theories," to borrow Jonathan Hodge's expression, dominated 19th-century discussions of heredity.

Such a reappraisal of the 19th century has forced a readjustment in our understanding of the rise and goals of early 20th-century genetics. There now appears to exist a more profound intellectual divide between these eras of biology than was formerly allowed. The historical focus has shifted from the specifics of the "rediscovery" year of 1900 to the broader trends in the transition period between 1880 and 1910 when a hereditarian mindset superseded a developmental one and when genetics separated from embryology and evolution as a distinct field of study. The transition, however, was uneven, and different countries responded in different ways to the advent of nuclear cytology, Mendelism, and classical genetics. American and, to a lesser extent, English geneticists focused on the implications of the chromosomal theory of heredity. German investigators, more chary of a "Kernmonopol," pursued a more integrative approach, and French biologists pretty much ignored classical genetics. These national differences, particularly, have provided historians an opportunity to examine the interplay between scientific programs and theories and social concerns and expectations. Hodge, Robert Olby, John Farley, Jan Sapp, Garland Allen, Jane Maienschein, and this reviewer, among others, have each in his or her way developed particular aspects of this revised story.

Peter Bowler is interested in broadcasting the results of this scholarship in general terms that will be easily understood by the nonspecialist. He readily admits that this is not his area of historical research and that all he intends is a tertiary account. He has performed the task of summary and popularization in a comprehensive way, and he demonstrates a solid, though not complete, grasp of the Anglo-American secondary literature. His book provides a readable introduction to the changes in formal theories of heredity that captures the essence of what the specialists have been working toward. Bowler also presents a much-needed discussion contrasting social Darwinism and the eugenics movement. As a source of reference to the secondary literature the work will be useful.

Perhaps because it is wholly derivative, however, the book fails to provide a sense of the nuts and bolts of the scientific research. Biologists during the 19th and early 20th century, above all, possessed a deep familiarity with living organisms, with the diversity in organic forms, and with the complexities of the processes perpetuating life. Without some grounding in this fascinating world or some account of the particulars of nuclear cytology and the calculus of hybrydization, the contrast drawn between the generation theories of the 19th century and the hereditarian theories of the 20th century appears formal and superficial.

Where he does introduce biological particulars, Bowler sometimes confuses rather than elucidates the details. Thus he describes meiosis as a "quadruple cell division" (p. 86); he confounds Mendel's law of independent assortment with the law of segregation (pp. 101–102); and he writes six pages on the rise of population genetics without a word about the Hardy-Weinberg equilibrium principle (pp. 138–143). More confusing yet, Bowler identifies the 19th-century attitude toward heredity with the phenomenon of "growth," as though generation or development were the same process as an extension of size. This conflation of two quite different phenomena obfuscates the fact that the 19th century sought to understand the generation of new form, not the extension of existent form. By substituting "growth" for "development," Bowler corners himself into writing some comical phrases, as in his references to Wilhelm Roux's "mosaic theory of growth" (p. 79) and Hans Spemann's concept of "an organizer field to coordinate growth" (p. 148).

Bowler, however, is more interested in generalities than details, and he prefers exploring another level of historical explanation. He draws upon the recent trend in the history of science to invoke political and social forces as the primary shapers of scientific theories. To his credit Bowler is at most a cautious "social constructionist," who levels some perceptive criticisms at the "strong programme," as today's jargon has it. Nevertheless he peppers the reader with provocative assertions, most of which he fails to follow up with demonstration or refutation. Thus he suggests that the modern dominance of genetics and evolution theory is "a product of professional and ideological decisions" (p. 146), that classical genetics was an "artificial construct of American and British science" (p. 152), and that "early Mendelians redefined the concept of heredity to focus attention on the problems that they alone had the techniques to solve" (p. 153). Now, I do not quarrel with Bowler for reporting these claims (whether he accepts them or not), nor do I object to social constructionists for "exposing" the institutional politics and social ideologies in science. I have no doubt that both factors operate here as in all other spheres of human activity. They do not, however, define the limits of human aspirations. The challenge, which has been rarely met and in this book is casually ignored, is to show in a precise way how politics and ideology interact with unexpected "factual observations" to construct in a step-by-step manner a particular scientific theory. Vague correlations, innuendos, and bold assertions simply will not do—even in a tertiary text.

A quotation on the dust jacket will reveal that I am an admirer of some of Bowler's previous books. This one, however, fails to live up to earlier standards.

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Underrepresentations

Blacks, Science, and American Education. WILLIE PEARSON, JR., and H. KENNETH BECHTEL, Eds. Rutgers University Press, New Brunswick, NJ, 1989. xxii, 174 pp., illus. $35.

That blacks are underrepresented in the study and practice of science (and engineering) in the United States is well documented. Blacks constitute 12% of the population but only 7% of undergraduates majoring in science and engineering, 2% of graduate students in these fields, and 2% of employed scientists and engineers. This book is devoted to exploring the historical and current causes of this underrepresentation. In seven chapters the accumulated evidence on the status of black science students and black scientists and engineers is ably and usefully summarized.

Following a gracious foreword by Walter Massey, former president of the American Association for the Advancement of Science, in which the contribution of Shirley Malcom to the advancement of minorities in science is highlighted, the history of blacks in American science is briefly recapitulated. Then, beginning with high school and proceeding to professional employment, successive chapters describe the evidence that may help to explain the underrepresentation of blacks in science and engineering. In the final chapters, strategies for increasing the participation of blacks are discussed.

If the book has a problem it is that the confidence with which the authors draw conclusions is not always supported by the data. Phrases such as "this proves," "it is clear," and "the only factors" occasionally leave one wishing for more data or more consideration of competing hypotheses. For example, federally funded intervention projects are credited with increasing the test scores of black students although the only evidence cited is that the two events (onset of funds and rising scores) tended to coincide.

The book is intended to be a data-based

document, and indeed a large quantity of data are presented, in some cases for the first time. In this respect, the book is valuable and well worth owning for the student of social progress in the United States (though many of the tables might have been made more easily comprehensible).

The dismal history of discrimination against blacks in this country is familiar, including for example laws passed throughout the South in the early 1800s making it a crime to instruct any slave or free black. Not so familiar is the thesis Bechtel puts forward here that, following the Civil War, blacks were denied education because educating them "would have meant extending a privilege that had historically been restricted to the upper classes in the South; it would elevate the former slave to a status higher than that of most former slave owners" (p. 3). At the end of the Civil War, according to Bechtel, "95 percent of the black population in America was illiterate." In well-documented detail, he describes the emergence of separate but unequal schools for blacks. The recounting of the adversity and bigotry encountered by the early black scientists is both disconcerting and fascinating, convincing the reader that it is no wonder that "the black scientist is both rare and relatively unknown" (p. 19).

Subsequent chapters concern black students' instruction in mathematics and science (or lack thereof) in high school and college. Substantial evidence is provided that black students, even when enrolled in the academic curriculum, do not take as much advanced mathematics and science as white students. Relevant recent results from the College Board, the National Assessment of Educational Progress, and a national longitudinal study known as High School and Beyond are described in detail. But throughout the book, especially in Anderson's insightful chapter, the need for further research is emphasized.

Clewell describes three intervention programs in enough detail to persuade the reader of the major premise of her chapter, namely, that what interventions are most appropriate depends primarily on the educational level of the participants.

Fechter's chapter is distinguished by the clarity of the presentation of important and highly relevant data, mainly from the files of the National Research Council, concerning graduate school enrollments and postgraduate school appointment. As in the case of the NAEP data, Fechter has organized the NRC survey results so as to give them new significance. In the case of Ph.D. attainment, for example, he demonstrates that the median time from the receipt of the baccalaureate to receipt of the Ph.D. was two years longer for blacks than for whites (10.3 versus 8.2) in 1985, in part because blacks spend almost twice as much time in nonregistered status. This in turn may be attributable to a dramatic shift in sources of funding for graduate training, away from federal grants and fellowships toward loans, personal (or family) financing, and "other" sources.

In an erudite sociologically oriented chapter on the benefits of black participation in science, Gaston makes the simple but cogent point that if newly recruited black scientists are more talented than the least talented white male scientists then the average level of talent in science will be increased provided, of course, that the less talented white scientists are not also hired. He also argues that increasing the black presence in science would maximize the probability that potentially significant research problems would not be neglected.

In the final chapter Pearson summarizes, integrates, and skillfully enlarges upon the contributions of the authors and ends with the thought that societal opportunities must be created to help black people to help themselves.

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Recombination

Gene Transfer in the Environment. STUART B. LEVY and ROBERT V. MILLER. McGraw-Hill, New York, 1989. x, 434 pp., illus. $54.95. Environmental Biotechnology.

Among the higher eukaryotes, gene transfer in the environment prevents pandas from going extinct. For the prokaryotes, it's a different matter. We know some exquisite details about their mechanisms of gene exchange in captivity, but do they really do these things in nature? They do, and the fascinating story is just beginning to unfold.

Prokaryotic gene transfer is a fairly open system: DNA may be passed between cells in close contact (conjugation), delivered by phages (transduction), or broadcast by living cells for subsequent pickup (natural transformation). Here the inanimate environment is not shut out: it often participates. The regular delivery of specific genes to plants is yet another story.

From these goings on, and their results in the context of powerful selective forces, we recognize a wild card in evolution that permits organisms occasionally to acquire genetic properties from phyletically distant sources. There are four essentials for an enduring long-distance gene transfer: (i) the origin or assembly of an unusual genotype (at least unusual to the recipient); (ii) its transmission to an extraspecific cell; (iii) a resulting advantage to the recipient; and (iv) the multiplication of the recombinant to numbers that render it safe from random loss. Each of these components is improbable. The necessary combination is extremely improbable in the short run, but there is now abundant evidence of its repeated occurrence somewhere among the vast numbers of organisms over vast periods of time. Now genetic engineering has, depending on the case, raised the probability of one or more of these component events. This makes gene transfer far more likely. The nature of the genotype often makes it dangerous as well, adding a new reason to learn about this unfamiliar subject.

This book, by turns informative and exasperating, appears to be the first serious effort to cover the subject, and on balance it is well worth reading, at least for the experienced scientist, to whom it is directed. It begins by describing a variety of genes and plasmids involved in the dramatically widespread acquisition and transfer of antibiotic resistance, continuing with other kinds of resistance and then metabolic functions. All this seems unnecessarily hard to follow, but it leaves no doubt as to what's happening.

The next section contains three excellent chapters on transfer mechanisms: conjugation (both chromosomal and plasmid transmission), transduction, and natural transformation, which is not the same as the experimentally induced type. Also, transposable elements, which can diversify the potential effects of gene transfer, are described superbly by Douglas Berg.

The major section of the book, on model environments, is mixed: in some chapters one finds many intriguing tidbits but little rigor. The chapter on soil does begin in a most enlightening way by illustrating its subject's infrastructure. The chapter on conjugal transfer in plants by Stephen Farrand should be started with the description of the *Agrobacterium* system, an excellent introduction to the otherwise confusing earlier half, which is laden with undefined terms. Other chapters cover the aquatic environment, *Streptomyces*, the (human) urogenital and respiratory tracts, and epidemiology, this last with some interesting case studies.

The obvious motivation of this volume is to lay the groundwork for the responsible release of genetically engineered microorganisms, and it is clear that this must begin with an understanding of the major avenue of risk: gene transfer. The introduced genetic material may find its way into an uncontrollable organism, or the engineered organism may acquire the means of escaping control. Thus the mechanisms of gene trans-