

of historical details—a feature of the book I particularly enjoyed. The occasional slips do occur. There's the temporarily confusing typo (page 26) in a discussion on the invention of logarithms, where we suddenly go from multiplying 2.67 by 3.51 to multiplying 2.87 by 3.41 and then back again. Then there's the more seriously erroneous statement (page 107) that a probability density function $\phi_x(x)$ gives the probability that the value of the random variable X is x . In fact, $\phi_x(x)\Delta x$ is the probability that X has some value in the interval x to $x+\Delta x$.

My biggest concern about the book is the huge variation in mathematical expectation that Stewart has made. The logarithm chapter, for example, has a long exposition on how exponents work, whereas the chapters on Maxwell's equations and the Navier–Stokes equations feature casual uses of vector differential operators to calculate curls, gradients, and divergences. However, for readers who can handle that variance, *In Pursuit of the Unknown* is an interesting and highly entertaining book. It would make a great gift for a bright high school grandchild who has expressed interest in a technical life, or for a physicist's own secret reading.

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Reinventing Discovery The New Era of Networked Science

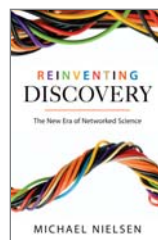
Michael Nielsen
Princeton U. Press, Princeton, NJ, 2012.
\$24.95 (280 pp.).
ISBN 978-0-691-14890-8

One primary reason I play golf is that occasionally I pull off a stroke no professional golfer could hit better. Of course, a professional golfer consistently hits such strokes. But occasional brilliance from nonprofessionals raises the question of whether a team of amateurs can beat a professional golfer if at every hole the best shot from the amateur pool is selected.

A related experiment has been tried in chess: In 1999 chess champion Garry Kasparov played against an “online world team”—some 50 000 people from 75 countries—and he ultimately won after 62 moves. Kasparov hailed it as the “greatest game in the history of chess”; a pivotal 10th move by the world team has since been added to the legendary

moves of chess. Even the way Kasparov won is instructive: The world team selected its 51st move after Microsoft's online voting system was compromised; the move, which circumvented “the wisdom of the crowd,” gave the chess champion an advantage that he converted into victory 11 moves later.

In *Reinventing Discovery: The New Era of Networked Science*, Michael Nielsen posits that in disciplines with a “shared praxis,” online communities above a critical size can scale collective intelli-



gence and significantly enhance cooperative problem-solving capabilities. Some mathematics and science problems are well suited for this “amplification of collective intelligence.” In the Polymath Project, a particular mathematical problem was solved by an online collective of 27 mathematicians in 37 days; in marked contrast, the proof of Fermat's last theorem and of the Poincaré conjecture were the results of lengthy individual heroic struggles by Andrew Wiles and Grigori Perelman, respectively.

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Nielsen assembles a collection of intriguing case studies and makes the claim that online collective intelligence is ushering in the era of networked science, which will be the most dramatic change science has seen in three centuries. Indeed, the taxonomy of problems that lend themselves to large, online, scientist–nonscientist collaborations reveals that the skills solicited of nonspecialists can be efficiently collocated by using the internet. Furthermore, the lower entrance barrier and more convenient ways for amateurs to become involved in online collaborations could become important assets for outreach in exploratory research in astronomy or environmental science. Those assets suggest important opportunities that need to be pursued. However, the author's claim that networked science will redefine the relationship between science and society is an unsubstantiated exaggeration.

Many of the early traits of networked science outlined in *Reinventing Discovery* need to be examined in the context of the recent significant transformations in how we do science. Those transformations are characterized by large interdisciplinary teams of scientists and engineers coming together to tackle mission-oriented goals or “big” scientific questions such as in the hunt for the Higgs boson, which recently celebrated a milestone. The teams share instruments and experimental results, work at large national and international facilities, and in many cases also engage in entrepreneurial and industrial research activities. And yet no viable alternative has been put forward to supplement the traditional academic system that relies on public knowledge, individual tenure, promotion contests, and peer-reviewed scientific papers as the main deliverable of grant money—despite repeated and strong claims that peer review, for instance, needs to be modified or even replaced.

Online or not, large collectives pursuing a common goal can exacerbate the alienation of the individual scientist; in any field, diluting the impact of the individual scientist makes it increasingly difficult to assess his or her contributions. *Reinventing Discovery* lacks a deeper and more nuanced discussion of the traditional academic cultural practices and reward systems, which all break down if we cannot individualize what Nielsen calls “micro-expertise.” Those are less important concerns for the citizen-scientist participating in online research networks. But

even there, personal recognition of the amateurs who provide valuable input, and in some cases make significant scientific discoveries, tends to become part of the historical narrative.

Reinventing Discovery provides an important first sketch of the rapidly emerging networked science and makes it clear that certain fields of discovery can take advantage of an unprecedented acceleration enabled by online networks. Natural scientists, social scientists, and humanists together need to address the near-term demands for open access to data created with public funding. But this book falls short in outlining a strategy to implement what it calls “networked and open science.” Openness by itself will not result in “enhancing humanity's problem-solving ability.” A coherent alignment of many cultural and political processes is needed to advance toward that goal.

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