Crow's lab. Even a cursory glance at a typical Mukai paper shows that his designs were both better and larger (more chromosomes sampled and more flies counted) than Dobzhansky's. For some reason both Dobzhansky in his GNP series and Lewontin in his assessment of Dobzhansky's work have ignored this entire effort by Crow and his followers. This is not a trivial point. If the Crow-Mukai interpretation that for naturally occurring alleles h is close to .5 is correct for most loci, then Dobzhansky's theories about the maintenance of genetic variation are quite simply wrong. Moreover, since much of equilibrium population genetics theory relies on overdominance to maintain variation, a good part of it would also be a casualty. No matter how much we may wish that Crow's results were different, they will not go away, and to ignore them when trying to assess the contributions of Dobzhansky is unacceptable.

Dobzhansky's unassailable contributions to evolutionary biology are easy to identify. One of these that was new to me was his formulation of the biological species concept. He appears to have been the first to realize that the definition of a species must involve the nature of the gene flow between populations rather than the conventional morphological criteria used by systematists. He differed sharply from Sturtevant in this point of view. Sturtevant at that time was more persuaded by the requirements of museum workers than by the biology involved.

The contributions of the first half of the GNP series are manifold and are well covered in Lewontin's essay. These early papers are the core of observations that all of us in the business rely on for our notions of the genetic structure of populations. I often find it surprising that Dobzhansky's work, particularly my favorite papers from the mid '50's, are not cited more often by theoretical types. For example, in the six 1981 issues of *Theoretical Population Biology* there were only two citations of Dobzhansky, and neither one of these was to a GNP paper. Perhaps the publication of this collection will stimulate theoreticians to begin incorporating more of Dobzhansky's (and Crow's!) results into their theories.

Another contribution of Dobzhansky's that cannot be overlooked is the enormous number of students he produced. Many of the most conspicuous contributors to both theoretical and experimental population genetics are former students of his. Among these are two of the editors of the GNP book, Lewontin and Wallace. Most of these students harbor a great deal of affection and admiration for their mentor.

There is another side to Dobzhansky that is revealed in the collection of his "travel letters" edited by Glass. These engaging letters were written from various countries over a span of 12 years, from 1948 to 1960. They are mostly descriptions of events that occurred during collecting safaris to some often remote and primitive areas of the world. The letters are light reading. They do not indulge in profundities about the conditions in underdeveloped countries or the state of mankind, although they too often reflect some dated notions about the state of womankind. This collection would have been more interesting to the uninitiated if the cast of characters had been identified in the introduction. As it stands I had little idea who these people were that Dobzhansky was describing. Occasionally a well-known geneticist appears, but in general most readers will know nothing about most of those mentioned. The first letter is actually from the Columbia University Oral History Project. It describes three collecting trips to Central Asia that Dobzhansky took while in his mid-20's, before he came to this country. It is a somewhat self-conscious monologue that nonetheless gives some insight into Dobzhansky's strong roots as a natural historian.

The vastness of Dobzhansky's scientific output has probably been a deterrent to its assimilation into the thinking of younger population geneticists who were brought up outside the Columbia sphere of influence. It is to be hoped that the reprinting of these works in addition to Columbia University Press's planned reissue of the first edition of *Genetics and the Origin of Species* will focus attention back on this older experimental literature.

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Products of a Centennial

The items discussed here are celebrations of Einstein's 100th birthday that by chance and publishers' design have accumulated on the bookshelf of *Science*. They well represent the general celebratory literature; purely technical festschriften have been set aside for separate review.

The most important and substantial of the works from *Science*'s shelf are the products of symposia held in Berlin (Nelkowski *et al.*), Jerusalem (Holton and Elkana), and Princeton (Woolf), which brought together scientists, historians, and philosophers. Contrary to much previous experience, it appears that the different sets of savants have something to say to one another if they study the same texts. The Jerusalem and Princeton volumes are further enriched by the craftsmanship and style of distinguished straight (not science) historians: Isaiah Berlin on "Einstein and Israel" and Fritz Stern on "Einstein's Germany" (Holton and Elkana) and Felix Gilbert on "Einstein's Europe" (Woolf).

A second genre consists of collections of mainly new material (Aichelburg and Sexl; Consejo Nacional; Kinnon *et al.*) and compendia of old and new (the fine sampler of Einstein commentary and reminiscence edited by A. P. French). The remaining works apart from Broda are printings or reprintings of source material: Einstein's *Autobiographical Notes*, his nontechnical writings on general relativity (Tauber), a few letters (Rosenthal-Schneider), and the charming chrestomathy edited by Dukas and Hoffmann. Unfortunately, the most important new collection of source material, two volumes published by the Berlin Academy of Sciences (*1*), is not present. Nor is there a centennial biography, no one apparently having had the courage to try. (An account of the older biographies is given by D. Cassidy in Nelkowski *et al.*, pp. 490–510.)

Science's shelf contains no more than 20 percent of the serious centennial literature. And this literature, though large and important, does not greatly augment the volume of Einstein studies. The recently published *Literature on the History of Physics in the 20th Century* (*2*) lists 7000 items, of which over 10 percent directly concern Einstein. Long before his hundredth birthday he was already the most quoted physicist of modern times (*3*).

The attention paid Einstein derives in large part from the tendency of histori-

ans to create representative types and of physicists and journalists to create heroes larger than life. Einstein lent himself to these practices. He burst upon the public consciousness as a hero, outside Germany at least, when British astronomers announced that observations made during the solar eclipse of 1919 confirmed the general theory of relativity. It appeared that a single rational animal had managed by the unaided power of his reason to deduce the most delicate behavior of the heavens while his fellow men were slaughtering each other in holes in the mud. When it was further discovered that this rational animal had an earthy sense of humor, looked like an Italian violinist, and gave social and political advice freely, journalists invented the 20th century's image of the scientist. For the last 35 years of his life Einstein was a public figure.

Einstein stood up under this unwelcome attention, unaffected by fads in science or politics, describing his peculiar world-line, not compromising his decency, honesty, or rationality. It is for these strengths of character, as well as for his capital gifts to science, that Einstein continues to inspire. In pursuing his science and his social goals Einstein, like the rest of us, adjusted to circumstance and changing self-awareness; the Machist empiricist of the special theory of relativity became the unfettered rationalist of the general theory; the pacifist turned into an advocate of armed resistance; the cosmopolite antinationalist was also a fervent Zionist; and the champion of the individual condemned the entire German nation for the destruction of the Jews. In none of this, however, was there opportunism. Einstein demanded not absolute consistency but absolute honesty. He had no capacity for self-deception or evasion (Berlin in Holton and Elkana, p. 286).

He also lacked, at least in his later years, a capacity for sentiment or intimacy (U. Tal in Holton and Elkana, p. 308; K. von Meyenn in Nelkowski *et al.*, p. 464). Or, to put the point the other way, Einstein the humanitarian had little need for human beings; he stayed "at a distance" (Gilbert in Woolf, p. 13), "apart" (A. Pais in Woolf, p. 198), "remote" (C. P. Snow in Swenson *et al.*, p. 21). Stern (Holton and Elkana, p. 334) observes that this blank prevented Einstein from understanding the passionate, the irrational, the desire for camaraderie in others. Einstein's God, who does not play dice, is not the Judeo-Christian Creator solicitous of his creatures but the aloof unmoved mover of the Greeks, whose existence is thinking about thinking.

Einstein's Physics

Einstein's first published papers concerned the foundations and applications of thermodynamics and statistical mechanics. He did not feel the distaste for the mechanical world picture that many modern commentators suppose to have been appropriate to reforming physicists at the turn of the century. Rather, he wondered that mechanical concepts can capture essential features of nonmechanical phenomena like light and heat (M. Klein in Holton and Elkana, p. 41, and in Woolf, p. 162). In this mood, he can be considered the natural successor to Boltzmann (Broda, pp. 3–5). Despite the intrinsic importance of these early papers and their relevance to Einstein's later work, they have not received much attention from historians. Klein's account of them (Woolf, pp. 161–185) is a welcome contribution.

The most extensive survey of Einstein's work on quantum theory on the *Science* shelf also goes further than is customary, including a valuable account of the origin of Bose-Einstein statistics (Pais in Woolf, pp. 197–251). Pais and others also present more familiar material, for example, Einstein on the light-quantum, fluctuations, and the A and B coefficients. Two reservations about these presentations may deserve mention. First, they aggrandize Einstein's part in the history of the light-quantum hypothesis. The difficulty of interpreting

Einstein Centennial Works Reviewed Here

AICHELBURG, PETER C., and ROMAN U. SEXL, Eds. **Albert Einstein: His Influence on Physics, Philosophy and Politics**. Vieweg, Braunschweig, 1979 (U.S. distributor, Heyden, Philadelphia). xvi, 220 pp., illus. $26.50.

BRODA, ENGELBERT. **Einstein und Österreich**. Verlag der Österreichischen Akademie der Wissenschaften, Vienna, 1980. 30 pp. Paper, DM 7. Veröffentlichungen der Kommission für die Geschichte der Mathematik, Naturwissenschaften und Medizin, Heft 33.

CONSEJO NACIONAL DE CIENCIA Y TECNOLOGÍA. **Einstein**. Consejo Nacional de Ciencia y Tecnología, Mexico City, 1979. 146 pp., illus. Paper, $11. Originally published in *Ciencia y Desarrollo*, March–April 1979.

DUKAS, HELEN, and BANESH HOFFMANN, Eds. **Albert Einstein: The Human Side**. New Glimpses from His Archives. Princeton University Press, Princeton, N.J., 1979. viii, 168 pp. Cloth, $12.50; paper, $3.95.

EINSTEIN, ALBERT. **Albert Einstein: Autobiographical Notes**. A Centennial Edition. Translated and edited by Paul Arthur Schilpp. Open Court, La Salle, Ill., 1979. vi, 90 pp. $10.95.

FRENCH, A. P., Ed. **Einstein: A Centenary Volume**. Harvard University Press, Cambridge, Mass., 1979. xx, 330 pp., illus. Cloth, $20; paper, $8.95.

HOLTON, GERALD, and YEHUDA ELKANA, Eds. **Albert Einstein: Historical and Cultural Perspectives**. Papers from a symposium, Jerusalem, March 1979. Princeton University Press, Princeton, N.J., 1982. xxxii, 423 pp. $35.

KINNON, COLETTE M., A. N. KHOLODILIN, and J. G. RICHARDSON, Eds. **The Impact of Modern Scientific Ideas on Society**. In Commemoration of Einstein. Papers from two meetings, Munich-Ulm, Sept. 1978, and Paris, May 1979. Reidel, Boston, 1981 (distributor, Kluwer Boston, Hingham, Mass.). xiv, 204 pp. $26.50.

NELKOWSKI, H., A. HERMANN, H. POSER, R. SCHRADER, and R. SEILER, Eds. **Einstein Symposium**. Berlin, March 1979. Springer-Verlag, New York, 1979. viii, 552 pp., illus. Paper, $29.20. Lecture Notes in Physics, vol. 100.

ROSENTHAL-SCHNEIDER, ILSE. **Reality and Scientific Truth**. Discussions with Einstein, von Laue, and Planck. Thomas Braun, Ed. Wayne State University Press, Detroit, 1980. 150 pp., illus. $13.95.

SWENSON, LOYD S., C. P. SNOW, HOWARD STEIN, and ILYA PRIGOGINE. **Albert Einstein: Four Commemorative Lectures**. University of Texas Humanities Research Center, Austin, 1979. Unpaged, illus. Paper, $3.50. Reprinted from *The Library Chronicle*, n.s. 12.

TAUBER, GERALD E., Ed. **Albert Einstein's Theory of General Relativity**. Crown, New York, 1979. 352 pp. $14.95.

WOOLF, HARRY, Ed. **Some Strangeness in the Proportion**. A Centennial Symposium to Celebrate the Achievements of Albert Einstein. Princeton, N.J., March 1979. Addison-Wesley Advanced Book Program, Reading, Mass., 1980. xxxii, 540 pp., illus. $43.50.

x- and γ-rays as high-frequency light occurred to many people and prompted discussions of what we call the wave-particle duality long before the First World War. The extreme light-quantum hypothesis did not conquer physics, however, owing to the quantity of phenomena, easily explained on wave theory, that conflicted with it. Here a small but important correction is required to Pais (Woolf, p. 203); Einstein's Nobel Prize, given in 1922 for 1921, did not reward discovery of the photoeffect or even its theory; it was given "for his services to theoretical physics and especially for his discovery of the law of the photoelectric effect" (*4*).

The second reservation concerns the relation of Einstein's work on quantum theory to Planck's. Almost all authors agree, at least tacitly, that Planck at first did not realize what he had wrought. Nonetheless they—Klein, Pais, R. Jost (Woolf, p. 195), Miller (foreword to Rosenthal-Schneider), H. Ezawa (Aichelburg and Sexl, pp. 78–80)—ascribe the invention of quantum theory and realization of its attendant puzzles to Planck. This is to ignore the striking evidence published by T. S. Kuhn in 1978 (*5*) and briefly recapitulated by him at the Princeton symposium (Woolf, pp. 186–191). Kuhn shows that Planck did not quantize the individual oscillator, but required that the total energy possessed at equilibrium by all oscillators in the frequency range $\nu + d\nu$ equal a multiple of ν; and he argues that Planck perceived the requirement as a straightforward application of Boltzmann's combinatorial method, not as a break with classical theory.

Einstein once wrote to Freud, "To punish me for my contempt of authority [God has] made me an authority myself." The punishment now includes analysis in the scholastic manner. This technique, the merits of which have long been known, is practiced preeminently by the Harvard school of Einstein studies. In several centennial papers (Aichelburg and Sexl, pp. 89–108; Holton and Elkana, pp. 3–26; Woolf, pp. 66–91) and in an informative book (*6*) A. I. Miller sets forth the prehistory of relativity in the work of Lorentz and Poincaré, and presents Einstein's paper of 1905 in snippets and commentary. One set of Miller's editors wonders at a methodology "which might seem to the physicist to be overly accurate" (Aichelburg and Sexl, p. vii); but nothing better could be imagined for terminating a subject that has already received sufficient consideration.

The proprietor of the Harvard school, G. Holton, is represented by an analysis of a passage in a letter of 1952 from Einstein to M. Besso (Aichelburg and Sexl, pp. 109–136). It is a bold attempt to extract a deep philosophy from a casual sketch illustrating Einstein's conviction that the move from sense experience to the "free creations of the human mind" that constitute physical theory is not a logical one, nor is the reverse step from theory to experimental confirmation. A soberer view of Einstein as philosopher is presented by P. Janich (Nelkowski *et al.*, pp. 412–427), who concludes that Einstein's dependence on, interest in, and contributions to epistemology and philosophy have been greatly exaggerated, "a part of the Einstein legend." Rosenthal-Schneider recalls (Woolf, p. 522; Rosenthal-Schneider, p. 90) that Einstein once said to her that Kant was like a highway with many milestones and modern philosophers like little dogs, "each depositing his contribution." Y. Elkana's claim that Einstein thought in the style of the modern epic theater, rather than in the fatalistic fashion of Greek tragedy, is also developed by the Harvard method (Holton and Elkana, pp. 205–251).

Most of the centennial accounts of general relativity are free and unhistorical, as befits a subject whose current ramifications are among the most exciting topics in science. (An exception is J. Stachel's good overview of Einstein's route to the general theory (Nelkowski *et al.*, pp. 428–442).) C. F. Everitt discusses classical tests of the theory and newly practicable ones, like the Stanford gyroscope experiment (Tauber, pp. 141–159); there are also J. Weber on gravity waves (Aichelburg and Sexl, pp. 25–31; Tauber, pp. 236–239) and I. I. Shapiro on time delays occasioned by gravity (Woolf, pp. 115–136). R. Penrose popularizes black holes with elegance and restraint (Aichelburg and Sexl, pp. 33–50). John Wheeler pulls out all stops (Woolf, pp. 341–375) and asserts that not only matter, but physical law itself, is crushed out of existence in gravitational collapse.

Wheeler's paper, a free creation of the human mind, connects the crushing of law in the final crunch and its concomitant creation at the big bang with the business of the quantum physicist. According to some interpretations of this business, the physicist, by choosing which of complementary aspects of nature he wishes to realize, helps to create his physical world. If physical law can also be created, the experimenter's interrogation of nature might help to make it. No mere Moses writing law to dictation, the physicist actively participates in drawing up the rules of the Lord's dice game.

This promiscuous law-making would not have pleased Einstein, who rejected the Copenhagen interpretation of quantum mechanics on which it rests. He would not accept what he called the "tranquilizing philosophy" that taught resignation to restrictions that he deemed inappropriate in a complete physical theory. To meet the argument (not paradox!) of Einstein, Podolsky, and Rosen, recapitulated in the centennial literature by N. Rosen (Aichelburg and Sexl, pp. 57–67), Bohr made explicit that physical systems that have once interacted might be forever entwined, irrespective of how far apart they eventually move. This and other dark teachings Einstein thought to be consequences of the unjustifiable retention in quantum mechanics of ordinary mechanical quantities (Stachel in Woolf, p. 226). His call to jettison these concepts is interpreted by M. Jammer (Nelkowski *et al.*, p. 147) as radical; not Einstein but his opponents were the true conservatives.

Dirac observes that students must adopt the standard interpretation, that is, if they are to succeed in their examinations. But, after passing, they "may be inclined to feel the force of Einstein's argument." Although quantum electrodynamics agrees with experiment to extraordinary accuracy, the agreement is attained by a trick, disfiguring the theory. This ugliness shows that a new theory is required, one that might well "have determinism in the way that Einstein wanted" (Dirac in Holton and Elkana, pp. 84–85, and in Kinnon, p. 23).

Biographical Matters

"You don't know the 25 year old man when you are 65." This aphorism of Einstein's (reported by E. Straus in Woolf, p. 483) has not been heeded by many of his intellectual biographers. In reconstructing his path to relativity and the quantum theory, the heedless rely on his *Autobiographical Notes* and other late writings, mixing up evidence drawn from very different times and occasions. For his part, Einstein had no interest in general history (Stern in Holton and Elkana, p. 321; Gilbert in Woolf, p. 16) and little in his own (Snow in Swenson *et al.*, p. 22).

Nowhere in the literature under review is Einstein's interest in technology discussed. Nothing about his industrial consulting, his patents, his suggestions for military hardware; his job with the patent office appears as a chore to keep

the body alive while the head sublimed to relativity, rather than as the congenial occupation it probably was. From childhood Einstein must have heard talk about gadgets at the family table. His father and uncle ran a company for manufacturing electrical equipment, some of it advanced and clever, designed by the uncle. The classical theory of electromagnetic induction, which figures prominently in Einstein's first paper on relativity, was crucial to the design of the motors and power distribution systems of interest to the Einstein firm (*7*). This is not to say that Einstein took his central problems from the expanding electrotechnology of his day, but that he probably became acquainted with some of these problems in the framework of his father's engineering concerns.

Also one should probably not credit Einstein's memory that German militarism prompted his premature departure from the Munich Gymnasium. He was then a rebellious and lonely adolescent, wishing to join his family, who had moved to Italy, probably suffering from anti-Semitism, and certainly wanting to evade military service (Stern in Holton and Elkana, p. 327). His detestation of Germany arose from frustration over failure of the Weimar Republic, which he had publicly supported, and from an accurate evaluation of the Nazis, who had made him an early and special target (A. Kleinert in Nelkowski *et al.*, pp. 501–516).

The rise of the Nazis killed Einstein's pacifism. Among practical results of its demise was his signing the famous letter to Roosevelt recomending consideration of an atomic bomb. Here again Einstein is a poor guide to history. However important to him personally this signing might have become, it did not, as he supposed, have any practical importance in the construction or the timing of the atomic bomb (P. Doty in Holton and Elkana, p. 354). It did, however, lend drama to his continuing efforts to curb the postwar arms race (B. T. Feld in Holton and Elkana, pp. 369–383).

In closing the Berlin symposium, A. Hermann draws an analogy between Einstein's political and scientific development. At first, according to Hermann (Nelkowski *et al.*, p. 548), Einstein's politics, like his physics, displayed unerring insight; with the advent of the Nazis and quantum mechanics, both began to go awry. The pursuit of his will-o'-the-wisp, the unified field theory, had its parallel in his inability to consider the possibility that democracy might establish itself in Germany. In a speech at the opening of the centennial year, the president of the Bundesrepublik took up the challenge. To Einstein's declaration, "It is impossible to make good democrats of those people," he replied: "We have begun to prove the contrary."

Hermann comments: that is the best way to honor this great and good man Einstein, not taking his every word in politics or science as unalterable truths, but striving further along his path, "zu einer besseren Wissenschaft, zu einer besseren Gesellschaft." Other essayists put the same thoughts in virtually the same words: Einstein stands for "a more perfect society and for a deeper comprehension of the physical universe" (P. Bergmann in Holton and Elkana, p. 27), for "el camino del conocimiento, de la valorización del hombre, de la defensa de la verdad, de la construcción de un mundo nuevo" (C. Firmiani in Consejo Nacional, p. 78).

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2. J. L. Heilbron and B. R. Wheaton, *Literature on the History of Physics in the 20th Century* (Office for History of Science and Technology, University of California, Berkeley, 1981).
3. B. R. Wheaton and J. L. Heilbron, *An Inventory of Published Letters to and from Physicists* (Office for History of Science and Technology, University of California, Berkeley, in press).
4. Nobel Foundation, *Calendar* (Stockholm, 1977), p. 52.
5. T. S. Kuhn, *Black-Body Radiation and the Quantum Discontinuity* (Oxford University Press, New York, 1978).
6. A. I. Miller, *Albert Einstein's Special Theory of Relativity: Emergence (1905) and Early Interpretation (1905–1911)* (Addison-Wesley, Reading, Mass., 1981).
7. L. Pyenson, "Audacious enterprise: The Einsteins and electrotechnology in late nineteenth-century Munich," *Hist. Stud. Phys. Sci.* **12**, 373–400 (1982).

Encapsulations of Scholarship

Concise Dictionary of Scientific Biography. Scribner, New York, 1981. x, 773 pp. $100; prepaid and library orders, $66.67.

Dictionary of the History of Science. W. F. BYNUM, E. J. BROWNE, and ROY PORTER, Eds. Princeton University Press, Princeton, N.J., 1982. xxxiv, 494 pp., illus. $40.

The success and standing of the 16-volume *Dictionary of Scientific Biography* are by now a matter of record. So alas is the price (originally $695 and now, in an eight-volume format, $595), which puts the *DSB* out of reach of all but the most determined scholar. It is therefore good news that Charles Scribner's Sons have brought out a one-volume abridgement where for a much lower price one may find "the essential facts from all the entries, set forth briefly and clearly and in significant proportion to the scope of the original articles."

Many questions come to mind. How faithful is the abridgement?—that is, can a scholar in his or her study use this condensation to determine whether a trip to the reference library to consult the original will be worthwhile? How valuable is the *Concise DSB* as a reference work, in itself? How well does it compare with other biographical dictionaries of scientists? Can the one-volume work serve as a guide to "the extant knowledge of the history of science," as the publisher claims? Or should one turn instead to the new *Dictionary of the History of Science*?

The first question is the easiest to answer. The 18 editorial staff listed on the title page of the *Concise DSB* have done their work well, though I doubt that I will be alone in feeling a sense of shock at the shrunken, "ghosted" versions of the essays I wrote long ago for the fuller work. Those versions are faithful to the tenor of their originals—thus the entries on John Dalton, Albert Einstein, and Sigmund Freud discuss their subjects' lives as well as their ideas, while Pierre Simon Laplace remains a disembodied mind. Only the proportions of the space allotted have undergone a change: in the *Concise DSB* Einstein has finally triumphed (two pages, to one each for Dalton and Laplace and half a page for Freud), whereas in the original Laplace ruled over all (130 pages, compared to 21 for Einstein and 10 each for Dalton and Freud).

The great strength of the full *DSB* lies in its lengthy, authoritative, and often compelling accounts of the genesis and growth of the scientific ideas of its subjects. The editor, Charles C. Gillispie, took great pains in his commissioning and shaping of this aspect of the work, and the results were of very considerable credit to him and of major value to scholarship. Gillispie was more tolerant of variations in the detailed information on family backgrounds, education, and career in the 5000 entries written by the hundreds of contributors from many countries. Unfortunately, accounts of scientific ideas do not condense easily, while variations in basic information become irritating when concentrated in a one-volume work intended for quick reference. By way of example, the six-line entry on Andrew Lapworth tells us that he "studied at Birmingham," but the eight lines devoted to his father, Charles Lapworth, give no hint of where, or if, he was educated. Laplace appears with-