Tanner 1976, appendix).

It is important to realize that height at a particular age reflects an individual's history of *net* nutrition. A substantial share of food received by the body is devoted to maintenance, and other claims on the diet are made by work or physical activity and by disease. The nutrition left over for growth may be further reduced by a synergistic effect of malnutrition and illness (Scrimshaw, Taylor, and Gordon 1968). Poorly nourished children are more susceptible to infection, and infection reduces the body's absorption of nutrients. The character of stature as a net measure implies that explanations for temporal or geographic patterns must recognize not only inputs to health such as diet and medical care but also the implications of work effort and related phenomena such as methods of labor organization for growth. Similarly, researchers must attempt to understand ways that exposure to infectious disease may have placed claims on the diet.

The sensitivity of growth to deprivation depends on the age at which it occurs. For a given degree of deprivation, the adverse effects may be proportional to the velocity of growth under optimal conditions (Tanner 1966). Thus, young children and adolescents are particularly susceptible to environmental insults. At the end of a period of slow growth, normal height may be restored by catch-up growth if nutritional conditions are adequate.[11] If conditions are inadequate for catch-up, normal adult height may be approached by an extension of the growing period by as long as several years. Prolonged and severe deprivation results in stunting, or a reduction in adult size.

6.2.3 Relationship of Stature to Per Capita Income and Its Distribution

While it will be argued that income is a potent determinant of stature that operates via diet, disease, and work intensity, one must recognize that other factors may be involved. The disease load is a function of personal hygiene, public health measures, and the disease environment, while technology and methods of labor organization influence work intensity. In addition, cultural values such as the pattern of food distribution within the family, methods of preparation, and tastes and preferences for foods may also be relevant. Income is probably the most important determinant of diet (Caliendo 1979; Berg 1973). Extremely poor families may spend two-thirds or more of their income on food, but a high proportion of very low income purchases few calories. Malnutrition associated with extreme poverty is known to have a major impact on height. Once calorie requirements are satisfied, additional expenditures on food purchase largely variety, palatability, and convenience.

Impoverished families can afford little medical care, and additional income

11. Ingestion of toxic substances, such as alcohol or tobacco, in utero or in early childhood may create permanent stunting regardless of nutritional conditions.

may have an important effect on health through control of infectious diseases. While tropical climates have acquired a bad reputation for diseases, Maurice King (1966) argues that poor health in developing countries is largely a consequence of poverty rather than climate. There is a group of diseases that are spread by vectors that need a warm climate, but poverty is responsible for the lack of doctors, nurses, drugs, and equipment to combat these and other diseases. Poverty, via malnutrition, increases the susceptibility to disease.

Gains in stature associated with rising income are not limited to developing countries. Within industrialized countries height rises with socioeconomic class (Eveleth and Tanner 1976, 34). These changes in height may be related to improvements in the diet, reductions in physical work loads, and better health care. Expenditures on health services rise with income, and there is a positive relationship between health services and health (Fuchs 1972).

At the individual level, extreme poverty results in malnutrition, retarded growth, and stunting. Higher incomes enable individuals to purchase a better diet, and height increases correspondingly, but once income is high enough to satisfy caloric requirements, there is little further increase related to change in the diet. Height may continue to increase with income because more or better medical care services are purchased. As income increases, consumption patterns change so that more and more of a person's genetic potential is realized, but once the potential is reached, environmental variables have no more effect. The limits to this process are clear from the fact that people who grew up in very wealthy families are not physical giants.

If the relationship between height and income is nonlinear at the individual level, then the relationship at the aggregate level depends upon the distribution of income. Average height may differ for a given per capita income depending on the fraction of people with insufficient income to purchase an adequate diet. Since the gain in height at the individual level increases at a decreasing rate as a function of income, one would expect average height at the country level to rise, for a given per capita income, with the degree of equality of the income distribution (assuming there are people who have not reached their genetic potential). Therefore one should proceed with caution to estimate and interpret the relationship between per capita income and average height at the aggregate level.

The aggregate relationship between height and income can be explored by matching the results of the extensive height studies tabulated in Eveleth and Tanner (1976) with per capita income data compiled by Summers, Kravis, and Heston (1980) for market-oriented economies and by the World Bank (1980) for centrally planned economies.[12] The tables in the appendix of the Eveleth and Tanner volume give the same type of information for each study, includ-

12. The method of comparative evaluation is an issue in the use of per capita income data for various countries. It would be desirable to have data based on detailed price and output comparisons, as suggested in Summers, Kravis, and Heston (1980), but the number of countries for which data are available is insufficient for the type of analysis undertaken here.

ing country, the people or place, height by year of age up to age eighteen (heights are not available for some ages), and adult height. The volume includes several national studies of height as well as studies of numerous smaller groups within these populations, such as rural, urban, student, military, poor, and rich residents. Despite the large number of factors that may influence average height at a given level of per capita income, there is a high correlation between these variables. Table 6.3 shows that simple correlations between average height and the log of per capita income are in the range of 0.84 to 0.90.[13]

The analysis of average height can be expended to include studies of various subsets of a country's population by employing a regression framework. I examine adolescents and adults separately because the independent variables may have different effects on the heights of these groups. The independent variables available, in addition to the log of per capita income, include a Gini coefficient, which is a measure of income inequality that varies from zero (complete equality) to one (complete inequality), and dummy variables representing poor, rich, urban, rural, university student, and military residents.[14] The urban, rural, and student variables may operate as proxies for income; the poor tend to be located in rural areas, and university students tend to come from high-income families. The effects of military employment are unclear; some countries have minimum height standards while others have universal service, and the bulk of the personnel in many countries is drawn from lower socioeconomic classes. The height studies include populations of Europeans, Africans, Asians, Indo-Mediterraneans, and people with European ancestry or African ancestry.[15] The ethnic variables could measure genetic factors or environmental influences (other than income) such as food prices, health care availability, the disease environment, cultural factors affecting food use, and so forth. The equation for children includes those from ten to fourteen years, ages at which growth is particularly sensitive to environmental influences.

Table 6.4 sets forth the estimated equations.[16] The income variable, the

13. The functional form of the relationship was explored by regressing average height on various polynomials in per capita income and the log of per capita income. There is a substantial improvement in fit by going from the linear to the quadratic formulation and a slight additional improvement from the quadratic to the cubic. Because the semilog form fits approximately as well as the cubic but is simpler, results are reported for the semilog formulation.

14. Attained height is a function of income during the years of height growth, and a more elaborate model would include several lagged values of per capita income. In view of the large differences in per capita income across countries, lagged values would probably add little to the analysis, and one may question whether their inclusion would justify the additional complexity. It should be noted that some research on the lagged relationship between income and stature, which is discussed below, has gone forward for the Netherlands (Brinkman, Drukker, and Slot 1988).

15. There are no observations on adult Africans due to a lack of income distribution data.

16. While it is safe to argue that causation runs one way from per capita income to the heights of children, per capita income and adult height are jointly determined. Height is an index of health and nutrition, and the health and nutrition of workers are known to affect output (see, for example, Weisbrod 1961; Mishkin 1962; Perlman 1966; Meeker 1974). Healthy workers have greater physical vigor, fewer days lost from work, and longer working lives. By using two-stage least squares

Table 6.3 Correlations between Average Height and the Log of Per Capita Income

Group	Correlation	Number of Countries
Boys aged 12[a]	0.90	16
Girls aged 12[a]	0.89	15
Adult men[b]	0.84	16
Adult women[b]	0.90	17

Sources: Calculated from data in Eveleth and Tanner (1976), Summers, Kravis, and Heston (1980), and World Bank (1980). The results are reproduced from Steckel (1983).

[a]The countries represented for boys and girls are Czechoslovakia, Egypt, German Democratic Republic, Ghana, India, Japan, Lebanon, the Netherlands, New Zealand, Republic of Korea, Soviet Union, Taiwan, United States, and Uruguay; the boys also include Mozambique. The United States has two height studies.

[b]The countries represented for adults are Bulgaria, Czechoslovakia, India, Indonesia, the Netherlands, Paraguay, Soviet Union, Taiwan, and the United States. The adult men sample also includes Denmark and Zaire, and the adult women sample also includes France, New Zealand, Republic of Korea, and Ireland. India and Zaire have multiple height studies.

Gini coefficient, and the rural, poor, and rich variables have the expected signs.[17] The findings on per capita income and the Gini coefficient are noteworthy results that are discussed at various points in the remainder of the paper. The negative sign of the urban variable may reflect inflows of short people from rural to urban areas; many urban areas also have large numbers of poor people and congested living conditions that spread communicable diseases. Minimum height standards may dominate the effects of the military variable. The coefficient of the gender variable is positive among adolescents,

it is not necessary to specify the complete model involving adult height and per capita income; exogenous variables excluded from the height equation must be used, though, to identify the height equation. Any reasonable model of per capita income determination would probably include the value of the capital stock per worker, a measure of human capital per worker, and the percentage of the population of working age. Reliable estimates of the capital stock per worker are available for only a few countries, and therefore the other exogenous variables are used to identify the height equation. The adult literacy rate is used as a measure of human capital.

In the data of this study the correlation between expectation of life at birth and the log of per capita income is about .88. Consequently, estimates of the separate effects of these variables on height are unreliable. Although the regressions include only the log of per capita income, the estimated coefficients of this variable reflects the effects of both income and health.

17. One cannot rule out the possibility that the Gini coefficient is an indicator for other variables. It has been argued, for example, that income eventually becomes more evenly distributed during the course of economic growth (Kuznets 1955). The correlation between the log of per capita income and the Gini coefficient is only about −.17 in these data. The range of the Gini coefficient is .314 to .568 in the adult regression and .204 to .537 in the adolescent regression.

The results for adults are not sensitive to the method of estimation. Ordinary least squares estimates are similar to the two-stage least squares estimates reported for adults in table 6.4. The OLS coefficients of the Gini and the log of per capita income variables are −36.2 and 3.1, respectively.

Coefficients for "poor" and "rich" variables are absent in the adult regressions because height studies were lacking for these classes of residents in the data sources for adults.

Table 6.4 **Regressions of Average Height on Per Capita Income, Gini Coefficient, Place of Residence, Gender, Ethnic Group, and Age**

	Adolescents		Adults	
Variable	Coefficient	*t*-value	Coefficient	*t*-value
Intercept	116.0	33.38	160.5	13.99
Log per capita income	3.545	7.644	3.490	2.223
Gini coefficient	−8.260	1.283	−36.74	4.408
Urban	−0.3085	0.3591	−0.1478	0.0909
Rural	−3.392	3.539	−2.524	1.315
Poor	−7.968	4.938		
Rich	5.483	6.426		
Student			1.225	1.148
Military			2.599	1.765
Female	0.1171	0.2637	−11.24	16.05
European ancestor	−4.452	3.313	−1.170	0.5954
African	−0.6789	0.3187		
African ancestor	−3.328	2.010	−1.903	0.9970
Asian	−6.315	4.582	−1.673	0.6294
Indo-Mediterranean	−4.531	2.166	2.321	0.7658
Age 11	5.250	7.961		
Age 12	11.11	16.85		
Age 13	16.81	24.80		
Age 14	21.43	31.32		
R^2	0.92			
N	163		30	
Method	OLS		2SLS	

Sources: Calculated from data in Eveleth and Tanner (1976), Ginsberg (1961), Jain (1975), Summers, Kravis, and Heston (1980), UNESCO (1957), and World Bank (1980). The results are reproduced from Steckel (1983).

Notes: Dependent variable = average height in centimeters. Income is measured in 1970 U.S. dollars for the year that the height study was published. The omitted class refers to a national height study of Europeans. Age ten is an excluded variable in the regression on adolescent height. Observations on "poor" and "rich" groups do not exist for the adults.

The countries represented for adolescents are Argentina, Egypt, German Democratic Republic, Hong Kong, India, Japan, Republic of Korea, Lebanon, Malaysia, New Zealand, Spain, Sudan, Taiwan, United States, Uruguay, and Yugoslavia. The countries represented for adults are Egypt, France, Hong Kong, India, Republic of Korea, New Zealand, Taiwan, Thailand, Turkey, United Kingdom, and the United States. Several counties have more than one height study.

probably because girls begin the growth spurt earlier than boys. The ethnic variables may capture possible genetic differences, but in view of the important role attributed to environment by human biologists, environmental factors may underlie the results. Among adults the ethnic variables have no statistically significant effect, but among children all ethnic variables are negative, and four out of five are statistically significant. This finding may reflect the fact that children are relatively sensitive to the environment; some deprivation in childhood may be overcome by an extension of the growing period. Our understanding of environmental consequences would be improved by analysis of individual level data.

Table 6.5 depicts the estimated relationship between average height and per capita income derived from the regressions in table 6.4 under the assumptions that the Gini coefficient was evaluated at the sample mean and the group was people with European ancestors. Height is particularly sensitive to income at low income levels. Among boys aged 12, for example, height increases by 6.7 centimeters as per capita income increases from $150 to $1,000, whereas the gain is 5.7 centimeters as per capita income increase from $1,000 to $5,000.

The relationships given in table 6.5 suggest that it may be feasible to use data on average height to infer levels of per capita income. Because other factors also influence height, one should proceed with caution in this endeavor. A reduction in the Gini coefficient of 0.2, for example, increases average adult height by more than 7 centimeters. Moreover, changes or differences in public health measures, personal hygiene, the disease environment, or methods of labor organization could lead to different levels of average height for a given per capita income. Despite this possibility, Roderick Floud's (1984) study of per capita income and average heights in Europe from the mid-nineteenth through the mid-twentieth century, using an analysis similar to that in Steckel (1983), suggests that the relationship may have been relatively stable. The pattern of Floud's results, given in table 6.6, is remarkably similar to that reported in table 6.5. This stability gives credence to more recent attempts to "backcast" per capita income using a polynomial distributed lag model. Brinkman, Drukker, and Slot (1988) estimate such a model for the Netherlands, based on data for the years 1900 to 1940, to predict levels of per capita income beginning in 1845. Their results challenge claims that substantial economic development, as measured by per capita income, occurred in the Netherlands before the mid-1800s.

Table 6.5 Estimated Relationship between Average Height (centimeters) and Per Capita Income

Per Capita Income (1970 U.S. $)	Boys Aged 12	Girls Aged 12	Adult Men	Adult Women
150	137.1	137.2	160.9	149.7
250	138.9	139.0	162.7	151.4
500	141.4	141.5	165.1	153.9
1,000	143.8	143.9	167.5	156.3
2,000	146.3	146.4	169.9	158.7
3,000	147.7	147.8	171.4	160.1
4,000	148.7	148.8	172.4	161.1
5,000	149.5	149.6	173.1	161.9

Source: Calculated from table 6.4, assuming a national study for a population with European ancestors and a Gini coefficient evaluated at the sample mean.

Table 6.6 Relationship between Height and Per Capita Income in Europe

Per Capita Income (1970 U.S. $)	Average Height (centimeters)
500	163.8
1,000	166.9
2,000	169.9
3,000	171.7
4,000	173.0

Source: Floud (1984, table 3). The results are calculated assuming a national height study for Italy using a semilog model.

In contrast, the data for the United States (discussed below) show that native-born Americans were tall despite their low per capita income. If plausible levels of per capita income that existed in 1800 (Weiss, chap. 1 of this volume; converted to 1970 dollars using U.S. Bureau of the Census 1975) were substituted into table 6.5, for example, predicted stature would be roughly 9 centimeters below the level observed. While no firm answer to this question is currently available, there are several promising potential explanations. First, the degree of wealth or income inequality in early America may have been low compared with developing countries, a line of inquiry made attractive by the finding that average height is sensitive to the Gini coefficient. Many developing countries are characterized by considerable income inequality, and probate records suggest that inequality in wealth was modest in the late-eighteenth-century America (Jain 1975; Jones 1980). Second, the relationship between height and per capita income expressed in table 6.5 depends upon income comparisons calculated using exchange rates, but work by Summers and Heston (1991) using purchasing-power-parity concepts shows that exchange rates systematically underestimate the real income of poor countries compared with rich ones. A sense of the importance of this methodology for understanding height comparisons in the United States can be obtained by substituting relative per capita GNP in the United States in 1800 into the framework of results obtained by Summers and Heston. U.S. GNP per capita in 1800 (Weiss, table 6) adjusted for price changes (U.S. Bureau of the Census 1975, ser. E 135–166; U.S. Department of Labor 1991) was about 5.5 percent of that in 1980 (World Bank 1982). At this level of income relative to that in the United States in 1980, real income measured by purchasing power parity is, on average, roughly double that measured by exchange rates (Summers and Heston 1991, figure 1), which would explain about one-quarter of the 9-centimeter difference between predicted (according to the height-income relationship expressed in table 6.5) and observed heights given per capita income that prevailed in 1800. These calculations assume, among other things, that incomes in the early-nineteenth-century United States can be treated like the per capita incomes of poor countries today within the Summers-Heston framework, something that awaits verification. While these calculations should be refined and their underlying assumptions investigated, these preliminary results suggest that the method of comparing incomes is relevant, but not a dominant factor in understanding the early achievement of near-modern stature in the United States.

A third line of investigation (discussed in more detail below) would explore differential experience made by claims on the diet associated with disease. Given the relatively low density of population in the late eighteenth century, it is plausible that Americans were exposed less to communicable diseases than the typical resident of a developing country in the twentieth century. Moreover, the temperate climate of America may have fostered lower levels of exposure to disease than the tropical or semitropical climate characteristic of many developing countries.

6.2.4 Stature and the Intellectual Tradition of Living Standards

Given that average height is highly correlated with per capita income, it is appropriate to ask how average height fits in with the intellectual tradition of measuring living standards as devised by economists. The earlier discussion noted that the welfare basis of the national income accounts was widely debated in the 1930s, but for practical reasons and desires to establish methods that would help in the management of fluctuations in income and employment, the accounts have a narrower focus on production. However, a revival of interest in these issues occurred in the 1970s with economists proposing welfare measures. Average height is particularly adept at assessing degrees of deprivation, a feature that places the measure nicely within the basic-needs approach to living standards. While the basic-needs approach has been criticized for the conceptual problems associated with ascertaining what is basic, in many ways average height finesses this problem because it is a measure of net nutrition. Average height incorporates the extent to which individuals have greater needs created by factors such as a harsher disease environment or greater work loads. In this vein, average height is also conceptually consistent with Sen's framework of functionings and capabilities, though, of course, height registers primarily conditions of health during the growing years as opposed to one's status with respect to commodities more broadly.

Average height also meets satisfactorily the criteria set forth by Morris Morris (1979, chap. 4) for an international standard of the physical quality of life:

1. It should not assume that there is only one pattern of development. In other words the measure should be adaptable to diverse societies including those with modern economic structures, village economies, or tribal systems.
2. It should avoid standards that reflect the values of specific societies.
3. It should measure results, not inputs.
4. It should be able to reflect the distribution of social results.

5. It should be simple to construct and easy to comprehend.
6. It should lend itself to international comparison.

Stature obviously measures results, not inputs, and the regression analysis presented in table 6.4 made clear that the measure is sensitive to the distribution of income. Moreover, measurements of stature are simple to construct, easy to comprehend, and amenable to a variety of economic structures and to international comparison once differences in genetic potential, if relevant, are recognized. One can allow for genetic differences by comparing stature relative to percentiles attained on the appropriate local height standards. It may be possible to question average height on grounds of point 2 in the sense that the measure may imply that "bigger is better," which could be construed as a cultural value. It is claimed, however, not that stature is an end in itself but that it is merely an indicator of health.

6.3 Stature and the Standard of Living in America

It was stature's versatility in measuring living standards in diverse societies that led to its first application in historical debates of the mid-1970s. Progress on the controversy over the sexual mores of American slaves hinged on knowledge of the age at which slave women had children, relative to when they could have had children (Trussell and Steckel 1978). Heights collected as part of an identification scheme on shipping manifests were useful for this purpose because menarche typically occurs within a year or so following the peak of the adolescent growth spurt. From this application the use of stature spread to issues of slave health more generally (Steckel 1979) and to the health of other populations (see Fogel et al. 1983 for additional discussion). While the study of average heights in the past has confirmed some widely held beliefs, such as the poor living conditions of urban areas in the eighteenth and nineteenth centuries, the most interesting applications involve challenges to traditional beliefs. This sections discusses examples in American history.

6.3.1 Long-Term Trends

Table 6.7 presents evidence on the long-term trend of heights of the native-born in the United States. The most surprising feature of the table is the early achievement of nearly modern stature. Contrary to the popular assumption that there was a secular increase in stature, troops measured during the mid- to late 1700s were nearly as tall as those who were measured over a century and a half later. Soldiers in the French and Indian War attained a mean of about 172.1 centimeters, or the thirty-fifth percentile of modern standards (as tabulated in Tanner, Whitehouse, and Takaishi 1966), and those who participated in the American Revolution reached, on average, the thirty-ninth percentile.

The situation during the late colonial period was remarkable not only compared with twentieth-century America but also compared with contemporary European populations. During the third quarter of the eighteenth century,

Table 6.7 Heights of Native-Born White Males

Dates of Measurement	Age	Sample Size	Mean	Source
1755–63	24–35	767	172.0	Sokoloff and Villaflor (1982, 459)
1755–63	21–30	885	172.2	Steegmann and Haseley (1988, 415)
1775–83	24–35	968	172.9[a]	Sokoloff and Villaflor (1982, 457)
1861–65	25–30	123,472	173.2	Gould (1869, 104)
1916–18	21–30	868,445	171.4[b]	Davenport and Love (1921, 67)
1943–44	20–24	119,443	173.2[c]	Karpinos (1958, 300)

[a]Adjusted for minimum height standards.
[b]Includes foreign-born.
[c]Tallest age group.

Swedish troops attained about 166 to 168 centimeters (Sandberg and Steckel 1987), while those from Britain and from the Habsburg Empire were 162 to 168 centimeters (Floud, Wachter, and Gregory 1990; Komlos 1989). Although the Swedes and the British experienced substantial but temporary gains to approximately 170 centimeters following the Napoleonic Wars, they did not reach the American stature of the late colonial period until the late 1800s.

The data of table 6.7 alone suggest a temporal stability that did not exist in the American record. If the heights are arranged by birth cohort, as shown in figure 6.2, then cycles or fluctuations are a better characterization of the American experience than is the high plateau evident from the table. The first identifiable surge began in the two or three decades before the French and Indian War. Heights were approximately constant at about 171 to 172 centimeters for those born between 1720 and 1740, but those born in the mid-1750s had gained about 1.0 centimeter over their predecessors. The evidence has not been gathered for some cohorts, and interpolation is required, but the available data indicate that the spurt of the mid-1700s was followed by a plateau of about 172.5 to 173.5 centimeters from births of 1780 to 1830. Thereafter heights declined irregularly to a low of approximately 169 centimeters for births in the late 1800s, which was followed by the more familiar secular improvement of the twentieth century.

The heights of adult slaves recorded on the coastwise manifests also displayed cycles. Those born in the 1770s reached, on average, about 171.3 centimeters, which corresponds to the thirtieth percentile of modern standards. Then the mean declined to 169.6 for those born in the early 1790s, after which there was an irregular recovery to about 171.5 centimeters by those born in the late 1820s. The measurements of children point to increasing net nutritional hardship for those born after 1830; the stature of adolescents aged 12 to

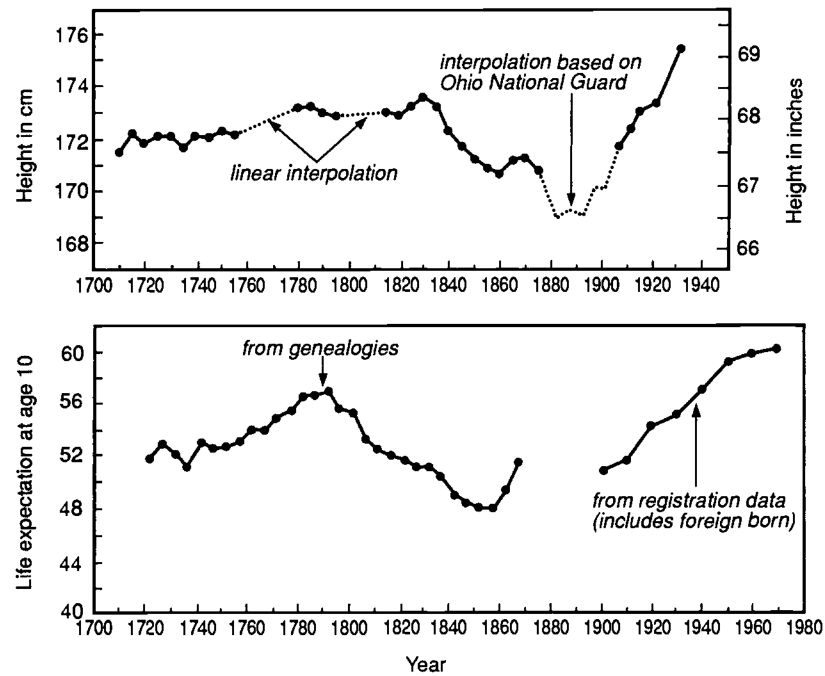

Fig. 6.2 Average height of native-born white males by year of birth and the trend of their life expectancy at age ten
Sources: Fogel (1986); Steckel and Haurin (1990).
Note: See table 6.8 for data.

17 who were born in the early 1840s was over 5 centimeters below that of children the same age born only 10 to 15 years earlier. Since those born in the early 1840s did not reach adulthood before the recording system was abolished, it is unknown whether these children were stunted as adults.

6.3.2 Geographic Differences

Several studies have noted differences in height by state or region. Small stature for those born or living in the Northeast was an enduring pattern, while residents of the South or the West were frequently tall. This pattern may have begun as early as the colonial period. Sokoloff and Villaflor (1982) report that among troops of the French and Indian War, southerners were 0.5 centimeters taller than those from the Middle Atlantic states. The North-South gradient also appeared during the American Revolution when southerners were 0.8 above those from the Middle Atlantic states, and 1.3 centimeters taller than New Englanders. Using a different sample and a more refined geographic grid, Steegmann and Haseley (1988) report, however, that heights of French and Indian War troops were tallest (173.5 centimeters) from noncoastal east-

Table 6.8 Data for Figure 6.2

Life Expectation at Age 10		Stature	
Years on Which Observation Is Centered	No. of Years	Year on Which Observation Is Centered	Height (centimeters)
1720–24	51.8	1710	171.5
1725–29	52.7	1715	172.2
1730–34	52.0	1720	171.8
1735–39	51.2	1725	172.1
1740–44	52.9	1730	172.1
1745–49	52.3	1735	171.7
1750–54	52.5	1740	172.1
1755–59	52.9	1745	172.0
1760–64	53.9	1750	172.2
1763–69	53.7	1755	172.1
1770–74	54.8	1760	
1775–79	55.2	1765	
1780–84	56.4	1770	
1785–89	56.5	1775	
1790–94	56.7	1780	173.2
1795–99	55.4	1785	173.2
1800–1804	55.2	1790	172.9
1805–9	53.0	1795	172.8
1810–14	52.3	1800	
1815–19	51.9	1805	
1820–24	51.4	1810	
1825–29	51.1	1815	173.0
1830–34	51.0	1820	172.9
1835–39	50.2	1825	173.1
1840–44	48.7	1830	173.5
1845–49	48.2	1835	173.1
1850–54	47.9	1840	172.2
1855–59	47.8	1845	171.6
1860–64	49.2	1850	171.1
1865–69	51.4	1855	170.8
1870–74		1860	170.6
1875–79		1865	171.1
1880–84		1870	171.2
1885–89		1875	170.7
1890–94		1882.5	168.9
1901	50.6	1887.5	169.2
1910	51.3	1892.5	169.0
1920	54.1	1897.5	170.0
1930	55.0	1902.5	170.0
1940	57.0	1906.5	171.6
1950	59.0	1911	172.2
1960	59.6	1916	172.9
1970	59.8	1921	173.2
		1931	175.5

Sources: Fogel (1986); Steckel and Haurin (1990).

ern Massachusetts, noncoastal Connecticut, and the mid–Hudson valley and declined as one moved south to 169.2 centimeters for these from Delaware, southeastern Pennsylvania, and eastern Maryland.

The disadvantage of the Northeast was clear during the Civil War, World War I, and World War II. At ages 27 to 30 Union troops from Kentucky and Tennessee were tallest (175.5), followed by other slave states and the Midwest at approximately 174.7, New England (173.4), and the Middle Atlantic states at 172.8 (Gould 1869, 123). The World War I recruits were shortest from the Northeast (about 169.5) and tallest from South at approximately 173.0 (Davenport and Love 1921, 75). During World War II inductees were largest from the West (174.6), followed by the South Central (174.2), the North Central (173.2), the Southeast (173.1), and the Northeast (171.6; Karpinos 1958). During the mid-1800s West Point cadets from the South were about 1 percent taller than those from the Middle Atlantic states and the West (Komlos 1987). It should be noted that the secular decline in stature of the nineteenth century, noted above, occurred despite the relative shift of population out of the low-stature states of the Northeast and into the high-stature states to the west.

Among southern whites who signed amnesty oaths during the 1860s, those from the interior states of Kentucky, Tennessee, Missouri, and Arkansas tended to be 0.8 to 1.8 centimeters taller than residents from the lower coastal states such as Alabama, Louisiana, South Carolina, and Texas (Margo and Steckel 1992). A similar but less pronounced regional pattern existed among ex-slave recruits. The former slaves from South Carolina were particularly small, falling 2.3 centimeters below those from Kentucky or Tennessee.

The slight growth advantage observed for people from urban areas in studies on modern data is probably a new phenomenon. As recently as World War II the stature of troops declined by 1.2 centimeters as their community size increased from a population of under 2,500 to 500,000 or more. Ohio National Guard recruits from rural areas were about 0.5 centimeters taller than urban recruits (Steckel and Haurin 1990).The advantage of rural residence was larger earlier in the century, as evident from Civil War troops from cities and towns of 10,000 or more people who were 1.3 centimeters shorter than their country counterparts. A similar advantage for rural residents prevailed among regular army troops who were measured between 1815 and 1820, but a half a century earlier that were no statistically significant urban-rural differences.

6.3.3 Socioeconomic Patterns

Systematic height differences existed by occupation, foreign birth, and condition of the population (whether free white, free black, or slave). As a general pattern the occupational differences were larger during the nineteenth century than during the present century or the late colonial period. Among World War II recruits, all but the shortest occupation were tightly packed within 0.5 centimeters, and the tallest, farmers and farm laborers, was only 1.2 centimeters larger than the shortest, clerks and kindred workers (Karpinos 1958). Half a century earlier in Ohio the range exceeded 2 centimeters; professionals were tallest at 175.5 followed by farmers (174.7), clerical and skilled workers (174.0), and laborers (173.3). Union troops who were farmers were 0.4 centimeters taller than white collar workers, who were 0.8 centimeters taller than skilled artisans, who were 0.9 centimeters taller than laborers. West Point cadets whose fathers were farmers were 1.1 percent taller than the shortest group, whose family background was in blue collar work (apparently children of laborers did not enter the academy). The results during the late colonial period are mixed with respect to occupation. In the French and Indian War sample farmers were about 1.5 centimeters taller than artisans or laborers, but the occupational differences vanished among troops of the American Revolution.

Since European residents were several centimeters shorter than Americans, the result that the foreign-born were smaller than the native-born throughout the period is not surprising. Yet the advantage of the native-born was substantially less than the difference in average heights between Europe and America, which indicates that trans-Atlantic migrants may have been taller and in better health than those who remained behind. It is also possible that newcomers from Europe who had not yet reached adult height benefited from improved nutrition after arriving in America. The native-born Ohio National Guard recruits, for example, were 2.1 centimeters taller than those who were foreign-born. The difference in favor of the native-born was about 3.2 centimeters for Union Army recruits, and 2 to 4.8 centimeters for troops of the French and Indian War or the American Revolution.

Although the differences in adult stature between native-born whites, free blacks, and slaves existed during the early and mid-1800s, the contrasts were less than observed between native and foreign-born and across occupations. Adult male free blacks in Virginia were only 0.7 centimeters smaller than northern whites, and at 170.6 centimeters slaves were 1.9 centimeters shorter than the free blacks. Yet comparisons of growth profiles from early childhood to maturity make clear that slaves were remarkably different (Steckel 1986c, 1987a). The slave children were extraordinarily small, approaching the early childhood heights of the Bundi of New Guinea. Slaves fell below the first percentile of modern height standards before age 6 and reached less than the second percentile before age 10. Average heights in this neighborhood are sometimes observed in poor developing countries or in poor countries of the past, but if the children were small, the adults in these populations were also small. Similarly, if the children were large, the adults tended to be large. The American slaves were remarkable because the children were small and the extent of catch-up growth was large if not unprecedented. The catch-up accelerated during adolescence and the age at maximum increment was 13.3 in females and 14.8 in males, only 1 to 1.5 years after that for well-nourished modern populations. Prolongation of growth helped bring slave adults to the twenty-seventh (male) or twenty-eighth (female) percentile of modern standards.

6.3.4 Discussion

Because study of socioeconomic, geographic, and temporal patterns is still at an early stage, the findings reported here should be regarded as preliminary. Nevertheless, enough is understood to report more than an agenda for research. The discussion emphasizes the unusual pattern of slave growth, the early achievement of near-modern stature, and cycles in height.

Examination of materials relevant to the unusual pattern of slave growth suggests that newborns got a poor start in life. The infant mortality rate was probably in the neighborhood of 350 per thousand or more, and losses for those aged 1 to 4 were about 201 per thousand on large plantations (Steckel 1986a, 1986b). Poor medical knowledge and practices of the era claimed many children, but slave losses before age 5 were roughly double those of whites who lived in the United States from 1830 to 1860. Regional differences in the survival rates of whites suggest that only a portion of the excess losses (perhaps 15 to 30 percent) could be attributed to a harsh disease environment and other factors affiliated with residence in the South (Steckel 1988). Although the vigorous adolescent growth spurt indicates that workers were well-fed, seasonal patterns of neonatal mortality and plantation work records indicate that pregnant women had an arduous work routine during peaks in the demand for labor, such as the plowing, planting, and harvesting seasons. The labor demands of the institution are clear from estimates that slaves produced about 30 percent more output per year than free farmers (Fogel and Engerman 1974). A number of features of slave skeletons from the colonial and antebellum periods document the strenuous physical labor demands, particularly in areas of the shoulders, hips, and lower vertebrae (Kelley and Angel 1987; Rathbun 1987). Claims on the diet placed by work were made worse by malaria and other fevers common during the "sickly season" of late summer and early autumn. It is also likely that certain vitamin and mineral deficiencies, such as for iron, calcium, vitamin C, and niacin, aggravated overall maternal ill health. Since stillbirths and neonatal deaths are sensitive to deprivation at or near conception, and neonatal deaths are elevated by deprivation during the third trimester, this evidence points to seasonal nutritional deprivation of the fetus as an important ingredient in poor infant health.

Although poor prenatal care and low birth weights underlay many neonatal deaths and contributed to high losses in the postneonatal period and beyond, a poor diet and infections also entered the picture. Slave women usually resumed regular work within three to five weeks after delivery, and while mothers were in the field, the young children typically remained in the nursery. Initially the mothers returned to the nursery two or three times per day for breast-feeding, but within three months after delivery their productivity in the fields reached normal levels, which suggests that one or more of the daytime breast-feedings were eliminated. As a substitute the infants received starchy paps and gruels, often contaminated or fed using contaminated utensils. Thus, young children who survived the hazardous neonatal period faced a poor diet and diseases that were often related to poor nutrition. The child's diet emphasized hominy and fat, and owners and medical practitioners frequently cited whooping cough, diarrhea, measles, worms, and pneumonia as causes of death. Concentrations of children on medium and large plantations probably promoted the spread of these diseases.

By ages 8 to 12 work entered the picture of slave health. Other things being equal, increased physical activity would have placed a claim on the diet that retarded growth. Yet it was at ages that work usually began, initially as a light activity, that some catch-up growth occurred. Other things must not have been equal. Specifically, slave workers received regular rations of meat (about one-half pound of pork per day) and other foods that may have been supplemented by garden produce, chickens, pigs, and game. In addition, as slaves matured they may have become more experienced and efficient at their work (using less wasted motion), thereby leaving more nutrition from a given diet for growth. A substantial incidence of Harris lines on leg bones uncovered from a South Carolina plantation points to late childhood and adolescence as the major period of recovery from deprivation (Rathbun 1987). The strong catch-up growth as teenagers and workers reinforces the view that nutrition was at least adequate, if not exceptional, for the tasks performed by slaves.

Caribbean slave children were approximately as small as slave children in the United States, but the Caribbean population displayed much less recovery, attaining only the third to the fourteenth percentile of modern standards as adults (Higman 1984). In the Caribbean the age at maximum increment was about 14.7 years for males and 13 years for females. The pattern of stunting with relatively little delay may have been caused by liberal rations of rum given to all working slaves, including pregnant women. It is also possible that the strenuous work of Caribbean sugar plantations that began in adolescence contributed to the meager catch-up growth.

Why did Americans achieve nearly modern heights as early as the mid-1700s while Europeans lagged behind a century or more? A substantial answer to this question is not yet available, but the evidence points to several ingredients of an interpretation that emphasize sources of good nutrition, a relatively low incidence of epidemic disease, and widespread access to land and other resources. First, the abundance of good land in America enabled farmers to choose only the most productive plots for cultivation, possibly allowing them to exert less physical effort, after clearing the land, for a given amount of output compared with European farmers. Second, most of the population was nestled along the coast between two abundant sources of protein—fish from the Atlantic and game from the forests. Third, the land was lightly populated in America, which tended to reduce the spread of communicable diseases that lessened the ability to work and that claimed nutrition from the diet. The benefits of isolation, low population density, and little commercial development for stature have been noted for outlying areas of Sweden, Austria-Hungary, Japan, and the American South (Sandberg and Steckel 1987; Komlos 1989; Shay 1986; Margo and Steckel 1982, 1992). Finally, the available evidence suggests that income and wealth were more equally distributed in the United States during the late colonial period than at any time except the mid-twentieth century and that inequality in the 1700s was probably much less in the United States compared with Europe (Gallman 1978; Jones 1980; Williamson and Lindert 1980). As noted earlier, a move toward equality in access to resources at a given level of income tends to increase the average height of a population, because a given income distributed from the rich to the poor will decrease the heights of the rich by less than the increase in the heights of the poor, assuming, of course, that the poor had not reached their growth potential. Given that average incomes were growing during the mid-nineteenth century, the redistribution argument is effective in explaining the height decline only if inequality increased fast enough to more than offset the health gains attributable to rising average incomes.

Several countries, including Sweden, England, Austria-Hungary, and the United States, have experienced cycles in heights. Although cycles are not unusual, the episode of stature decline that began in the United States during the second quarter of the nineteenth century is particularly interesting to economic historians because it challenges firm beliefs that the middle decades of the nineteenth century were prosperous by conventional income measures, estimates of real wages, productivity measures, and capital stock estimates. The United States began the process of industrialization in the Northeast during this era, and the economy achieved what is called "modern economic growth," or sustained increases in real per capita income at rates on the order of 1 to 1.5 percent or more per year (Gallman 1966). Estimates of real wages suggest that this measure of living standards increased by roughly 50 percent between 1820 and the late antebellum period (Margo and Villaflor 1987; Margo, chap. 4 in this volume). The antebellum period also witnessed productivity improvements in agriculture and manufacturing and increases in the capital stock per capita (Rothenberg, chap. 7 in this volume; Gallman, chap. 1 in this volume). Regional estimates of per capita income indicate that the Northeast was highly prosperous in the mid-1800s, yet the military data show that this region had the lowest average stature (Easterlin, 1961).

How can the height decline and the regional patterns be reconciled with the evidence of economic prosperity? One answer dismisses the height data as inaccurate, unrepresentative, or responding to genetic changes. While possible, I find this answer unappealing because the cycle registers in several data sources, including Civil War muster rolls, regular army recruits, West Point cadets, adolescent slaves, skeletal evidence, and mortality records. While one may quibble with estimates of short-term fluctuations from these sources, the existence of a substantial secular decline in the mid-to-late nineteenth century is well established. Large samples from the Civil War muster rolls and evidence from West Point cadets show that the decline began for those born after approximately 1830, and data from regular army enlistments following the Civil War indicate that the decline continued for those born in the years immediately following the Civil War (see figure 6.2 and Komlos 1987). Although the evidence collected to date is thin for the next three decades, Ohio National Guard muster rolls show that the trough was reached for those born in the 1880s or early 1890s, and data for World War II troops arranged by year of birth show the modern secular increase in stature began around the turn of the century (see Steckel and Haurin 1990; Karpinos 1958). Skeletal evidence also identifies the recovery underway at the turn of the twentieth century and suggests that a low point in stature was probably reached among those born in the 1880s (Trotter and Gleser 1951). Moreover, mortality evidence from genealogies, given in figure 6.2, and from plantation records indicate that life expectation tended to deteriorate while heights declined during the antebellum period. The height disadvantage of the Northeast is well-established from abundant military records. Although genetic drift cannot be ruled out as a factor in the height patterns, it should be noted that modern populations show little evidence of drift in stature when living conditions are approximately constant.[18] Moreover, it is known that stature does respond to the environment, and progress has been made in linking the stature patterns of the eighteenth and nineteenth centuries to changes or differences in environmental conditions.

If the height data are credible, the search for explanations should recognize that traditional national income accounting measures, real wage series, and average heights focus on different aspects of living standards. None of these measures gives a comprehensive picture of the standard of living broadly construed; the first two emphasize market behavior and various imputations for productive activity, while average height reflects net nutrition and the distribution of income or wealth. Thus, a particular type of prosperity may have accompanied industrialization while other aspects of the standard of living deteriorated. Other things being equal, one would expect that the measured economic prosperity of the mid-1800s would have increased average stature. The secular height decline and the regional patterns suggest that other things must not have been equal. Specifically, nutritional liabilities (either claims on nutrition or lower nutritional intake) that more than offset the advantages bestowed by higher incomes must have accompanied the economic prosperity.

The search for understanding should recognize that most of the antebellum height decline occurred within the rural population. Thus, one cannot base an explanation primarily on urbanization and the adverse health conditions in the cities. Although the available evidence indicates that health conditions were poor in the cities, only a small share of the population lived in these areas

18. Genetic issues are discussed in Tanner (1978) and Eveleth and Tanner (1976).

before the Civil War, and the height differences were modest between farmers and residents of large urban areas. The share of the U.S. population living in places of 10,000 or more people was 6 percent in 1830, and as late as 1860 it was only 14.8 percent (U.S. Bureau of the Census 1975, ser. A 57–72). Soldiers who were born in urban areas of 10,000 or more population were approximately 1.3 inches, or 3.3 centimeters, shorter than farmers (Margo and Steckel 1983). Therefore, the increase in the share living in these urban areas of $14.8 - 6.0 = 8.8$ percent would explain only $0.088 \times 3.3 = 0.29$ centimeters of the height decline that was approximately 2.5 centimeters between 1830 and 1860.

In contrast with the evidence for the antebellum period, the data for the Ohio National Guard following the Civil War indicate that height declines were substantial in large urban areas. Compared with the heights of those born before 1880, the heights of cohorts born in 1880–96 declined 0.25 centimeters among farmers, 2.0 centimeters among the nonfarm rural population, 0.25 centimeters among residents in small cities, and 2.3 centimeters among residents in cities with 50,000 or more population (Steckel and Haurin 1990). The share of the population living in urban places of 50,000 or more population increased from 12.7 percent in 1870 to 22.3 percent in 1900 (U.S. Bureau of the Census, 1975, ser. A 57–72). This evidence suggests that urbanization played a supporting role in the height decline of the late nineteenth century.

Several additional explanations are worth investigation. One emphasizes the sensitivity of average heights to the distribution of income or wealth. Based on the regression reported in table 6.5, a rise of .17 in the Gini coefficient from 1830 to 1890 would have offset the rise in per capita income and account for a decline of 4 centimeters in average stature. This line of thought is appealing because there is evidence from many countries that inequality tends to rise and then decline during development (Kuznets 1955; Lindert and Williamson 1985). The modest evidence on inequality trends in the United States during the nineteenth century has evoked controversy, but it seems plausible that growth in inequality could have contributed significantly to the secular decline in stature (Margo and Villaflor 1987; Margo, chap. 4 in this volume; Soltow, chap. 8 in this volume; Williamson and Lindert 1980).[19]

John Komlos (1987) argues that the height decline may have been caused by a deterioration in the diet created by the sectoral shift in production that occurred during industrialization. According to this view, urbanization and the expansion of the industrial labor force increased the demand for food while productivity per worker and the agricultural labor force grew slowly, causing a decline in food production (especially meat) per capita. It would be possible to test the argument that declines in inputs to net nutrition were re-

19. Unfortunately, little information on the course of wealth or income inequality is currently available for the nineteenth century. However, within a couple of years I expect to have some results based on a methodology of matching census manuscript schedules with tax records for the period 1820 to 1910.

sponsible by examining information on diets, cooking and food preparation technology, and systems of food distribution. However, the most recent survey of research in this area does not suggest that dietary deterioration occurred after 1825, though more research is clearly needed (Walsh, chap. 5 in this volume). An indirect test of the hypothesis can be conducted using data on relative prices. If per capita food production declined, the relative price of food should have risen, which may have caused a decline in stature. Table 6.9 presents the ratio of the wholesale price index of foods to the wholesale price index of all commodities from the 1820s through the 1880s. Consistent with the height decline, the relative price of food rose from the 1820s through the 1830s. However, the relative price reached a peak in the late 1830s, declined in the early 1840s, and fluctuated moderately thereafter. This evidence suggests that the temporary rise in food prices may have prompted modest and short-lived reductions in nutritional intake during the early phase of the secular decline, but other factors were probably involved in the early phase, and certainly thereafter.

Other hypotheses that are under study include greater exposure to infectious disease brought on by higher rates of interregional trade, migration, and immigration, and the push of midwestern farming into marshy and river-bottom lands that hosted malaria. Migration and trade may increase morbidity and mortality by spreading communicable diseases and by exposing newcomers to different disease environments (Smillie 1955; May 1958; Curtin 1989). These adverse consequences could have been substantial before public health measures became effective. Indeed, prior to the late nineteenth century isolated, preindustrial populations in sparsely settled regions were often relatively tall, as discovered in Ireland, the interior of the American South, Austria-Hungary, Sweden, and Japan (Sandberg and Steckel 1987; Shay 1986; Komlos 1989; Nicholas and Steckel 1991; Margo and Steckel 1982, 1992). Consistent with the idea that increased concentration of population and growth of trade have adverse net nutritional consequences before the era of modern public health, evidence from human remains suggests that popula-

Table 6.9 **Ratio of the Wholesale Price Index of Foods to the Wholesale Price Index of All Commodities, 1821–1825 to 1886–1890**

Years	Ratio	Years	Ratio
1821–25	1.012	1856–60	1.068
1826–30	1.021	1861–65	0.977
1831–35	1.049	1866–70	1.031
1836–40	1.128	1871–75	0.963
1841–45	0.985	1876–80	1.020
1846–50	1.042	1881–85	1.020
1851–55	1.070	1886–90	0.998

Source: Calculated from the Warren and Pearson price indexes (U.S. Bureau of the Census 1975, Ser. E 52–63).

tions that entered settled agriculture had greater nutritional stress than their hunter-gatherer predecessors (Cohen and Armelagos 1984). These sources of greater exposure to infectious disease merit attention because interregional trade, migration, and immigration expanded substantially during the mid-nineteenth century. The cholera epidemics from the 1830s through the 1860s are well-known examples of disease transmission that illustrate this point (Rosenberg 1962). The epidemic of 1832, for example, entered the continent at New York, Quebec, and New Orleans, and spread by travellers along the major routes. The importance of immigration in nineteenth-century disease transmission is confirmed by positive correlations between immigration rates and urban mortality rates and by information that epidemics often spread from immigrant districts to other areas (Higgs 1979; Meckel 1985). The early and mid-nineteenth century also witnessed numerous epidemics of yellow fever, typhoid, typhus, and smallpox that were spread by population movements. The high degree of churning in population movements from rural to urban areas may help to explain the rural character of the height decline. Low persistence rates in moves from farms to cities and towns indicate that rural-to-urban migrants often returned after short periods of time, bringing communicable diseases with them (Steckel 1987b). Westward migration also led to encounters with malaria, particularly in the numerous marshy and river-bottom areas of the Midwest. Travel accounts, memoirs, army statistics, and medical journals establish that malaria was a substantial seasonal health problem in the Midwest until the late nineteenth century (Ackerknecht 1945). Since this region of the United States was settled largely after 1815, the explanation is consistent with the timing of the height decline, its recovery near the end of the century, and its rural character. Although this explanation of the secular trend fails to account for the height disadvantage of the Northeast, it should be noted that other factors, such as population churning and changes in labor organization noted elsewhere, might explain that situation.

Changes in labor organization that led to greater exposure to disease in the workplace and may have required more physical exertion by workers deserves some attention in a list of potential explanations for the mid-nineteenth-century decline in health reported in figure 6.2. The home manufacturing typical of the eighteenth century diffused geographic patterns of work and insulated the population from contagious disease. Those employed at home also progressed at their own pace. In contrast, factories and artisan establishments that emerged in the 1820s and 1830s concentrated employees in the workplace under conditions that increased the risk of exposure to infectious diseases. Claims on nutrition were made by long hours in work arrangements paced by machines, and numerous people crowded in dusty or humid environments, typical of textile mills, led to the spread of tuberculosis and pulmonary illnesses. These conditions are important for understanding the secular decline in stature of the mid-nineteenth century, because children made up a substantial share of the labor force during America's industrial revolution (Goldin and

Sokoloff 1982). By the 1830s and 1840s poor working conditions in New England mills and factories received the attention of groups such as the New England Association of Farmers, Mechanics, and Other Workingmen; the National Trades' Union; and the Massachusetts Medical Society (Rosen 1944). The geographic spread of industrialization to the midwest widened the scope of this claim on nutrition.

It is conceivable that new opportunities for trade reduced nutritional intake in rural areas. This could happen if the transportation revolution made manufacturing goods available at low cost, tempting farmers to trade so much of their products that nutritional intake diminished. If rural residents placed extraordinarily high value on manufactured goods, their utility could have increased while their diet deteriorated. The abundance of land and growth in agricultural productivity in the mid-nineteenth century suggest that this effect, if it existed, was weak. However, it is a line of argument that is probably worth exploring.

The puzzle of height decline in the face of economic growth that the middle decades of the nineteenth century poses for economic historians also applies to the height disadvantage of northeastern residents. Although per capita incomes were relatively high in states of the region, the population was less well-off as measured by stature. One possible explanation of the pattern notes the dense settlement, high rate of commerce, industrialization, and substantial immigration into the area. The growing concentration of population in cities and towns after 1820 reinforced the harmful aspects of this disease environment. The region also had a smaller supply of good farmland per person than did the Midwest or the South, which may have been an important consideration before the substantial interregional trade of the mid-1800s.

The decline in adult heights of slaves born after 1775 and the subsequent recovery for those born after the mid-1790s may have been affiliated with changes in the concentration of the African-born in the American slave population. The African-born were 5 to 10 centimeters shorter than native-born or creole slaves (Eltis 1982; Higman 1984), and the annual rate of importation was at its highest level from 1780 to 1807. Unfortunately the share of African-born is unknown from the slave manifests, but an increase of 15 percentage points in this share could have accounted for about three-quarters of the decline. Since the African slave trade was outlawed after 1807 and smuggling was probably a minor or negligible part of population growth thereafter, the downturn in adolescent heights after 1830 had causes largely unrelated to the African-born. Possible explanations include rapid westward migration of the 1830s, which helped to spread communicable diseases, the rise of larger plantations, which had more demanding work routines and greater concentrations of children, and the appearance of epidemic diseases such as cholera. It is also possible that owners reduced rations and increased work requirements in response to the agricultural depression of the late 1830s and early 1840s.

6.4 Concluding Remarks

This paper reviews the intellectual history of living standards from the approaches of national income accounting and of auxology. Although the earliest efforts in these methods of assessing human welfare extend back to the seventeenth century, collaboration in these fields has occurred only recently. Since the mid-1970s economic historians have compared and contrasted these measures, collected data on stature, developed analytical techniques, and sifted output for novel comparative results. The typical American of the eighteenth and nineteenth centuries was nutritionally well-off compared with the average European, but diversity in the United States existed by social class, region, and time period. Young slaves, who were among the smallest children ever measured, had extraordinarily poor health. In the nutritional sense slave children had the worst living conditions of any ethnic group in America and were at least as badly off as any population in Europe. The free population was relatively tall in the South but short in the Northeast, and the stature of the native-born declined for over half a century for cohorts born after 1830. The geographic patterns and the secular decline appear to conflict with substantial evidence of economic prosperity. Although researchers should continue to probe the factual basis of these measures of living standards as an explanation for their apparent conflict, it should also be noted that they measure different aspects of living conditions. Economic conditions could improve while nutritional circumstances decline if greater claims were made on the diet by factors associated with the economic conditions, such as greater inequality in the distribution of income or wealth, more work effort, and increased exposure to infectious disease. If economic prosperity, measured by traditional means such as per capita income, increased claims on the diet, then it is important to adjust those measures for the loss in human welfare. Research is just beginning on the methodology appropriate for this purpose. Jeffrey Williamson's (1981b) use of the bribery principle to estimate the disutility of industrialization represents an important step in this direction. The resulting debate (Pollard 1981; Williamson 1981a) over assessment of risks, the accuracy and suitability of mortality estimates, and the equilibrating processes in labor markets serve as a guide for future research on this important issue of assessing human welfare.

The gathering and analysis of height data and related anthropometric measures, such as weight, will undoubtedly be an important academic enterprise in coming years, particularly since substantially more data are available, but I expect that future research will place greater emphasis on the functional consequences of height and related anthropometric measures. This aspect of research is important because many social scientists have little or no clinical experience with stature, and those not participating in height research or something related, such as physical anthropology, have read little or none of the underlying literature on human biology. As a consequence most social scientists find this measure difficult to interpret in isolation; average height has meaning only in relation to more familiar measures such as per capita income, Gini coefficients, real wages, labor productivity, human capital, social class, mortality, and fertility. Moreover, it is in terms of these measures that they have defined problems, framed hypotheses, and taken positions in debates. Social scientists will have an incentive to learn about the underpinnings of this line of work if height is accepted as a proxy or at least a measure similar to variables and concepts in which there is an established interest.

Some progress has been made in documenting the relationship of height to mortality and to labor productivity. Work on the slave registration data of Trinidad has measured the effect of height on the chances of survival (Friedman 1982; John 1988). Analysis of data from contraband slaves in the Civil War demonstrates that value increased with height, probably because taller slaves were stronger and lived longer (Margo and Steckel 1982). These examples portend the direction of this type of research, but scholars have merely scratched the surface of the available data. Pension records of former soldiers, for example, hold great promise for understanding the consequences of height for occupational choice, labor productivity, disability, and disease-specific causes of death. Stature could be used as the basis for extending per capita income estimates in several countries to the early industrial and, in some cases, the preindustrial eras, but one must be wary in this research. The conflicting patterns of stature and per capita income discussed for the United States in the nineteenth century suggest that other factors, such as the distribution of income or wealth and claims on the diet made by work or disease, must be taken into account. Projects are underway to document the course of birth weights from hospital records, such as the Lying-in Hospital in Montreal (Ward and Ward 1984) and the Philadelphia Alms House (Goldin and Margo 1989). Work has yet to begin on historical relationships among stature, nuptiality, and fertility. As an aid to this entire research agenda, economic historians have only begun to exploit information that may be available about stature and its consequences from skeletal evidence and from populations in developing countries.[20]

Efforts should also be made to extend the portion of the life span over which information is collected on the biological quality of life. Heights inform us about the history of health during the growing years, particularly every childhood and adolescence, but are silent on conditions after adult height is attained. Weight-for-height measures, such as the body mass index (weight in kilograms divided by the square of height in meters), is a useful measure of health risks among adults (Fogel 1991). Waaler (1984) reports that death rates

20. Efforts to use skeletal remains were made at a conference, "Diet, Disease, Work, and History: Techniques of Physical Anthropology and Historical Methods in the Reinterpretation of the Past," which was held in November 1990 at the Economics Department of Ohio State University.

among Norwegian men rose substantially among those whose body mass indexes exceeded 28 or fell below 22. Unfortunately, use of the body mass index on historical problems is limited because information on both height and weight was rarely reported before the late nineteenth century.

I propose that research efforts be devoted to defining and estimating a measure of the biological standard of living throughout the life span. The foundations of such a measure should be (1) the length of life and (2) the biological quality of life at each age while living. In designing this measure one could take a cue from the work of medical examiners and physicians who assigned pensions to Civil War veterans based on an individual's degree of disability. Courts that estimate the loss of a person's biological capacity following accidents operate on similar principles. For example, the biological standard-of-living index for individual j (I^j_{bsl}) could be defined as follows:

$$I^j_{\mathrm{bsl}} = \sum_{i=1}^{100} Q^j_i \quad \text{where } Q^j_i = Q_i(x^j_1, x_2, \ldots, x^j_k),$$

i denotes the year of life, and Q_i is a function whose arguments are measures of the biological quality of life. The function Q_i, which takes on values from 0 to 1, measures the biological quality of life in year of life i. Excellent health is indicated by a function value of 1 and very poor health by a function value near 0. At death the function Q_i takes on a value of 0.0. A person who had excellent health throughout life and died at exactly age one hundred would have an index value of 100, but an individual who lived forty years in moderately poor health ($Q_i = 0.5$ for all ages from birth to death) would have an index value of 20. Age 100 is an approximate upper limit to the life span in most populations, and it provides a convenient maximum numerical value for the index.[21] Average values for the index could be used in comparative analyses, and since the index is based on individual data, one could use the measure to study inequality in the biological standard of living in much the same way that economists study inequality of wealth or income. Major research questions for this framework are the specification of the Q_i functions (perhaps some form of a logistic function would be suitable) and sources of data on indicators of the biological quality of life. One would like to have longitudinal data on a person's state of health from birth to death. A sequence of annual physical examinations would achieve this purpose, but more refined measurements, such as monthly, weekly, or even daily observations on health, would be desirable.[22] Unfortunately, such data are rare, even in modern populations. Alternatively, an individual's record of health could be approximated using information from skeletal remains. Although the skeletal record provides an incomplete picture of health, emphasizing chronic as opposed to acute condi-

21. Obviously the index could be scaled on the basis of a longer life span.

22. A device, implanted in the body, that continuously monitored an individual's state of health would be ideal for this purpose.

tions, it nonetheless provides a consistent way of measuring important aspects of health across diverse populations (Steckel and Rose 1991).

Although poverty and inequality have been enduring concerns for social scientists and there is a huge literature on methods of assessment and on the extent to which these phenomena exist (see, for example, Jencks 1979; Lebergott 1976; Taubman 1978; Tullock 1986), attempts to use height in monitoring living standards and to evaluate the efficacy of social policy have been rare. However, a growth surveillance program (National Study of Health and Growth) for this purpose has existed in England since 1972 (Rona 1989, 1991). There is a clear need for health surveillance in poor countries, and the World Bank recommends that stature be included as a component of living standards surveys in developing countries, but few systematic efforts are in place in industrialized countries.[23] Even in wealthy societies there are disadvantaged groups that are exposed to fluctuations in socioeconomic circumstances, which creates a need for a program for assessing nutritional status. Such a program has a sound methodological base and, I expect, would be sensible, given the ease of collecting anthropometric data. I therefore conclude with a call for study of the costs and benefits of incorporating measures of the biological standard of living into our social accounting apparatus.

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23. For discussion of living standards surveys that include height see Ho (1982).

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Comment Carole Shammas

Over the past decade, economic historians have greatly expanded our knowledge of past living standards by using height as an indicator of nutritional status. Richard Steckel, a prominent researcher in this area, has presented a comprehensive overview of this work and makes a strong argument for including stature as a measure of material well-being worldwide.

Steckel traces the parallel but never intertwining development of national income accounting and measures of human growth, pointing out that in the national income accounts concerns about living standards have tended to take a backseat to issues relating to industrial production. Considering that preoccupation, it is perhaps not surprising that no links between per capita income measures and human growth emerged. What I find more puzzling is that those income analysts who used household budgets to study consumption had no contact with auxology research, given their prime interest in the percentage of income spent on diet.

Steckel is right to stress the great advantages of height records as a measure of living standards during the past three hundred years. These data go back further in time and are more continuous than income statistics. They are easily compared over time and space without the messy cost-of-living problems involved in evaluating income. There are disadvantages, though. Without information on weight, stature can only provide evidence about childhood deprivation, not current health status. The preponderance of military records as sources for height information, moreover, mean that women are usually excluded from the calculations. Given the patriarchal nature of most societies, past and present, and the strong preference for sons rather than daughters, one cannot assume that trends in male stature are the same as trends in female stature.

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Perhaps the most controversial finding that has come out of the research on stature is the great impact of environment and the much lesser role of genes in explaining variation. Steckel estimates correlations of .9 between per capita income and mean heights, meaning that, generally, the richer the nation the taller the people. There is, of course, currently much intercorrelation between per capita income and race. The fact that the Japanese, one of the few Asian groups with living standards on a par with the United States and western Europe, do seem to have a genetic predisposition to being shorter will only feed the skepticism of the nature-over-nurture proponents.

In his cross-national analysis, Steckel discovers inequality had a strong effect on height attainment. He shows that a .10 increase in the Gini coefficient, his measure of inequality, results in a drop of 3 ⅔ centimeters or almost 1 ½ inches in a nation's average height. At the conference, there was much discussion about this result because of what it suggests about the costs of an unequal income distribution within a country.

This paper also provides a succinct summary of the major findings to date in research on height trends in the United States from the colonial period to the present. These findings have implications not only for standard-of-living questions but also for more traditional problems in political and economic history. Recent work has shown the "modern" height attainment of white eighteenth-century American soldiers and their clear physical advantage over their counterparts in the British forces. Did that translate into a military advantage? The disturbingly low heights recorded for slave children in the nineteenth century indicate very poor nutrition for African-Americans not yet in the field work force and abuse of pregnant and lactating mothers. If the children survived, American slave youth made up much of their loss in stature once they joined the field workers. The high infant and child mortality rates produced by these practices, however, suggest that earlier estimates of slavery's profitability have to be adjusted downward.

The height data relating to America have also strengthened the pessimist case against nineteenth-century economic development. The data show a drop in the average height of U.S. white males during the nineteenth century. Beginning with the cohort born after 1830 and continuing until the cohort born in the 1890s, mean height fell by about 4 centimeters. The drop seems to coincide with other standard-of-living indicators, including a rise in mortality. Attributing cause here, however, is trickier than it might seem. As was mentioned in conference discussion, scholars disagree as to whether increased inequality, produced by industrialization or by anything else, occurred in the middle third of the nineteenth century. Jeffrey Williamson and Peter Lindert have argued for such a rise, but Lee Soltow finds inequality as high a generation earlier, long before any deterioration in mean height levels. It also seems that urbanization and the movements of populations may have had more to do with the drop than did industrial activity per se, but what exactly was going on is unclear. Surprisingly, not until almost the mid-twentieth century did the urban disadvantage in heights disappear.

The problem of explaining the mid-nineteenth-century drop in heights leads to questions of just how robust this finding of discontinuity is. For example, in Lee Soltow's table on the heights of army recruits age 18–35 elsewhere in this volume, there seems little change in stature between recruits measured in 1799–1819 and during the Civil War. The Soltow data are not arranged by birth cohort, yet clearly the first group would have had to have been born by 1801 and nearly all of the Civil War recruits after 1830. Why no difference?

Whatever the answer may be, the imaginative work done in the 1980s on long-term trends in stature seems truly exceptional and of undeniable importance in the measurement of material well-being in the past.