BOOK REVIEWS

Daniel V. Schroeder, *Editor*
Department of Physics, Weber State University, Ogden, Utah 84408; dschroeder@weber.edu

The Electric Life of Michael Faraday. Alan Hirshfeld. 258 pp. Walker & Company, New York, 2006. Price: $24.00 ISBN 0-8027-1470-6. (Hans Christian von Baeyer, Reviewer.)

The book opens with an astonishing epigraph by the novelist Aldous Huxley: "[E]ven if I could be Shakespeare, I think I should still choose to be Faraday." In view of the bard's universal fame, Faraday's relative obscurity, and the arcane nature of his discoveries, the sincerity of the quotation might well be questioned. What in the world did Huxley have in mind?

That Faraday's story is remarkable is beyond question. Virtually unschooled and apprenticed to a bookbinder at age 14, he was hired as a laboratory assistant by the great chemist Sir Humphry Davy at 22. By dint of industry, perseverance, and natural ability he quickly rose in stature to become arguably the foremost experimental physicist of his age. Three inventions place him in the pantheon of scientific immortals: A primitive apparatus for using an electrical current to move a wire—the first electric motor; a device for creating a current from another, separate current—the first transformer; and a machine for producing a current from motion—the first generator. The technology spawned by these inventions would revolutionize the world's industry, transportation, and everyday life, thereby putting Faraday in the company of the most influential reformers in history. Perhaps that's what impressed Huxley.

A particular appeal of Faraday to the lay public was his total ignorance of mathematics. While his contemporaries in the development of electrical science depended on Newton's highly mathematical method, the self-taught Faraday had to make do with words and pictures. His ideas were abstract, to be sure, but they were expressed in ordinary English, and thereby conceivably accessible to every educated reader. Huxley might have felt that, while Newton's mind is beyond imagining, Faraday was, in the end, just an ordinary human.

Although Aldous never met Faraday, his grandfather, Thomas Henry Huxley, was a scientific colleague of the physicist, so there might have been a lively tradition of Faraday worship at the Huxley dinner table. At the height of his career, Faraday had a tremendous following in England as a popular lecturer. His presentations of the most varied scientific topics to the general public, always accompanied by elaborate and meticulously prepared practical demonstrations, were often sold out. The descriptions of his performances, and the general principles of the art of public lecturing that he handed down, put living physics professors like myself and the author of this book to shame. It is humbling, but also inspiring, to find out how much we can still learn in this age of PowerPoint. Without belaboring it, Hirshfeld hints at his professional admiration of his subject in this respect.

In the end, Huxley may have been thinking as much about the man Faraday as about the scientist. While we know very little about Shakespeare as a person, we know a lot about Faraday, and it all turns out to be good. He was, by all accounts, simply a very nice man. Humble, generous, honest, fun-loving, broad-minded, adventurous, a loyal friend, a devoted family member, a caring husband, a devout Christian—the accolades flow freely. Although he participated in his normal human share of controversies and squabbles, and called himself a proud man, he invariably acquitted himself with honor. Perceptive people sensed these exceptional human qualities. One of the scientists Faraday met in Geneva, where he traveled as assistant and valet to Humphry Davy, remarked: "We admired Davy, we loved Faraday."

Obviously this prince among men has been celebrated in countless biographies before. In preparation for this review I read one of them, entitled *Michael Faraday* and published in 1965 by L. Pearce Williams, who is quoted and acknowledged by Hirshfeld. Since Hirshfeld's purpose is not to reassess the life and role of Faraday, it is fair to ask: Why do we need another biography?

In addition to repeating the commonplace remark that every generation must interpret the past for itself, I will single out some features of Hirshfeld's book that recommend it to physicists and the public alike. Historians of science, such as Pearce Williams, are always on guard against anachronistic reasoning. In order to understand Faraday's thinking, they take care not to explain his experiments in light of modern insights. Hirshfeld, on the other hand, wisely does not feel bound by this scholarly stricture. After describing an experiment, and telling us how it puzzled Faraday, he often puts us at ease by using modern concepts to explain what really went on. Popularization of science, he knows, is not to be confused with history of science.

Hirshfeld's language is unaffected, fluid, and colloquial. I imagine that it is the way he talks to his freshmen. But he does not hesitate to quote long passages in the eloquent, flowery language of the Victorians. The juxtaposition of the two styles provides an interesting and exciting texture to his book. In time I hope he will become sufficiently confident of his own skill to avoid marring a fine metaphor by the use of a pair of utterly superfluous and pusillanimous quotation marks, as in this passage: "…every time [Faraday] rose from his basement laboratory, he delivered yet another hard-won pearl from nature's store of mysteries. Then, barely catching his breath, he would 'dive' down for more."

The most effective feature of Hirshfeld's book is its brevity. In 258 pages, compared to Williams's 531 considerably longer pages, he manages to paint a vivid picture of Faraday the scientist, the teacher, and the man. To be sure, he is occasionally forced to reduce lengthy topics to laundry lists—as, for example, of the subjects on which Faraday published or the variety of items that merited inclusion in his diaries— but those are perhaps inevitable in view of Faraday's inexhaustible energy. Hirshfeld's brief biography is much more accessible than Williams's daunting tome, and therefore more useful to more readers.

By the time you are three-quarters through the book, Faraday, for all his gifts, hasn't reached Shakespeare's lofty stature yet. But then you arrive at his greatest legacy, which ironically turns out to be theoretical. Physics, as Faraday knew very well, cannot be divided neatly into two separate disciplines. Theory and experiment must always go hand in hand in a mutually supporting partnership. In order to design his brilliant experiments, Faraday needed a framework for thinking about how electricity and magnetism work. Even if this framework was provisional, or incomplete, or wrong, it was necessary to prevent his observations from degenerating into a congeries of unrelated facts.

In the absence of a mathematical theory, two competing and equally unsatisfactory conceptions of nature were available to Faraday. On the one hand there was Newtonian gravity, a so-called action-at-a-distance force between two separated objects that changes instantaneously in strength when one of the objects moves. Newton himself once called this idea an "absurdity," and Hirshfeld characterizes it correctly as "blatantly mystical." But, this was the model theoreticians were using to describe the action of electrical charges and of magnets on each other. The other model pictures the world as made of atoms that resemble minuscule marbles, and interact only when they touch. Faraday, who was a world-class chemist as well as a physicist, was able to explain many of his electrochemical observations in such terms. Even electrical currents might be understood in this manner, but forces between separated charges or magnets surely could not. As a compromise, Faraday conceived of space as crisscrossed by what he called lines of force, real but immaterial threads that interact when they touch and that transmit ripples at a finite, though to him unknown, speed. Unlike almost all of his contemporaries, Faraday trusted this image, and wrested from it powerful conclusions and predictions.

One of the few physicists who took the idea seriously was James Clerk Maxwell, who wrote a paper in 1857 entitled "On Faraday's Lines of Force." In his hands they became electrical and magnetic field lines, and the whole vast subject of electromagnetism was unified in a mathematically impeccable field theory. Inasmuch as the dominant paradigm of physics today is modeled on the quantized version of Maxwell's theory, Faraday must be credited with teaching us a new way to imagine the world. On his last page, Hirshfeld quotes Einstein's characterization of the Faraday-Maxwell theory as the "…greatest alteration…in our conception of the nature of reality since the foundation of theoretical physics by Newton." If Shakespeare illuminates the human condition, Faraday opens our eyes to the physical universe. Read this book to help you decide who you would rather be.

Hans Christian von Baeyer is Chancellor Professor of Physics, Emeritus, at the College of William and Mary in Williamsburg, Virginia. His latest book is Information: The New Language of Science, *Harvard University Press, 2005.*

The Wisdom of Crowds. James Surowiecki. 306 pp. Random House, New York, 2004. $24.95 (cloth) ISBN 0-385-50386-5; $14.00 (paper) ISBN 0-385-72170-6. (Mark P. Silverman, Reviewer.)

Whenever I learn of yet another egregiously unwise action taken by a faculty committee, I cannot help think of the website Demotivators.com. Under an inspirational image of many hands reaching from all directions towards a common center to touch one another in group solidarity is the unexpected aphorism: "*None of us is as dumb as all of us*." The sentiment must be a deeply rooted one because acid comments about group intelligence—or "the wisdom of crowds," as the author prefers to call it—goes back ages. Nietzsche, for example, wrote "I do not believe in the collective wisdom of individual ignorance." Or consider Bernard Baruch's comment: "Anyone taken as an individual is tolerably sensible…as a member of a crowd, he at once becomes a blockhead." And the most succinct version of all by Tommy Lee Jones, the Man in Black, protecting the Earth from the "scum of the universe:" "A person is smart. People are dumb." I could go on and on, but I won't.

Running counter to a vast literature in favor of individual intelligence and expertise is the best-selling book by James Surowiecki. The author, it should be noted, is not a scientist, but a business columnist for the *New Yorker*. Nevertheless, he has scrupulously researched and entertainingly and informatively presented numerous examples to propound what, in reality, is a fairly radical hypothesis. *Entertainment Weekly* expresses it this way: "under the right circumstances, it's the crowd that's wiser than even society's smartest individuals." Nobelist (in economics) Kenneth Arrow is a little more reserved, but says much the same thing: "…the average opinions of groups are frequently more accurate than most individuals in the group." Although neither the author nor the people whose work he cites are physicists, the hypothesis, and therefore the book, ought to be of keen interest to anyone—especially physicists—concerned with the acquisition, verification, and implementation of information. Besides, physicists are by virtue of their training "experts," and the thought that their individual judgments on a scientific matter may actually be less useful than the average opinion of, let us say, 30 people randomly chosen off the street, should be disturbing.

Indeed, the author seems to have had physicists and mathematicians in mind when he chose his opening examples of the superiority of group over individual intelligence. In 1968 the US Navy lost the nuclear submarine *Scorpion*—by which I mean the vessel simply vanished at sea—whereupon the task of finding it was assigned to John Craven, USN chief scientist for special projects, who, not long before, had succeeded in finding a thermonuclear bomb that the US Air Force lost off the coast of Spain. Craven, according to the author, assembled a team of diverse specialists, listened to each man's speculative account of events and conjectured location, and then by means of a Bayesian search procedure compiled a group solution that correctly located the submarine to within 220 yards at a spot no individual expert had picked. In another such example, Surowiecki revisited the Challenger disaster of 1986. Every American physicist probably has heard of Feynman's dramatic "O-ring experiment" during the congressional hearings following the long enquiry into the cause of the explosion. However, by Surowiecki's account, “within a half hour of the shuttle blowing up, the stock market knew what company was responsible,” and by implication (since the company manufactured the solid-fuel booster rocket) what more or less may have gone awry. There had been no clues to the accident and no insider trading and no stock dumping…so *who* knew? According to Surowiecki: “It was all those investors—most of them relatively uninformed—who simply refused to buy the stock.”

From these intriguing beginnings, the author compiles numerous other cases drawn from a broad spectrum of human activity requiring critical decisions—science, engineering, business, sports, government—illustrating the greater reliability of judgments by “crowds” than by “experts.” The book is not really about “crowds,” but about groups. And not really about “wisdom,” but about information, which, as we often are reminded too late, is quite a different thing. Nevertheless, are these instances of superior collective insights merely coincidences or actual manifestations of some kind of physical law of human behavior? The author’s explanation for why the wisdom-of-crowds hypothesis works is relatively simple. Each person’s guess contains information and error. In the average of a large number of diverse, independent estimates or predictions, the errors effectively cancel, and “you’re left with information.” The information is useful because we are all products of evolution and therefore equipped to make sense of the world. In short, Surowiecki tells us that “the answer rests on a mathematical truism,” but he does not say which.

Since the author is not a mathematician, I can think of only two such “truisms” that may have come to his attention. The first is the “law of large numbers” in which the mean of a sample of independent observations from a given population approaches the population mean as the sample size increases. Consider, for example, an election poll. In a population of 1 million people, a sample of 10 000 will give a more accurate representation of opinion than a sample of 100. However, the collectivity of opinion of the population *determines* the election. This is *not* the case for a group estimate of a preexisting external fact like the location of a missing boat or the culpability of a company. The second is the “central limit theorem” in which the sum of a large number of independent observations of a random variable is approximately distributed in a bell-shaped curve, the Gaussian or normal distribution. However, there is no *a priori* scientific or mathematical reason why the distribution of guesses from a large group of diversely (un)informed people should be *centered* on the correct answer. I am reminded here of Feynman’s anecdote in *Surely You’re Joking, Mr. Feynman* about the length of the Emperor of China’s nose. Nobody was permitted to see the Emperor of China. To find out the length of his nose (a burning question of the day, I suppose), couriers traversed the length and breadth of the land asking people for their opinion, and the outcome was the average of all the guesses. “But it’s no way to find anything out,” Feynman wrote, “when you have a very wide range of people who contribute without looking carefully at it, you don’t improve your knowledge of the situation by averaging.” And yet that is *precisely* Surowiecki’s argument for how, not only to improve your knowledge, but to do so in the most effective manner.

If valid, the societal ramifications of this radical proposition are mind-boggling. Why, for example, decide a criminal trial with a jury of 12 randomly chosen people when one could put the facts of the case on a website and simply compile the average verdict from millions of internet responses? And regarding national security, why not have a betting market where betters from all over the world can lay odds on the next terrorist attack? Come to think of it, the Pentagon actually proposed something like this in 2003 but quickly scuttled the idea in face of vehement criticism from horrified members of Congress and the news media. Should they have persisted? *Is* the hypothesis valid?

As a physicist interested in statistical phenomena, I decided to see for myself with a series of trials involving a class of 30 physics students. The experiment was implemented in four phases. In the first, students were asked to estimate various familiar physical quantities more or less at hand such as the number of shot in a jar, the height of the classroom ceiling, or the distance around the periphery of the college. In the second, students were to make “Fermi-type” estimates of quantities not at hand or familiar such as the number of banks in town. In the third, the students were asked to make predictions of the outcomes of events like the mean class score on the upcoming quiz (a familiar activity), or the Dow Jones Industrial Average (DJIA) at day’s end (an unfamiliar activity for most). And in the fourth, the class was partitioned to solve logic-type problems such as locating a lost treasure (rather than a lost submarine), the objective in this case being to see whether more correct answers came from students working in groups or from “experts” (selected by me) working individually. The results were enlightening and perhaps surprising—or perhaps not—depending on what one thought of the wisdom-of-crowds hypothesis to begin with.

Given the space limitations of a book review, let it suffice to say that in nearly all trials the class mean did *poorly* compared to the best scores of individuals, yielding a superior result in only a single instance (prediction of the upcoming average quiz score). The class median did a little better. To my knowledge, Surowiecki never defined what he meant by “average,” but from his text I inferred he meant the mean. It is worth noting, therefore, that the mean of a sample is highly sensitive to “outliers” (i.e., extreme data points), whereas the median is unaffected. Among the various interesting findings, one in particular stands out: Where the class as a whole was largely uninformed, the collection of individual responses resembled a broad uniform distribution. (Feynman was correct; this is not the way to estimate the length of the Emperor of China’s nose.) To the extent that members of the class had some previous experiences to rely on, the distribution bore a closer resemblance to a normal distribution—although not necessarily centered on the correct answer.

So does the wisdom-of-crowds hypothesis work or not? I am inclined to believe the following. In matters for which true expertise (and therefore legitimate experts) can be identified—for example, questions of global warming, biological evolution, stem cell research, or a lost submarine—I would much rather rely on the best judgments of the most knowledgeable specialists than a crowd of laymen. But in matters for which (in my opinion) no expertise or training is genuinely involved—in other words, in dealing with fields of study whose principles are ambiguous, contentious, and rarely testable, and circumstances where anyone is conceivably an expert, as, for example, questions of economics, politics, and popular culture—then yes, there is sense to polling a group of people to arrive at an average (mean or median) reply. The wisdom-of-crowds hypothesis can in fact be quantified by a relatively simple statistical model to estimate to what extent a nonexpert group of certain size can be "uninformed" and still lead in their individual replies to a distribution centered on the correct answer. The description of my model, however, will have to be given elsewhere.

Whether you come to believe in the author's main thesis or not, *The Wisdom of Crowds* is a thought-provoking and amusing book well worth reading. In examining numerous instances of bad decisions and their unfortunate consequences, the author provides useful insights that are bound to serve physicists and other scientists well as they are called upon with increasing frequency to offer their expertise in matters of mounting urgency.

Mark P. Silverman is Professor of Physics at Trinity College. His most recent book, A Universe of Atoms, An Atom in the Universe (Springer, New York, 2002), *discusses, among other things, his solution to the problem of galactic dark matter. He writes of his theoretical and experimental investigations of quantum phenomena in the forthcoming book*, Quantum Superposition: The Heart of the Matter from Electrons to Black Holes, *to be published by Springer*.

BOOKS RECEIVED

The Comprehensible Cosmos: Where Do the Laws of Physics Come From? Victor J. Stenger. 340 pp. Prometheus Books, Amherst, NY, 2006. Price: $28.00 ISBN 1-59102-424-8.

Differential Geometry and Lie Groups for Physicists. Marián Fecko. 697 pp. Cambridge U. P., New York, 2006. Price: $75.00 ISBN 0-521-84507-6.

Diffraction, Fourier Optics and Imaging. Okan K. Ersoy. 413 pp. Wiley, Hoboken, NJ, 2006. Price: $110.00 ISBN 0-471-23816-3.

Electronic and Optical Properties of d-Band Perovskites. Thomas Wolfram and Şinasi Ellialtioğlu. 315 pp. Cambridge U. P., New York, 2006. Price: $135.00 ISBN 0-521-85053-3.

Mathematical Methods for the Magnetohydrodynamics of Liquid Metals. Jean-Frédéric Gerbeau, Claude Le Bris, and Tony Lelièvre. 310 pp. Oxford U. P., New York, 2006. Price: $110.00 ISBN 0-19-856665-4.

Quantum Physics (translation). Michel Le Bellac. 585 pp. Cambridge U. P., New York, 2006. Price: $80.00 ISBN 0-521-85277-3.

Science, Understanding, and Justice: The Philosophical Essays of Martin Eger. Edited by Abner Shimony. 538 pp. Open Court, Chicago, 2006. Price: $46.95 (paper) ISBN 0-8126-9461-9.

Scientific Perspectivism. Ronald N. Giere. 160 pp. U. of Chicago Press, Chicago, 2006. Price: $30.00 ISBN 0-226-29212-6.

Thinking with Objects: The Transformation of Mechanics in the Seventeenth Century. Domenico Bertoloni Meli. 389 pp. Johns Hopkins U. P., Baltimore, 2006. Price: $70.00 (cloth) ISBN 0-8018-8426-8; $29.95 (paper) ISBN 0-8018-8427-6.

INDEX TO ADVERTISERS